Change Management & Process Improvement for PEMS

Scania Södertälje 2012

Mårten Carlsson & Erik Lindholm

Department of Industrial Management and Logistics Lund University, Faculty of Engineering, Box 118 SE-221 00 Lund

Acknowledgment

This thesis is the final part of our five years Master's degree in Mechanical Engineering at Lund University. The project was conducted during the fall of 2012. Scania, Södertälje, initiated the thesis in order to investigate the future usage and implementation of Portable Emission Measurement System (PEMS).

Living in Södertälje and writing the thesis has been a positive and challenging experience. The opportunity has given us a valuable insight of the Scania organization, being one of the best-known performers of lean manufacturing.

Therefore we would like to take this opportunity to thank the people that have supported us throughout our journey completing our degree.

First of all we would like to thank our two supervisors at Scania, Lena Daudistel and Henric Naessen for their commitment and valuable support, time and effort. Also, big thanks to Björn Leksell, head of the department, who came up with the idea and established the purpose of the project.

At last, we would like to thank our academic supervisor Bertil I Nilsson at Lund Institute of Technology for an extraordinary guidance and support, making this journey possible.

Lund, 2012-12-03

Mårten Carlsson

Erik Lindholm

Abstract

Title:	Change Management & Process Improvement for PEMS
Authors:	Erik Lindholm and Mårten Carlsson
Supervisors:	
	Lena Daudistel, Project Manager, Scania
	Henric Naessen, Project Manager, Scania
	Bertil I Nilsson, Adjunct Assistant professor, Department of Industrial Management and Logistics, Lunds Institute of Technology
Background:	The automotive industry in Europe has been forced to develop new solutions for the vehicles in order to fulfill the emission standards set by the European Commission according to European Emission Standards (Euro -). The latest, Euro 6, involves new demands on continuous audits of emissions during a vehicles lifecycle. The standards are legislated and without approval a manufacturer may lose its license.
Purpose:	The purpose of this thesis is to produce and recommend a solution for an industrialized method to implement PEMS measurements within the production. This should involve a technical concept solution, method for the handling of data and work descriptions as well as the distribution of responsibility. Complemented with process descriptions and if possible a financial estimation of the project.

Problem definition:	The analysis should eventuate in a recommendation of potential implementation. A procedure for measuring the emissions within area of the production line and include: • A technical method for testing and handling relevant information. • Process ownership responsibilities. • Method and process description for testing and deviation handling. • Estimation of investment cost related to the testing.
Method:	To minimize the risk of influence the work will be divided into different phases. The first phase includes process mapping and descriptions to increase the understanding and visualize the differences between the processes. In extension the processes will be compared in matter of maturity in order to evaluate the potential to find a feasible flow. The evaluation will be followed by a conceptual assessment for different PEMS-solutions, which are developed in parallel. The final phase will be to estimate the investment cost of the compiled solution.
Conclusion:	According to Scania´s demands as well as technical requirements for a realistic approach for PEMS measurements has grounded in a conceptual method. The future concept is based on an external trailer solution where the interfaces for connection have been minimized to reduce time and complexity of usage. A feasible work process has been developed suitable

for implementation as a coordinated flow parallel performed with the internal audit process.

Keywords: PEMS, Euro 6, emission, Scania, process mapping, PEMM

Abbreviations

AUDIT – Division responsible for internal audits of finished vehicles

CO – Carbon Monoxide

CO_2 – Carbon Dioxide

COP - Conformity of Production

FA* – Functional Area of the vehicle assembly line

FFU – Fit For Use

ISC - In-Service Conformity

LEAN – Management philosophy with aim to reduce all kind o waste

NMET – Division responsible for performance and emission control

NMHC - Non-methane Hydrocarbons

OBD - Onboard Diagnosis

PEMM - Process and Enterprise Maturity Model

PEMS – Portable Emission Measurement System

PM - Particular matter

QFD – Quality Function Deployment

1 Table of Contents

2 Table of illustrations

1 Introduction

The purpose of the first chapter is to provide the reader with fundamental information and an introduction to Scania, the European emission standard and our problem definition. The problem description is presented in association with the statements of the purpose. In the end of the chapter there is an outline of the report with a short interpretation of the chapters.

1.1 *Scania*

The place of origin of the company could be derived from the name, which is the Latin name of the region in the south of Sweden, Skåne. When the company first started in Malmö in 1891 Scania primary produced bicycles. Overtime, the company developed its product portfolio to include both cars and trucks.[1]

In order to meet the competition on the European market, the company merged with the Södertälje based company Vabis in 1911, which at the moment was producing cars. Together they became Scania-Vabis and started to produce buses and trucks. This has continued and by the time the company has concentrated their operations to Södertälje where the Head Office is located together with assembly and most of the manufacturing.[2]

Beside Sweden, there are production facilities in France (Anger), Belgium (Zwolle) and in Brazil (Sao Paulo). This is complemented with a set of facilities such as assembly, sales and service units around the world. In total, the company is represented in more than 100 markets where Scania supplies the markets with buses and heavy trucks. The company turnover in 2011 was approximately 87 Billion SEK and Scania Group employs more than 37’500 employees.[3]
Since 2008, the large automotive manufacturer Volkswagen is the

[1] www.scania.se
[2] Ibid
[3] Ibid

majority owner. As a result of the acquisition, Scania is now in the same family as the former competitor MAN.

In addition, both in Sweden and international, Scania is known for its version of LEAN manufacturing and usually regarded as one of the leading performers and the above example for their philosophy and working methods.

1.2 *Road Traffic Emission*

Road traffic is one of the main sources of air pollution. Tailpipe emission from road vehicles such as carbon monoxide, hydrocarbons and nitrogen oxides has often been in focus for the environmental debate. In order to counter environmental pollution from motor vehicle emissions, exhaust legislation has been stepwise tightened. Technology development in correlation with legal regulatory has increased the amount of solutions for an extensive package of measures available to reduce air pollution. This method includes both control of new vehicles and testing of vehicles in-use.[4]

1.2.1 European emission standards

Since 1993 the European Commission has defined a number of directives in order to control the exhaust emissions. These directives are legislated for all new vehicles sold in the European Union's member states and there are regulations on emissions of nitrogen oxides (NOx), non-methane hydrocarbons (NMHC), carbon monoxide (CO), total hydrocarbon (THC) and particular matter (PM). Depending on the type of vehicle, there are several directives and classifications to apply according to weight and usage.

---

4 http://publikationswebbutik.vv.se/upload/2969/2007_43_swedish_in_service_testing_programme_on_emissions_from_passenger_cars_and_light_duty_trucks.pdf

The first emission standard was the Euro 1; introduced in 1992, until now there have been four updated versions for standards with the present Euro 5.[5]

1.2.2 Euro 6

By the end of December 2013, a new updated version named Euro 6 will be mandatory for the automotive industry.[6] These new legislated standards are demanding and the industry is worried, not only about the new directives, but how the new measurements and follow-ups should be managed. These demands are not only concerning the emission levels, but also third part access to vehicle information. The new standard states that the emission durability period should effect for seven years or 700'000 km[7]. This is an increase by 130% in matter of distance according to the Euro 5 seen in table 1[8] which is a part of the regulation of In Service Conformity.

Table 1 History of exhaust emission standards within the EU.

Table 1
EU Emission Standards for HD Diesel Engines, g/kWh (smoke in m^{-1})

Tier	Date	Test	CO	HC	NOx	PM	Smoke
Euro I	1992, < 85 kW	ECE R-49	4.5	1.1	8.0	0.612	
	1992, > 85 kW		4.5	1.1	8.0	0.36	
Euro II	1996.10		4.0	1.1	7.0	0.25	
	1998.10		4.0	1.1	7.0	0.15	
Euro III	*1999.10, EEVs only*	*ESC & ELR*	*1.5*	*0.25*	*2.0*	*0.02*	*0.15*
	2000.10	ESC & ELR	2.1	0.66	5.0	0.10 0.13[a]	0.8
Euro IV	2005.10		1.5	0.46	3.5	0.02	0.5
Euro V	2008.10		1.5	0.46	2.0	0.02	0.5
Euro VI	2013.01		1.5	0.13	0.4	0.01	

a - for engines of less than 0.75 dm^3 swept volume per cylinder and a rated power speed of more than 3000 min^{-1}

5 http://europa.eu/legislation_summaries/environment/air_pollution/l28186_en.htm
6 http://europa.eu/legislation_summaries/environment/air_pollution/l28186_en.htm
7 http://www.cumminseuro6.com/what-is-euro-6
8 http://www.dieselnet.com/standards/eu/hd.php

The illustration in figure 1[9] gives an overview of the extensive differences concerning the amount of PM and NOx included in exhaust emissions since the first release. This can give a hint on the pressure given on the automotive industry to develop new solutions.

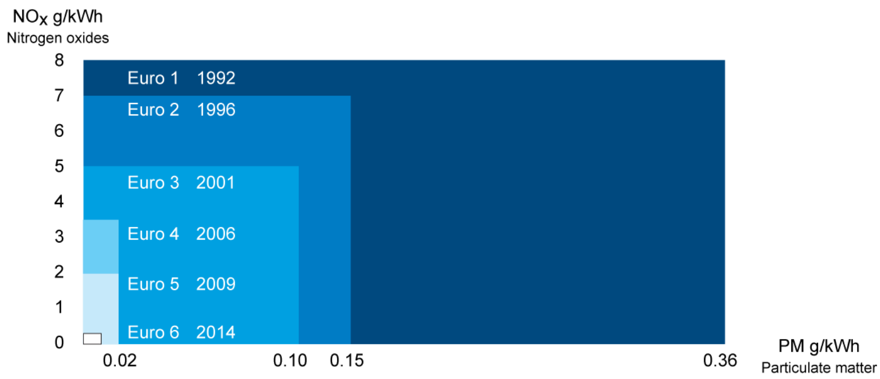


Figure 1 Progression of PM and NOx since Euro 3

1.2.2.1 In service conformity - ISC

To ensure that the vehicles fulfill the regulations not only initially, but also throughout a normal lifecycle of a vehicle, the European Commission demands controls to assure durability of the emission levels. These controls should be performed within a mileage or a period of time dependent on the type-approval of the engine or vehicle. The time span and mileage the vehicle must pass are getting more rigid every time a new Euro-standard is released and at the moment the regulations are as following seen in Table 2[10].

Table 2 Increase of emission durability periods from Euro 5 to Euro 6.

Emission Durability Periods

Vehicle Category†	Period*	
	Euro IV–V	Euro VI
N1 and M2	100 000 km / 5 years	160 000 km / 5 years
N2 N3 ≤ 16 ton M3 Class I, Class II, Class A, and Class B ≤ 7.5 ton	200 000 km / 6 years	300 000 km / 6 years
N3 > 16 ton M3 Class III, and Class B > 7.5 ton	500 000 km / 7 years	700 000 km / 7 years

† Mass designations (in metric tons) are "maximum technically permissible mass"
* km or year period, whichever is the sooner

9 http://www4.scania.com/en/globalengineplatform/START/?ineuro=3&invehicle=bus#start

10 http://www.dieselnet.com/standards/eu/hd.php

1.2.2.2 On-Board Diagnostics - OBD

On-Board Diagnostics is the term for a central system supporting the user to identify malfunctions on the vehicle´s sub systems. Information about the engine status, its malfunctions and the identification of the problematic area are stored on a memory and will be available for off-board analysis through an accessible interface.[11]

1.2.2.3 Requirements and tests

To ensure the correct exhaust emission levels, the manufacturers should equip vehicles and engines with components that reduce the emissions in order to fulfill the legislations. This should be performed without usage of any types of external defeat strategies to reduce effectiveness of the emissions control equipment.

The European Commission provides legislative levels and procedures within the following areas:[12]

- Tailpipe emissions, including test cycles.
- Crank house emissions.
- OBD-systems and in-service performance of pollution control devices.
- Emission durability control devices for conformity of in- service engines and vehicles.
- CO_2 emissions and fuel consumption
- Granting extension of type approvals
- Testing equipment
- Reference fuels e.g. petrol, diesel etc.
- Measurements of engine power
- Correct function and regeneration of pollution control devices.
- Specific provisions to ensure the correct operation of NOx control measures.

---

[11] REGULATION (EC) No 595/2009 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL, EEA, European Comission http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:188:0001:0013:EN:PDF

[12] Ibid

1.2.2.4 Access to information

Manufacturers are obligated to provide unrestricted and standardized access to vehicle information to independent operators. The information provided shall include tools containing relevant software, service and maintenance information.[13]

1.2.2.5 Financial Incentives

To meet the obligations the member states within the European Union may provide financial incentives. These should then apply on all new vehicles at the actual state's market. If the obligations are not fulfilled the state may also put financial incentives for retrofitting vehicles in use and scraping vehicles that do not comply with the regulation. The occurrence of any financial incentives as well as changes has to be reported to the European Commission.[14]

1.3 *Obligations for manufacturer*

The ability for the manufacturer to ensure that all criteria is fulfilled, according to the Euro 6, requires critical improvements in the development of the power train. To meet these specifications and avoid legal restrictions provoking the production, action has been taken throughout the whole development process.

A crucial part of the Euro 6 regulation is to assure the Conformity of Production (COP) and the In-Service Conformity. Non-compliance of these can imply complete delivery-stop and processes for re-certification. Additionally, the approving authorities may prescribe campaigns to adjust all already delivered vehicles. The ISC contains regulations concerning the sustainability of emissions on the current vehicle fleet. According to this, it is crucial to secure the product quality throughout the whole supply chain for ingoing components.

---

[13] REGULATION (EC) No 595/2009 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL, EEA, European Comission http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:188:0001:0013:EN:PDF

[14] Ibid

Scania performs a quality method called Design Failure Mode and Effect Analysis (D-FMEA), to ensure that all failure modes and effects influencing emissions are known. With this information everything in the design, affecting emissions, must be verified for its intended lifespan.[15]

1.3.1 Classification of Requirements – COR

To assure the quality in every single step of the development each part is classified according to company standards based on the "*ISO/TS 16949 7.2.1.1 – Customer-designated special characteristics*" where the impact is described in the following classes in table 3:[16]

Table 3 Classifications of requirements - COR

Class	Failing to comply with requirements can mean
<C> Critical	**Direct effect on characteristics to the customer** • Risk of injury. • Substantial economic consequence, which can entail unplanned stop and thereby making it impossible to carry out the work task.
<M> Major	**Interference with or reduction of important characteristics to the customer** • Significant economic consequence. • Can entail extra maintenance procedures for replacement or adjustment.
<S> Standard	**Insignificant effect on important characteristics to the customer**

The reason for using classifications is to highlight the critical aspects as a support for a more robust construction. The purpose is to reduce the consequences from failure and thereby reducing the risk assessment of production. A company presentation for guidelines used in this work process is seen in *Appendix 1*.

[15] RTPM Irene Ericsson; "Euro 6, COR & FMEA – Vad innebär det för oss?" PowerPoint Scania Inline 2011-06-13

[16] RTPM,Kent R Johansson & RTPM Irene Ericsson; "STD3944 Classifications of requirements - COR"; Scania Inline 2007-10-24

Scania´s classifications for ingoing parts in the engine development are shown in *Appendix 2*. Where the emission is classified as <C> critical due to the earlier mentioned case of forced production stop.[17]

1.3.2 PEMS

The regulations of In Service Conformity are mandatory for all vehicles produced and classified as Euro 6. These obligations for Scania are to secure sustainable regulations for exhaust emissions, and the company is obligated to perform on-road measurements. According to the European Commission, these measurements are to be performed with support from a Portable Emission Measurement System (PEMS).

Testing is done by sampling the tail pipe emission together with data from the vehicles OBD as well as GPS positioning data for the route driven. Samples have to contain enough data to be suitable to measuring the levels of NO_x, CO, CO_2, HC as well as the amount of PM. The equipment for this analysis is today using a gas analytical approach where the emission sample is combusted by supportive gases inside the analyze equipment with a method called flame ionization detection (FID).[18]

[17] RTPM,Kent R Johansson & RTPM Irene Ericsson; "STD3944 Classifications of requirements - COR"; Scania Inline 2007-10-24

[18] C. Weaver, P.E. Ravem System Technical Summary Version 3.1 Febuary 2006. http://www.efee.com/download/RAVEM%20Technical%20Summary.pdf

The method and equipment includes the following equipment:

- PEMS emission analyzer seen in *figure 2*.
- GPS module.
- External power source.
- Emission pipe, including pre-heating wire.
- Tail pipe adaptor including sensors.
- Three supporting gas tubes.
- Wiring for OBD data sampling.

Figure 2 Horiba - PEMS OBS 2000

This equipment is primary mounted at the foundation of the passenger seat. Wiring and emission pipe are drawn through the unused transfer for the steering axel at the passenger side of the cabin. The external power generator is externally placed behind the cabin and straps onto the frame of the chassis mount the tail pipe adaptor.

Sample data is recorded throughout the test time and analyzed by support of software calculations to ensure correct values for the measured vehicle.

1.4 *Problem description*

The new emission regulations concern all actors in the automotive industry, which are working hard to fulfill the Euro 6 requirements. The new standards will increase the demand and testing on vehicles in order to verify the emission limits as well as to maintain license for production and distribution of vehicles within the European Union.

Today, Scania is using a temporary and limited testing method for on-road measurements (PEMS), performed externally from the production line. The company requires development of a new reliable testing method and routines that can be implemented as a process of the production line.

By reviewing the present assembly processes, flows, legal requirements and demands from the power train department, At the moment Scania see’s a gap between the existing processes and is interested to have them evaluated and reviewed. The knowledge could later be used to develop future reliable, sustainable solutions.

1.5 *Purpose*

The purpose of this master thesis is to review the possibilities for a future industrialized solution suitable for production flow including recommendations for:

- A technical solution for testing and handling of data.
- Work descriptions for performing the measurements as well as responsibilities between the stakeholders.
- Method and process description for testing a mounted vehicle
- Cost descriptions (investment, handling/mounting time etc.).
- Establish work descriptions for any implemented processes or operations.

The thesis should follow a logic pattern and investigate the current situations and demands in order to find a possible solution for implementing the requested measurements. The master thesis should result in a suitable recommendation of how this work should be performed within the Scania assembly line.

1.6 *Delimitations*

Focus of the review will be to map the processes at the assembly line as well as the routines for PEMS according to the internal interests of finding possible synergies for a future coordination. European emission classification standards include all types of road-based vehicles including buses and trucks. Due to the fact that SCANIA Södertälje only build busses as semi-produced chassis for further assembly at future tiers are exclude them from our analysis.

PEMS-measurement as verification for on road emissions measurements on vehicles delimits the review to the production area for final assembly. Therefor the processes of interest will be focused on sections close to the end of line (EoL) and until the point of customer delivery.

NMET, the division for sustainable emissions and performance, is responsible for testing of audited vehicles from the production and liable for methods used to meet specified criteria's for PEMS.

The main processes of the two departments are individually defined and the goal is to find a suitable coordinated solution. The focus will be on the methods used for PEMS measurement and fulfilling specified test criteria, excluding ingoing technical specifications concerning the equipment.

1.7 *Objective*

The objective of this master thesis can be divided into two different subjects, which booth can be down structured into separate sub goals:

1. Mapping of the current situation

1.1 Clarification of the PEMS measurement process and the existing processes handling the complete vehicles in order to increase the understanding.

1.2 Review of the processes, activities and procedures.

2. Redesign for feasible processes.

2.1 Resulting in an improved technical method for testing and handling inbound and outbound information for PEMS usage.

2.2 Clarify new resources and work responsibilities between relevant processes. Estimation of costs related to the redesign that might include investments, handling costs, mounting time etc.

2.3 A presentation and a scientific article to the improved redesign.

If the result shows that there is not any suitable solution of integrating the PEMS measurements into the existing processes, there should be a recommendation of how to conduct the test in an alternative way supported by theoretical guidelines for change management.

To validate the outcome of the research, the result will be presented and briefed in terms of the actual and future status of the PEMS situation. This information will be given throughout two separate seminars, in focus groups, for the stakeholders involved in the PEMS project at Scania Södertälje.

1.8 *Outline of the report*

In order to make the reading as logical as possible the report follows in chronological order. Every chapter has a short introduction with a laconic summary of the content and aim.

Here follows an outline of the chapters:

- **Chapter 1:** Introduction, the first chapter introducing the company, the problem description followed by the purpose of the thesis and at last explaining the structure of the report.
- **Chapter 2:** Research Methodology, explaining and describing the methods used throughout the report, used for collecting data and the underlying theory for the further analysis.
- **Chapter 3:** Frame of Reference, introduces theoretical frameworks concerning the fundamentals of a systematical approach in change implementations and management of organizations. Presenting the benefits and possible gaps in the transformation phase that have to be considered to succeed with the future outcome of an implementation.
- **Chapter 4:** Methods, Introduction and description of the different methods and analyzing tools that have been used. They are introduced with a short history, followed by an explanation of how the methods are administered and how to render the potential outcome.
- **Chapter 5:** Analysis, presents the ingoing analysis of the current processes and concept evaluations. The analysis is based on the information from previous data collection methods and conducted with the help of the frameworks presented in the methodology chapter.

- **Chapter 6:** Conclusion and Result, presents conclusions based on the gathered information from the previous analysis. The conclusion regards the possibilities of a future process redesign suitable for PEMS measurements in the production flow. The results are completely based on the present situation and matched by best feasible solutions.
- **Chapter 7:** Discussion and follow up, debates how well the purpose of the thesis is fulfilled. Presentation of general conclusions for future alternative measuring concepts and process coordination methods that would contribute to Scania future progress with Euro 6. The future work is complemented by a theoretical framework for change implementations.
- **References**
- **Appendices**

2 Research Methodology

This chapter is conducted for explaining and describing the terminology of research methods used throughout the report. Explaining methods used for collecting data and the underlying theory for research structure for the further analysis

2.1 *Scientific approach*

Research methodology is seen as the map for using appropriate tools to realize the paradigm and guide your research through a systematic path. As logistical research areas more often are ill structured real world problems, multi disciplinary and cross-functional approaches are necessary to describe the situation. Used as a helpful strategy to guide the process towards a satisfying result. Factors that influence the researchers choice of method would be:[19]

- The format of the questions asked (i.e. “what”, “how”. “who”, “why” etc.) which requires different adequate tools for answering.
- Description of the nature of the researched phenomena
- The extent of control required over behavioral events in the research context
- The researchers philosophical stance and understanding of the social reality of the phenomena

To answer these objectives, it is necessary to choose an appropriate path for methods used in the research.’

2.1.1 Paradigm

To determine a primary picture of a given problem description it is crucial to express and explain the world-view to make a clear paradigm. This is done to see booth the potential and limitations of the different forms of research methods that will be used.

[19] R. Frankel, D. Näslund, Y. Bolumole, „The white space of logistics research: A look at the role of methods usage‟, Journal of Business Logistics, Vol. 26, No. 2, 2005, pp. 185-208.

