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# Continuous Improvement in Product Development

## An action research study for enhancing quality culture

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# Abstract

This master thesis has been carried out as a collaboration between Chalmers University of Technology and Powertrain Engineering during the spring and summer of 2012. Powertrain is a company within the Volvo Group and develops engines, transmissions and axles for the Group's products. Powertrain has 1700 employees globally, whereof about 800 are situated in Sweden where this thesis has focused its efforts.

It is the notion of this thesis that quality can drive development of important business factors, such as efficiency, development lead times, customer satisfaction and, in the end, bottom-line performance. Hence, a company culture consistent with the values of quality becomes important. For defining the values of quality this thesis leans on Total Quality Management. One of the central values in TQM is to improve continually and it is the purpose of this thesis to review Powertrain's current improvement work and propose changes towards an enhanced quality culture.

The theory used in this thesis includes a framework for evaluating improvement work by Bessant et al (2001). This framework was originally developed for a manufacturing context but since Powertrain is a product developing company, adoptions of the framework were made. This was done through studying additional theory on differences between manufacturing and product development. The result was that a special focus was put on learning and knowledge management, cross-functional interaction, innovation, and measurements. The data collection for this study has consisted of semi-structured interviews, company documents, and personal experiences.

The results and analysis show several gaps between the framework and Powertrain's improvement work. It is concluded that Powertrain's improvement work carries a legacy from manufacturing, not optimal in a product development context. Further, it is also concluded that top management attention at Powertrain is mainly directed towards increasing efficiency. It is argued that this direction poses a risk of generating a shortsighted development of the ways of working at Powertrain. On the other hand, strengths of the company include a genuine interest from co-workers in improvement work, eagerness to share knowledge, an alternative career path for specialized technicians, and the approach toward supporting root-cause analysis. Weaknesses include lack of a holistic view of improvement initiatives, poor recognition for successful improvements, inadequate measurements of improvement work, and lack of a connection between product malfunctions and process improvements.

This thesis argues for enhancing the presence of quality values in Powertrain management's attention to develop the organization. Subsequent recommendations include consistency between strategy and improvement initiatives, shifting the knowledge management approach from databases to a more social one, and develop the use of a problem solving practice, e.g. PDCA. Finally, Google's empowerment approach to innovation as well as creativity and the concept of serendipity has been discussed as alternative mindsets for Powertrain that could be beneficial.



Keywords: Quality, Culture, Continuous Improvement, Product Development



Rikard Nilsson Graas & Martin Jansmyr
Chalmers, Göteborg, 2012

## Acknowledgement

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Rikard Nilsson Graas, 2012

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Martin Jansmyr, 2012

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## Abbreviations

| | |
|---|---|
| 3C | Concern, Cause, Countermeasure |
| CI | Continuous Improvement |
| DTL | Daily Team Leadership |
| DVG | Design Verification Guidelines |
| GOT | GOThenburg |
| GTT | Group Trucks Technology |
| KPI | Key Performance Indicator |
| PE | Powertrain Engineering |
| PD | Product Development |
| R&D | Research & Development |
| RCA | Root Cause Analysis |
| VPS | Volvo Production System |
| VPS PDP | Volvo Production System Product Development Process |

# 1 Introduction

*This chapter is an introduction to this master thesis conducted at Powertrain Engineering and Chalmers University of Technology during the spring of 2012. The chapter includes a background to the thesis and why it is interesting from an academic point-of-view. Further, a problem definition, purpose, and research questions are presented defining the scope of the thesis. The chapter ends with a presentation of the company and an outline for the report.*

## 1.1 Background

Over the years a lot of companies have been inspired by Toyota and their strive towards perfection and zero waste, Volvo is no exception. In 2004 it was recognized that there were sporadic and uncoordinated attempts of applying Lean throughout the Volvo Group. A pre-study was launched with the objective to tailor a *lean* production system for the Volvo Group and consequently, the first version of Volvo Production System (VPS) was launched in 2007. The VPS model is formed like a pyramid with customers at the top and the group's vision, mission and values, which are also referred to as *The Volvo Way,* constituting the foundation. Finally, 5 principles link Volvo to its customers. The objective of VPS as stated by Volvo is to be a global initiative for happy and satisfied customers as well as improved financial performance.

At first VPS was only applied within the manufacturing parts of Volvo, but due to the good results from the initiative it was decided to apply VPS to the R&D organization within Volvo as well. The work with adapting VPS to product development (PD) started in 2009 and was named Volvo Production System - Product Development Process, or in short, VPS PDP. The VPS pyramid with the principles and modules for the product development process are visualized in Figure 1. When VPS PDP was rolled out it naturally included Powertrain Engineering. However, a master thesis from 2009 states that the implementation of VPS PDP was poorly planned and that the feeling of ownership for the system throughout the R&D organization was very low (Faghih & Myrelid, 2009). Consequently, VPS PDP has had difficulties in making an impact. In order to try and establish VPS PDP and draw some benefits from it the Powertrain Engineering site in Gothenburg has chosen to have a special focus on improving the Quality Culture, a module within the principle Built-In Quality. This focus constitutes an important part of the background to this thesis work.

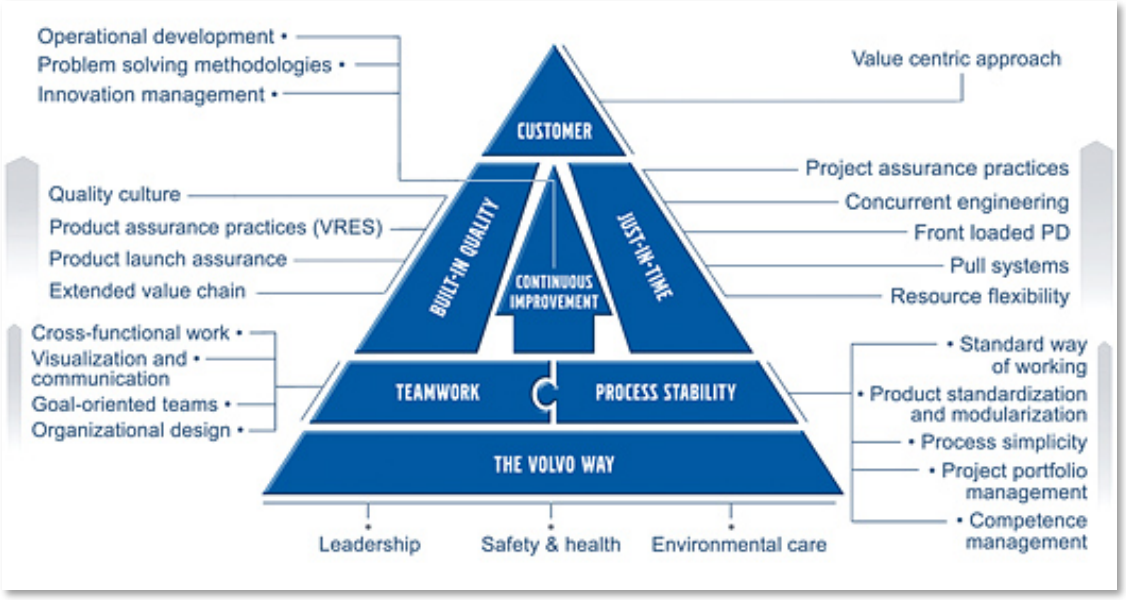


**Figure 1 Presentation of VPS PDP with principles and modules.**

## 1.2 Company Profile

Volvo was founded in 1924 in Gothenburg, Sweden. In 1927, Volvo presented their first series-manufactured car. From that time up until now a lot of things have happened and Volvo has evolved into one of the world's leading manufacturers of trucks, busses, construction equipment, and drive systems for marine and industrial applications. However, the Volvo Group no longer manufactures cars. That part of Volvo was sold in 1999 to Ford and as of 2010 the Chinese holding group Zhejiang Geely owns Volvo Cars.

The Volvo Group today has about 100,000 employees, production in 19 countries, and sales in more than 180 countries. The group's markets are divided into three divisions; EMEA (Europe, Middle East and Africa), Americas (North and South), and APAC (Asia and the Pacific region). The Volvo Group markets and sells a series of brands and amongst them are: UD Trucks, Mack Trucks, and Volvo Trucks. Figure 2 shows the marketing and sales organization but also the other parts of the Volvo Group. Powertrain Engineering is a part of Group Trucks Technology, which is the R&D organization of the Volvo Group. (Volvo Group, 2012)


**Figure 2 Illustration of the Volvo Group organization as of January 1st 2012.**

### 1.2.1 Powertrain Engineering

Powertrain Engineering, henceforth just Powertrain, is responsible for the powertrain development for the Volvo Group, which consist of engines, gearboxes, and axles. Powertrain's customers are the different business areas within Volvo Group, such as Volvo Trucks, Mack Trucks, UD Trucks, Renault Trucks, Volvo Penta, Volvo Construction Equipment, or Volvo Buses. Powertrain consists of three main areas represented in all of its five sites; Advanced Engineering, Execute Projects, and Maintain Products. Further, Powertrain is divided into four subsystems and three support functions. The subsystems are Base Engine & Materials, Control Systems, Combustion, and Drivelines & Hybrids. The support functions are: New Products, Product Maintenance & Verification, and Quality, Process & IT. (Volvo Group, 2012) With a new CEO for the Volvo Group an extensive re-organization has been initiated as of January 1st 2012. This will have consequences for Powertrain Engineering which is difficult for this thesis to overview but it is probable that the re-organization offers opportunities to change old habits and improve products as well as processes.

Powertrain is a global company located at the following sites: Gothenburg and Malmö in Swden, Curitiba in Brazil, Ageo in Japan, Lyon in France, and Hagerstown in the USA and has around 1700 employees in total. Powertrain in Sweden, where this thesis has been focused, has around 800 employees. The Powertrain site in Gothenburg where the authors have been located, lies on the island Hisingen in the Lundby area. Powertrain's facilities in Lundby mainly consist of offices in old buildings rich on Volvo traditions. The heart of powertrain development in Gothenburg is actually situated in the building where the first Volvo cars were built nearly ninety years ago. (Volvo Group, 2012)

## 1.3 Problem Analysis

High quality is a unique selling point for most of the Volvo Group's products and the neverending strive for efficient ways of working are getting ever more important as new markets and competitors emerge. Further, Volvo PD has not been unaffected by the different trends that have arised in the field of business development during the last twenty to thirty years, in which Lean Product Development is one of the most recent examples. Due to a variety of initiatives, a fast-paced globalization the last ten years as well as a now ongoing re-organization there seems to exists a confusion and frustration surrounding direction, concepts, and tools in Powertrain Engineering's quality and improvement work. These concepts and tools for CI are henceforth referred to as Powertrain's CI-system. This thesis aims at clarifying what is what and how the connections between different initiatives in the CI-system work. Furthermore, there are fundamental differences between production on the one hand and development on the other. This thesis will look at what differences and difficulties that has to be taken into account when applying theories and concepts developed for producing organizations in product development contexts. Finally, building on the understanding created for the quality culture and structure for improvement work at Powertrain, the organization will be evaluated on its abilities to develop itself and the methods utilized for developing products.

## 1.4 Purpose

The purpose of this Master Thesis is to review current efforts by Powertrain Engineering in the area of continuous improvements and, based on this review; propose a way forward towards a learning, continuously improving company culture.

### 1.4.1 Research Questions

1. What are the differences between Continuous Improvement in manufacturing versus Continuous Improvement in product development?
2. How is Powertrain Engineering's improvement work structured?
3. What are Powertrain Engineering's strengths and weaknesses when it comes to continuous improvement?

## 1.5 Delimitations

This thesis has been carried out as a collaboration between Chalmers Technical University and Powertrain Engineering, a company in the Volvo Group. As stated in the company profile Powertrain is a global company with operations on four continents. To give this study a reasonable scope it was decided to let the data collection only include the two Swedish sites, Gothenburg and Malmö. When it is refered to Powertrain in the text it only refers to Powertrain in Sweden, i.e. the Gothenburg and Malmö site.

Continuous Improvement is a broad concept and it has different meanings for different persons. Throughout this thesis CI mainly refers to improvements on processes, the ways of working at Powertrain. Naturally, processes and products are closely intertwined and argumentations and results on occasion spill over on product improvements as well. But as said, process improvements and process quality is the main focus of this thesis.

## 1.6 Report Outline

In order to answer the research questions in a way that is easy to comprehend and overview this thesis has been structured as follow:

Introduction: This first chapter aims at getting the reader acquainted with the subject and context for this thesis as well as briefly explaining background, what work that has been done and what kind of results that can be expected from this study.

Methodology: The second chapter describes in detail how the work with this thesis has been carried out. It includes the strategy and methods chosen for answering the research questions as well as reflecting upon reliability and validity of the results

Theoretical Framework: This chapter presents the theoretical foundation on which the analysis will be built. It will include; an explanation why CI is important for quality, a maturity framework assessing the CI capabilities of a company (Bessant, et al., 2001), and two frameworks focusing on the differences between CI in a production environment vs. product development (Caffyn, 1997) (Reinertsen & Shaeffer, 2005).

Empirical study: This chapter aims to present the interview results together with the experience of the researchers.

Analysis: This chapter analyses the results and insights of the researchers in comparison with the theories presented.

Conclusion and discussion: Finally, the last chapter aims to answer and elaborate upon the research questions.

# 2 Methodology

*This chapter describes the methods applied during this master thesis. It further explains how the interviews were performed, the literature review, and finally discusses the validity and reliability of this study.*

## 2.1 Research Strategy & Design

This thesis is a Qualitative study. As a typical Qualitative study, it is inductive and an inductive study is driven with the notion that research generates theory. The theory that is generated is however to some degree Powertrain specific and possibly only applicable for Volvo Group companies or companies similar to Powertrain. The research questions are defined from what is interesting from Powertrain's perspective, given the focus area of quality culture. However, the studied situation is generalized to be able draw conclusions to other areas than those studied at Powertrain. Further, a good action research study should have implications that relate to other situations than those studied. The defined research strategy converges into the research design of the study; Action Research. Action Research as a research design defines the relation between the researcher and the research objective. This means that members of the organization participate actively and that they also should benefit from the research. Action Research is also characterized by an iterative process of problem identification, planning, action, and evaluation (Bryman & Bell, 2011).

During the master thesis the authors where mostly situated at Powertrain in Lundby. Together with the master thesis work, the thesis authors engaged in regular activities such as regular meetings and strategy days. The researchers also engaged in assignments related to the scope of the thesis such as; process development and tool improvement. The close connection with Powertrain and to be able to engage regular as well as improvement activities at Powertrain increased the understanding of what quality culture and CI is for Powertrain.

## 2.2 Research Methods

The research methods chosen for this study are a literature review and semi-structured interviews. Further, this subchapter describe how the methods were used and why.

### 2.2.1 Literature

A literature review within the field of Continuous Improvement was conducted with the aim to explore the research area. There is a plethora of literature about implementation of CI, CI itself, and culture supporting CI. The literature is in most cases developed by studying a manufacturing environment. One of the main contributors to the field of CI is named John Bessant. Bessant's fellow researcher Sarah Caffyn has contributed to the field of CI by extending it to the new product development setting. The older and more developed CI literature together with the Caffyn's PD literature founded the basis of literature review for this thesis. The literature, which is further described in the theory chapter, can be used to assess an organization. The different type of companies and their behavior's is serving as a base for evaluating Powertrain, analyzing their ongoing CI initiatives and their quality culture.

Bessant et al. (2001) presents a framework for developing capability for CI that has been developed since the early 90's. This framework is used in this thesis but

since it is developed for a manufacturing setting some parts of it are less applicable. A part of the framework is do assess the maturity of an organization, however there has been some critique to this part of the framework since organizations do not seem to develop in a linear fashion (Aloini, et al., 2011). It is therefore this thesis do not focusing in assessing the maturity of an organization but rather what kind of behavior that aligns with developing capabilities within CI. These behaviors have also been compared with what Caffyn (1997), Aloini et al. (2011), and Reinertsen and Shaeffer (2001), state as main differences between manufacturing and product development in terms of CI. The differences have been subject for extra attention in the analysis and discussion in this thesis.

For the literature review Google scholar was used along with Chalmers library databases. Key words: Product Development, Continuous Improvements, Implementation, Success factors, Quality Culture, and Continuous Learning.

### 2.2.2 Documents

Internal documents have also been a part of the data collection. In the early planning phases as well as for the background of this thesis the internal documentation was helpful in gaining a holistic view of Powertrain and organizational structure.

### 2.2.3 Data Collection

The main part of data collection was done through a number of semi-structured interviews. Interviews were held with managers representing three levels of management within Powertrain GOT. These three levels are; G-PE, Section, and Group level. Their managerial responsibilities are the following: the group managers, responsible for approximately 10 to 25 co-workers, section managers, responsible for a technology area as well as members of the Powertrain Engineering management team in Gothenburg (PEMT GOT), and members of top management at Powertrain, called Global Powertrain Engineering management team or G-PE. There were however some other persons included as well, namely a HR representative and a quality expert. Further, 31, hour-long interviews were carried out. The aim with the interviews was to explore if there were any gaps in perception of CI and the CI-system. The questions asked were based upon a framework by Bessant et al. (2001) presented in the theory chapter. A form with the interviews questions are attached in Appendix I.

The interviews have been based on both qualitative and quantitative questions. The initial and major part of the interview included both straightforward questions needing only short answers as well as questions demanding the respondent to further develop their answer. These interview questions were formed in such a way that they should not be leading the respondent. However, if the respondent would not understand the true meaning of the question and it would seem that he or she has knowledge about it, there were additional questions following up that topic more specifically. The second part of the interview included nine multiple choice questions based on a five step Likert scale, meaning that respondents could choose to answer; fully agree, agree, neutral, disagree or fully disagree. These questions relate to the qualitative questions, validating the previous answers. The last part of the interview consisted of open questions, giving the interviewers a chance to ask respondents

about especially interesting issues that had come up during the interview or things that the interview guide did not cover.

To understand the organization, the way employees are working, and the culture, the researchers participated in activities regarding quality, quality tools, CI system, CI tools, etc. The understanding of reality or "Gemba" is important to be able to understand the real problems within the organization and how people within the organization perceive them. (Bryman & Bell, 2011)

## 2.3 Reliability

The data collection conducted during this thesis is built on primarily two different sources of data; literature and interviews. When it comes to the literature study a lot of effort has been put into reviewing books and articles to find multiple sources of facts as well as the origin and development of the different models and other theory applied in this thesis.