" A research paradigm consists of beliefs about knowledge, whereas research methods are specific ways of gathering data. Paradigm is our world-view, the lenses through which we view the world- our Weltanschuungen (Chekland 1993)"

The paradigm is easiest structured into three separate elements. *Ontology*, describes the nature of reality and the existence of the researched object. Secondly *epistemology* deals with how we perceive the world and how the researchers interpret their view to their environment. At last the *methodology* influenced by the ontology and epistemology describes the way of how we gain knowledge about the researched object.[20]

2.1.2 Analytical approach

In the perspective of an analytical approach there is an objective reality in which patterns and casual relations can be investigated through the research process. The researcher is supposed to stay outside the research object and refrain from interacting with it in order to avoid exerting an influence and hence distort the reality he or she is trying to disclose. The basic theory of this atomistic approach is that the world can be analytically decomposed into small elements and that each element can stand alone. In order to approach reality methodologically, researchers are supposed to decompose reality into the smallest possible elements, transform these elements into concepts and finally try to find cause-effect relations by hypothesis testing.[21]

---

[20] R. Frankel, D. Näslund, Y. Bolumole, „The white space of logistics research: A look at the role of methods usage", Journal of Business Logistics, Vol. 26, No. 2, 2005, pp. 185-208.

[21] Britta Gammelgaard, (2004),"Schools in logistics research?: A methodological framework for analysis of the discipline", International Journal of Physical Distribution & Logistics Management, Vol. 34 Iss: 6 pp. 479 - 491

2.1.3 Systems approach

Describing the world from a system's approach, dividing reality into parts is meaningless. According to the system's theory the world must be understood in terms of mutually dependent "components", as a system with parts, links, goals and feedback mechanisms.

The more holistic view in a system's approach for the researcher is to describe and bring understanding of the relations among and between the included parts and activities performed at the given part of the world. As the primary purpose of a systems research is to improve or develop a solution that works in practice. The pragmatism of the systematical approach implies that the researcher has closeness to the object. The final result more often is an improvement of the actual research objects used in practice. The researcher should if possible influence the object during the time of research.[22]

2.1.4 Actors approach

With the perspective that the reality is not objective, but the result of social constructions, the actors approach differs completely from the analytical- or systems approach. Reality is rather seen as a construction and knowledge is perceived as socially constructed by the interpretation of the researcher. In order to understand the object the researcher should, if possible, be a part of the objects' reality to understand and construct the future from inside the process. The approach is highly dependent on the context and argues that it is impossible to make any predictions based on external cause-effect relations. This is based on the intentionality of human beings. According to this, the understanding of the reality of the research objects environment primarily requires a qualitative study of the intentions.[23]

---

22 Britta Gammelgaard, (2004),"Schools in logistics research?: A methodological framework for analysis of the discipline", International Journal of Physical Distribution & Logistics Management, Vol. 34 Iss: 6 pp. 479 - 491

23 Ibid

Table 4 The Arbnor and Bjerke framework

	Analytical approach	Systems approach	Actors approach
Theory type	Determining cause-effect relations. Explanations, predictions. Universal, time and value free laws	Models. Recommendations, normative aspects. Knowledge about concrete systems	Interpretations, understanding. Contextual knowledge
Preferred method	Quantitative (qualitative research only for validation)	Case studies (qualitative and quantitative)	Qualitative
Unit of analysis	Concepts and their relations	Systems: links, feedback mechanisms and boundaries	People – and their interaction
Data analysis	Description, hypothesis testing	Mapping, modeling	Interpretation
Position of the researcher	Outside	Preferably outside	Inside - as part of the process

The review of the organizational structure and its processes brought us closer to the research object. Major parts are conducted from inside the organization, during the time at Scania (fall 2012), as a part of an ongoing project we used an mixture of the ingoing elements described in the multi methodical approach to describe our project according to the Arbnor and Bjerke framework.[24]

[24] Britta Gammelgaard, (2004),"Schools in logistics research?: A methodological framework for analysis of the discipline", International Journal of Physical Distribution & Logistics Management, Vol. 34 Iss: 6 pp. 479 - 491

2.1.5 Quantitative vs. Qualitative

The methodologies generally range between the more objective, scientific (quantitative) to the more subjective or more constructive (qualitative). The more objective, scientific research methodologies dealing with quantitative statistical data are designed to quantify how a phenomenon responds to changes and stimuli in its environment. The qualitative research methodologies are based in the social sciences to be able to study social and cultural changes. The qualitative research is seen as multi methodic and has an interpretive naturalistic approach to its subject in its natural settings. The research involves collection of a selection of empirical materials such as observations, interviews, interactions, case studies, personal experiences and visual texts describing and visualizing the reality for the spectator.[25]

Qualitative research is according to lack of multi method research often criticized of being to exploratory and objective and therefore more seen as journalism. As mentioned earlier it is crucial to know that *the world can only*

> "*be understood from the point of view of the individuals who are directly involved in the activities which are to be studied"*
> *(Denzin and Lincoln 1994).*[26]

On the other hand, quantitative research often gets criticized for the fact that analyzes tend to seek for casual relationships in correlation with the pre stated hypothesis. Concerns are made that data can be clouded due to the fact of unsuitable sample sizes and that the complexity of suitable methods are difficult to find.

---

25 D. Näslund, (2002), "Logistics needs qualitative research – especially action research", International Journal of Physical Distribution & Logistics Management, Vol 32, Iss: 5 pp. 321-338

26 (2)R. Frankel, D. Näslund, Y. Bolumole, „The white space of logistics research: A look at the role of methods usage", Journal of Business Logistics, Vol. 26, No. 2, 2005, pp. 185-208.

A. Bryman & E. Bell have constructed a graphical table that generalizes the different aspects to enlighten the differences between the two characteristics in researchers approaches. This should be seen as a tool to differentiate the differences due to the fact that a multi methodical approach uses parts from both of them to describe the world as naturalistic as possible.[27]

Table 5 Fundamental differences between quantitative and qualitative research strategies

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

2.2 *Data collection*

Collection of appropriate data is crucial to completely cover all aspects of a researchers object and be able to obtain reliable data for further analysis. As modern logistical research strives to develop according to Frankel *et al.* by trying to balance the "white space" it is necessary to be open minded and question paradigms and usage of research methods by challenging the knowledge and choice of data sources. The benefit of multiple sourcing and different methods for

[27] Alan Bryman , Emma Bell, Business Research Methods, 2nd Edition Oxford University Press 2007

collection is to see what kind of synergies each method could give and how they possibly can complement each other. No single source or method for collection has a complete advantage over another and not all methods are suitable for all cases of research.

Frankel *et al.* identify eight primary methods for data collection, *surveys, interviews, observations, focus groups, case studies, experiments, literature review* and *content analysis* that further will be described to obtain a deeper knowledge of the benefits of using them.[28]

2.2.1 Surveys

Surveys are a structured method for data gathering in form of a predefined questionnaire. The questions are preferable defined in a way so that the researcher can access and analyze the data. The administration for data collection can differ in form from non-electronic to electronic including web-based solutions or e-mail surveys.[29]

We have chosen to see the survey tool as a complement to our work in focus groups where we constructed a suitable model of the Process and Enterprise Maturity Model. As a part of the workshop, we guided the participants through a structured questionnaire to let the process owner judge his or her process in terms of a reliability scale for the statements.

2.2.2 Interviews

Interviews are a suitable source for data collection covering a variety of formats but with a design suitable for a personal meeting between an interviewer and respondent. The structure of an interview varies from un-structured, semi-structured to completely structured in format. The benefit of using different format of the interview is that

---

[28] R. Frankel, D. Näslund, Y. Bolumole, „The white space of logistics research: A look at the role of methods usage", Journal of Business Logistics, Vol. 26, No. 2, 2005, pp. 185-208.

[29] Ibid

the interviewer has the opportunity to choose how specific and controlled the data will be depending on the "depth" in the used questionnaire. The completely structured interview can be described as a verbal survey with fixed response options, to the opposite where the purpose of the interviewer is to uncover underlying motivations, attitudes and beliefs etc. The differences from an interviewer's perspective is that in less "depth" interviews the data are more comparable, due to the low grade of involvement, and underlying intentions of the interviewer is less important for the result.[30]

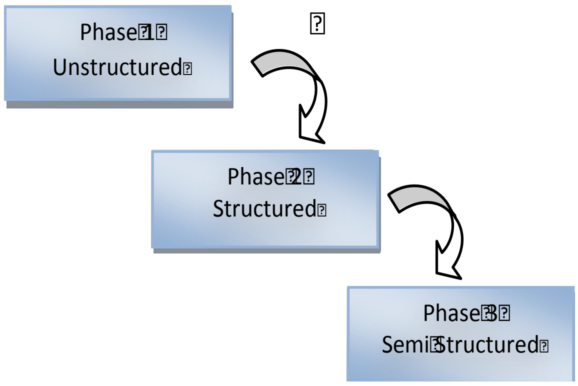


Figure 3 Interview structure

Throughout the project, more or less structured interviews have become one of the most valuable tools to proceed forward. The complexity of the project involving several divisions with unclear motives of the projects purpose has contributed to use interviews as the most powerful tool. In the initial phase as a source for information concerning basic understanding and knowledge described as primarily data collection. As interviews are an excellent

[30]R. Frankel, D. Näslund, Y. Bolumole, „The white space of logistics research: A look at the role of methods usage", Journal of Business Logistics, Vol. 26, No. 2, 2005, pp. 185-208.

tool for building personal connections the incentive throughout the project was to use the network for quick responses. This was used for supporting more structured questions often through e-mail related as a second phase of interviews.

In the third phase, the interviews provided support and validation in the proposals for a future redesign and brought the researchers to a more influential position.

2.2.3 Observations

The purpose of an observation is to objectively collect information and get insight by ocular or participation in the phenomena of interest. The case could be of different kinds of nature such as behavioral patterns of people, objects and events in a systematic manner. The role as an observer can vary from a perspective where the observer completely observes without interfering to complete participation. The major difference is that the participant is supposed to be a part of the ongoing process and is supposed to communicate and behave as an ordinary member of the organization.[31]

There are some criticisms dealing with the concerns that an observer's involvement are affecting with the nature of the phenomena and are known as the observer effect.[32]

Primary parts of the thesis concern the mapping of dependencies and obstacles. In this case, between well industrialized established and new, less established processes and the probability of a future coordination. Starting with observations booth as complete observers and as participants to get familiar to the nature of the daily routines on the line.

---

[31] R. Frankel, D. Näslund, Y. Bolumole, „The white space of logistics research: A look at the role of methods usage", Journal of Business Logistics, Vol. 26, No. 2, 2005, pp. 185-208.

[32] D. Coon, J. O. Mitterer ,Introduction to Psychology: Gateways to Mind and Behavior, 12th Edition, 2010

2.2.4 Focus groups

Focus groups are conducted by a trained moderator among a small group of respondents with a purpose to gain insight by listening and talk about issues concerned by the researchers. It is usually done in a group of people from appropriate markets or divisions in the organization.[33]

The project is performed from the chassis division point of view with interests in work methods and specifications from R&D and focus groups has therefor been an excellent forum for cross-functional discussions. Especially as a fact to support all members involved being able to gain knowledge and discuss the common problem areas.

2.2.5 Literature review

Literature reviews involve an in-depth analysis and critical summary of other authors' previously collected data, i.e. secondary data."[34]

The main purpose for the literature review was to build a solid understanding of the variables and aspects concerning how the different ingoing divisions in the project viewed and evaluated their processes and requirements. The result from such review in combination with interviews and observations is to be able to find a research gap where future studies are needed to be addressed. A part of this work has been to review the process documentation to collect valuable knowledge for future improvements and to be able to guide the process owners during the maturity evaluation.

2.2.6 Content analysis

The definition of content analysis is somewhat correlated to observations. Despite that it is seen as a separate part justifies its placement as a separate category for data collection. Content analysis concerns the reviews of documents, websites, archival

---

[33] R. Frankel, D. Näslund, Y. Bolumole, „The white space of logistics research: A look at the role of methods usage‟, Journal of Business Logistics, Vol. 26, No. 2, 2005, pp. 185-208

[34] Ibid

records, organizations intranet content and documented routines etc. Content analysis is beneficial for processing an objective picture of the object or organization from a broad perspective.[35]

The primary use of content analysis was to get familiar with the infrastructure of the organization and to find the right sources for information. Access to Scania In Line has provided the project with knowledge of the separate divisions suitable for the research. Scheduled appointments with people involved in the project contributed with the basic information about the assignment and a better foundation of the ingoing areas for the problem description.

The second phase has been to find sources for data to build a more structured analysis of the information needed for future methods and analysis.

---

[35] R. Frankel, D. Näslund, Y. Bolumole, „The white space of logistics research: A look at the role of methods usage", Journal of Business Logistics, Vol. 26, No. 2, 2005, pp. 185-208.

2.3 ***Trustworthiness and authenticity***

Scientific research in the logistical field is based either on quantitative or qualitative data, or as a combination of the two. It has a major importance to guarantee trustworthiness and credibility of the final result. This thesis mainly focuses on a qualitative approach. The evaluation of trustworthiness and authenticity is highly concerned and explained more thoroughly.[36]

2.3.1 Induction, deduction and abduction

There are mainly two methodical approaches used when analyzing data, the inductive approach and the deductive approach. An inductive approach implies that the research data is analyzed in order to create a theory and the deductive approach works the other way around by verification of theory through empirical research. The researcher should, on the basis of what is known about a particular issue, deduce a hypothesis that must be subjected to empirical scrutiny.

Criticism about the methods is given and in particular that an inductive research face the fact that the theory created will not contain anything that is not presented in the empirical data. An inductive approach is however useful when exploring new fields of knowledge.[37]

As research attempts to develop a combined method of the two commonly known as abduction. The two methods provide a logical reasoning where existing theories are used for the analysis at the same time as the researcher can use the empirical data to find new relationships.

---

[36] Alan Bryman , Emma Bell, Business Research Methods, 2nd Edition Oxford University Press 2007

[37] Ibid p.11-15

2.3.2 Reliability

The fundamental concern of reliability deals with the issues of the consistency of measures. The statement of the reliability in research follows three prominent factors.[38]

- *Stability* - asking if the confidentiality of the measures is stable over time and the determination if the respondents fluctuate.
- *Internal reliability* - concerning if the scale or index for indicating the measures are consistent.
- *Inter-observer consistency* - treats the content of subjective judgment involved in analyzing and categorizing of the measured variables and their behavior.

2.3.3 Validity

"Validity refers to the issue of whether or not an indicator (or set of indicators) that is devised to gauge a concept really measures that concept." [39]

2.3.4 Authenticity

Authenticity concerns a wider political impact of the research and refers to whether the research fairly represents different perspective observed. The concept of authenticity can be described in four different aspects.

- *Ontological authenticity* concerned about if it help members to get a better understanding of their social environment.
- *Educative authenticity* concerns or helps the members appreciate the perspectives of other members of their social situation.
- *Catalytic authenticity* refereeing to if the research has provided members with an incentive to engage in action.

---

[38] Alan Bryman , Emma Bell, Business Research Methods, 2nd Edition Oxford University Press 2007, p410-411.
[39] Ibid

- *Tactical authenticity* dealing with the fact that members has been empowered to take the necessary steps to change their circumstances.[40]

2.3.5 Credibility

Credibility also described as the internal validity of a research describing concerns whether there is a good match between the researchers observations and the theoretical ideas they develop.[41]

2.3.6 Transferability

Transferability refers to the degree of which the findings of a result hold in another context or even in the same context at future research. Qualitative findings usually tend to be oriented to the contextual aspects of the case or social event studied and it is therefore important to provide a thick and detailed picture of the fundamental concepts to be able to provide the reader with sufficient information for making judgments about transferability to other environments.[42]

2.3.7 Dependability

Dependability concerns the statement of whether the results of a study are repeatable for future evaluations and case studies. It is the basic foundation for trustworthiness for the research and set the criteria for well-documented methods and documentations of the work processes.[43]

---

[40] Alan Bryman , Emma Bell, Business Research Methods, 2nd Edition Oxford University Press 2007, p. 414

[41] Alan Bryman , Emma Bell, Business Research Methods, 2nd Edition Oxford University Press 2007, p.411-412.

[42] Alan Bryman , Emma Bell, Business Research Methods, 2nd Edition Oxford University Press 2007, p.413-414.

[43] Alan Bryman , Emma Bell, Business Research Methods, 2nd Edition Oxford University Press 2007, p.414.

2.3.8 Conformability

Conformability concerns the fact that the research is completely objective and as much as possible ensuring that the researcher has acted in good faith. Stating that it should consequently be evident that the researcher has not permitted personal values or influences from the researched object to modify the behavior of the research and the findings derived from it.[44]

2.4 *Strategy of research*

Figure 4 illustrates the approach conducted in the research and is a part of the first outline from the given problem description. Visualization of the ingoing parts in the initial problem description showed out to be a very useful tool when aligning and verifying the expectations and strategy with the supervisors at Scania.

The basis of the strategy is to work with two different tracks at the same time and keep them as separated as possible. This was done to eliminate intentions and to stay objective and not influence the processes "As-Is"-state. The two different tracks are shown as *Phase I* and *Phase II* in the figure.

- ***Phase I:*** *R*eviews the current situations and processes of relevance for the areas of the final chassis assembly including flows from the end of assembly until customer delivery.
- **Phase II:** Analyses the process for emission measurement and how it is, should and preferably could be performed according to requirements and regulations. This phase will include comparison with similar measurement systems as well as technical concept evaluation, interviews and observations.
- **Phase III**: Develops and evaluates the new redesign of the PEMS process that will be suggested to fit within a suitable flow at the production facility

---

[44] Alan Bryman , Emma Bell, Business Research Methods, 2nd Edition Oxford University Press 2007, p.414.

- **Phase IV**: If possible and if time is given, the strategy is to further develop the process mapping with documentations for the specific work descriptions and routines.

The four phases are conducted with the earlier mentioned ways of collecting data and later on analyzed and evaluated with suitable tools and methods. The double-headed arrows correlate with the process of continuous improvements and are meant to show that research is not conducted as a straight path, but as continuous audits of the work process. A theoretical framework highlighting the current situation and how to establish a change process will support recommendation of future progress in change management.

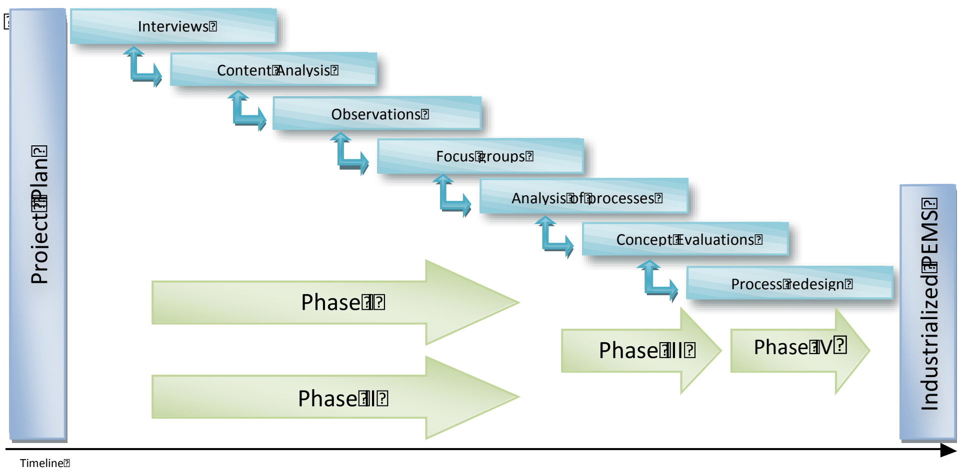


Figure 4 Strategy of Research

2.4.1 Method of analysis

The strategy of research shows the four different phases of the approach during the thesis. Enabling the research, these phases have specific features and methods connected to them.

The first two phases are similar, with the difference of the focus area. The phases are mainly conducted through process mapping and process description. Collecting data combined with observations and informal interviews will give an understanding for the processes, which will result in process maps and a detailed process description.

When processes are mapped, the next phase could start. The third phase's purpose is to compare the maturity of the processes and visualize if they are compatible for a future implementation. The method for evaluating the maturity of processes is called Process and Enterprise Maturity Model, PEMM. The main focus with the model is process redesign and comparison between processes; this will be supplemented with conceptual evaluation for different PEMS solutions being developed in parallel.

The final phase will be to estimate a business case including investments, and resources connected to the redesign.

3 Frame of reference

This chapter introduces theories concerning the fundamentals of a systematical approach in change implementations and management of organizations. Presenting guidelines for the work performed in future organizational changes.

3.1 *Eight steps to transforming your organization*

Professor John Kotter has through years of experience in the field of change management and leadership studies achieved to translate his knowledge into a systematic framework. He proposes that managing a change is rather a significant method of leadership throughout what he calls the “Eight steps of transforming your organization”. He emphasizes that all organizational changes are described as a stepwise change where each completed step is a part of a time-consuming change process.[45]

The eight-step framework’s purpose is to support the change initiative and clarify the activities of change. This is useful to help the organization to impart and visualize the concepts so that everyone gets familiar and involved within the change process. The systematical approach starts by establishing a sense of urgency for the transformation to support motivation and create a future “to-be” vision. Making a clear plan by visualizing possibilities and threats by using tools appropriate for benchmarking such as SWOT analysis etc. People with enough competence and power then communicate the new vision throughout the organization to realize it. To keep the change initiative actual and prioritized by the organization it is crucial to create credibility by showing short-term wins. This is done to convince the people involved that the goals set are achievable and works as a momentum for the future change implementations. The catalyst effect by the increased credibility of the visualized short term wins, should be further used for system as well as structural changes and policies that conflict with the new vision. As a final step of the framework, connections between the new behaviors and

[45] J.P. Kotter, “Leading Change: Why transformation efforts fail“, 1995.

corporate success should be articulated in order to make people believe in and embody these new approaches.[46]

Figure 5 Kotter´s Eight Steps to Transforming Your Organization

---

[46] J.P Kotter, "*Leading Change*, 1998.

Stressing through or skipping one or more of the eight steps of the process is not recommended, and worth mentioning is that significant mistakes in any of the phases may cause devastating impact on the future result. *Kotter (1995)* states that:

> *"In reality, even successful change efforts are messy and full of surprises. But just as a relatively simple vision is needed to guide people through a major change, so a vision of the change process can reduce the error rate. And fewer errors can spell the difference between success and failure."*

4 Methods

In this chapter the different methods and tools that have been used throughout the review and analysis are described as a foundation for our further evaluation and development. They are all introduced with a short history, followed by an introduction and an explanation of how the methods are administered and how to render the potential outcome.

4.1 *Process mapping*

To clearly understand the methodology about process mapping it is crucial to be aware of the basic foundation of a process and according to *Ljungberg* et.al, a process can be defined as.