The interviews reliability is considered to be high. The questions were structured, following a guide. The time was in almost every case sufficient, making it possible to ask every question and the respondents able develop their answers accordingly. Since the interviews where held in Gothenburg at Volvo Lundby the certain setting might be crucial for determining the interviews outcome. Factors such as culture or personal networks and even education might be dependent on local factors. Volvo is a global company and if attempting to replicate the study at another site it might come to other results and conclusions.

## 2.4 Validity

External validity represents how generalizable the findings are to a greater context. As explained in the chapter about action research the results are based upon the studied environment at Powertrain. However, certain attributes can be generalized which makes conclusions generalizable to a certain extent. This can have implications on transferability i.e. how applicable the findings are to other contexts. There is also a possibility of "going native" when conducting an action research study. By "going native" means the extent the researchers are being affected by the corporate climate. Further, it is problematic to evaluate the degree that one has been influenced. However, a professional approach to the study has been applied, not letting own values influence the study therefore not jeopardizing confirmability.

# 3 Theoretical framework

*This chapter presents the literature and theories that will later be used to analyze the empirical results. It includes a very brief overview of the history of continuous improvement and its connections to the area of quality. Secondly is a framework for how the maturity of a company's CI work can be assessed. Finally there is a part with literature that examines differences between CI in manufacturing and product development.*

The most fundamental argument to why quality in the product development process is important is connected to changes in the product. If defects and poor designs are discovered early it is much easier and cheaper to adjust them compared to if the product is already in production or released in the market. (Bergman & Klefsjö, 2003)

## 3.1 Why continuous improvement is important for quality

Shortly after the end of the Second World War, Japan decided to concentrate efforts on reversing the country's production's poor reputation when it came to quality. Influenced by amongst others Deming and Juran something often referred to as the *Japanese Miracle* was started. This period of thirty years between 1955 and 1985 produced concepts such as the Toyota Production System, also known as Lean Production and the 7 QC tools by Kaoru Ishikawa. Japanese philosophy emphasized both the commitment in quality from top management. Also the participation by everyone was seen as important and lead to the dawning dispersion of the QC circle, with the purpose of giving everyone opportunities to do improvements. Based on the QC-circle phenomena, Juran in 1966, at a conference in Stockholm, predicted that Japan within twenty years would be world leaders in quality. History shows that he was right and this also demonstrates the impact improvement work can have on quality. (Bergman & Klefsjö, 2003)

Moving from the concept of quality to that of *quality culture*, quality culture is not a common concept in research and an unanimous definition is difficult to find. However, Smith (2011) says on the topic of quality culture that "*Quality needs to become a basis for guiding, empowering and supporting the constant pursuit of excellence by everyone in the organization."* This quote emphasizes the participation of all co-workers in an organization and it can be stated that if the behavior of everyone is consistent with values or principles beneficial for quality, a quality culture develops. Such values or principles have been applied in this thesis in the form of TQM (Total Quality Management). TQM argues that a number of other *corner stones* along with committed leadership and customer focus are what makes up quality development (Bergman & Klefsjö, 2003). The cornerstone model of TQM is shown in Figure 3. The picture shows how customer focus and satisfaction is reached through the four cornerstones and that leadership committed to this cause is essential to succeed.

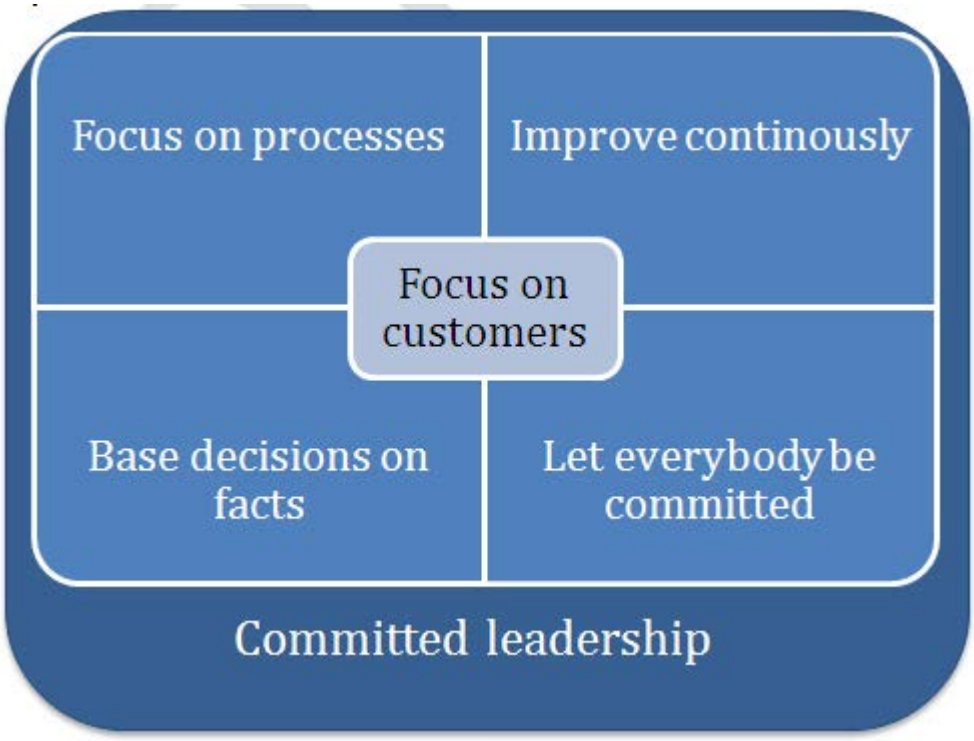


**Figure 3 The TQM cornerstone model (Bergman & Klefsjö, 2003)**

This thesis focuses on the corner stone *Improve continuously* which is described by Bergman & Klefsjö (2003) as a mental picture. Hence, TQM focus to a great extent on the behavior of people instead of focusing on tools. CI is justified with that costs of poor quality often amounts to between ten to thirty percent of sales and the basic rule of CI is that it is always possible to improve products and processes while using less resources. As in the case of the Japanese QC-circles, CI can in many cases give dramatic effects on improved quality and reduced total costs. To provide this study with an evaluative framework for CI, this thesis utilizes theory developed by John Bessant and his fellow researchers at CIRCA (Continuous Improvement Research for Competitive Advantage). This framework is essential for this thesis and is presented below.

## 3.2 A maturity framework for Continuous Improvement

During the 1990s Brighton Business School ran a program called CIRCA and this program developed a model for assessing companies' abilities within CI through collaboration with British industry. The complete model was published in 2001 and includes 5 levels of maturity connected to abilities and behaviors, the connections are shown in Figure 4. The definition of CI used by the CIRCA while designing this framework was "*a company-wide process of enabling and sustaining a continuing stream of focused incremental innovation*". This definition include both the small scale bottom-up perspective of everyone's involvement and enthusiasm as well as pointing out the responsibilities of the leaders to provide a direction and create conditions in terms of time, space or money.

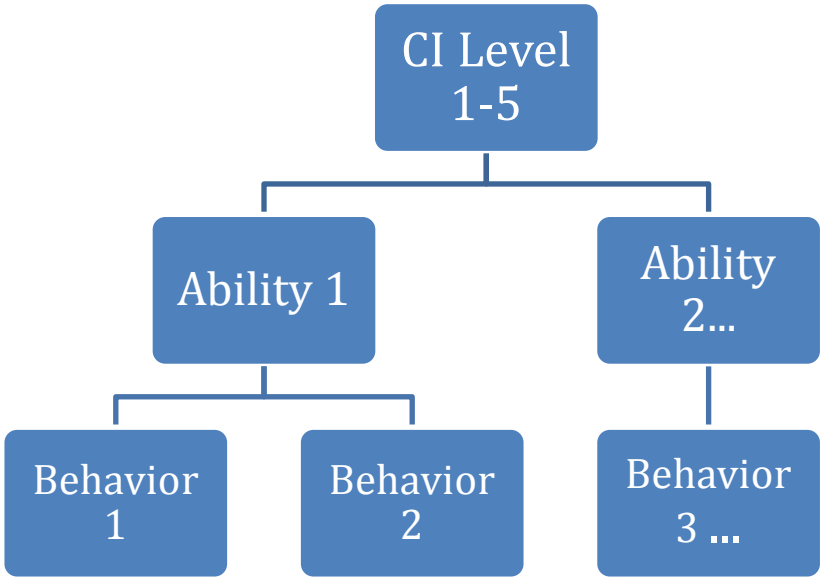


**Figure 4 Illustration of how behaviors and abilites makes up the continuous improvement level. (Bessant, et al., 2001)**

Entering the twenty first century the work with CIRCA resulted in a network of researchers and companies called CINet (Continuous Innovation Net). This network aims at facilitating research in the field and to coordinate conferences, seminars and workshops for its members. Two extensive surveys on companies' capabilities in CI have also been carried out, of which the questionnaire to the second one has been an inspiration to the interview guide used for this thesis. Further the 5 levels of CI maturity from the model developed by Bessant (2001) are illustrated below in Table 1.