"A process is a repetitive used network of in order linked activities supported by information and resources to transform "object in" to "object out" from identification to satisfaction of the customer needs"

4.1.1 The components of a process

A process is in most cases connected to systems together with other processes as a part of a bigger system. These can be on different levels, upper or lower according to the studied process or even at the same level. The common factor is that all processes can be divided into part processes or directly into activities shown in figure 6. The main objective is to transform the *object in* to a processed and refined version called *object out* or as a transformation of a need to a satisfaction. To clearly understand the ingoing components of a process, a shorter description of them are presented below.[47]

[47] Larsson, E. & Ljungberg, A.:Processbaserad verksamhetsutveckling.Studentlitteratur, Lund, 2001. P206-209

Object in - is a central part of a process. The object in is the trigger for the process as well as for the ingoing activities. Without an object in the process or activity it is not possible to start. *Ljungberg* (2001) also enlightens that the correctness of the object in is crucial for the future result of the process output.

Object out - is commonly known, as the earlier mentioned output of the process and is the result of a processed and refined object in.

Activities - are defined as the operations done to refine the input in this case the object in.

Resources - is the material or work that is consumed to transform an object in through the process to refine it to an object out. *Ljungberg* (2001) describes the resources as[48]

"what effort that is necessary for an activity to be performed"

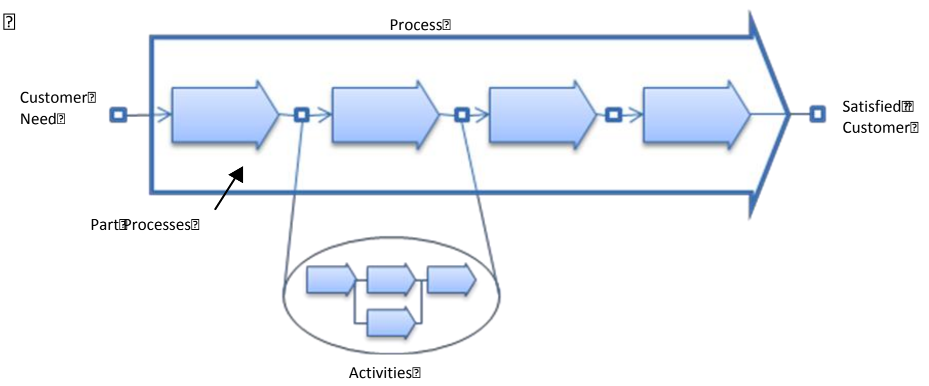


Figure 6 The ingoing parts of a process

[48] Larsson, E. & Ljungberg, A.:Processbaserad verksamhetsutveckling.Studentlitteratur, Lund, 2001. P206-209

The ability to map processes in an effective and relevant way is supported by a structured and well-known workflow. This framework is not only effective, but also helpful to eliminate common mistakes and errors, such as:

- Activities are stacked on top of each other without any good definitions and reflections.
- Early focus on details.
- The initial phase until the mapping gets stated is too long.
- The improvement phase of the map is getting started before the As-is is defined.

In order to eliminate and minimize this type of mistakes, the following approach is used when mapping the different processes:[49]

1. **Define the purpose of the process with start- and endpoint.**
   Before the initial phase of mapping the process it is recommended to know the conditions and the scope for the process. Therefore it is important to define the total purpose of the process and follow up with the start and the end.

2. **Brainstorm all the activities and document them.**
   It can be difficult to define all the activities within a process by brainstorming. Performing the activity identification as a team usually simplifies the task. Doing this together is also a good way to gain different views from the participants to clarify the activities. Using for example post-it notes it is easy to get an overview and rearrange and to modify the activities if necessary.

3. **Rearrange the activities**
   It is an important step to test and modify the activities to find the most feasible solution. The aim is to clarify all activities and its ingoing purposes of the present situation.
4. **Merge and add activities**

[49] Larsson, E. & Ljungberg, A.:Processbaserad verksamhetsutveckling.Studentlitteratur, Lund, 2001. P206-209

In this phase the mapping-group often finds that activities are similar and fulfilling the same purpose as well as activities could be missing out. To manage the situation it might be necessary to merge different activities, rename them with better descriptions of purpose or even add new activities.

5. **Define input and output for the activities**
   When the activities are defined, the next step is to connect these to each other through inputs and outputs. This step is quite often missing out and results in a non-complete process with limited usability.
   With well-defined input and output the understanding for the different activities is increased and can be beneficial for any further measurements of the process.

6. **Secure activities to be connected through the in- & outputs**
   To verify that the activities are connected with inputs and it is a good advice to check if any activities are missing or if there is any backlashes etc.

7. **Control that activities are at the same level and are well named.**
   After the process has been connected to all activities the next step is to compare that they are at the same level of detail. Often there are different levels of details throughout the process description and it is difficult to reveal, but important to even out the difference. It could often be solved and revealed by control the names of the activities as the earlier steps.

8. **Correct until there is a satisfactory description of the process.**
   Finally, the total process map has to be controlled and corrected in different aspects until it is good and useful.

4.2 *PEMM – Process and Enterprise Maturity Model*

The Process and Enterprise Maturity Model, introduced by Dr. Michael Hammer in 2007, is a benchmark and guidance tool for organizations to increase their process knowledge and become more process oriented. The model is based on the fact that all companies have to ensure that their business processes become more mature meaning that the capability of performance should increase over time. For carrying out this, there must be a development within two different characteristics: *process enabler*s, which intend to evolve the processes within the organization and the *enterprise capabilities,* which are focusing on the entire organization.[50]

Five different process enablers conduct the framework for processes development*:*

- **Design** – the developed description on how the process must be carried out

- **Performers** – the skills and knowledge of the executers of the processes

- **Owner** – maps the process identity, activities and authorities and are responsible for its result.

- **Infrastructure** –management system and information flows that the support the processes.

- **Metrics** – what type of measurement systems for metrics the company use to track performance.

These are followed by four *enterprise capabilities:*

[50] The Process Audit; M. Hammer, Harvard Business Review, 2007

- **Leadership** – managers supporting and developing the creation of the processes.

- **Culture** – the company values of the customer focus, the employee interaction and willing to change.

- **Expertise** – the knowledge and skills in methods of process redesign.

- **Governance** – routines and mechanisms for change initiatives when managing major project of higher complexity.

The capabilities and enablers are to be used simultaneously in order to progress in the process transformation of the enterprise. Evaluations of these are to include different important key attributes where the organization decides how these should be improved to enable performance increase. These attributes are then complemented with different statement in four different steps describing the grade of maturity of the process. Each statement is to be valued according to the validity and weighted as *largely true* (at least 80% correct), *somewhat true* (between 20% and 80% correct) and *largely untrue* if the result is lower than 20% correct.[51]

These statements are translated into colors, green, yellow and red, that indicate how the enterprise is situated. Green means that there is nothing or little work to do, yellow that there is moderate adjustments and red that there is a real effort to be done. This visualization gives a clear view of what to improve to support the organization to advance in terms of process orientation. The process audit is not the tool for how to manage the resources and succeed to be a flawless process oriented organizations in terms of what methods needed. It is more seen as a highly valuable tool for

[51] The Process Audit; M. Hammer, Harvard Business Review, 2007

auditing the ongoing work and gives the user guidelines for what to prioritize. A layout of the framework could be seen in *Appendix 3.*

4.3 *Quality Function Deployment, QFD*

Customer centered planning, *in Japanese called "hinshutsu kino tenkai", was* introduced in Japan in 1966 by Professor *Shigeru Mizuno (1910 – 1989)* and Dr. *Yoji Akao (1928 -).* The concept was developed as an approach to provide companies, facing rapid changes in market demands and technological innovations, with a tool to assure high quality throughout their product development process. As the market for products and services has changed during the last decades and customer demands has increased in terms of social and economical aspects companies have found out that the effort to develop new products is crucial for their survival.[52]

4.3.1 Data collection

The methodology of QFD supports an increased utilization of cross-functional decisions and provides a better participation and communication among the ingoing organizational functions. Supported by a reliable step-by-step solution aimed to translate customer demands into specific design targets, QFD supports the user with major quality assurance points. These are to be used in further production stages and will eventually fulfill the customer with satisfaction. The systematic framework steps will be described more ingoing as follows where the user has to:[53]

- Compose a marketing research to collect and analyze the customer needs and expectations.
- Implement a competitor analysis to compare and evaluate competitors' ability to fulfill the customer needs.

[52] Quality function deployment; integrating customer requirements in product design / author and editor-in-chief, Yoji Akao; translated by Glenn H. Mazur introduction by Bob King. 1990

[53] Kvalitet; från behov till användning, Bo Bergman, Bengt Klefsjö 2007, p. 133-144.

- Based on the earlier analysis, identify key success factors for the product or service provided.
- Transfer these factors to specific conditions that have to be included in the future development and manufacturing of the product or service provided.

Collection of data can be conducted according to several methods such as surveys, focus groups, interviews etc. The method chosen is not fundamental for the result, but more concerned that the data is valid for the analysis. To assure the validity of the competitor analysis it is recommended to perform frequent audits to be able to reevaluate the competitiveness of the development.

4.3.2 Work structure

Transferability of customer demands throughout the development process is considered as the most valuable criteria for success. To manage this, the process has to be holistic and systematically down structured in segments suitable for the project. A preferred way of doing this is to break down the customer specific demands into four separate levels. Each level should evaluate how to completely cover the demands in an effective and efficient way as possible. This is done to increase the economical and functional quality for the product or service. Bergman and Klefsjö describe these steps as:[54]

1. **Product planning** - First phase aims to translate the customer requirements or "Voice of the customer" into product requirements. This is done by weighting criterias' to what is seen as primary important for the end customer and what regulatory that has to be fulfilled. The work is more often done by a marketing department and documented in a graphical method called the House of Quality.

2. **Product design** - Second phase is usually led by the engineering department and creates production concepts suitable for requiring the needs from the customer review.

[54] Kvalitet; från behov till användning, Bo Bergman, Bengt Klefsjö 2007, p. 133-144.

3. **Process planning** - Third phase contributes with knowledge in manufacturing processes and finds suitable solutions to meet standards for the ability of manufacturing of the product.

4. **Manufacturing design** - Last phase documents what performance indicators that will be used to monitor the process and routines for maintenance and working flow methods. Parts of the operational risk management is analyzed and documented to reduce future risks of quality deviations.

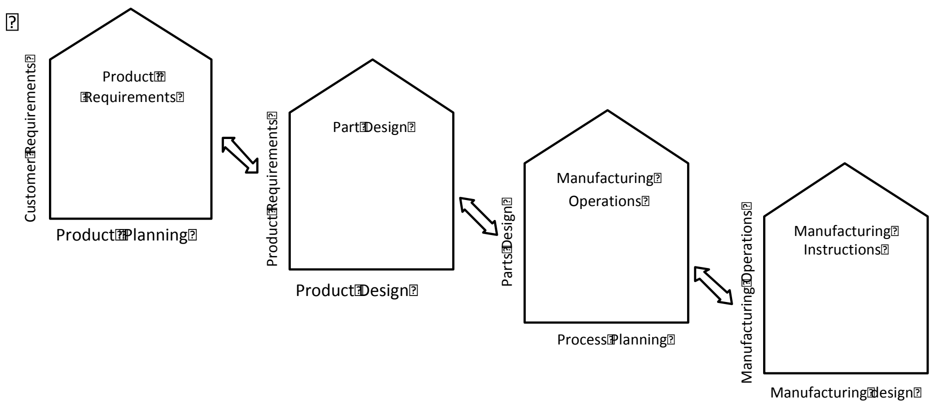


Figure 7 Quality Function Deployment – The House of Quality

The methodical framework for succeeding with quality based development, is seen as a powerful guideline for both manufacturing of products as wells as for development of services.

4.3.3 The House of Quality

The House of Quality is a developed method for matrix analysis seen as one of the seven management tools described by *Bergman and Klefsjö.* The aim is to visualize correlations between customer needs and required specifications in products or services. The approach for its use is strictly systematic and stepwise described graphically in *Appendix 4*.

Step 1: Customer requirements - " Voice of the Customer"

The first step of constructing the base matrixes is to determine information about the customer requirements. Using an appropriate tool for data collection such as a tree diagram does this. It is helpful to categorize the requirements into different criterias such as usability, performance etc.

Step 2: Regulatory Requirements

Even if the customer needs are the primary criterias for a suitable solution, not all of the customers are aware of legislation or company standards that have to be followed. These aspects have to be considered as well as the once in step 1.

Step 3: Customer Importance Ratings

This is the first step of weighting the requirements, by rating them on a scale from 1-5, in terms of importance. A five is considered as the most valuable rating.

Step 4: Customer Rating of the Competition

The fourth step is the first external benchmarking between the company's product and service compared to the competitors on the market. This phase is preferred for survey-based research conducted as a second market research. This information can support additional considerations for remodeling at an early stage of the development process.

Step 5: Technical Descriptors – "Voice of the engineer"

A technical descriptor is an attribute that is measurable and able to benchmark entirely to competitors or past products or services.

Step 6: Direction of Improvement

As the technical descriptors are specified, the direction of improvement has to be considered. This is how the measureable value will contribute to a better or worse product. For example, if a car should be more or less environmental friendly in terms of exhaust emissions.

Step 7: Relationship Matrix

This is the phase where the development team determines if the company has the ability to meet the customer needs. These relations are measured as weak, moderate or strong and translated into numerical values of 1, 3 or 9.

Step 8: Organizational Difficulty

Here the company policies are the parameters that have to be considered. Explained in terms if it is relevant or even forbidden to develop some solutions according to company policies. As an example by not use of different colors on painting due to the fact of higher stock holding etc.

Step 9: Technical Analysis of Competitor Products

Benchmarking the competitors' technical descriptors gives understanding about the competition. This is mostly done by reversed engineering either by reviews of documentation or as a complete hardware test of the other manufacturers products.

Step 10: Target Values for Technical Descriptors

In this phase, the evaluation team establishes numerical values for each descriptor to be able to have measurable goal values for further development.

Step 11: Correlation Matrix

This part correlates as the roof on the House of Quality and useful as a visual marking on how the descriptors correlate.

Step 12: Absolute Importance

Here, the development team will determine the importance of each technical descriptor by multiplications of the correlation factor and the weighted value and the adding them up to a total. The result gives a clear picture of which technical aspects that is most valuable for the end user.

The building and analysis done in the House of Quality are then transferred through the next three following steps in the QFD process. In this way, a cross-functional analysis is made and expertise from all segments of the organization is involved to reach an optimal efficiency and effectiveness of the translation of the customer needs throughout the development.[55]

4.4 *Gantt-chart*

The chart is named by Henry Gantt in the early 1900s, he was not the original developer of the model, but introduced it to the public.[56]

The activity times within a Gantt chart are shown as bars, the only difference is that they are laid down horizontally instead of the more common vertical direction in a histogram. The method of using the chart is nowadays well known and especially within the construction business, but could be useful in different situations due to its simplicity.

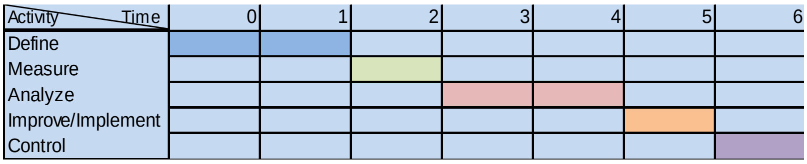


Figure 8 Illustration of Gantt Chart

---

[55] Becker Associates Inc, http://www.becker-associates.com/thehouse.htm

[56] Joana Geraldi, Thomas Lechter, A critical analysis of its roots and implications to the management of projects today, ISSN: 1753-8378

When planning a Gantt chart, all of the different activities represented by bars are placed within the time span. The completed chart summarizes all the work that is needed in order to complete the project. The simplicity of the chart it is easily understood by both people involved as well as for external stakeholders.

The model has due to its simplicity some limitations, for example there are not any connections or dependencies between the activities, making it impossible to visualize what will happen to the total project time according to delays. Due to lack of control, the dependencies and risk of delays could endanger a project. To reduce the risk of strategic impact, other charts and models where dependencies and other properties are taken into consideration often complement Gantt-schedules.[57]

Although, the major strength with this method is the limited workload needed. To clarify and map the different activities is positive not only for the time planning, but also to illustrate and understand the activities involved. As much of this workload already is done in the regular planning and procurement, the extra workload for constructing a Gantt chart is limited and gives a good overview of the activities involved. To get the full return of the chart it has to follow, otherwise it has to be made all over again not to putting the whole project to danger.

[57] Fisk, e., Construction Project Administration, Prentice-Hall Inc., 1997, ISBN 0-13-502279-7

5 Analysis

This chapter presents the analysis of the current processes and concept evaluations. The analysis is based on the information from previous data collection methods and conducted with help of the frameworks presented in the methodology chapter.

5.1 *Process mapping*

The work approach for mapping the involved processes in the review was conducted through slightly different approaches. As both of the processes for FA6 and Audit where well established in terms of structure and documentation, the description is based on content analysis and complemented by shorter unstructured interviews with the process owners. The mapping of the PEMS-process was supported by the step vise approach described by *Ljungberg (2001).* The individual processes and ingoing activities are described below and supported by graphical descriptions as well as activity lists in the appendices.

5.1.1 FA6

The area that is called FA6 (Function Area 6) or FO6 in Swedish (Funktionsområde 6) is the final step in the chassis assembly. This is where most of the parts have been mounted and the trucks are ready to be driven for the first time. The main purpose of this section is to control the systems of the car and that the features are working properly. This is performed in a number of smaller steps where sets of activities are put together to match the current tact time. The process input is an assembled vehicle from the line, ready for delivery or for mounting of complementary equipment. The process output is a fully verified functionality of the vehicles according to the standards set by the manufacturer and regulatory safety specifications.

If the vehicles are controlled and approved as desired, the next step will be customer delivery. Other potential ways for the vehicles are listed below and will be mentioned and graphically displayed in figure 9.[58]

- The truck does not meet the demands and have errors, it will be sent to a service-unit who control and fixes any defects.
- To control the quality of the vehicles, it might be sent to audit where most of the parts are re-controlled and documented.
- The truck has been ordered with minor or major customizations and will be sent to units specialized for this kind of operations with complementary equipment. The two main units of this kind are called FA7 or FFU.

The complete process of FA6 is visualized in *Appendix 5*.

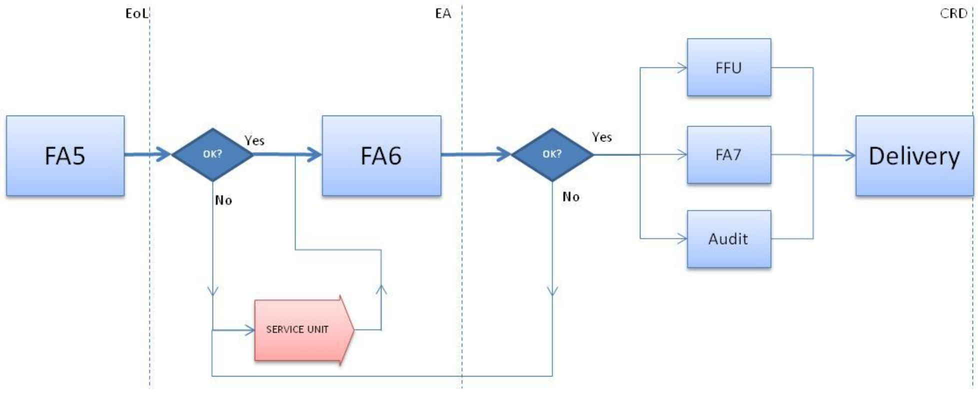


Figure 9 FA5 to Delivery

[58] Internal documentation at Server interview and content analysis with Jakob Wijkström

5.1.1.1 Mapping

- **FA6.1**

First station in sequence at FA6 is the **Brake Analyzer.** Performed on a mechanical roller measuring the brake performance, sensitivity and balance at each individual break position on all axis equipped with brakes. The analysis is performed by roller resistance measures and test routines and results are graphically visualized on screens outside of the cabin. The test performer verifies correct result and smaller deviations are corrected by the andon. The vehicle then continues to the next step in sequence.

Next activity treats the function of the **Control Level Regulator** controlling the vertical functionality of the pneumatic suspension level regulation.

Final activity at FA 6.1 is the section named **Control Light Function** performed as a visual check of the exterior light functionality from inside the cabin including brake light, direction indicators, reversing lights, positioning lights, parking lights and head reflectors. If all the described activities are acceptable according to the functional standards the vehicle is driven to the next section of FA6.

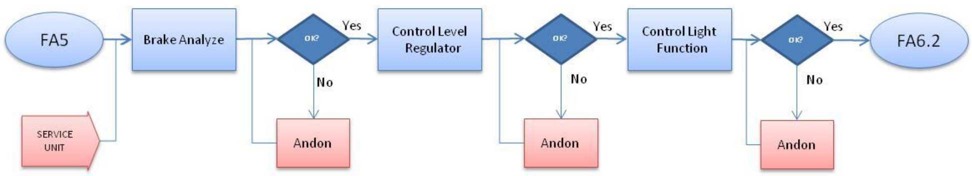


Figure 10 FA 6.1

- **FA 6.2**

  As the second physical section of FA6 line the OBD is connected to verify electronically software configurations called **SCQT 2** (Scania Chassis/Cab Quality Tool). This procedure is fully computerized and supported by a stationary screen with operator instructions and verifications of the result. At the same section the operator performs **De-airing of Heater** by connecting electrical power into the heater. This is done to quicker be able to control the function of the diesel driven internal cabin heater.

  External Trailer connections behind the cabin are tested to verify correct electrical signals for exterior lights on trailer. Followed by **Headlight aiming adjustments** that are done by mechanically adjusting the reflectors of the front headlights to assure a correct beam distribution. After the first startup of the engine and assembled components the prefilled levels of fluids are distributed into the hoses and a **Refill of Glycol** is done to maintain correct levels. At the same section of the line measurements of the pre set **Cab Height** and **Cab Leaning** are controlled by measuring specified positions in accordance with the instructions.

  At the same time an **ELC Check** is performed to assure the configuration of the Electronic Level Control (ELC). This system controls the Suspension Management System (SMS), which is an ECU system for air suspension controlling the pressure of the air bellows. The operator is also responsible to secure the mounting of the external **Spare Wheel** onto the frame of the chassis or at a specified position. A satisfying result from all of the ingoing activities in FA 6.2 gives the vehicle clearance to move forward in the line.

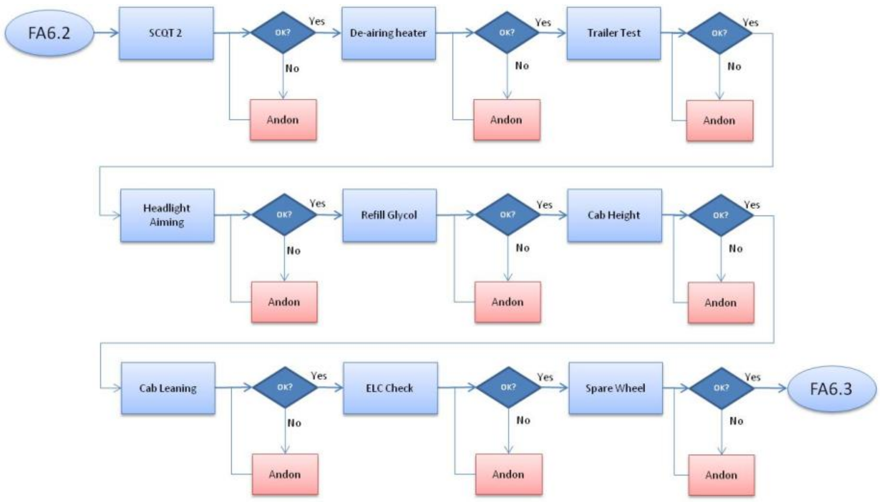


Figure 11 FA 6.2

- **FA 6.3**

The ingoing steps in the third section of the FA6 main process is to secure and adjust the **Wheel Alignment** by controlling the steering axis' alignment according to the primary drive axis. Mounting optical sensors at each wheel and at the steering wheel perform this. The sensors detect each individual positions alignment according to the others and present a graphical result on a screen outside of the truck. The result on the screen contributes to the operators with information to mechanically adjust the angle of the wheels from a pit under the vehicle. An external **Paint Control** is performed to secure the finish of the truck.

The next activity is the **AICC Alignment** that adjusts the Autonomous Intelligent Cruise Control (AICC) sensors to be accurate in direction. The locking and alarm system is controlled during the **LAS Control** by manually locking and unlocking the cabin with the immobilizer.

The last activity at FA6.3 is to visually perform **Leakage Control** to secure all fluid and pneumatic hoses. **Connection of Fuel Pipe**, **Clamping of Fuel Pipe and Clamping of (Tire**

Pressure Measurement) TPM are done to secure the parts' positioning. **Caps are Dismounted** and finally the **Brake Hoses are Controlled** before sending the vehicle to the tectyl painting.

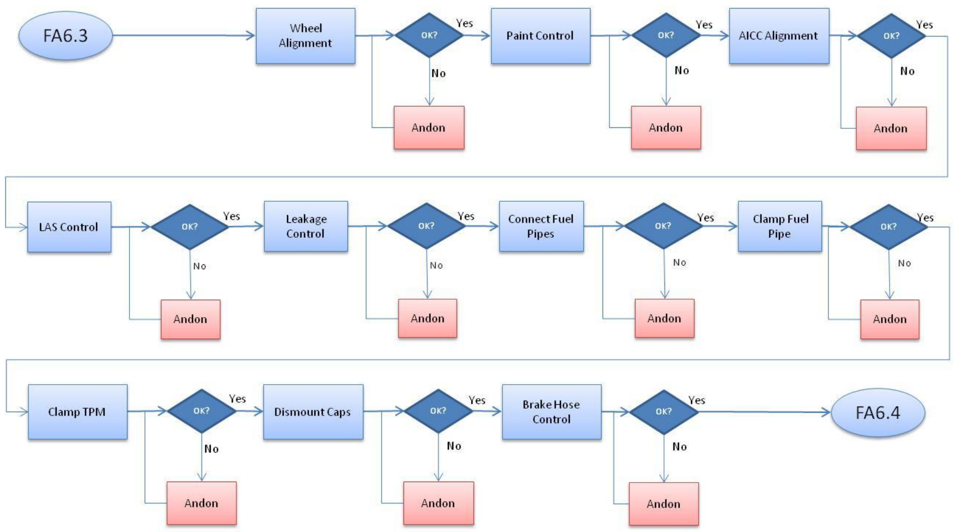


Figure 12 FA 6.3

- **FA 6.4**

This step of the FA6 process is special in the matter that it not only includes controlling and calibrating operations but also assembly. The vehicle is sprayed with an anti-corrosion agent called **Tectyl**, this is done on all untreated areas and mostly on the bottom. After this, the assembly takes action when mounting the **noise shield, dust cover** and **bar** onto the truck.

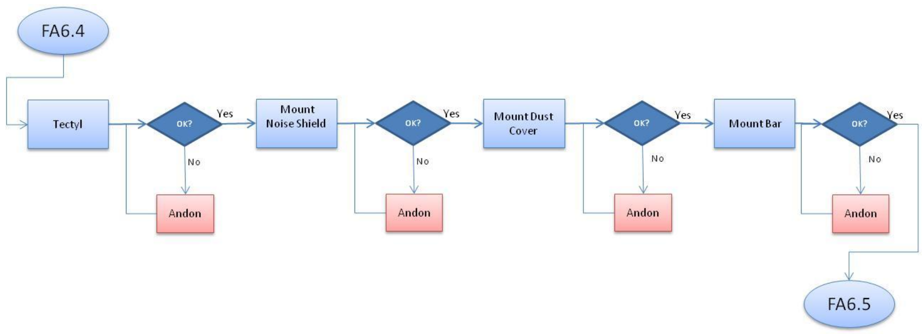


Figure 13 FA 6.4

FA 6.5

The next step is to drive the truck into a **drying box** where the unit will stand during the whole tact-time. The purpose is for the tectyl to dry and start working as anti corrosion agent before the vehicle is exposed to any external environmental impacts. Before this process is done the responsible is checking the function of the **windshield- wiper and washer**. If acceptable, the truck is delivered to the next step.

Figure 14 FA 6.5

- **FA 6.6**

After the truck has gone through the drying box and has got a positive feedback, the next step is to **test-drive** the unit. This is done at a short testing track that goes around the plant and is approximately 1 km long. The track is driven two times in order to control and check all the necessary systems and features. Standard features that are controlled are the signal horn and to make sure that all the gears work properly.

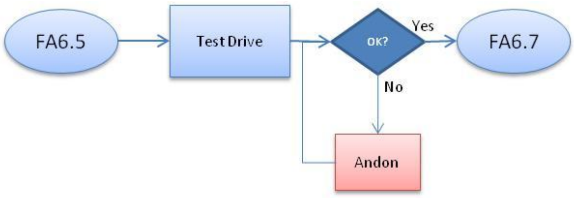
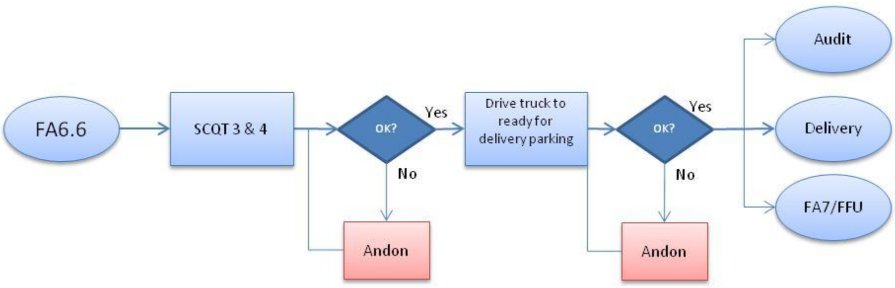


Figure 15 FA 6.6

- **FA 6.7**

  The final step within FA6-process is to control the trucks' data system for any excising or potential error. This is done by the same system as before, the **SCQT** (Scania Chassis/Cab Quality Tool). At this point, the third and fourth control of the truck systems is done. Because this is the final step within the assembly line the controlled systems are reset to default to prevent any historical data is accompanies when the truck is delivered to customer.

  From the building where the tests are executed, the **truck is driven to the delivery parking** where other processes and activities could take action. The activities are shown in figure 16.



- **Figure 16 FA 6.7**

5.1.2 NMET – Performance Tools

This division is a part of Scania's Power Train division (N) responsible for engine properties in terms of performance and emission for the vehicles. The main objectives for the division are to analyze operational data, simulations and testing to confirm emission standards and fuel consumptions.

The are also responsible for the regulatory sustainability tests of emissions according to the In-Service-Conformity (ISC) and In-Use-Compliance (IUC) where the PEMS is included.

This is the division that performs the PEMS-measurements at the moment and is the main objective for this thesis's research in terms of understanding the process involved within the procedure of measures.[59] The actual process for PEMS measurement is seen in *Appendix 6*.

5.1.2.1 Mapping

- **P1 – Changing turntable (fifth wheel coupling)**

  To minimize the risk of damage to the vehicle and the attachments the first step in the process is to remove the fifth wheel coupling. The coupling is remove and replaced by another, specially used for the testing.

- **P2 – Engine Adaption**

  Every engine is unique and has its own special features. To optimize these features the vehicle's computer usually saves data during the lifecycle and calibrates key figures. This adaption is done without any notice and results in a better-utilized engine and takes a couple of hundred kilometers to be tuned in properly. When testing vehicles there is no time or possibility for doing this practically and the customer does not want a "brand new" vehicle already passed hundreds of

[59] SCANIA InLine (Intranet)

kilometers. Instead the truck is forced to adapt through simulated drive cycles. The cycles are developed to test the engine in normal driving situations as well as extreme circumstances. This is done in a workshop with a monitored made-up rolling highway. The test takes a less time than performing the real test drive and leaves no marks on the vehicle.

- **P3 – Removing Interior**

  After the engine adaption the next step is to remove some of the interior in the cab. The main interior that has to be striped is the passenger seat. The procedure takes some time to avoid to leave any marks on the dashboard etc. and to maneuver the seat through the doorway.

- **P4 – Assembly of PEMS**

  With the passenger seat removed, the assembly and mounting of the PEMS-equipment can take action. The gas tubes are installed into the cab together with the measuring equipment and are connected to the exhaust pipe thru the cabling canal of the cab. The truck is connected with the OBD-socket. To secure the need of external power supply the diesel generator is mounted on the platform on the back of the truck.

- **P5 – Pre heating of PEMS**

  To enable the measuring properly, the exhaust must be at the same temperature (195 degrees C°), this is guaranteed thru a heated hose connected to the equipment inside the cab. Before the test drive is started, the hose will have to be preheated together with the rest of the PEMS-equipment, the result is better data and a shortening of the test drive.

- **P6 – Calibration of PEMS**

  To get the right accuracy of the equipment it will have to be calibrated. This is done with calibration gas and has to be done each time a test is performed.

- **P7 – Test Drive**

  With all the equipment on place the test drive can start. The route driven is the same as the Audit are driving, a 114 kilometer route south of Södertälje. The biggest difference between the two cycles is that the second one is performed with a trailer attached to the truck, this because of the need of payload.[60]

- **P8 – Data Analysis**

  After the test cycle, all the collected data is to be analyzed. The main analyze is done at the office with a excel macro and saved for future use, securing the features and emission of the engine.

- **P9 – Removing PEMS**

  When the test is completed, the PEMs equipment is removed from the truck, done in the opposite way it was earlier mounted.

- **P10 – Refitting Interior**

  The interior is carefully reinstated without making any wear to the completed truck that is to be delivered to the end customer.

- **P11 – Changing Turntable (fifth wheel coupling)**

  The original turntable is reinstalled. The turntable is mounted with brand new bolt securing the quality and condition. When

[60] Internal documentation and content analysis with members of NMET

the turntable is changed there is a need for an inspection to secure that there has not been any wear on the truck when the test was performed.

- **$P_{NMETSupport}$ – In case of invalid data**

  If there is any invalid data, the truck will be delivered to $NMET_{Support}$* for further measurements and analyzes. This will increase the time span further dependent on the error and necessary activities.

5.1.3 Audit

The functionality audits are performed to ensure the quality and function of the vehicles produced. This is done for internal use only and not for any public record. The procedure is standardized as well as the requirement list of objects that should be taken in consideration. The audition of a vehicle takes approximately two days to complete for each unit and is performed in the same way at all sites included in the Scania Group. All types of deviations will be investigated in terms of the methods used for manufacturing. The deviation information will be presented into a quality report presented to responsible managers. Because of the standardization the different sites can benchmark their results and deviations to evaluate improvements and knowledge together.

When describing the different steps it should be mentioned that there are not any intermediate decision point, instead the audit report is written continuously during the process and taken into consideration for future the report. The documents are stored with the rest of the documentation that belongs to the vehicle, which can be used for future analysis, if necessary.

* NMETSupport is a workshop responsible for further investigations and modifications for engines.

The checkpoints in the audit are referred as COP (Conformity Of Production), this is a verification that the part has been mounted in order to the description and that it will be controlled with a specific frequency per year to secure quality and durability[61].

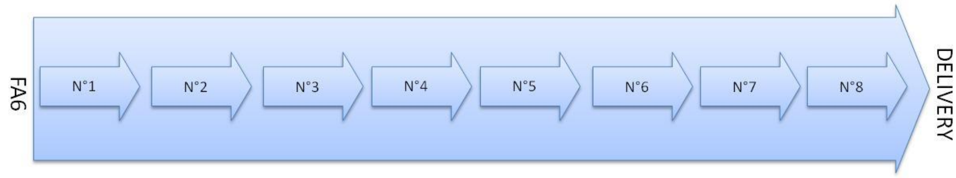


Figure 17 Main Audit Process

5.1.3.1 Mapping

- **N°1 - Test Driving**

  The main activity in the Audit process first step is that vehicles are taken on test-driving; this is done on public roads and is a standard loop of approximately 114 km south of Scania´s facilities. The route is shown in figure 18. Before the start of the test the inspector will take a walk around the vehicle to **check the interior and exterior cleanness** and for any **visible damages.** This will be followed by a **safety check** ensuring that the vehicle is safe for perform the test. If completed without any remarks, the inspector will **start the engine** and begin to check the systems shown in the checklist (*see Appendix 7*). The **test drive** takes about 2 hours and includes several operations controlling different functions and systems of the vehicle. The process ends with a wash of the chassis and control for any leakage and later on the truck will be driven into the test building for further audits.

  Each step is approved by the inspector and reported in the protocol and deviations are remarked in the report.

[61] Internal documentation and content analysis with Peter Jabrin

Figure 18 Test Route - Järnslingan

- **N°2 - Functions and measuring**

  This part process is performed within the test building and is focuses on the measurements of the cab and its ingoing systems. Checking of the inclination of the cab and that dimensions are correct according to pre defined requirements. The coolants freezing point is another checkpoint on the list seen in A*ppendix 8* and will be followed with inspections such as control of the wheel alignment. When this is done, the results are analyzed and will be communicated and recorded.

- **N°3 - Assembly and torques under chassis**

  The third part process includes lifting the vehicle with a mobile lifting device to gain access to the vehicle from below. Control starts by checking the mounting and torques on attachments for rear axle and followed up by checking the same for the front axle. Mountings on all parts seen in A*ppendix 9* are controlled to ensure that correct torque is used according to the assembly requirements. When the bolts are done the procedure continue by controlling the attachment of the electrical wires and mounting of hoses and pipes accessible from beneath. Lowering the chassis and returning the mobile lifting devices close the sequence.

- **N°4 - Assembly and torques on top of chassis**

  During the fourth step of the audit process, activities will be similar to the previous control points, but with the difference that they are done on parts accessible on top of the chassis. There are more control points according to instructions, seen in *Appendix 10*, to be checked making the procedure more time consuming. Apart from that, there are similarities in the approach and operations with N°3. The cabin for some particular models will be tilted to gain access to the mountings of the front wheels and attachment of the cab. Tilting the cab to its original position and performing a general visual inspection of the vehicle finishing the process.

- **N°5 - Assembly and torques at front**

  The fifth process of the audit's main process is made after the vehicle is lowered down and inspections concern mountings and equipment situated on the front of the cabin. According to the checklist in *Appendix 11* the first eleven activities deal with visual controls of **lights adjustment** and **oil dipstick** as well **as torques for mounted parts** such as hoses and bumper. The next phase concerns the **CEU** (**Central Electric Unit)** and its mounting and safety protection of cables and insulation. The third main objective concerns the **mounting and chafing of the plastic pipes, hoses and electrical cables** mounted outside of the CEU including air-, hydraulic-pipes and hoses. The equipment involved in the inspection steps is parts of the brake system, auxiliary heater, windscreen wipers as well as alignments of the grille mounting.

The final activities treat the Conformity of Production and are a part of the inspection that controls that parts are mounted according to the pre-defined specifications from the line assembly. At N°5 these parts are the ingoing parts in the steering gear and the **Front Under run Protection (FUP**).

- **N°6 - COP and specifications**

  As mentioned in the previous part process the conformity of production assures that the correct parts are mounted according to fitting, function and finish. This is done for all ingoing parts of the check list such as tires, light devices, doors, cat walk and side skirts etc. An extra part of the inspections also concerns Fit for Use (FFU) and specifications of S or R* orders correlated to minor changes in customer defined adjustments or equipment mounted on the vehicle.

  Each ingoing activity is approved by the inspector and reported in the protocol and deviations are remarked in the report in *Appendix 12*.

- **N°7 - Reporting and presentation**

  All activities inspected throughout the earlier part processes will be reported in a presentation to be announced as an audit report. This information is crucial for all parties involved in the manufacturing of the vehicles to be able to manage and maintain the quality. The information about the audit including deviations codes is stored together with the assembly information of the truck. The information report is sent out to the focus group responsible from each segment of the

* S and R orders are special orders with customized equipment mounted after assembly line

assembly. Concerns about the deviations are taken and the vehicle is reported and sent to readjustment, see ingoing steps in *Appendix 13*

- **N°8 - Safety Points**

  The final part process deals with the safety and inspection of safety points and equipment on the vehicle. This visual inspection concerns parts as split pins on spring brackets, cover on battery, side skirts etc.

  These ingoing parts shown in *Appendix 14* are not reported in the audit as they are supposed to be pre equipped from the manufacturing.

5.2 *Process and Enterprise Maturity Model*

Mapping of the current situation of the individual processes maturity according to the framework of PEMM in close collaboration with the process owner. This was performed as focus groups where the role as researchers are to support the recipients throughout the model and give supportive explanations to clearly define the process borders and convey guidelines for the statements.

The continuously process depth that the P-1 to P-4 levels describes, brought a good insight in the complexity of the researched processes. This supports the process owners with an objective knowledge for understanding the relations and interfaces necessary for a process to be coordinated into a main enterprise process such as the chassis manufacturing process.

The purpose of the assignment was to discover a possible match for the PEMS process to be suited as a part of the main process. The model is excluded in certain topics such as the *Enterprise Maturity Model as well as* sub categories as *Behavior of the Performers*, *The authority of the owner* and *the infrastructure of the human resource systems.* To decrease the depth in the analysis of *enterprise* *performance of the performers* at higher levels, only level P-1 to P-2 as well as the depth of *Owner Identity* in terms of the department focus on the process has been evaluated. These assumptions where based on the fact that there where only interests in the single process structures and the interfaces for a innovative collaboration for the PEMS-measurement.

A future functional solution for use of portable emission testing, seen, as a process was entirely new for Scania as all primary testing, was managed as customized procedures. *M. Hammer 2004*[62]*describes* enterprise changes in terms of innovations as the change itself challenging the paradigm of how the structure of the process should be performed.

"Operational innovations is a step change: It moves a company to an entirely new level. Once there, the organization can focus its efforts on generation of additional changes – refinements of the innovation – that will keep it ahead of the pack until the inevitable time comes for a new wave of innovation." M. Hammer Deep Change: How Operational Innovation Can Transform Your Company April 2004.

5.2.1 FA6

The last part of the truck assembly line is the section named FA6. This section has earlier been more or less independent and separated from the overall combined flow and tact time. What differs this section is that it is the only section of the line where no assembling is made. FA6 also has the possibility to be performed in two parallel flows and can be used as a redundant flow if necessary.[63]

[62] M. Hammer, "Deep Change: How Operational Innovation Can Transform Your Company"
Harvard business review, ISSN 0017-8012, 04/2004, Volume 82, Issue 4, p. 84

[63] Internal documentation at Server interview and content analysis with Jakob Wijkström

5.2.1.1 Design

Purpose

The FA6 process has been redesigned to fit into the overall flow and is currently primarily using one single flow of the line. This has been done to correlate with the overall performance of the manufacturing line and to match the interenterprise performance.

Context

All ingoing needs are known throughout the process according to the ingoing activities in terms of functionality and quality. These control points and expectations of inspection and functionality are mutually established both interenterprise and from the process owner.

Documentation

There is a complete end-to-end documentation of the process and all of its ingoing activities as well as method description of all ingoing details in the operational work instructions. There is also an operational excellence model of the process used as a guideline for all sites within chassis assembly.

5.2.1.2 Performers

Knowledge

Operators at FA6 are flexible in terms of process knowledge and they follow their vehicle throughout the ingoing steps to assure the quality. They clearly understand the overall expectations and are fully responsible for actions to be made in case of deviations.

Skills P-1 P-2 P-3 P-4

Performers are skilled in teamwork and problem solving skills and are supported by the andon in terms of deviations.

5.2.1.3 Ownership

Identity P-1 P-2 P-3 P-4

There are well-defined roles for the ownership of the process. The owner is responsible for change management and improvement areas for the process performance.

Activities P-1 P-2 P-3 P-4

The owner participates in overall strategic planning and communicates the expectations throughout the process. Strategic decisions as well as tactical can be in form of improving the tact time or as more functional changes such as new technology implementations.

5.2.1.4 Infrastructure

Info Systems P-1 P-2 P-3 P-4

FA6 is a part of the overall performance measurement system according to the combined flow. The same daily flow measurements are visualized to support the performance and accuracy for the operations. Internal activities are also supported by information systems for testing and adjustment verifications as well as support for vehicle diagnosis.

5.2.1.5 Metrics

Definition

Throughout the activities of FA6, cost and quality metrics are defined in terms of time and labor density. The metrics are correlated to the overall strategic metrics of the interenterprise of assembly.

Uses

Performance measures are continuously reviewed and evaluated daily as a part of the daily meeting. The process owner is also responsible for being a part of the strategic improvements and goals such as they yearly strategic “chase of seconds” performed to improve the flow through time of the vehicles.

5.2.2 NMET – Performance Tools

NMET as a part of the Power Train division is currently involved in the improvement and testing of emission performance with main focus on sustainability of quality. As most of the work is performed as research and laboratory testing the process related methodology is not the main focus of the work. To be able to find synergies and future areas for improvement the PEMM supports by communicating the necessity of a clear purpose of the ownership and structure process oriented strategies.[64]

---

[64] Internal documentation at Server interview and content analysis with members from NMET

5.2.2.1 Design

Purpose

The purpose of the design correlates to statements of how well known the process is in terms of maturity. NMET corresponded that the majority of the process concerning the actual activities within PEMS more or less consisted of craftsmanship and customization.

Context

Thoughts concerning the process definitions of inputs and outputs were clear for all members according to the ingoing activities and sequence of them. As NMET is the division responsible for continuously updates of their knowledge according to mandatory regulations, enterprise expectations as well as legal directives.