**Table 1 The five stages in the evolution of a CI-system. Adapted from Bessant et al. 2001.**

| **CI maturity level** | |
|---|---|
| Level 1 – Pre-CI | Interest in the concept has been triggered - by a crisis, by attendance at a seminar, by a visit to another organization, - but implementation is on an ad hoc basis. |
| Level 2 – Structured CI | There is formal commitment to building a system which will develop CI across the organization. |
| Level 3 – Goal oriented CI | There is a commitment to linking CI behavior, established at 'local' level to the wider strategic concerns of the organization. |
| Level 4 – Proactive CI | There is an attempt to devolve autonomy and to empower individuals and groups to manage and direct their own processes. |
| Level 5 - Full CI Capability | Approximates to a model 'learning organization'. |

To further define the model it also includes, as mentioned earlier, abilities and behaviors connected to continuous improvement. Table 2 presents the eight abilities along with their corresponding behaviors.

**Table 2 Abilities and behaviors connected to CI maturity level. (Bessant, et al., 2001)**

| Ability | Constituent Behavior |
|---|---|
| 1. Understanding CI – the ability to articulate the basic values of CI | • People at all levels demonstrate a shared belief in the value of small steps and that everyone can contribute, by themselves being actively involved in making and recognizing incremental improvements.<br>• When something goes wrong the natural reaction of people at all levels is to look for reasons why etc. rather than to blame individuals.<br>• People make use of some formal problem-finding and solving cycle. |
| 2. Getting the CI habit – the ability to generate sustained involvement in CI | • People use appropriate tools and techniques to support CI.<br>• People use measurement to shape the improvement process.<br>• People (as individuals and/or groups) initiate and carry through CI activities – they participate in the process.<br>• Closing the loop - ideas are responded to in a clearly defined and timely fashion – either implemented or otherwise dealt with. |
| 3. Focusing CI – the ability to link CI activities to the strategic goals of the company | • Individuals and groups use the organization's strategic goals and objectives to focus and prioritize improvements<br>• Everyone understands (i.e. is able to explain) what the company's or department's strategy, goals and objectives are.<br>• Individuals and groups (e.g. departments, CI teams) assess their proposed changes (before embarking on initial investigation and before implementing a solution) against departmental or company objectives to ensure they are consistent with them.<br>• Individuals and groups monitor/measure the results of their improvement activity and the impact it has on strategic or departmental objectives.<br>• CI activities are an integral part of the individual or groups work, not a parallel activity |
| 4. Leading the way - the ability to lead, direct and support the creation and sustaining of CI behaviors | • Managers support the CI process through allocation of time, money, space and other behaviors.<br>• Managers recognize in formal (but not necessarily financial) ways the contribution of employees to CI.<br>• Managers lead by example, becoming actively involved in design and implementation of CI.<br>• Managers support experiment by not punishing mistakes but by encouraging learning from them. |
| 5. Aligning CI - the ability to create consistency between CI values and behavior and the organizational context (structures, procedures, etc.) | • Ongoing assessment ensures that the organization's structure and infrastructure and the CI system consistently support and reinforce each other.<br>• The individual/group responsible for designing the CI system designs it to fit within the current structure and infrastructure.<br>• Individuals with responsibility for particular company processes/systems hold ongoing reviews to assess whether these processes/systems and the CI system remain compatible.<br>• People with responsibility for the CI system ensure that when a major organizational change is planned its potential impact on the CI system is assessed and adjustments are made as necessary. |
| 6. Shared problem-solving - the ability to move CI activity across organizational boundaries | • People co-operate across internal divisions (e.g. cross-functional groups) in CI as well as working in their own areas.<br>• People understand and share a holistic view (process understanding and ownership).<br>• People are oriented towards internal and external customers in their CI activity.<br>• Specific CI projects with outside agencies - customers, suppliers, etc. - are taking place.<br>• Relevant CI activities involve representatives from different organizational levels. |

| Ability | Constituent Behavior |
|---|---|
| 7. Continuous improvement of continuous improvement - the ability to strategically manage the development of CI | • The CI system is continually monitored and developed; a designated individual or group monitors the CI system and measures the incidence (i.e. frequency and location) of CI, the development of CI activity, and the results of CI activity.<br>• There is a cyclical planning process whereby (a) the CI system is regularly reviewed and, if necessary, amended (single-loop learning).<br>• There is periodic review of the CI system in relation to the organization as a whole which may lead to a major regeneration (double-loop learning).<br>• Senior management makes available sufficient resources (time, money, personnel) to support the ongoing development of the CI system. |
| 8. The learning organization - generating the ability to enable learning to take place and be captured at all levels. | • People learn from their experiences, both positive and negative.<br>• Individuals seek out opportunities for learning / personal development (e.g. actively experiment, set their own learning objectives).<br>• Individuals and groups at all levels share (make available) their learning from *all* work experiences.<br>• The organization articulates and consolidates (captures and shares) the learning of individuals and groups.<br>• Managers accept and, where necessary, act on all the learning that takes place.<br>• People and teams ensure that their learning is captured by making use of the mechanisms provided for doing so.<br>• Designated individual(s) use organizational mechanisms to deploy the learning that is captured across the organization. |

### 3.3 Adaption of the framework

In order to apply the framework for CI by Bessant et al. (2001) in this thesis it is important to be clear on how the different concepts relates to each other. The purpose throughout this thesis has been how the quality culture at Powertrain Engineering, a company in PD, can be enhanced through CI. Through TQM it is shown how continuous improvement is a part of quality and hence, quality culture. Further, it is also believed that the presented framework for CI is consistent with TQM values, thus there is no contradictions in defining quality based on TQM and then apply the work of Bessant and CIRCA. However, before the framework is applied its contents as well as the implications of a PD setting need to be discussed.

The framework for CI by Bessant et al. (2001) is a result of a serious and extensive research project. Although, there are some concerns about the practical use of some parts that needs to be discussed before the framework is put into use. Namely, the connections between the abilities and CI maturity level, shown in Figure 4, as well as the formulation of the maturity levels. Concerning the connection it is unclear how abilities and behaviors actually are interpreted into the five different levels. Since the model is supposed to have quantitative input from surveys some threshold limit values or other directives could be expected. For example, to what extent do the different abilities have to be fulfilled to achieve the five levels? Moreover, it should be noted that this study is mainly based on a qualitative data collection in contrast to the surveys done by CIRCA. This results in difficulties to state that, for example, behavior two in ability three is fulfilled to 45 percent affecting the maturity level this or that much. Further, about the design of the maturity levels, it is sometimes difficult to interpret the intentions with them. Their meaning is ambiguous which impacts the reliability and validity. The most obvious example is level four – Proactive CI which is presented in Table 1 and says: *There is an attempt to devolve autonomy*

*and to empower individuals and groups to manage and direct their own processes.* In this requirement "*There is an attempt...*" makes the meaning of this statement quite hollow. The same kind of vague formulations can be found in levels two, "*there is formal commitment*" and three, "*there is a commitment*" as well. This kind of requirements does not have an absolute meaning which opens up for different interpretations as well as discussions.

Another, more general, argument against applying a strict maturity model is that such models create linear approaches towards the implementation of innovation systems, such as CI. It is easy to imagine that if a maturity model is guiding the development of a CI-system, focus will be on achieving the next level, probably even if the requirements of "the next level" is not what the organization needs or asks for. In literature there are signs of that a linear approach in the development of CI might not at all be desirable (Jørgensen, et al., 2006). This opinion is based on other innovation processes more thoroughly researched and studied over a longer timeframe than CI, processes such as decision making, organizational change, or new product development. History shows that these areas have initially been imposed with firstly oversimplified models, sequential and stage-wise to their nature. Later, researchers have paid more attention to the complexity and a higher appreciation of concurrent or interrelating activities has evolved. As Jøergensen et al (2006) state, CI process theory is only at the start of its development and there are strong reasons to believe that CI will follow the same path.

Based on the arguments above it has been decided to not apply the part of the framework concerning maturity levels and instead focus on the abilities and behaviors as a checklist for CI.

### 3.4 A model for principles, methods and tools

During the data collection in this thesis work it has shown that there exists a confusion at Powertrain concerning the application of methods and tools, especially in improvement work. People seem to get lost in applying models such as PDCA or 8D and tools as fishbone diagrams or process mapping are perceived as not generating relevant results. The outcome being that problem solving in improvement projects become slow and burdensome. Dean & Bowen (1994) presents a way of thinking that constitutes of dividing concepts into principles, practices and techniques. Principles are high-level guidelines for what is to be done. Practices are in this case synonymous with methods, being descriptions on what activities that should be carried out to fulfill the principles. Techniques have the aim of, when needed, supporting the performance of miscellaneous activities proposed by the practices (Dean & Bowen, 1994). An illustration of this way of thinking, applied to robust design, is shown in Figure 5 (Hasenkamp, et al., 2009). Here techniques have been exchanged for tools but the meaning is no different than that of Dean & Bowen. It could be argued that this model is way too simplified compared to reality but it is believed that the model can fill a purpose in the specific setting of this thesis. Namely to clarify what is what and help Powertrain Engineers to maintain overview and focus when applying the different practices and tools that exists in the company's toolbox.