Documentation

The knowledge and efforts of a well documented process as support for change management and optimization did not exist at all. All activities are conducted from knowledge and experience supported by equipment instruction.

5.2.2.2 Performers

Knowledge

All members of NMET are specialized in sustainable engine performance and have several years of experience in the field of testing and analysis. Due to this fact, most of the criterion concerning their knowledge and how their work affects the company, scored as largely true. Even if there was a certain lack of process related design the intention of a future transfer of the process stated that they would be connected in terms of supportive expertise.

P-1 P-2 N/A N/A

Skills

As mentioned before, all of the members work in close collaboration with the testing and are individually skilled as well as a team. The reasons why P-3 and P-4 are marked as N/a are that these have been excluded because of the enterprise depth of the statements.

5.2.2.3 Ownership

P-1 P-2 N/A N/A

Identity

The statements concerning the ownership and identification of the PEMS-process were hard to resolve. NMETs' vision of the process includes MSDQ who is responsible for the selection and quality of delivered vehicles at Chassis as the complete flow for testing include their activities. NMET would like to translate the testing into functionality in comparison with other specific parts controlled and owned by MSDQ. As the actual situation is different from that the group agreed that the ownership and responsibility of the PEMS belonged to them.

Activities

The PEMS measurements and the verification of the result seen as a function have meant a lack of interest in process related activities. As the scope of the ownership is more concerned about the actual functionality of the process there is not any certain documentation related to this. On the other hand, there are several conceptual ideas and a clear documentation concerning the limitations and enterprise requirements that are well documented.

5.2.2.4 Infrastructure

Info Systems

Describing the infrastructure and in particular the structure of the information systems the supportive components used by the process such as ERP systems are evaluated criteria. In this case and process, the only tools used are supporting software for calculations in analysis. Except from that the test data is saved on several, different servers. It is only seen as fragmented IT systems and not as a supportive tool and therefore the vague level of maturity is presented.

5.2.2.5 Metrics

Definition

When the statements and definitions were introduced for the process metrics it became clear that it have not been established at all, except some basic metrics concerning the resource consumption in terms of time. The fact that the process is almost undocumented and undefined is clearly correlated to the lack of usable metrics.

Uses

As there are no clearly defined metrics the managers or process owner is in any be case unable to track performance or process the improvement of the process.

5.2.3 Audit

Internal audits of vehicles are done as a separate function and assure the quality of the manufactured vehicles. All audit vehicles are selected as a sample that cover all different set ups for both buses and trucks. The need of high quality assurance of the controls is based on a thoroughly described documentation that covers all regulatory as well as COP standards that has to be fulfilled. All audits are performed by skilled personal with good knowledge of the assembly process and the complexity of the different models. Data has been collected for maturity evaluation in collaboration with the process owner to conduct a clear view of the process' different aspects.[65]

5.2.3.1 Design

Purpose

The process's main task is to provide a quality assurance of the entire manufacturing and it is thoroughly described for this area. With the purpose to support the enterprise with crucial information about the delivery is basically the best way of assuring satisfaction of the quality to the customer.

[65] Internal documentation at Server interview and content analysis with Peter Jabrin

Context

The flow through audit is pre defined to collect a valid sample of the produced vehicles and according to that fact, the context of the process is clearly defined in terms of suppliers and customers. The interenterprise expectations are mutually established with a goal set to discover all deviations that are not detected on the line.

Documentation

All activities are fully supported by checklists and work documents. Each single activity and information is documented and saved together with the vehicles' information to secure traceability for a predefined period. All process documentation is public on Scania's intranet and a clear structure is defined for storage of vehicle data.

5.2.3.2 Performers

Knowledge

The personnel at audit are well aware of how their work about how their work affects the result and are also responsible for presenting the result of their work. They are familiar with the enterprises' industry and its trends and are aware of their qualitative approach. There are still some suggestions about being involved in implementations in an earlier phase than today.

Skills

Operators are skilled and experienced in both teamwork as well as individuals. All of them have a wide knowledge of the ingoing equipment of the vehicles and are individually responsible for a qualitative delivery to the process result.

5.2.3.3 Ownership

P-1 P-2 N/A N/A

Identity

The process has an official process that is responsible for the management of the process and assures the quality of the routines together with the operators and functional responsible.

P-1 P-2 P-3 P-4

Activities

All activities performed at audit are reported in real time and the process owner is aware of the affects of deviations in quality. The ownership also involves strategic improvements for best in class performance that contributes to standards for Scanias' other producing business units. There are also strategic collaboration in terms of yearly global workshops with ambition to calibrate and improve the processes.

5.2.3.4 Infrastructure

P-1 P-2 P-3 P-4

Info Systems

More or less of the operations performed at the vehicle audits are inspections, both physical as well as visual. Most of the work is seen as craftsmanship in terms of experience and knowledge, but is supported by digitalized checklists. All of the checkpoints are collected and saved as data to be presented in a quality report for each individual vehicle. Apart from that, all deviations are reported by SMS throughout the assembly in real time to be able to visualize points of improvements.

5.2.3.5 Metrics

Definition

As mentioned earlier, all activities are documented in terms of time and are clearly defined metrics in terms of quality standards that have to be controlled. All of these quality assurances are correlated to the enterprise overall quality certifications.

Uses

All metrics are used to report the quality in form of presentation in cross functional groups for further investigations and improvement operations, as well as strategic level information concerning the qualitative output.

5.3 *PEMS Concept descriptions*

The following section presents four different suggestions of concept descriptions for the mounting of PEMS-equipment on the vehicles. Concepts have been developed and suggested by *Markus Walseth,* member of the development department NMET at Scania. This thesis aim to recommend a solution to hopefully recommend a solution to the most suitable concept, these are to be evaluated and audited. Noticeable, is that all the concepts are produced with present techniques of measurement, the one described in earlier chapter. The set up uses the same equipment and interfaces pervading all of the drafts.[66]

[66] Internal documentation at Server interview and content analysis with Markus Walseth

5.3.1 Concept 1. PEMS mounted on passenger seat

This is how the equipment is currently used and measuring is performed. The arrangement could be divided into a number of areas depending on the installing area. At first, the passenger seat in a truck cab has to be removed. It is replaced with the PEMS analyzing equipment that is mounted with its gas tubes within the cab as shown in figure 19. This equipment has to be connected to the exhaust pipe that will be extended in order to work properly. A gasoline generator secures the external power supply. The analyzer is connected to the exhaust pipe with both a preheated plastic hose that leads the exhaust, and by several sensors that indicate the structure of the different gases. These hoses and cables are passed through the unused passage for steering axis on the passenger side of the cabin. Due to the need of external power supplies, there will be an additional cable running from the platform on the back of the truck through the passage and into the cab supplying the analyzer with electricity. The final step will be a connection of the system into the trucks OBD port to enable to fully integrate the PEMS equipment to the vehicles main computer.

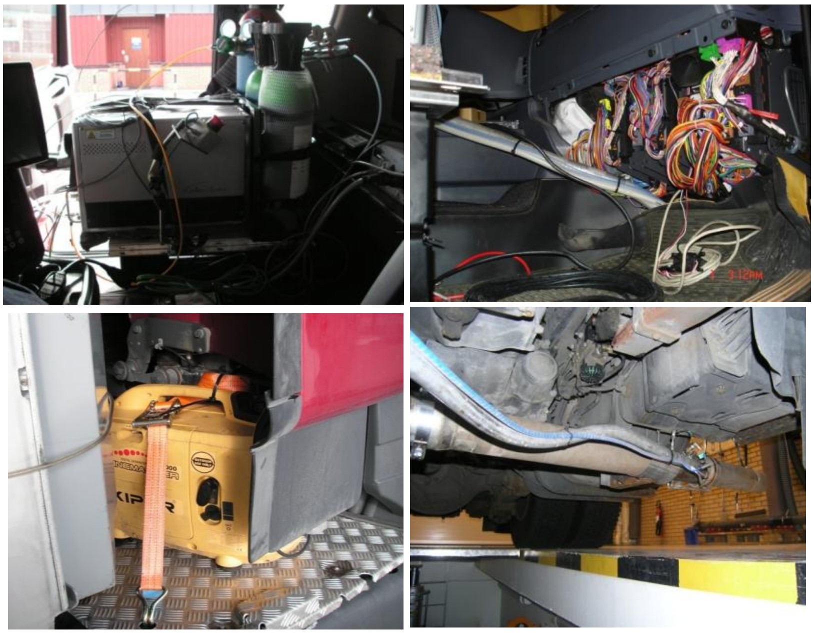


Figure 19 Mounting of PEMS inside cabin

5.3.2 Concept 2. PEMS mounted in a box on 5th wheel

The idea of the concept is to mount the PEMS-equipment inside of a box. The box is climate controlled with ventilation and heating, shortening the preparation time and making the testing suitable in a wider range of temperatures. The climate box will be mounted on the outside of the vehicle and most preferable on the fifth wheel coupling. From the box, the cabling and hose connections from the PEMS to the OBD could be connected with a Wi-Fi dongle[67] and the exhaust pipe will be adapted through the insulated pipe to the equipment. Just as the first concept, there is a need of external power source provided by a diesel generator, which could be mounted either within the climate box or on the platform on the back.

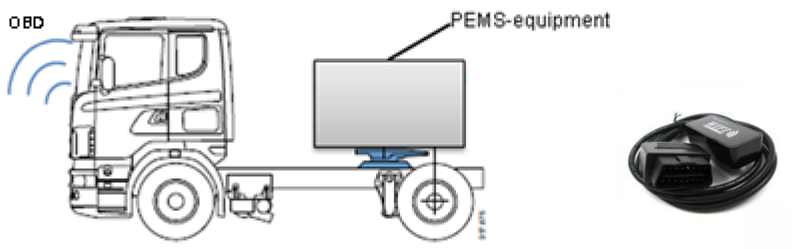


Figure 20 PEMS mounted on fifth-wheel with WiFi OBD

5.3.3 Concept 3. PEMS-equipment mounted in a trailer

As figure 21 shows, the approach is to mount the equipment inside a trailer that is attached to the fifth wheel coupling. The intention of the trailer is to protect the equipment and prepare it for testing before the truck arrives to site. For the protection, the trailer is designed to have either curtain sides or solid walls. The trailer is dedicated to the task and will thereby only be used during this type of testing; this will make the positioning of the equipment stationary and reduce the moving. In the set-up shown in the figure the PEMS is mounted in

---

[67] http://www.e-ville.com/sv/18-obd-kablar/6085-wifi.html

the front of the trailer, making the distance to the exhaust pipe and cab minimal due to the need of connection.

The generator has been placed in the back end but it is not dependent on any placement as long as it is connected with the PEMS. The connection to the OBD-interface will be mounted through the cabin window or alternatively with a wireless connection and will deliver the necessary data from the vehicle. The other connections attached to the exhaust pipe will be mounted in the same way as today. Because of the limited utilization of the trailer, there will be room for loads being brought during testing to increase the engine payload.

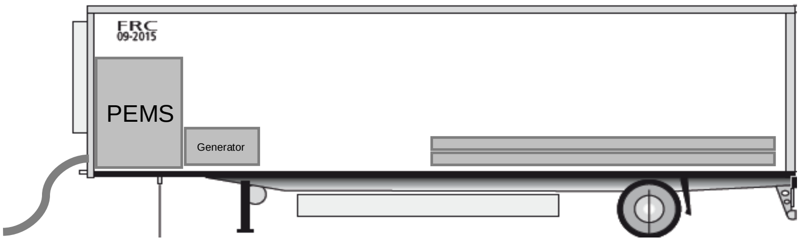


Figure 21 PEMS mounted inside a trailer

5.3.4 PEMS in a climate controlled box inside the trailer

The fourth and last concept is basically the same as the third, but with one major difference. Instead of just putting the PEMS-equipment inside the trailer, it will be mounted in a climate-controlled container inside of the trailer. This will shorten the set-up time and enable the testing equipment to be used at greater range of outside temperature and conditions.

The container will be supplied with an electrical gasoline generator that preferably will be switched on before the testing for pre heating to gain full benefit, just like the concept before.

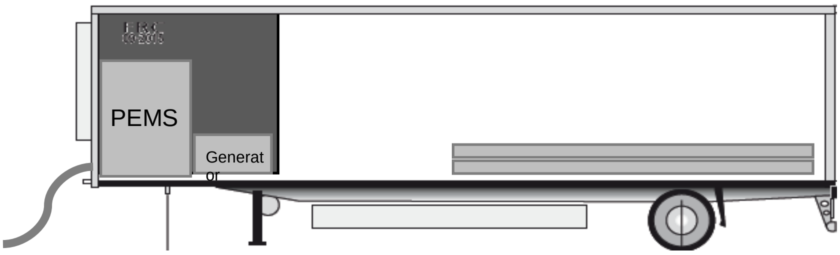


Figure 22 PEMS mounted inside a climate-controlled box on trailer

5.4 *QFD - Evaluation of concepts*

The method used as a part of the quality function deployment involves techniques for translating the demands in terms of “the voice of the customer” into understandable requirements. This is done both for customer needs as well as for technical requirements that are measurable in terms of quantitative metrics. As the analysis concerns only conceptual methods it is useful to conduct the house of quality at a top level translating the overall functional needs. The further steps of the analysis uses the same method on a more technical level as future method for the engineers or technicians involved in the implementation and manufacturing of the concept chosen.

5.4.1.1 Customer need

To enable a implementation of a process within the production line the process will have to fulfill a list of demands. These have been developed through the mapping of the processes combined with the process owners of the areas. The PEMS equipment and set-up of it has the same demands from the different departments and according to the overall flows the FA6 and Audit are feasible as the customers of the process and concept. If the demands are not met, there is no guarantee for any smooth and reliable process of the measuring.

- **Minimal impact on vehicle** – The tested vehicles are meant for customer use and any wear is unacceptable when delivering a new truck, as well as any deviations in assembly quality as a result of modifications throughout testing.[68]

- **Easy to connect to vehicle** – To minimize the workload and activities, the need of easily attachment of the equipment will be needed.[69]

- **High grade of standardization** – the methods in use must be proven and standardized to work properly. Including safe and qualitative interface connections to reduce the amount of time for installation. For example, individual tail pipe adaptors for each specific vehicle model.[70]

- **Simplicity in data collection** – the users of the equipment should not have to develop ways of reading the results. It should be a well-tried method without troubleshooting.[71]

- **High validity in measurement (Climate)** – To secure the result of the test, the impact from the environment has to be minimized and controlled.[72]

- **High safety** – the most important requirement is that the equipment and concepts are safe for the users. There should not be any hesitation or doubts using the equipment properly.[73]

- **Efficient and Effective usage** – using the equipment should be developed to use the resources efficient and effective.[74]

---

68 Demand from master thesis objective MSP
69 Ibid
70 Demand from master thesis objective MSP
71 NMET
72 Ibid
73 Demand from master thesis objective MSP
74 Ibid

- **High availability of equipment** – the equipment must not be occupied at any other occasions but when performing the tests. The need of the equipment at the right place at the right moment is necessary for fulfilling the other requirements mentioned.[75]

- **Ability to drive with load on vehicle** – the vehicle must be able to have a trailer attached, this because of the need of a payload, making the test cycle less time consuming and efficient.[76]

5.4.1.2 Technical requirements

To assure an accurate evaluation of what requirements that are most important for fulfilling the customer demands, the need of proper technical requirements is set. This describes more quantitative demands useful for benchmarking between concepts as well as guidelines for optimal quantitative requirements and will be described more thoroughly below.

- **Meet European standards** - concerning how the initial PEMS measurement, for internal audit, had to meet the standards of the European commission was a bit unclear. The requirements are clearly defined up to 7 years or 70’000 km, but not set for newly produced vehicles even if this should be included in the time span. The problem area for these tests is that the vehicle engines are unreliable in terms of the reliability of accurate emission throughout an initiation phase. This correlates to the engine adaption and unused components. To secure the validity the target or limit, value is set to 25’000 km for accuracy of the vehicle measurements.[77]

  Due to that fact, there are no clearly defined requirements in terms of the validity of the initial test performed at the vehicles. Scania as a manufacturer is more interested to find

[75] NMET
[76] Ibid
[77] Ibid

deviations and accurate data for a future follow up on the vehicle.

- **Numbers of interface connections - the PEMS measurements are** to be performed on road the security and the methods of usage have to be as standardized as possible. There are also qualitative aspects, concerning the mounting and assembly of the vehicle that should be taken in to consideration when mounting the measurement equipment. The goal is to reduce the number of interfaces needed for connections to fulfill the customer needs for appropriate usage. Both to minimize the wear of the vehicle as well as on the measurement equipment. The target value is set to three interface connections including the tail pipe, OBD connection and fifth wheel coupling to assure the capability of required load during the test.

- **Grade of wear on PEMS equipment -** internal audits are to be performed as measurements on approximately 100 vehicles a year. This means that the equipment is to be handled in terms of mounting and un-mounting at least 200 times a year. To reduce the wear of the equipment and assure the function of it, the target value has been set to none. To be able to assure as low wear as possible, a secure method for handling is crucial for the functionality.

- **Load capacity for testing -** the possibility o perform the PEMS measurements with appropriate load on the vehicle in terms of resistance reduces the time for accurate test data. The resistance is to be described as external load in terms of weight or as connection of a trailer. The validity of the data for analysis has to be sampled for a minimum engine load of 20% that is difficult to achieve without any load on a shorter distance without sufficient topography of the test track.[78]

---

[78] NMET

- **Number of activities connected to installation –** the number of activities concerning the installation are strictly correlated to the number of interfaces. These activities are described as external mounting and adjustments of fixtures for the equipment for each part connected between the truck and the PEMS equipment. For example, external tail pipe adaptor, adjustment of sample wiring and OBD connection module. As the goal is to minimize these activities to the interfaces the target value is set to three.

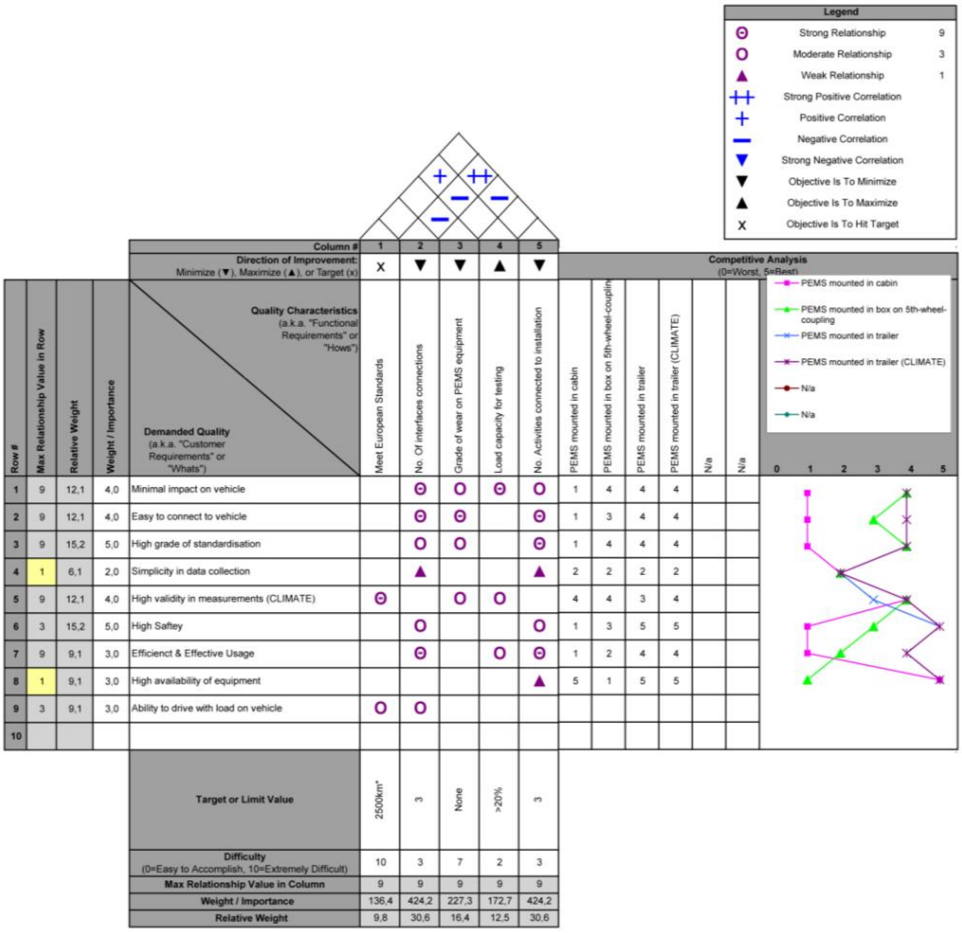


Figure 23 QFD- House of Quality

6 Conclusion and Result

In the sixth chapter conclusions will be drawn based on the gathered information from the previously analysis. The conclusion will describe improvements regarding the possibilities of a future process redesign suitable for PEMS measurements and the statements of how well the purpose of this thesis has been fulfilled. The result is completely based on the present situation and matched by best suitable solutions.

6.1 *A technical solution for testing and handling of data*

Throughout the concept evaluation concerning the specified customer needs as well as technical requirements, the analysis shows a strong correlation between the number of interfaces and the number of activities connected with the procedure of installation. These two requirements are also relatively weighted strongest in terms of necessity, 30.6%, for the future conceptual method, followed by the grade of wear on measurement equipment 16.4% and the ability of loading capacity for testing 12.5%.

According to the requirement of minimal impact on the vehicle and regulatory safety, the requirements concerning the handling of dangerous goods (ADR)[79], such as gases and explosives exclude the first concept from further development. This concept is also extremely time consuming and dependent on knowledge and skills of the involved persons in the installation process.

The three further solutions are all developed as external units for the measurement equipment, where two of the concepts include a trailer solution with the ability to control the load capacity of the transport during test drives. All of the three remaining concepts reduce the wear on the equipment as they are built in to a secure module where only the interface connections are external parts. The fact that the

[79] ADR = European Agreement concerning the international carriage of Dangerous goods by Road.
http://inline.scania.com/oliver_upload/upl345953-ADR-Introduction.pdf

climate-controlled box is installed on the fifth-wheel coupling excludes the option of variable loads in the same grade as for the trailer solutions. Both the installation and removal requires an external device for lifting the equipment, which concerns the security and wear of the equipment.

The last two concepts do both fulfill the requirements and demands that are crucial for a properly established method for the on-road measurements. They are both simulating a valid test situation very similar to the real situation of the customer usage of the vehicle. The wear of the equipment is reduced to a minimum because of the equipment permanent installation inside the trailer. The concept solutions are both beneficial in terms of the flexibility of load capacity as well as the interface and accessibility in terms of permanent storage of the equipment. Interface connections are more accessible in terms of closeness to the tail pipe than the first concept and solution for wireless transfer of OBD data is an option to consider to completely reducing wiring to the cabin.