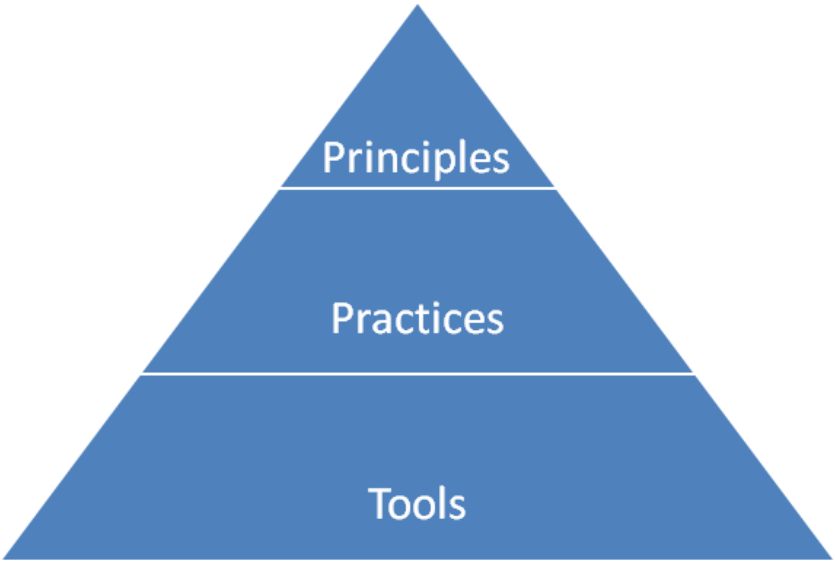


**Figure 5 A model of how to think about the roles of principles, practices and tools. Adapted from Hasenkamp et al (2009)**

## 3.5 Continuous Improvement within product development

In the late 90's the concept of CI took another turn and developed into something more than traditional CI, i.e. CI applied to manufacturing processes, including non-routine activities such as product innovation and administrative processes (Aloini, et al., 2011); (Caffyn, 1997); (Bessant & Caffyn, 1997). A new view upon CI emerges, focusing on innovation and learning. This new view also questions the tool-focused approach and the connection between tools and performance (Aloini, et al., 2011). However, the framework for CI created at CIRCA which is utilized in this thesis has been developed from studying a manufacturing context and the intention of this chapter is to discuss some fundamental differences between manufacturing and PD and their impact on the use of the framework.

As CI was developed for a PD context there have been some new aspects highlighted in the research. Aloini et al. (2011) pinpoints the evolution in two points. The first is that the organizational scope has expanded for CI within PD. Meaning that involvement, as in production, still have to be high but the context has expanded, employees have to work cross-functionally and collaborate in their efforts. Cross-functional collaboration is a way of understanding the often complex processes that span over a PD organization. The second point is the focus on learning, CI is regarded as a long term process that is being developed within the company rather than applied. Bartezzaghi et al. (1997) also focus on the aspect of knowledge and state that product development mechanisms such as fostering individual learning, recognizing and transferring it at the organizational level, and using the knowledge to improve actual performance are key factors for facilitating CI in product development.

Further, Sarah Caffyn has been developing and studying the field of CI within product development. In her work she has defined three main differences between manufacturing contexts and PD contexts, namely; tangibility, process characteristics, and evaluative frameworks (Caffyn, 1997). Reinertsen & Shaeffer (2005) are on the same track when listing differences between manufacturing and PD. Firstly, repetitive versus non-repetitive processes where variability in

the first case is always undesirable while there in the second case is a fine line between bad variability (waste) and good variability (creativity). Second, manufacturing deals with physical products while PD's product is information which, apart from physical objects, can exist in multiple places at the same time. Third, manufacturing works towards a fixed goal, a given result while PD has to evaluate and adjust on emerging knowledge, for example technological progress or the economic situation. (Reinertsen & Shaeffer, 2005)

To conclude, when applying the framework presented in this thesis to a PD context, special focus has to be put especially upon the four following areas. Creativity and process orientation; trade-offs between efficiency and creativity. Measuring CI; shaping CI with measurement. Emphasis on learning and knowledge management: how to generate and move relevant knowledge across the organization. Cross-functional work: people with different backgrounds working together to improve process understanding.

Finally on the matter of improvements in product development, Annika Steiber has for a number of years been studying innovation at Google. In an article concerning whether TQM impedes continuous innovation, in the sense of both incremental and radical innovations, it is concluded that the values of TQM and Google's approach to innovation, labeled OCCI (Organizational Characteristics for Continuous Innovation) are partly matching each other. The differences lie in the mental model of how to best organize people for both incremental and radical innovations. From an innovation perspective the mental difference mainly constitutes of the fear of killing creativity through process orientation and standardization. Consequently, OCCI when compared to TQM focuses less on processes and instead shapes the culture through a more loose semi-structured and ambidextrous organization as well as through emphasizing key values and heuristic rules. (Steiber & Alänge, 2012)

# 4 Empirical results

*This chapter presents the results from the data collection. The interviews are the main part but experiences from the action research, i.e. the authors' six months at the company are also a part of this thesis's empirical material. Firstly, the design of the system for Continuous Improvement (CI) at Powertrain is presented and a second part describes CI behaviors and how the CI-system is applied in practice.*

## 4.1 Powertrain Engineering's structure for Continuous Improvement

Powertrain Engineering in Gothenburg has an interest in working with continuous improvement. This is for example shown through the dual mission communicated from the executive level. On the one hand technical solutions shall be delivered but there is also a focus on delivering improvements to the ways of working. But before focusing solely on Powertrain, to get an understanding for the context, CI is explained from a Volvo Group level perspective.

There are many elements that make up the quality culture at Volvo. One of them is Volvo Production System, VPS, and its principle of continuous improvements. This principle implies an organizational focus on development of operations and learning. Another source is The Volvo Way, which states the same ideas and constitutes what the Volvo Group officially stands for. Below is a quote from The Volvo Way expressing the executive committee's view of CI.

*"The Volvo Way is based on the conviction that every individual has the capability and determination to improve our business operations, and the desire to develop professionally."* - (Volvo Group Executive Committee, 2009)

It also states that quality is achieved by continuously improving processes and products based on customers' needs. This shows how Volvo closely connects CI with quality and one of the main focuses in this area is to become lean and reduce waste. Moving down the organization there is Global Trucks Technology or GTT which is the product development organization. Its president Torbjörn Holmström chooses to emphasize the following.

"*Each employee within Volvo Group Trucks Technology is empowered and expected to actively contribute to the achievement of Quality excellence*" and "*Quality excellence will be achieved by identifying, documenting, visualizing and continuously improving our processes.*" – (Group Trucks Technology, 2012)

Consequently, there is a high focus from corporate level on Powertrain to continually improve as well as having individuals that contribute. The following paragraphs describes how the structure for continuous improvement at Powertrain is built and what elements that are included.

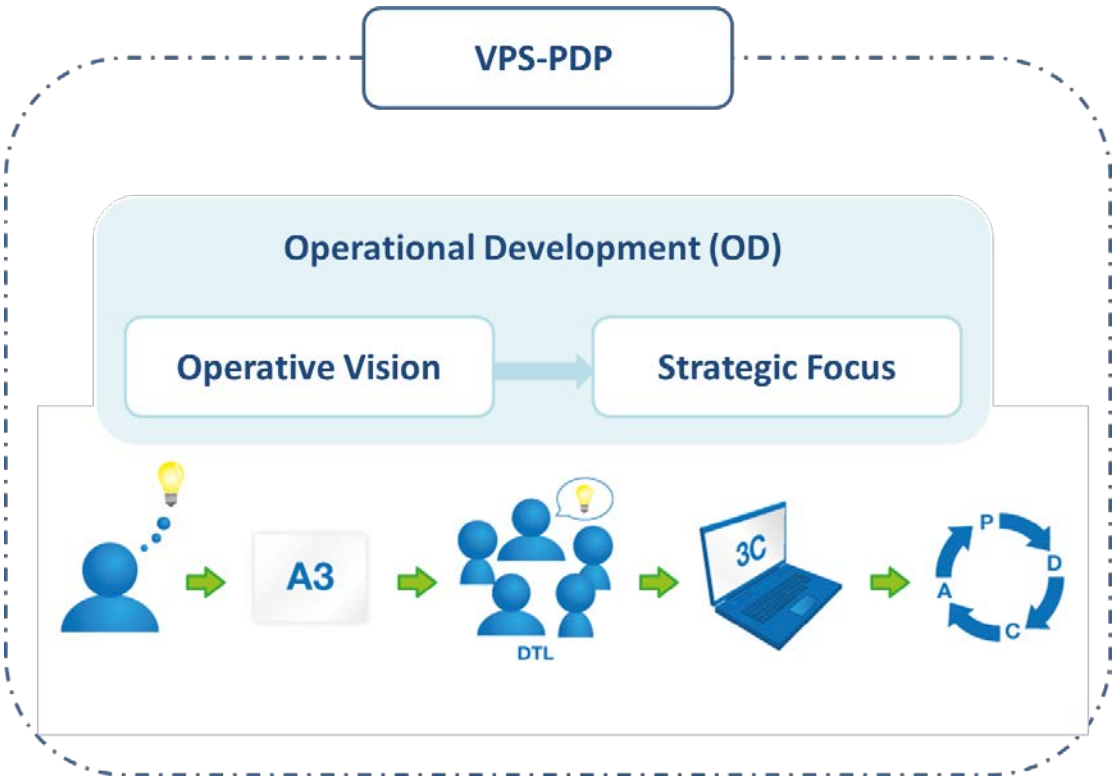


**Figure 6 A visualization of the CI-system at PE including VPS PDP, OD, DTL, and 3C.**

An overview of the CI-system is shown in Figure 6. The three main components making up the CI-system are Operational Development (OD), DTL and 3C. OD sets the direction for the work to be done, DTL is the forum for bringing up improvement ideas and discussing them, and 3C is the tool for administration and follow-up. Finally, Volvo Group's lean product development framework, VPS PDP is aimed at becoming a guiding star for the CI-system.

### 4.1.1 Operational Development

Some of the initiatives in the CI-system have been developed over time and has been operational at Powertrain for several years while others are more or less brand new. The oldest of the initiatives is OD or *Operational Development*. OD is Volvo Group's way of deploying top-down strategies in its companies and has been in use since 2000. It was originally developed by Volvo's truck manufacturing plant in Tuve, Sweden during the 1990s and before OD was inherited, Powertrain had no formal structure for CI. The purpose of OD is to develop Powertrain towards a state where it can cope with the challenges of the future. This state is reached by setting both long and short term goals. The long term goal is set by the Group CEO and is called *Operative Vision,* it concerns the whole corporate group of Volvo companies. Further, through OD and what is called strategic reasoning, the operative vision is supposed to be broken down, level by level, until it becomes a personal matter for every single co-worker. In this chain of events every company, site, section, group etc. should establish short term goals i.e. what can be done to contribute the long term vision. These short-term goals are referred to as *Strategic focuses*. Figure 7 shows an illustration of how OD is supposed to function and the different levels of escalation. Naturally the strategic focus becomes different in separate parts of the organization, depending on what is important for that part of the

organization in order to be able to contribute to fulfillment of the operative vision.

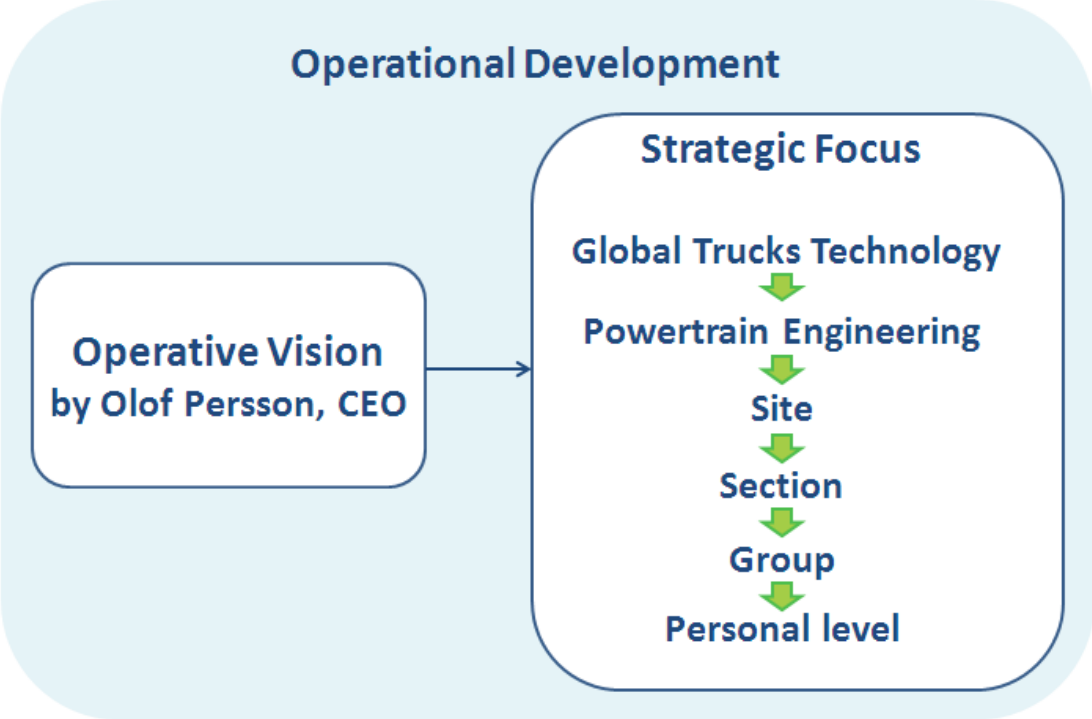


**Figure 7 Illustration of the Volvo Group's strategy deployment structure, OD.**

The Volvo Group's operate vision as of 2012 is to become the world leader in sustainable transport solutions by:

- Creating value for customers in selected segments
- Pioneering products and services for the transport and infrastructure industries
- Driving quality, safety and environmental care
- Working with energy, passion and respect for the individual

The interpretation that Powertrain GOT has done of this vision and set as their strategic focus for 2012 is "We drive sustainable improvements". Conclusion wise, OD can be described as what sets the direction for the CI work and determines what needs to be done in the organization to improve and fulfill the operative vision. However, it can be discussed that these visions are very general and in practice do not give much guidance or give the Volvo Group an edge in comparison with other companies.

### 4.1.2 Daily Team Leadership

DTL or *Daily Team Leadership* is the next part of the CI system at Powertrain, it was rolled out in 2009 and was a collaboration between the consultancy firm McKinsey and Powertrain. If OD and its strategic focuses is the top-down strategy deployment, DTL is the forum for handling every day work but also bottom up problem solving. Its purpose is to put focus on deliverables that are coming up and create a way to identify problems that risk causing delays as early as possible. One part of DTL is visual planning, which includes three boards; eight week planning, one week planning, and improvement projects. The

backbone of DTL is the one week planning white board where every member of the meeting has their name and a row. The one week board is shown in Figure 8. During the meetings each participant stands in front of the board for approximately one minute and explains what he or she is working on, deliveries that are approaching, experiences that have been done or ideas for improvements.


**Figure 8 Visualization of the one week planning board used in DTL.**

A typical DTL meeting lasts fifteen to thirty minutes, except once a week when a one-hour meeting is held and the eight week board is revised and updated and the improvement projects' progress are monitored and adjusted if necessary.

The DTL methodology is basically a meeting forum were a group shares their deliverables but also can ask for help to achieve them on time. Further, if there is an idea for an improvement, it can be presented at a DTL meeting and the meeting manager gives the idea a go or no-go status. DTL is also the forum for following up running improvement projects and serves as a forum for feedback and coaching. Practically, DTL has resulted in different behaviors depending on what part of the organization that is viewed upon. Originally DTL was designed for construction groups were close collaborations arise naturally and where daily meetings are meaningful. However, founded on good results from the implementation it was decided that all groups should use DTL including groups with project managers etc. This received some resistance and these groups had to adjust DTL to their needs. For example, in some cases meeting frequency has been cut from five to two or three a week since it showed not meaningful to meet every day.

### 4.1.3 A3 and 3C

The ideas picked up at DTL meetings and that are given a go from the manager are turned into so called 3C-issues. A 3C-issue is basically an idea for an improvement with a standardized methodology to support solving it. When solving a 3C issue it is meant to follow a problem solving method called 3C (Concern, Cause, Countermeasure). It is basically a version of a Plan-Do-Check-Act (PDCA) cycle which emphasizes the initial planning stage and neglects the final phases Check and Act. 3C was part of the package with DTL, rolled out in 2009. The next element of the CI-system is however a more recent addition.

Namely the A3 report, an essential part of the 3C process and recently adopted from Volvo Aero. The purpose of adopting the A3 was to find a way of reporting problem solving that facilitates and supports improvement projects through focus on the essentials, being easy to overview, and less administrative.

Moreover, 3C is also the nickname for the IT based tool that is used to follow up and administrate improvement projects. Each 3C-issue is logged in a database as a unique post and the data concerning the project is stored in this database for monitoring and follow up. In order to successfully finalizing an improvement project it remains to standardize the solution and capture the generated knowledge for future use. Except that knowledge exists in the minds of the co-workers Powertrain has some mechanisms for capturing learning. Firstly the 3C IT-tool archives all completed improvements. Concerning product knowledge there is a Wikipedia-like database named Design Verification Guidelines, or DVG. Finally, project managers are supposed to gather lessons learnt in a standardized form of project documentation, after and during projects. However, there are reasons to believe that these mechanisms are not always utilized as expected.