The choice between the two trailer concepts is completely dependent on the validity of the measurements in terms of environmental impact such as humidity and temperature for the equipment. As the tests are to be performed throughout the year with approximately two to three vehicles a week, the conditions are considerable. The more beneficial solution with a climate-controlled environment is to reduce the uncertainty in the reliability of the measurements. The fact of usage of a climate-controlled environment also minimizes the wear in terms of corrosion and temperature at storage of the equipment.

As the goal is to find the most standardized and accessible solution as possible for an industrialized approach of use, the concepts are evaluated with basic foundation in the actual measurement equipment. The fact is that the measurement method for PEMS measurement today is the only one that meet the regulations for Euro VI standards.

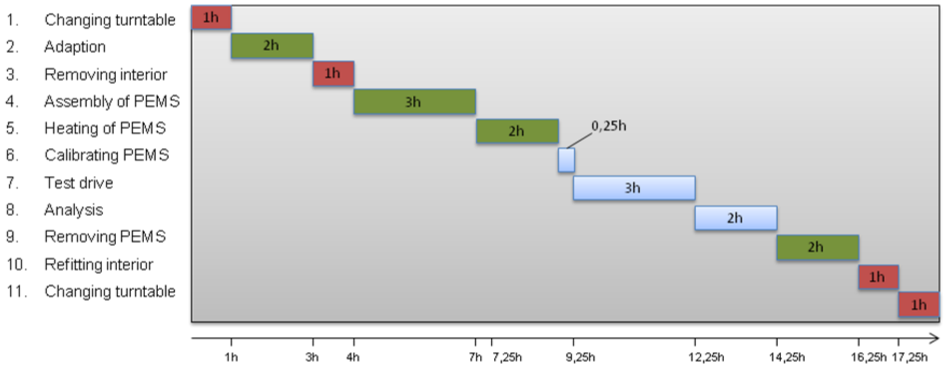


Figure 24 GANTT schedule of actual PEMS process

The aim has been to find the user-friendliest concept that possibly can fulfill the demands stated by the enterprise as well as the European Commission and has the ability to simulate real environment testing. The guideline throughout the concept evaluation has been to minimize the handling time and complexity in usage by mapping the activities within the PEMS process. Evaluation of the activities has been made in terms of value-based aspects according to each single activity's time and correlation of them described in figure 24. Some of the activities are completely non-value adding but crucial to be able to perform the test. Therefor some of the activities performed today could be completely excluded by the use of a trailer concept. This discussion is more thoroughly described as the cost in terms of time used for testing further down in the result.

The solution would also contain an accessible and accurate process for handling the PEMS-measurement data. As the emission after treatment system used for Euro VI engines is the main functional reason for lower emissions, this is as important as every other crucial function on the vehicle. As all inspections are made at both the production line and at audit, all of the functional deviations and results have to be stored and traceable to the specific vehicle for future investigations for 10 years.

A suitable infrastructure used by the audits department for their reporting of all functional points inspected will be suitable for the data handling of the PEMS functionality.

6.2 *Work descriptions and responsibilities between the stakeholders.*

The first phase of the project included mapping and review of the ingoing process flows that was relevant for a future coordination with the PEMS-process. Those flows are fairly complex due to the wide range of customer options for the equipment. This thesis's main goal main goal was to find a feasible solution that minimized the time spent for PEMS-measurement as far as possible. The options of suitable processes were limited to FA6 and vehicle Audit according to the fact of the closeness to production and involvement of other departments that are not situated inside the chassis building. The reason for this delimitation is that the functionality control has a close collaboration with all concerned processes in the assembly in case of deviation and follow up.

FA6 process with its ingoing activities was reviewed to clearly understand the process of a balanced flow. FA6 is also apart from that the first real functional inspection on a complete vehicle. This is a well-developed process and it is fully supported by the same infrastructural information systems as the previously parts of the assembly line including deviation reporting.

The Audit process is better described as an external support process with the aim to secure the customer quality. As Scania inspect vehicles chosen as a sample from the full range of models audits work has a high validity and credibility in the inspections. The time for a complete inspection is roughly 25 man-hours divided over approximately 2 days including external test drive. The competence and skills of the operators are very good as well as the structure and responsibility for the assignments that are performed and presented as reports for every inspected vehicle.

The goal was to find a suitable coordination for the PEMS-measurements to be performed at any process linked to the manufacturing using the selected trailer concept. The fact that the test drive and mounting of equipment are time consuming and the sample of vehicles, 100 per year, this flow is unsuitable as an activity at FA6.

Internal audits like the one performed at Scania Södertälje is also mandatory for the enterprise international business units and are developed as a best practice from the unit in Södertälje. As the Euro VI vehicles will be produced at all sites, the correlation of a commonly used method is favorable. The fact that the audit already performs a test-drive at the same distance and route as the PEMS, also minimizes the impact of the actual process.

As a conclusion for the choice of an appropriate fit for performing the PEMS-measurement at Audit is that the correlation is suitable in terms of time, skills and the sample of vehicles chosen for inspection. The vision of how the PEMS process could be performed with the trailer concept would not adventure any of the quality assurance on the vehicle, nor disturbing the work of the audit.

6.3 *Method and process description for testing a mounted vehicle complemented with a deviation description.*

The reason why the conceptual evaluation is based on both defined customer needs and technical requirements is to find a feasible and usable solution to simulate real environmental tests. The main purpose for a process-oriented approach is to translate an objective need and transform it into a subjective approach throughout a network of activities.

Throughout the review of the ongoing work with PEMS at Scania, several different visions of how it should, and especially could be implemented been conducted. Some of the conceptual visions are based on radical undefined technical approaches including equipment that is not used on the market or even invented. The approach is more subjective and focused on how efficient the process is performing today. As a result of this approach supported by methods for mapping and maturity evaluation clearly brought insight that the process nearly did not exist at all.

The approach has therefore been to visualize and document the basic foundation in collaboration with NMET with focus on the measuring equipment actually used for measurements today. This has supported the conceptual evaluation, which provided with enough information to redesign and improve the actual PEMS process into PEMS v.2 mapped in figure 25. This process approach is conducted with aim to reduce the total time used for test in terms completely reducing or rearrange non-value adding activities to be performed pro-actively or parallel with other activities.

6.3.1 PEMS v.2

The redesign of the PEMS-process is now described as the following network or sequence of activities seen in figure 25.

The clear benefits of the new redesign is that all activities performed inside the cabin such as interior demounting and mounting are excluded as well as all wire transfers from the cabin. The result of that is that the quality assurance from the assembly line is maintained. All equipment is permanently secured in the trailer increasing the accessibility and the ability of preheating the equipment before test drive. Also the transport and storing of gas bottles will be done in the trailer, reducing the risk and increase the accessibility.

The test drive follows the same route as the one performed at audit as mentioned in the analysis. The fact that the test would be performed with load in form of a connected trailer would also increase the validity of the audit test as the vehicles are supposed to be tested in real environment.

The view concerning the handling of data as well as the analysis that today is done manually supported by a macro should in the future solution be performed automatically through a software application.

The idea would be that the software would visualize a simplified deviation report supporting a clearance result as OK or NOT OK. This type of solution could be implemented by programming the software to use the output data from the Horiba equipment via the analysis software to final present a deviation report useable for the clearance.

If the result shows any deviation on the PEMS, the vehicle is reported to $NMET_{Support.}$ Their function would be to investigate the deviation in terms of adjustments if necessary.

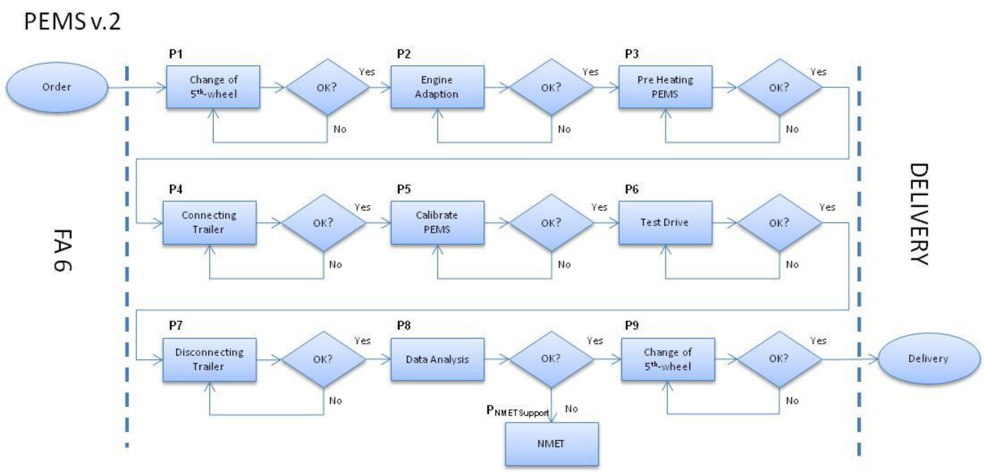


Figure 25 PEMS v.2

6.4 *Description of cost (investment, handling/mounting time etc.)*

Describing the financial aspects could be performed in several ways, due to the lack of decisions and established processes it would not be plausible to estimate and calculate any total investment cost (monetary). Therefore calculations for the estimated time consumption for performing the PEMS test was presented in a GANTT schedule before deciding which concept to recommend. The schedule has been revised, taking the concept into consideration and minimizing the non value-adding activities. Recommending a concept solution for the attachment and performance of the test come with a cost analysis of the solution with a trailer with a climate controlled box. This estimation is done without the PEMS-equipment, due to the fact that it is already bought and will not need any further investments.

6.4.1 GANTT-redesign

When redesigning the GANTT-schedule as a result to the concept evaluation, there was some elimination of previous activities that no longer were needed, and then minimized to reduce the non value-adding activities. The original time estimation is presented in figure 25 and the revised in figure 26.

The estimation shows the total time of the procedure is over 18 hours. As a normal working day for a laborer is approximately 7,5 hours, there will be a need of almost 2,5 employees performing this within a day.

With the revised schedule, some activities have been removed due to the fact that they are not needed because of the concept solution. Other activities are shortened down because the accessibility and interfaces has been improved when connecting the equipment. As a result, the total time of performing the test could be reduced to 9,75 hours.

The re-estimation of the schedule is enabled due to following aspect:

- The risk of wear on the turntable makes the activity of changing necessary and will take about 1 hour.
- Adapting the engine is nowadays takes approximately 2 hour and the expectation is to develop a faster adaption that would take 1 hour.
- The chosen concepts eliminate the need of removing any interior, reducing time with 1 hour.
- The PEMS equipment is already mounted inside of the trailer making the assembly and connecting to the truck minimal in comparison to the previous method.

- Because of the new permanent location of the equipment, it could be preheated during the other previous activities.
- The time of the calibration is constant as it has to be done and can at the moment not be done be made in any other way.
- Performing the test drive will be the most important activity and would be the same as it is compiled to the engine.
- Performing the analysis that is necessary for all concepts would be estimated with the same time in both estimations.
- Removing the PEMS would just be to unhitch the trailer and interface connections.
- The turntable is restored into its original with new unused bolts.

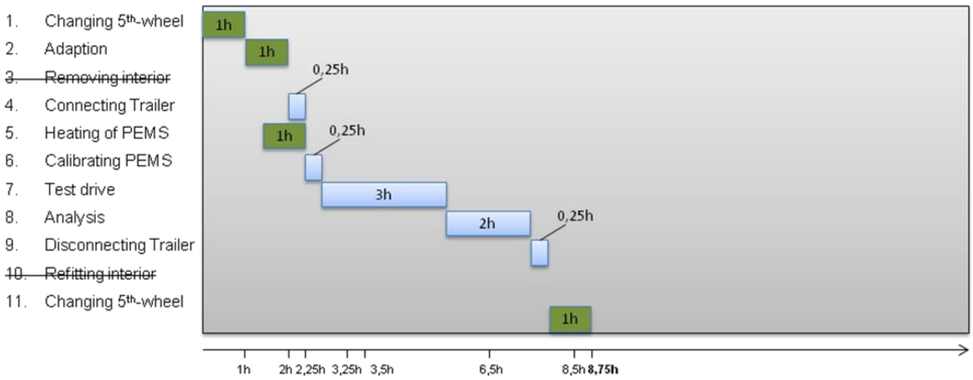


Figure 26 Estimated and rearranged time of the PEMS-process.

In summary, the reduced total time will be approximately 8 hours and 45 minutes, which makes the testing more suitable and less man-hour dependent.

6.4.2 Trailer Investment

The need of a trailer would result in an investment. The calculation should render out in a procurement of an isotherm semi-trailer that could control the temperature of the equipment as well as carrying payload. The reason why any further calculations have not been performed is that Scania has their own procurement processes with long-term suppliers of trailers and that the specifications for the actual procurement is not completely established.

6.5 *Establish work descriptions for implemented processes.*

The opinion is that the knowledge about the processes and activities must be increased. With an improved knowledge, the work descriptions could be established. The functional description should preferably be in the same format as the work documentation called SCIM-standards used for the activities within the Audit. The reason for excluding or wait with a recommendation of the ingoing work descriptions is due to the maturity of processes from the PEMM-analysis. The result shows that the processes are at completely different levels of maturity. In order to formulate representative and standardized process descriptions the maturity of the processes have to be improved from NMET concerning the PEMS-process.

Due to this fact, this deliverable have not been performed and improvements are included as recommendations in the future discussion. This subject would be an upcoming and necessary objective for future success with the project. These descriptions would preferably be done in parallel as the establishment of the PEMS-measuring process documentation for the trailer solution.

7 Discussion and follow up

In this chapter the authors will discuss and draw conclusions based on a theoretical framework for change management. This is combined with the authors' views on future points of improvements for succeeding with change implementation and process coordination methods that would contribute to Scania's future progress with Euro 6

7.1 *Change Management for the PEMS project*

A model established by *Kotter*, is used to structure this chapter. This model is called '8-Step Change Model' and is as the name indicates an eight-step model for change management of process and leadership. The aim is to describe, discuss and even recommend a way for Scania to proceed with the PEMS and Euro 6 legislation. The model is helpful to not underestimate certain steps and construct a foundation for further development and implementation. It is important to not skip any of the steps when using this framework, if it is done the consequences would be devastating and would probably have to be started all over again.

7.1.1 Establishing a Sense of Urgency

One of the largest dilemma of the work of developing and implementing the PEMS-testing, is that everybody knows and realizes the urgency of the project but no one wants to get really engaged. Because of the non existence of urgency, the people involved will prioritize regular work tasks.

The Euro 6 project involves Scania's whole organization and is present at all times. Despite this, there is a lack of leading and engagement when developing a method for testing the emissions for an internal audit focusing on the Euro 6 legislation. The lack of a responsible role model results in a non prioritized project that is given very little time.

The first step must be to clarify who is, and should be, the process owner. When this is elucidated, a sense of urgency and involvement could be sent out. The sense would make the personnel to prioritize the project. As the legislation and Euro 6 has been a part of the development since 2006 and enter into force on the 31st of December 2013, the schedule is under time pressure. It must be highlighted that the result of an engine not fulfilling the emission standards might in the end result in delivery prohibition. With a process owner and an awareness of the seriousness of the situation, the responsibility could be allocated to advance.

7.1.2 Forming a Powerful Guiding Coalition

According to the analysis, the responsibility for the method and development as well as the usage of PEMS-analysis is NMET. As mentioned earlier, there is a communicated interest regarding the necessity of the usage from other interenterprise stakeholders. The fact still remains that all of the resources concerning the actual work are owned by NMET as a division. During interviews with the division personnel, the definition of ownership was described as unclear apart from the fact that they were the only suitable division for this kind of analysis.

As Euro 6 has been one of the main prioritized projects for Scania during the past years it was clear that the PEMS measurements for internal audits have been giving very low priority.

During the first project meeting in September, NMET presented that requirements and definitions of the enterprise demands were clear in terms of the amount of vehicles that would be reviewed. The NMET division has been extended with further resources and the conceptual methods that have been evaluated and presented as ideas. But no further steps were taken.

The work correlated to the actual PEMS was unstructured and not given the right priority and interest in terms of resources and in line with fact of the importance in quality assurance from Scania.

The recommendation for succeeding to build interest and higher priority for the PEMS related work the ownership must be clarified to be able to find support for the project and be able to communicate internal demands. As any deviations from the PEMS-analysis are of interest for other divisions as well as the routines for performing the process an option would be to form a cross-functional ownership. In that way, the priority would be increased and an even clearer definition for the needs and requirements could be presented.

Most parts of this report could be useful to increase the knowledge for building a structure for the process and supportive in enlighten possibilities and obstacles that have to be solved in order to succeed.

7.1.3 Creating a Vision

Knowing who is the process owner and the forming of a powerful guiding coalition will have to be supported by a vision. This vision will show how the process should be performed and executed in the right way and what is needed to enable this.

Compared to today, there are several different visions that are not corresponding to each other. With a responsible process owner, this person could put the visions together and construct a realistic vision. The compiled vision should be stated and prepared to be transmitted to other stakeholders and involved departments. All activities needed for progressing towards the establishment of the process should be demonstrated within the vision.

7.1.4 Communicating the Vision

With a defined vision, the next step is to communicate it to the possible users. It will be important to enable a visual concept of the vision and to describe the activities within the process.

Communicating the vision would be to promote and involve the personnel to proceed with the stated activities. This would enable time schedule and deadlines to be established to mediate the necessary moment and when they should be done.

Typical tools for the communication are e-mail and meetings combined with visualized tables and kick-offs.

At the moment, without any person responsible, there is no communication at all and the personnel and department are working on their own, not integrating others and sharing any knowledge or demand. With no organized communication, the gap between the departments will become wider and make it even more difficult to meet and share information.

7.1.5 Empowering Others to Act on the Vision

To communicate the vision or conceptual model of the process throughout the divisions is the starting point for the real change. This is where it is absolutely necessary to keep up the momentum of the change and together find possibilities and solutions for obstacles that could undermine the approach.

Some of the obstacles found in the analysis are correlated to the further improvement for a completely valid and independent process for PEMS on the finished vehicles. These obstacles or possible parts of improvements are as follows:

- **The change of 5th-wheel coupling** – seen as time and resource consuming but still necessary due to the fact of the wear from test drive. If excluded, approximately 2 hours of work could be removed.

- **The engine adaption** – is probably the biggest obstacle for the validity and future transferability of the result. As all new engines, including their after treatment systems, are not adapted in terms of optimal performance, the result of the measurement would not be confident for correct validation. Adaption is today time consuming and done either in engine test cells or on road during a severe distance of drive. If there possibly could be a solution for forcing an adaption during an on road test drive, this will increase the reliability of the analysis.

- **Resources needed for PEMS** – the aim for this project has been to find a possible solution of industrializing and if possible perform testing as a function of the daily routines at the assembly site. The fact that any extra activities create a need for resources often frightens management employees for the division concerned by the change. It is absolutely crucial to be able to present a well-documented approach that also has the support throughout an initiation phase. By being supportive, clarify definitions and accurate in the requirements, this will not be an issue as the redesigned process is more efficient than the one performed today.

As a conclusion for this step dealing with empowering surroundings to act on the vision, it is crucial to clearly define the objective of the work. This is closely correlated to the earlier steps concerning the creation and communication of the vision. The recommendation for these main objectives is to clearly define the requirements and show the benefits of the possible improvement.

7.1.6 Planning for and Creating Short-Term Wins

Planning for and creating short-term wins will make the project more manageable. Spur is typically triggered by small achievements where the ability to see small steps are easier to perform than fewer large ones.

Within the PEMS-measuring, a first small step could be to compress the time-schedule and make it more suitable for the implementation. At the moment, a test is being planned with the following schedule:

	Torsdag	Fredag	Lö	Sö	Måndag	Tisdag	Onsdag	Torsdag	Fredag	Lö	Sö	Måndag
CD2 -körning samt PEMS (114km)	*Transport MS-NMOW Föreberedelse för test*	Installation av PEMS och vändskiva NMOW, NMET			*Körning CD2 (med samtidig PEMS-mätning) NMET, RTRZ*	Genomförande av ISC-prov på väg med PEMS-mätning NMET	Återställande av fordon. Transport NMOW-MS. NMOW, NMET	Reservdag				

Figure 27 Internal mail for first test week 45 2012

The time period taken into account is almost a week, this will result in a later delivery to the customer and is not efficient while performing. Using the concept solution or even just a stated procedure when performing the activities within the testing could reduce the time extensive and utilize the equipment and personnel better. Using a redesign process and schedule instead would be to take a small step and a short-term win in the progress of developing a fully suitable and stated process.

7.1.7 Planning Others to Act on the Vision

With a documented and accepted vision it becomes easier to explain and see opportunities with it. There are always opportunities for development and continuous improvements. The people most involved and engaged with the process should do this on the departments. Thriving people to get involved will lead to a positive attitude that will spread and be extended.

For the success of changing and developing the process it will be needed to involve people and make them contribute with their experience and expertise. With the ability to plan these employees into the vision the engagement will increase and gain evolvement towards the goal to realize the vision.

This is a mentality known within Scania due to the well established LEAN-methodology within the organization, and when the situation is on topic it will probably come natural.

7.1.8 Institutionalizing New Approaches

As the last phase for securing the implementation it is necessary to make the organization or division comfortable and acceptable with the new approach. It is important that resources and involved people are parts of the continuously improvements as described in the earlier step. The enterprise has to be able to see the benefits of the process results both in terms of functionality as well as financial.

The solution for the process is down structured to visualize and more clearly define the ingoing activities. This is Supportive to fulfill the demands and requirements for a measuring approach that is connected to the future PEMS audits that will be performed on the rolling fleet. As the numbers of interface connection are reduced to its minimum for tests on trailer trucks, a future measuring equipment could be used with the same concept. It is therefore crucial to inform that the method is the one to be used for the future, but that it is always possible to improve the use of it.

The final deliverable from the research was to inform the organization of the current situation and to increase their awareness of the urgency for a proper management of the processes included in PEMS. The information concluded in this project has been forwarded to all production managers at Scania's different manufacturing units world wide, producing Euro 6 vehicles.

References

Articles:

Creative Industries Research Institute; Product Brief Development Tool; Quality Function Deployment
http://www.ciri.org.nz/downloads/Quality%20Function%20Deployment.pdf

R. Frankel, D. Näslund, Y. Bolumole, „The white space of logistics research: A look at the role of methods usage", *Journal of Business Logistics,*
Vol. 26, No. 2, 2005, pp. 185-208.

B. Gammelgaard, „Schools in logistics research: A methodological framework for analysis of the discipline", *International Journal of Physical Distribution & Logistics Management,*
Vol. 34, No. 6, 2004, pp. 479-491.