### 4.1.4 VPS PDP

In 2007, an initiative called PD Factory was introduced as an attempt to apply Lean PD principles on Powertrain product development. As described earlier throughout this thesis, in 2009 Volvo decided to extend their corporate lean program in manufacturing to also include the R&D organization. As a consequence PD Factory was restructured and renamed to VPS PDP or *Volvo Production System Product Development Process.*

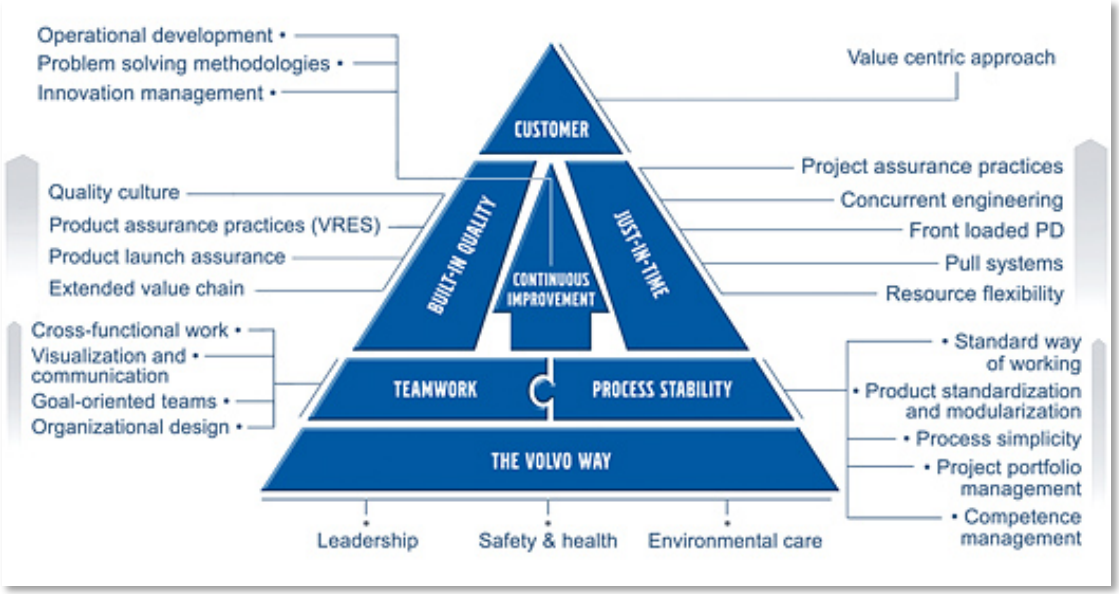


**Figure 9 Presentation of VPS PDP with principles and modules.**

VPS PDP has connections to the other elements in the CI system at Powertrain, which is illustrated in Figure 6, and could be seen as something that should be giving direction to all activities at Powertrain. VPS PDP is built upon principles and modules and as can be seen in Figure 9, continuous improvement is one of the principles in VPS PDP. The principle is constituted by operational development, problem solving methodologies, and innovation management. So far, so good and one could easily believe that what is explained as OD above

would be the same as organizational development here. However, it is difficult to determine the resemblance between the two since VPS PDP lacks concrete propositions on how to actually do things. The same goes for the principle problem solving methodologies.

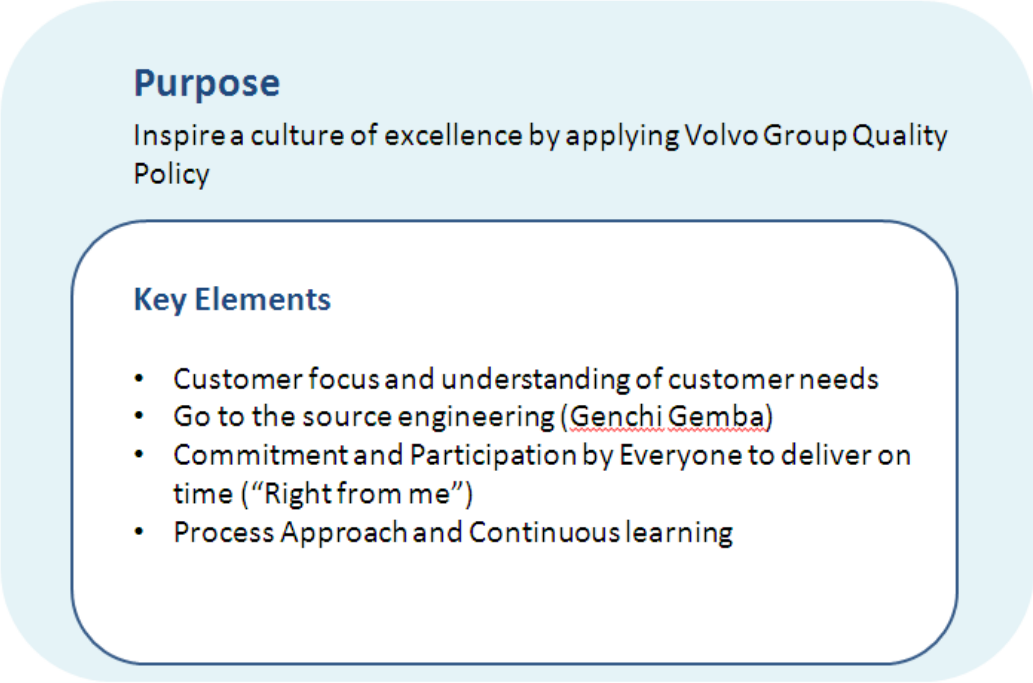


**Figure 10 The purpose and key elements of Quality Culture within VPS PDP**

Even though VPS is said to be a lean production system it resembles TQM significantly with its principles or cornerstones connecting the company, i.e. the Volvo Way, to the customer. It is thus interesting to see if the module of Quality Culture within VPS PDP is also consistent with TQM values. Figure 10 shows the contents of the Quality Culture module. Everyone's participation is included and the focus is rather on soft values such as understanding, the customer, and personal responsibilities than on tools. That continuous learning is mentioned is also positive due to the increased focus on learning and dispersion of knowledge that should be applied according to theory, given that this concerns a PD setting. In conclusion, it can be stated that using this material as guiding values is consistent with a TQM approach to quality. The model is however perceived as confusing. The confusion and the lack of thoroughness are obvious when looked into. The heart principle of the model is continuous improvement and continuous learning is a key element under the module quality culture which in its turn is under the principle built-in quality. Continuous improvement and continuous learning are closely related and not part of the same principle, which is just an example of how confusing the model can be.

## 4.2 Improvement behaviors

The purpose of this part is to present the results from the interviews and relate the answers to the CI-system presented above. The structure of this subchapter follows the same logic as the interviews did, starting with respondents' personal understanding, and involvement. Moreover there are results on how prioritizing

of improvements is done, leadership approach, problem solving, cross-functional initiatives, knowledge management, and finally how the CI-system is maintained.

The interviews were held with managers representing three levels of management within Powertrain. These three levels were; G-PE, Section, and Group level. The managerial responsibilities are the following: the group managers are responsible for approximately 10 to 25 co-workers, section managers are responsible for a technology area as well as members of the Powertrain management team in Gothenburg (PEMT GOT), G-PE or Global Powertrain Engineering management team is the top management at Powertrain. Among the interviewees was, for example, Anders Hellman chief executive at Powertrain and Olivier Ferlin manager of the Gothenburg. There were also two other persons included as well, namely a HR representative and a quality expert, in the results these two has been regarded as group managers.

### 4.2.1 Understanding of the concepts

To be able to comprehend the Powertrain managers' view, understanding and feelings towards the studied field, the interview began with two questions where the respondents were asked to freely elaborate upon quality culture and continuous improvements. This was done as a way of finding out what opinion and knowledge the respondents had of quality, CI, and basic incremental steps of improvement where everyone contributes. Respondents show a basic understanding of both CI and quality culture. Naturally, the interpretation of what is important in a quality culture is shifting between the different managerial levels. At the highest level of management, G-PE level, the emphasis is on the customer and standardized ways of working. At section and group manager level the emphasis is rather on doing things "Right from me".

The respondents' view upon CI is perceived to be collective. Respondents emphasize the strive forward to stay competitive. Table 3 shows the respondents' view of the outcome of CI. The table shows the collective view upon CI and what respondents perceive as CI benefits.

**Table 3 Respondents view of the outcome of CI**

| Response | All |
|---|---|
| Improved efficiency | 22 |
| Competitive products | 19 |
| Improved quality | 11 |
| Employee satisfaction | 13 |
| Stable processes | 8 |
| Increased knowledge | 5 |
| Improved quality culture | 2 |
| **Total** | **80** |

Figure 11 show the respondents' estimation of employees involved in improvement work at Powertrain. The interviews reveal that there are managers that take coordinator role, instead of being active in an improvement team. As a coordinator the managers focus on helping and coaching the different teams engaged with a specific task.

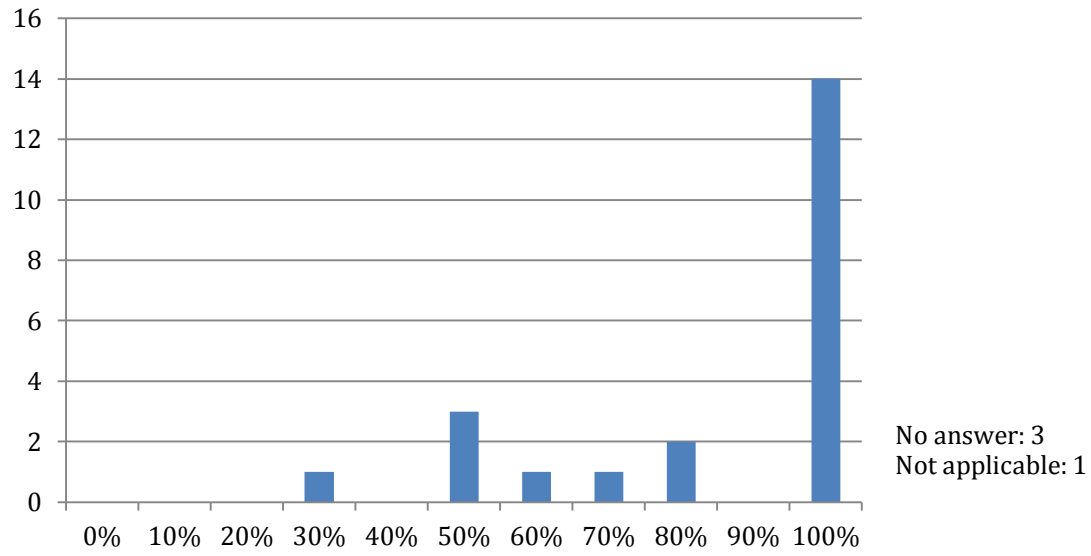


**Figure 11 The respondents estimate upon the share of employees involved in improvement work**

It was further asked if the managers personally were involved in any improvement work. Figure 12 together with Figure 11 show similar results, which indicate that the estimation of managers is somewhat close to reality.