M. Hammer, „Deep Change: How Operational Innovation Can Transform Your Company”
Harvard business review, ISSN 0017-8012, 04/2004,
Vol. 82, Iss. 4, p. 84

M. Hammer, „The Process Audit”
Harvard Business Review, ISSN 0017-8012, 04/2007,
Vol. 85, No. 4, p. 111

J. P. Kotter, „Leading Change: Why transformation efforts fail", *Harvard Business Review,*
Vol. 73, No. 2, 1995, pp. 59-68.

D. Näslund, „Logistics needs qualitative research – especially action research”, International Journal of Physical Distribution & Logistics Management,
Vol. 32, 2002, Iss: 5 pp. 321-338

C. Weaver, P.E. Ravem System Technical Summary V. 3.1 Feb. 2006.
http://www.efee.com/download/RAVEM%20Technical%20Summary.pdf

Books:

Y. Akao; translated by Glenn H. Mazur introduction by B. King, Quality function deployment; integrating customer requirements in product design,
Press,1990

B. Bergman, B. Klefsjö Kvalitet; från behov till användning, 2007

A. R J Briggs, M. Coleman, Research Methods in Educational Leadership and Management,
Press, 2002.

A. Bryman, E. Bell, Business Research Methods,
2nd Edition Oxford University
Press, 2007.

E. Larsson, A. Ljungberg, Processbaserad verksamhetsutveckling. Studentlitteratur, Lund, 2001.

J.P. Kotter, Leading Change, Richter,
Press1998.

Internet/Intranet:

Becker Associates Inc,
http://www.becker-associates.com/thehouse.htm

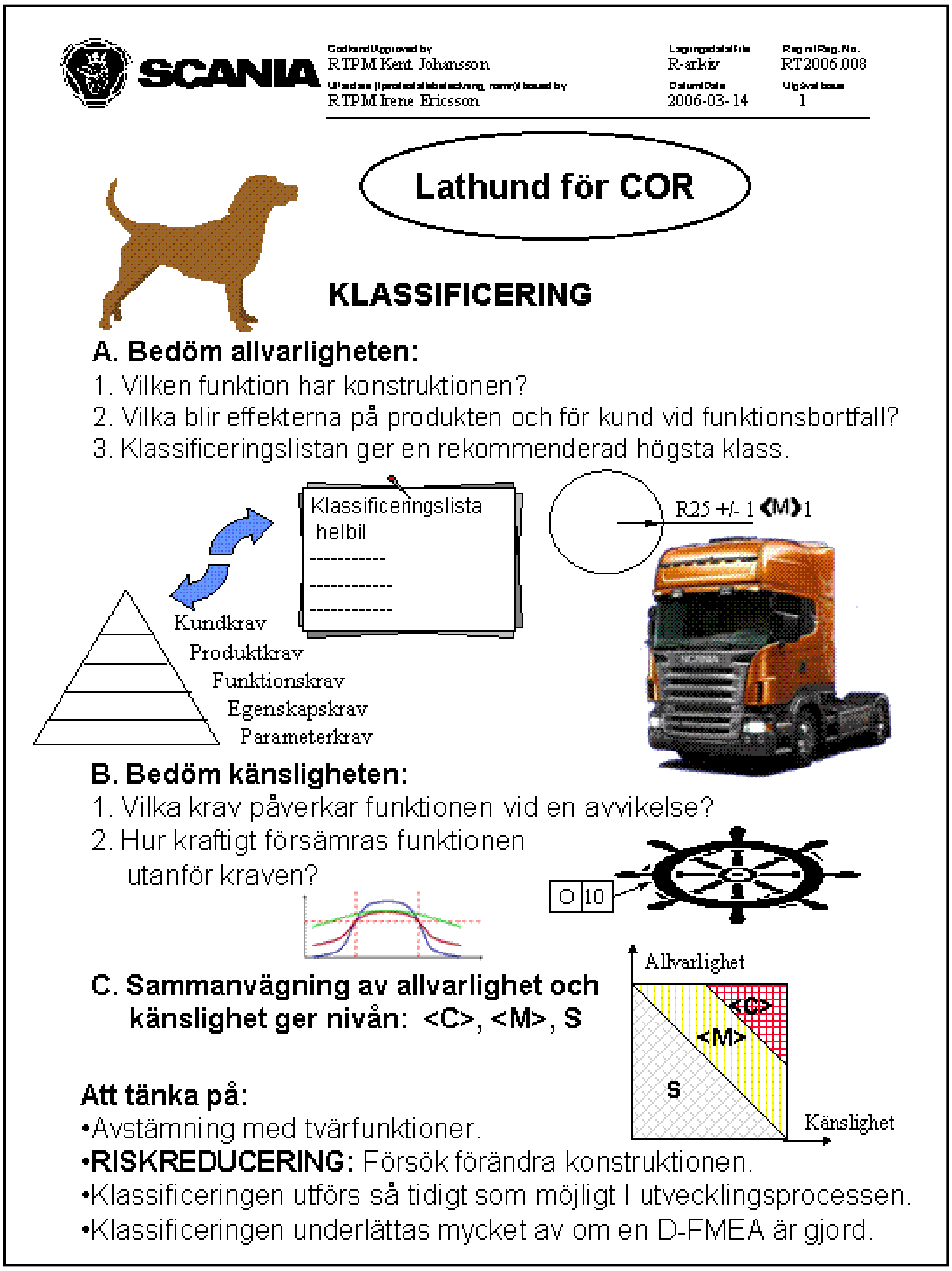
RTPM,K. R Johansson & RTPM I. Ericsson; "STD3944 Classifications of requirements - COR";
Scania Inline 2007-10-24

RTPM, I. Ericsson; "Euro 6, COR & FMEA – Vad innebär det för oss?"
Scania Inline 2011-06-13

YDRS, K-E Olsson, TRANSPORT OF DANGEROUS GOODS – AN INTRODUCTION TO ADR
Scania Inline 2010-11-29.

Appendices

Appendix 1



SCANIA

RTPM Kent Johansson — R-arkiv — RT2006.008

RTPM Irene Ericsson — 2006-03-14 — 1

Lathund för COR

KLASSIFICERING

A. Bedöm allvarligheten:

1. Vilken funktion har konstruktionen?
2. Vilka blir effekterna på produkten och för kund vid funktionsbortfall?
3. Klassificeringslistan ger en rekommenderad högsta klass.

B. Bedöm känsligheten:

1. Vilka krav påverkar funktionen vid en avvikelse?
2. Hur kraftigt försämras funktionen utanför kraven?

C. Sammanvägning av allvarlighet och känslighet ger nivån: <C>, <M>, S

Att tänka på:

- Avstämning med tvärfunktioner.
- **RISKREDUCERING:** Försök förändra konstruktionen.
- Klassificeringen utförs så tidigt som möjligt I utvecklingsprocessen.
- Klassificeringen underlättas mycket av om en D-FMEA är gjord.

Appendix 2

SCANIA		Dokumentnamn/Document name CORlist2011NM		Info klass/Info class I
			Kod/Code M80	
Godkänd/Approved by NM Björn Westman		Lagringsdata/File 2003_084.doc	Reg nr/Reg. No. DM2003/084	
Utfärdare (tjänsteställebeteckning, namn)/Issued by RTPM Irene Ericsson	Telefon/Phone 81546	Datum/Date 2011-03-11	Utgåva/Issue 2	Sida/Page 1 (2)
Fördelning/To		För kännedom/For information		

COR, Classification list for NM, Engine

Safety	
Personal injury	**C**
Fire risk	**C**
Traffic safety	**C**
Environment	
Emissions (Exhausts)	**C**
Leakage/ AC, oil	**M**
Noise, external	**M**
Reuse/recycling, marking	**S**
Uptime	
Reliability / Urgent visit to repair shop, Stop on the road - VOR	**C**
Uptime / Downtime due to service and service-intervals.	**M**
(Engine) Performance	
Driving rope (optimised, harmonised, synchronised)	**M**
Torque curve / Response	**M**
Vibrations	**M**
Driver environment/Comfort	
Noise, internal	**M**
Drivability	**M**
Manoeuvring force	**M**
Drivers comfort	**M**
Economy	
Fuel consumption	**M**
Service life	**M**
Repair and Maintenance cost	
Maintenance	**M**
Repair, Ease to service	**M**
Repair technique	-
Load capacity	
Weight	**S**
Road holding qualities	-
Suspension	-
Structural strength	-
Others	
Appearance/ Lacquer, Gap	**S**
Special market requirements	**S**
Documentation requirements	**C**

SV 91 c 94 - 03

Appendix 3

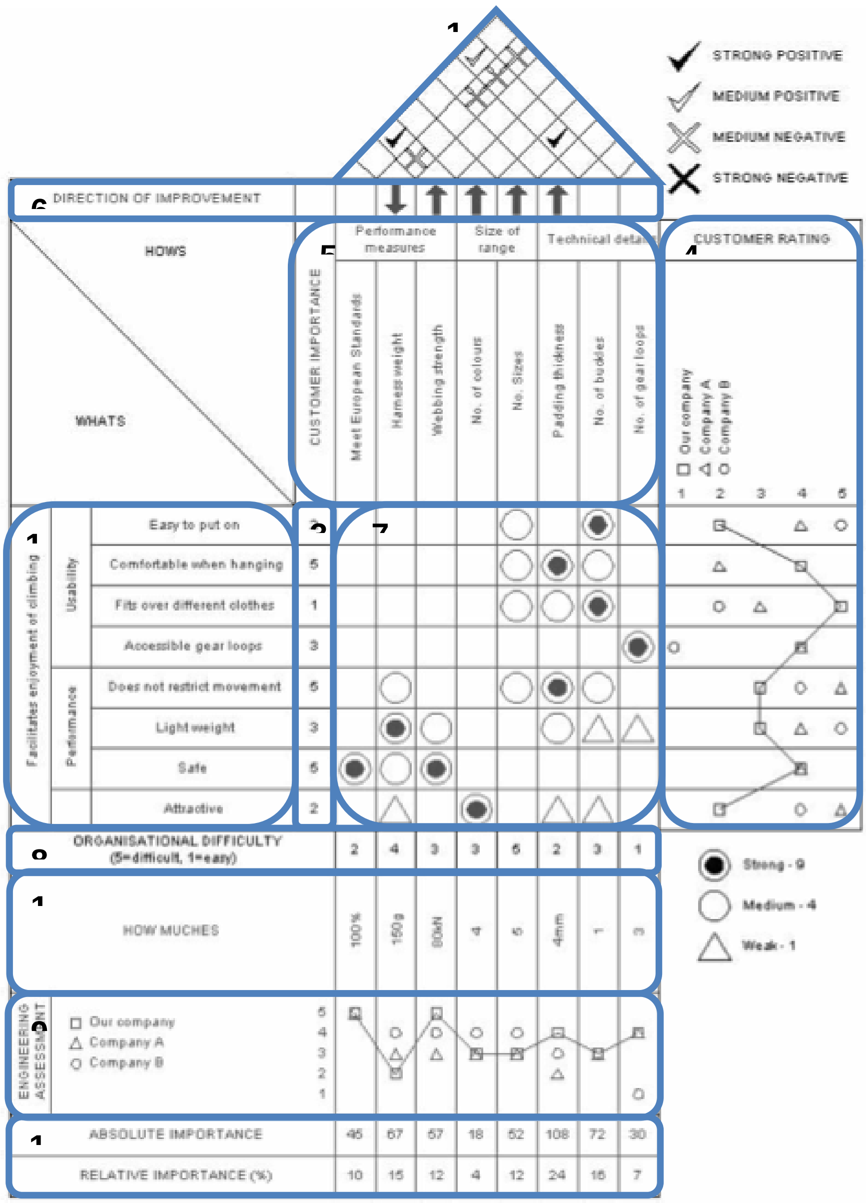
How Mature Are Your PROCESSES?

You can evaluate the maturity of a business process and determine how to improve its performance by using this table. Decide how the statements defining the strength levels, from P-1 to P-4, for each enabler apply to the process that you are assessing. If a statement is largely true (at least 80% correct), mark the box with a "G" to indicate the color green; if it is somewhat true (between 20% and 80% correct), mark the box with a "Y" to indicate the color yellow; and if it is largely untrue (less than 20% correct), mark the box with an "R" to indicate the color red.

GREEN: largely true | YELLOW: somewhat true | RED: largely untrue

		P-1	P-2	P-3	P-4	P-1	P-2	P-3	P-4
Design	Purpose	The process has not been designed on an end-to-end basis. Fuctional managers use the legacy design primarily as a context for functional performance improvments.	The process has been redesigned from end to end in order to optimize its performance.	The process has been designed to fit with other enterprise processes and with the enterprise´s IT systems in order to optimize the enterprise´s performance.	The process has been designed to fit with customer and supplier processes in orer to optimize inerenterprise performance.				
	Context	The process´s inputs, outputs, supplier and customer have been defined.	The needs of the process´s customer are known and agreed upon.	The process owner and the owners of the other processes with which the process interfaces have established mutual performance expectations.	The process owner and the owner of customer and supplier processes with which the process interfaces have established mutual performance exceptations.				
	Documentation	The documentation of the process is primarly functional, but it identifies the interconnections among the organizations involved in executing the process.	There is end-to-end documentation of the process design.	The process documentation describes the process´s interfaces with, and exceptations of, other processes and links the process to the enterprise´s system and data architecture.	An electronic representation of the process design supports its performance and management and allows analysis of environmental changes and process reconfiguration.				
Performers	Knowledge	Performers can name the process they excecute and identify the key metrics of its performance.	Performers can describe the process´s overall flow; how their work affects customers, other employees in the process, and the process´s performance; and the required and actual performance levels.	Performers are familiar both with fundamental business concepts and with the drivers of enterprise performance and links the process to the enterprise´s system and data architecture.	Performers are familiar with the enterprise´s industry and its trends and can describe how their work affects interenterprise performance.				
	Skills	Performers are skilled in problem solving and process improvement techniques.	Performers are skillled in teamwork and self-management.	Performers are skilled at business decision making.	Performers are skilled at change management and change implementation.			X	X
Owner	Identity	The process owner is an indivudual or a group informally charged with improving the process's performance.	Enterprise leadership has created an official process owner role and has filled the position with a senior manager who has clout and credibility	The process comes first for the owner in terms of time allocation, mind share, and personal goals.	The process owner is a member of the enterprise's seniormost decision-making body.			X	X
	Activities	The process owner identifies and document the process, communicates it to all the performers, and sponsors small-scale change projects.	The process owner articulates the process's performance goals and a vision of its future; sponsors redesign and improvement efforts; plans their implementation; and ensures compliance with the process design.	The process owner works with other process owners to integrate processes to achieve the enterprise's goals.	The process owner develops a rolling strategic plan for the process, participates in enterprise-level strategic planning, and collaborates with his or her counterparts working for customers and suppliers to sponsor interenterprise process-redesign initiatives.				
Infrastruc-ture	Information Systems	Fragmented legacy IT systems support the process	An IT system constructed from functional components supports the process	An integrated IT system , designed with the process in mind and adhering to enterprise standards, supports the process.	An IT system with a modular architecture that adheres to industry standards for interenterprise communication supports the process.				
Metrics	Definition	The process has some basic cost and quality metrics.	The process has end-to-end process metrics derived from customer requirements.	The process's metrics as well as cross-process metrics have been derived from the enterprise's strategic goals.	The process's metrics have been derived from interenterprise goals.				
	Uses	Managers use the process's metrics to track its performance, identify root causes of faulty performance, and drive functional improvements.	Managers use the process's metrics to compare its performance to benchmarks, best-in-class performace, and customer needs and to set performance targets.	Managers present the metrics to process performers for awareness and motivation. They use dashboards based on the metrics fot day-to-day management of the process.	Managers regularly review and refresh the process's metrics and targets and use them in strategic planning.				

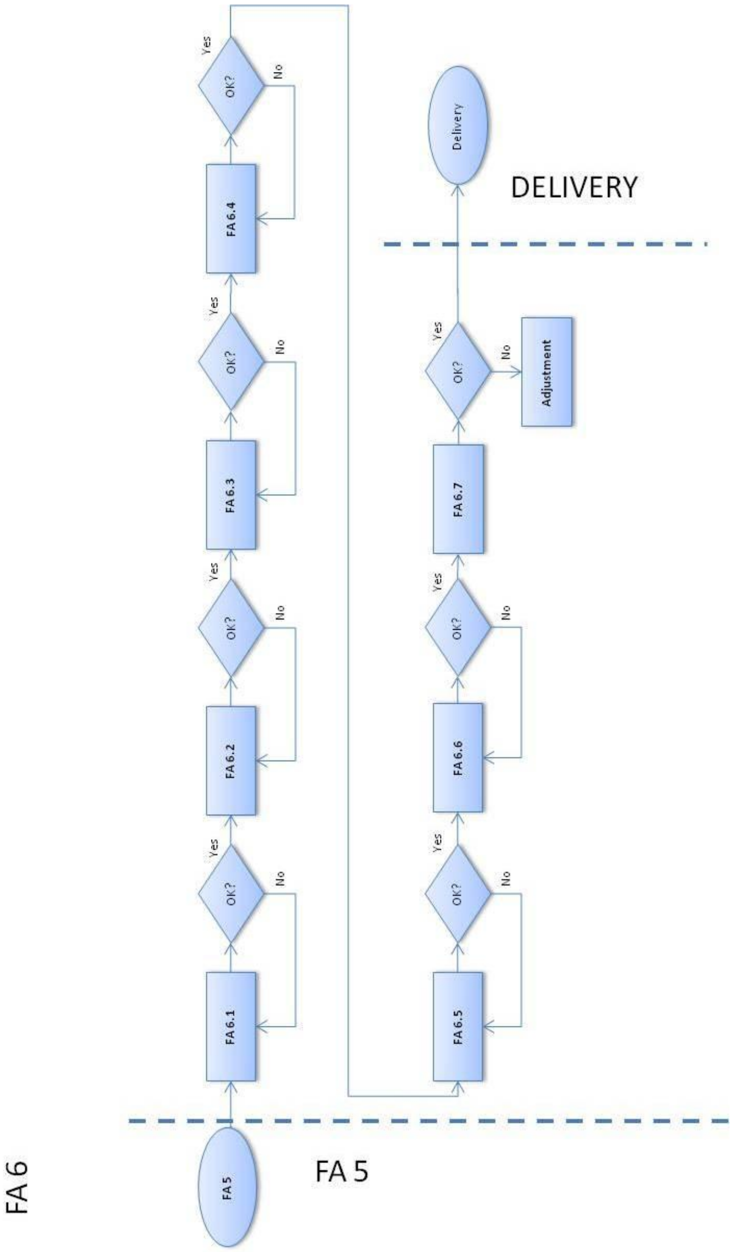
Appendix 4



Creative Industries Research Institute; Product Brief Development Tool; Quality Function Deployment

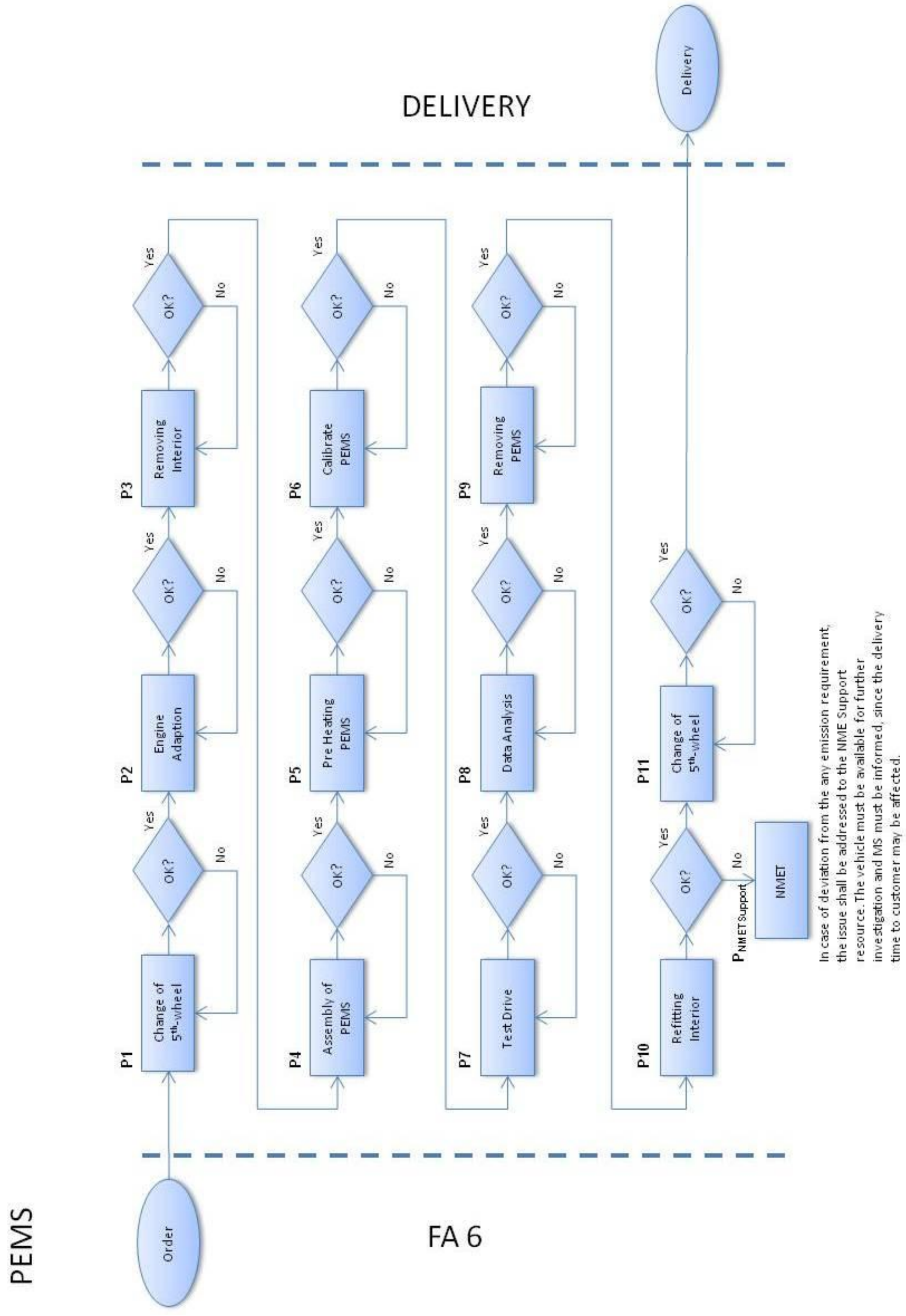
http://www.ciri.org.nz/downloads/Quality%20Function%20Deployment.pdf

Appendix 5



FA 6
FA 5
FA 5
FA 6.1
OK?
Yes
No
FA 6.2
OK?
Yes
No
FA 6.3
OK?
Yes
No
FA 6.4
OK?
Yes
No
FA 6.5
OK?
Yes
No
FA 6.6
OK?
Yes
No
FA 6.7
OK?
Yes
No
Adjustment
DELIVERY
Delivery

Appendix 6


PEMS
FA 6
DELIVERY
Order
P1
Change of 5th-wheel
P2
Engine Adaption
P3
Removing Interior
P4
Assembly of PEMS
P5
Pre Heating PEMS
P6
Calibrate PEMS
P7
Test Drive
P8
Data Analysis
P9
Removing PEMS
P10
Refitting Interior
P11
Change of 5th-wheel
OK?
Yes
No
P NMET Support
NMET
Delivery
In case of deviation from the any emission requirement, the issue shall be addressed to the NME Support resource. The vehicle must be available for further investigation and MS must be informed, since the delivery time to customer may be affected.

Appendix 7

	SCANIA Standard check-list **Scania product audit** N° 1 - Test driving	Auditor:			
		Audit N°:			
		Chassis N°:	Date: 2012-10-01		
N°	Operation	X	SCIM	Sum	Comment
	Get the truck				
	Prepare documents				
1	Take out specification from the system			5	
2	Check country codes (COP or not)		06800	0	
	Get the keys and control report from delivery department				
	Walk to the parking place at delivery park and fetch the chassis				
3	Check interior and exterior cleaness and damages		05010	7	
	Safety checks				
4	Make a safety check before test driving		05000	30	
	Start the engine				
5	Check parking brake (function)		05020	2	
6	Check the fuel heater and water separator filter		05930	1	
7	Windscreen wiper/washer operation, position nozzles		05210	1	
8	Check the white smoke limiter		05160	2	
	Drive to test track				
9	Check the function of two circuit steering system		05270	3	
10	Check the battery master switch (function)		05850	4	
11	Check the Locking Alarm System and functions		05800	10	
12	Check Fault codes/erase with computor		06125	10	
13	Check clutch function and play, tube connections		05260	1	
14	Check foot brake (brake pull)		05230	2	
15	Check exhaust brake		05165	0	
16	Check the differential lock test		05570	2	
17	Check the engine temperature during the test drive		05400	1	
18	Check the Steering wheel adjustment		05080	1	
19	Check the steering servo function		06210	2	
20	Check the power take off		05590	1	
21	Check the gear shifting qualities and gear lever pos. man. gearbox		05310	1	
22	Check manual gear box/Oil cooler		05315	1	
23	Check automatic gear box		00000	1	
24	Check Allison + 4 and retarder		05325	0	
25	Check the functions of the Opticruise		05340	5	
26	Check Torque converter		05330	0	
	Check the tachograph calibration				
27	Check the exhaust system leakages (including turbo)		05370	2	
28	Check the function of the over speed protection		05420	3	
29	Check the retarder function		05360	3	
30	Check the function of the stop off heater		06245	2	
31	Check Speed limiters COP or not		06090	2	
32	Check Speedometer COP or not		05290	1	
33	Check Auxiliary heater COP or not		05890	7	
34	Check the function on all wheel drive trucks		05250	20	
	Drive up to the ramp				
35	Check function of headlamp washer and wiper + Leakages		05650	3	

36	Check the light functions		05180	4	
37	Check the light adjustment		05980	4	Only MS
38	Check of mounting of the noise shields		06650	2	
39	Check mounting of plow bracket (bar between brackets)		06440	0	
	Take away noise shields				
40	Make a safety check under the truck before test drive		05000	2	
41	Check for liquid traces (oil) and wipe it off		05500	1	
42	Check for liquid traces (fuel) and wipe it off		05510	1	
43	Check for liquid traces (coolant) and wipe it off		05520	1	
44	Check for liquid traces (grease) and wipe it off		06040	1	
45	Check retarder level (not on GZ)		05360	5	
	Preparation of the road test				
	Install regulation plates and take documents				
46	Check the sealing tachograph		06070	2	
	Drive to the petrol station				
47	Fill fuel tank with a defined quantity of fuel and check fuel level		05060	5	
	Road test				
48	Check the Automatic chassis lubrication (ACL)		06040	10	
49	Check Mirrors COP or not		05190	120	
50	Heating and vibrating mirrors		05450	0	
51	Check for Air leakage windows, roof sealing, door openings (noise)		05390	0	
52	Check tyre condition and balancing		05720	0	
53	Check for Sound/vibrations/rattling on overall chassis/truck		05380	0	
54	Test Driving on the road around 100 kms		05005	0	
55	Seat heating (function)		05070	0	
56	Check the cab heating (function)		05005	0	
57	Check the function on hill hold		05005	0	
58	Check the engine emission (only for black smoke)		05005	0	
59	Check Lane Departure Warning System (LDW)		05007	0	
60	Check Distance Sensor (DIS) AICC		05008	0	
61	Check the function of the engine hour counting		05490	1	
62	Check Fault codes with computor		06125	10	
63	Check the disk of the tachograph after the test drive on the road		05005	1	
	Check if there are any leakages after the test drive				
64	Washer fluid leakages		05210	0	Only MS
65	Oil leakages		05500	0	Only MS
66	Fuel leakages		05510	0	Only MS
67	Coolant leakages		05520	0	Only MS
	Wash the chassis				
	Drive the truck to the test building				
	Towing the truck in to the test building				
	Analyse results and communicate if necessary				
	Record values and results if necessary				
			Tot:	306	5,1 h

Appendix 8

SCANIA Standard check-list **Scania product audit** N° 2 - Functions and measuring		Auditor:			
		Audit N°:			
		Chassis N°:	Date:		
			2012-10-01		
N°	Operation	X	SCIM	Sum	Comment
	Working inside the test building				
1	Check the inclination of cab		06140	2	
2	Check the dimension on cab suspension in front,rear		05750	2	
3	Check the coolant freezing point		05770	4	
4	Check the wash water freezing point		05210	0	
5	Check the coolant level		05760	1	
6	Check the battery and battery box cover (level and gravity)		06120	5	
7	Check the mounting of the side skirts or lateral protection (remove)		06550	5	
8	Check the mounting and torques on the cat walk and foot steep and remove the cat walk		06420	4	
9	Check the mounting of rear light and mudguards brackets and take away the top parts of the rear mudguards		06460	3	
10	Check Spray Suppression COP or not (front and rear) only hight		06340	4	
11	Check the function and assembly of the 230v outlet engine/cab heater and cables		05780	5	
12	Check the wheel alignment		05790	150	
13	Check the distances at mounted air suspended axles		06130	3	
14	Check the mounting and chafing of brake pipe and hoses at max wheel deflection during wheel alignment		05661	6	
15	Check of Air leakages		05580	3	
16	Check the electrical functions on trailer connections		06110	15	
17	Trailer connection and brake pressure test		05560	50	
18	Check the air suspension function and adjustments		06000	12	
19	Check the function of the air condition (AC)+ Leakages		06060	5	
	Analyse results and communicate if necessary				
	Record values and results if necessary				
			Tot:	279	4,7 h

Appendix 9

SCANIA

Standard check-list

Scania product audit

N° 3 - Assembly and torques under chassis

Auditor:	
Audit N°:	
Chassis N°:	Date: 2012-10-01

N°	Operation	X	SCIM	Sum	Comment
	Fetch the mobile lifting device and hoist the chassis				
	Check the mounting and torques on attachments for rear axle				
1	Check batteries and battery box rear		06120	0	
2	Anti roll bar		06269	0	
3	Air suspension and attachment tag axle		06272	0	
4	Shock absorbers		06273	0	
5	Leaf suspended rear axle		06270	8	
6	Air suspended rear axle		06271	10	
7	4-spring air suspension		06274	0	
8	Check the brake chambers release screws		05220	0	
	Check the mounting and torques on attachments for front axle				
9	Leaf suspended front axle		06260	10	
10	Air suspended front axle		06261	12	
11	Air suspension front axle adjustment		06000	3	
12	Bumper and towing member attachment		06280	7	
13	Check the mounting and torques exhaust system		06520	4	
14	Check the Ad blue module (SCR)		05470	0	
15	Check the mounting and tightening torque for cross member in frame		06440	4	
16	Check the mounting and torques on the engine suspension attachment		06380	3	
17	Check the mounting and torque of gearbox to fly wheel housing		06390	3	
18	Check the torque on ground cable between gear box and side member (aut clutch)		05740	0	
19	Check Cab tilt cylinder to base bracket N.B.! The screw shall be marked with		06400	0	
20	Check torque on clutch drive plate		05260	0	
21	Manual gear box/Oil cooler		05315	0	
22	Automatic gear box		00000	0	
23	Check Allison + 4 and retarder		05325	0	
24	Check the mounting and torques on the steering gear and steering joints		06210	5	
25	Check the mounting and torques on propeller shafts and bearing support		06220	6	
26	Check the mounting and torques on the air tanks		06430	3	
27	Check the mounting and torques radiator and air oil cooling pipes		06600	3	
28	Check of mounting and torques for wheel chock and retainer		06640	4	
29	Check the mounting and torques of the valves and brackets assembled towards frame		06490	3	
30	Check the torques and assembling of unions, plugs, and ring nuts		06500	15	
31	Check the assembly of the hose for the clutch at the gear box (clutch function and play, tube connection)		05260	3	

32	Check the battery cable on starter motor			06115	0	
33	Check the mounting of hydraulic piping for steering			06620	7	
34	**Check if there are any leakages after the test drive**				0	
35	Oil leakages			05500	3	
36	Fuel leakages			05510	3	
37	Coolant leakages and torque on hose clamps			05520	3	
38	Check for water leakages to windscreen wiper/washer operation, position nozzles			05210	3	
39	Check of Air leakages			05580	3	
40	Grease leakages on Automatic Chassis Lubrication (ACL)			06040	3	
41	Check the rust protection on the chassis			05960	3	
42	Visual check (color mismatch,damages,rust,dust ect)			05630	5	
43	**Check the mounting and for chafings of the plastic pipes, hoses and electrical cables**			05685	21	
44	Mounting and chafing of air pipes and hoses, fuel pipes and hoses			05661	0	
45	Mounting and chafing of hydraulic hoses and pipes			05661	0	
46	Mounting and chafing of coolant hoses			05661	0	
47	Mounting and chafing of electrical cables			05661	0	
48	Check the mounting of brake pipe under the truck			05705	0	
49	Check the mounting of cannon connections			05350	3	
50	Check overall lubrication on the chassis			06050	3	
51	Check the type plates under chassi			06190	0	
52	**Check COP demands (under the truck)**				0	
53	COP EMC Equipement			05950	0	
54	COP ADR electrics			05900	0	
55	COP ADR Hot surfaces			05860	0	
56	COP Check the type plates			06180	4	
57	COP Brakes			05540	0	
58	COP FUP (Check the approval number)			06320	0	
59	COP Check Spray Suppression			06340	4	
60	Check specification given by system and in the control report + S Order and R Order			05940	5	
61	Assemble the noise shields			06650	15	
62	**Lower the chassis and go back with the mobile lifting devices**				15	
63	**General visual inspection**				10	
	Analyse results and communicate if necessary					
	Record values and results if necessary					
				Tot:	219	3,7 h

Appendix 10

SCANIA

Standard check-list

Scania product audit

N° 4 - Assembly and torques on top of chassis

Auditor:	
Audit N°:	
Chassis N°:	Date:
	2012-10-01

N°	Operation	X	SCIM	Sum	Comment
	Tilt up the P and R-cabs				
1	Check the mounting of front wheel housing and brackets and dismountle all front mudguards	☐	06465	2	
2	Check the mounting of wheels nuts torque	☐	06370	5	
3	Do the inspection of mounting of draw beam and closing cross member	☐	06590	6	
4	Check the mounting and torques on factory mounted under run protection (rear)	☐	06570	5	
5	Check the mounting and torques on the cab tilt attachment	☐	06400	4	
6	**Check the torques and mounting of the rear axles**	☐		0	
7	Anti roll bar	☐	06269	0	
8	Leaf suspension and attachment rear axle	☐	06270	7	
9	Air suspension and attachment rear axle	☐	06271	7	
10	4-spring air suspension	☐	06274	0	
11	Air suspension and attachment Tag axle	☐	06272	0	
12	Shock absorbers	☐	06273	0	
13	Check the mounting and torques on the rear lights and mudguards brackets	☐	06460	10	
14	Check the mounting and torques on leaf suspension and attachement front axle	☐	06260	3	
15	Check the mounting and torques on air suspension and attachment front axle	☐	06261	8	
16	Check the torque on cab bracket and front suspension	☐	06250	5	
17	Check the torques of front wheel housing and brackets	☐	06465	7	
18	Check the torques on AC	☐	06060	0	
19	Check APS. Torques and mounting	☐	06030	6	
20	Check Air Cleaner, torques and mounting	☐	06035	0	
21	Check the mounting and torques on batteries and battery box cover	☐	06120	8	
22	Check the mounting and torques on the cross members	☐	06440	5	
23	Check the mounting and torque on the spare wheel carrier	☐	06470	4	
24	Check the torques on the brackets for side skirts or lateral protection	☐	06550	6	
25	Check the mounting and torques on the lead up ramps	☐	05610	4	
26	Check chassis mounted auxiliary heater	☐	06240	2	
27	Check the mounting of Ad blue module	☐	05470	0	
28	Check the mounting and torques exhaust system	☐	06520	4	
29	Check high air intake torques	☐	06545	0	
30	Check the mounting and torques of steering gear and steering joints at front/rear axle	☐	06210	6	
31	Check the mounting and torque of trailer connection	☐	05565	10	
32	Check torque on pipes for oil cooler/Manual gear box	☐	05315	0	
33	Check the torques and mounting of gearbox to fly wheel housing	☐	06390	4	
34	Check the mounting and torques cab tilt lock and rear suspension	☐	06510	6	

35	Check the gear shifting linkage,all joints on the gear box		06660	4	
36	Check the mounting and torques of the engine suspension		06380	3	
37	Check of mounting and torques for wheel chock and retainer		06640	4	
38	Check the mounting and torques for the fuel tank, straps and brackets		06350	4	
39	check the monting and torques on the propeller shafts and bearing support		06220	2	
40	Check the protection and connection of ground cables and screws		05740	5	
41	Cable harness BWS frame		05747	3	
42	Mounting of hydraulic piping for steering		06620	8	
43	Bording step for cab		05205	2	
44	Check the mounting and torques on axle load limiter		06360	4	
45	Check the mounting and torques on air tanks		06430	6	
46	Check the mounting and torques on trailer contact		06670	5	
47	Check the mounting and torques radiator underneath the cab		06600	6	
48	Check torque and mounting of charge air cooler		06540	6	
49	Check the mounting and torques of the valves and brackets assembled towards frame		06490	3	
50	Check the sun visor when the cab is tilting		05460	5	
51	Check the torques and assembling of unions, plugs, ring nuts		06500	6	
	Check the mounting and for chafings of the plastic pipes, hoses and electrical cables				
52	Mounting and chafing of air pipes and hoses ,fuel pipes and hoses		05661	5	
53	Mounting and chafing of coolant hoses		05661	5	
54	Mounting and chafing of hydraulic hoses and pipes		05661	5	
55	Mounting and chafing of electrical cables		05661	5	
56	Mounting and chafing of heater and AC-hoses		05661	5	
57	Mounting and chafing of brake pipe and hoses		05661	5	
	Check if there are any leakages after the test drive				
58	Windscreen wiper/washer operation,position nozzles		05210	2	
59	Oil leakages		05500	2	
60	Air leakages		05580	2	
61	Check grease leakages on Automatic Chassis Lubrication (ACL)		06040	2	
62	Fuel leakages		05510	2	
63	Coolant leakages , and torque hose clamps		05520	2	
64	Check the mounting of cannon connections		05350	3	
65	Check the insulation underside the cab (damages)		06020	3	
66	Check the sealing tachograph on the gear box		06070	6	
67	Check the sealing of the speed limiter on the gear box		00000	6	
68	Check the type plates		06190	5	
69	Visual check (color mismatch,damages,rust,dust ect)		05630	15	
70	Check the rust protection on the chassis		05960	2	
71	Check the overall lubrication		06050	3	
	Check COP demands (on top of chassis)				
72	COP Spray Suppression		06340	1	
73	COP Lateral protection		06310	0	
74	COP Mounting and position of fifth wheel		06530	6	
75	COP Rear Registration Plate Space		06450	0	
76	COP Fuel tank placing		05840	0	
77	COP Rear coupling		06580	0	
78	COP Brakes		05540	0	
79	COP EMC Equipement		05950	0	
80	COP External projections		06330	0	

81	COP REAR under run protection		00000	0	
82	COP Speed limiters		06090	0	
83	COP Head lamp cleaning		05651	0	
84	COP Type plate		06180	4	
85	COP ADR electrics		05900	0	
86	Mounting and torques on the HD fifth wheel and position		06531	0	
87	Mounting and torques on the fifth wheel and position		06532	0	
88	Assemble all mudguards at front axle		06465	2	
	Tilt back the cab on P and R-cab				
89	Check oil levels in tag axle hoist		06270	4	
90	Check the oil level in cab tilt pump		06400	4	
91	Check the mounting & torques on roof and side mounted air deflectors		06480	15	
92	Check High air intake torques		06545	0	
	General visual inspection				
	Analyse results and communicate if necessary				
	Record values and results if necessary				
			Tot:	331	5,5 h

Appendix 11

SCANIA Standard check-list **Scania product audit** N° 5 - Assembly and Torques at front		Auditor:		
		Audit N°:		
		Chassis N°:	Date:	
			2012-10-01	
N°	**Operation**	**X**	**SCIM**	**Sum**
	Check in front of the cab			
1	Check the light adjustment		05980	4
2	Check the oil in the engine and oil dipstick		05130	2
3	Check the torques in the front of the chassis		06410	2
4	Check the torques and assembling of the charge air cooler		06540	0
5	Check torque of HVAC (AC)		06060	0
6	Check the torques and assembling of the radiator and air oil cooling pipes		06600	7
7	Check the torques and assembling of the cab brackets and front		06250	4
8	Check the function and play, tube connections and assembling of the hose for the clutch		05260	6
9	Check the torques and assembling of the bumper in front		06280	4
10	Steering gear and steering joints		06210	1
11	Check the torques and assembling of unions, plugs, ring nuts		06500	5
	Check if the cover for central electric unit in front are correct			
12	Take away the covers central electric unit in front			0
13	Check the mounting of cables		05661	0
14	Cable harness Connection panel		05745	0
15	Check the protection and connection of Ground cable and screws		05740	0
16	Assemble the cover for the central electric unit in front			0
	Check the mounting and for chafings of the plastic pipes, hoses and electrical cables			
17	Check the mounting of brake pipe in front of cab		05705	0
18	Check the mounting of pipes & hoses		05661	0
19	Mounting and chafing of air pipes and hoses ,fuel pipes and hoses		05661	0
20	Mounting and chafing of hydraulic hoses and pipes		05661	0
21	Mounting and chafing of electrical cables		05661	0
22	Mounting and chafing of heater and AC-hoses		05661	0
23	Mounting and chafing of brake pipe and hoses		05661	0
24	Mounting of Auxiliary heater		06230	0
25	Check the alignment of the upper grille, gap demands on P or R Cab & chassis exterior parts		05640	4
26	Check the operation upper grille		05820	2
27	Check the operation lower grille		05830	1
28	Windscreen wiper/washer operation, position nozzles		05210	1
29	Check the paint in front for damages, rust or bad painting		05630	5
30	Type plates		06190	2
31	Check retractable rear cab steps and function CP 28/31		05200	5
32	Check the cab damages		05620	10
33	Check cab and chassis visual inspection (HINO)		05635	0
	Check COP demands (in front of cab)			
34	COP Steering gear part		06200	3
35	COP FUP		06320	1
	Global visual inspection			
	Analyse results and communicate if necessary			
	Record values and results if necessary			
			Tot:	69

Appendix 12

	SCANIA Standard check-list **Scania product audit** N° 6 - COP and specification	Auditor:			
		Audit N°:			
		Chassis N°:	Date:		
			2012-10-01		
N°	Operation	X	SCIM	Sum	Comment
	Check COP demands				
1	COP Crew cab		06710	0	
2	COP ADR tachograph crew-cab		05911	0	Only MS
3	COP Tyres		05710	0	
4	COP ADR electrics		05900	0	
5	COP ADR Hot surfaces		05860	4	
6	COP ADR Auxiliary brake		05870	3	
7	COP Auxiliary heater		05890	5	
8	COP Dimension		06290	0	
9	COP Lighting devices		05970	5	
10	COP Doors		06300	5	
11	Assemble the cat walk, foot step		06420	0	
12	Assemble the top parts of the mudguards at the rear		06460	0	
13	Assemble the side skirts or lateral protection		06550	0	
14	Check ADR equipement		05910	0	
15	Check specification given by system and in the control report + S Order and R Order		05940	25	
16	Inspection of FFU order		06535	0	
	Analyse results and communicate if necessary				
	Record values and results if necessary				
	Local operations				
17	Check Noise COP		06690	0	Only MS
18	Check Horn COP		06700	0	Only MS
19	Check COP instruction for Japan		06715	0	Only MS
			Tot:	47	0,8 h

Appendix 13

SCANIA

Standard check-list

Scania product audit

N° 7 - Reporting and presentation

		Auditor:			
		Audit N°:			
		Chassis N°:	Date: 2012-10-01		

N°	Operation	X	SCIM	Sum	Comment
	Reporting and presentation				
1	Send out the Audit info by mail the day before the show			5	Only MA, MS
2	Encode all deviations and use the SQC-code list			0	
3	Gather the hole audit group and go trough and classify all the deviation			0	
4	Put all the deviation in to the computer, check the one already recorded(Prossess)			5	
5	Prepare the deviation report with the deviations and			0	Only MS
6	Create an Audit report in Word/BO/KA DAT			5	
7	Put the audit report and deviation reports outside at the truck that will be showed			8	Only MA, MS
8	Show the truck for the people from the chassi assembling, preparators and design			45	Only MA, MS
9	Put the control report/keys in special place at adjustment department			3	Only MS
10	Arrange so the truck will be moved to the adjustment			5	
11	Change the parking place and department on the computer (Prossess)			2	
12	Adjust the audit report in the computer (Prossess) if any changes have to be done. Take out a new audit report			0	
			Tot:	78	1,3 h

Appendix 14

SCANIA Standard check-list **Scania product audit** N° 8 - Safty Points		Auditor:			
		Audit N°:			
		Chassis N°:	Date:		
			2012-10-01		
N°	Operation	X	SCIM	Sum	Comment
	Check Safty points				
1	Split pin on spring bracket		09001	0	
2	Noice absorbent		09002	0	
3	Mudguard (front)		09003	0	
4	Cat Walk		09004	0	
5	Cover on silencer		00000	0	
6	Side skirts			0	
7	Lateral protection		09007	0	
8	Cover on battery		09008	0	
9	Top of rear mudguards		09009	0	
10	Split pin on castle nut for panhard beem		09010	0	
11	Box with extra parts back in cab		09011	0	
12	Windows are closed			0	
			Tot:	0	0,0 h