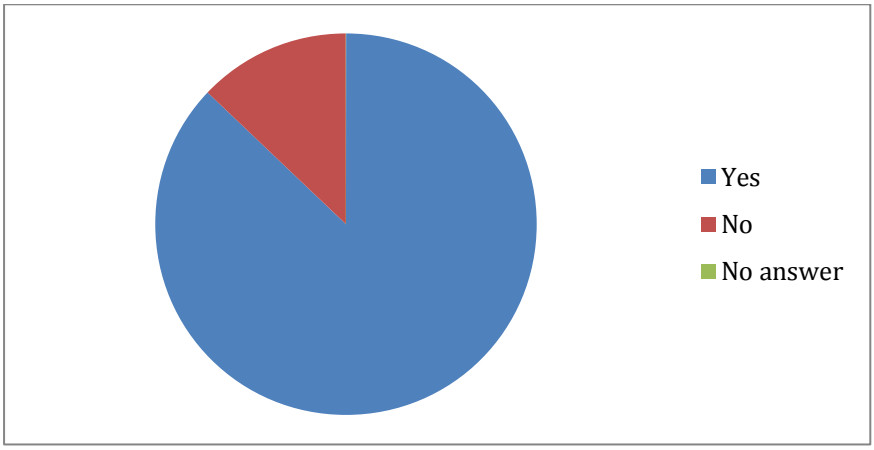


**Figure 12 Shows whether respondents are personally involved in some kind of structured improvement work.**

Figure 13 show the respondents view on who that is responsible for driving improvement work. The question aimed to investigate the managers' view of CI, how they delegate, and their view of autonomy. Most managers state that everyone should contribute to the CI work and that the CI work is autonomous enough to not hinder employee engagement in CI.

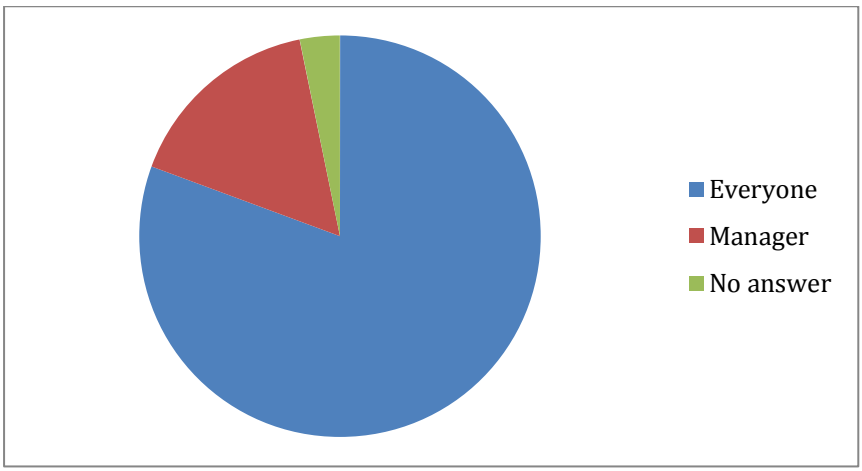


**Figure 13 Whom managers believe is responsible for driving improvement work.**

The mostly univocal opinion that everyone should be involved in CI was investigated further. It was looked into the role descriptions of different employees and if any of them stated CI as a responsibility or task. However, it was found that the majority of the role descriptions did not mention involvement in CI activities.

The interviewees reveal a tendency of being overwhelmed by the regular workload and hence a lack of time for engaging in CI related work. This tends to end up in many situations were problems are solved with taskforces, relying upon reactive problem solving. A task force is a specialized problem solving team summoned when an urgent problem occurs. Respondents express how the reactive work or taskforce problem solving in emergency situations is of world class. Interviews have also pointed out that a source to this problem can be how management perceives leadership qualities. Some respondents state that top management prefers a reactive, firefighting type of leaders.

It has also been investigated how employees has been trained in the relevant tools and methods that Powertrain is using for their CI work. There has been training in DTL which is a part of the CI system at Powertrain and the bottom-up forum for improvement ideas. There are also plans to extend the employees' knowledge in specific problem solving tools, such as root cause analysis in autumn 2012.

Interviews were held with all different functions within Powertrain Sweden. During interviews with business office and human resources a difference was noticed in how they perceive CI. These two functions have not adopted the CI structure and are not engaged in CI work in their daily work.

### 4.2.2 Strategy for CI

The next part of the interviews concerned company strategies and how they impact continuous improvement. When respondents were asked on what basis they allocate their resources for improvements, three things stood out, business cases, low hanging fruits, and involvement of co-workers in these decisions. Other things mentioned was that it is difficult to find the time for proper improvement work and that product improvements are often prioritized higher than improvements to the way of working. Only one respondent mentioned that the adopted strategy was guiding improvement efforts.

To examine the link between allocation of resources and strategy the following question for the respondents was if they thought that the cascading of strategies works and generates useful guidelines for them. The result is shown in Figure 14 and as can be seen, most managers are positive.

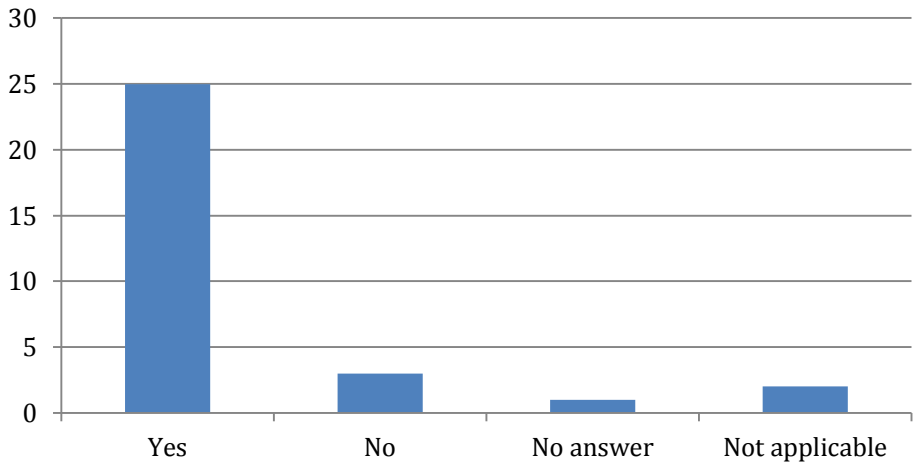


**Figure 14 Respondents' opinion on whether it is possible to break down more aggregated strategies, into something useful for them.**

Following the result above, interviewees were asked whether they could explain the strategy used by their organization, section or group. It is shown in Figure 15 and is essentially the same as the result from the previous question.

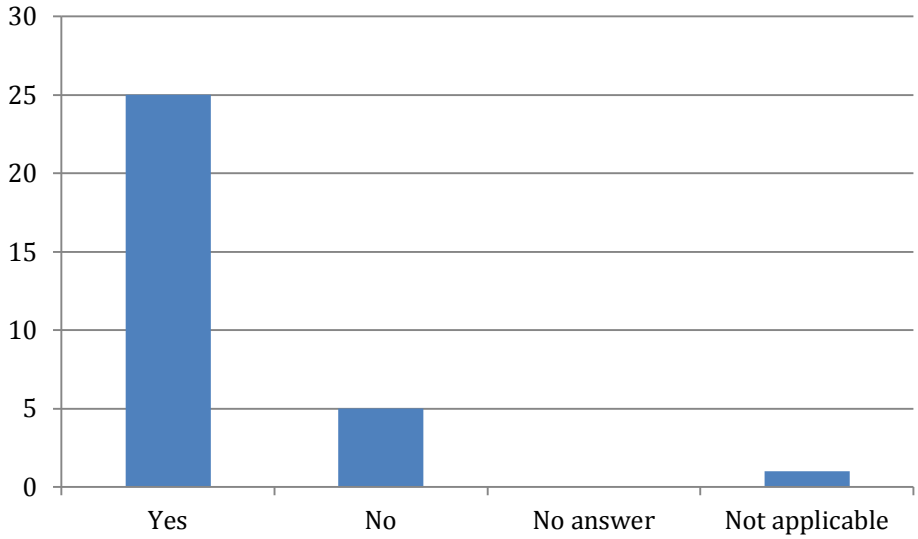


**Figure 15 Result on whether respondents could explain their organizations strategy, goals or objectives.**

Next result, shown in Figure 16, shows whether existing strategies or goals were used in prioritizing improvements and allocation of resources to such work. A majority of the respondents' perceive that they apply their strategy in improvement work. However, remember the results to the introductory question on this area where only one person spontaneously answered that current strategy was a guiding star in choosing and prioritizing improvement activities.

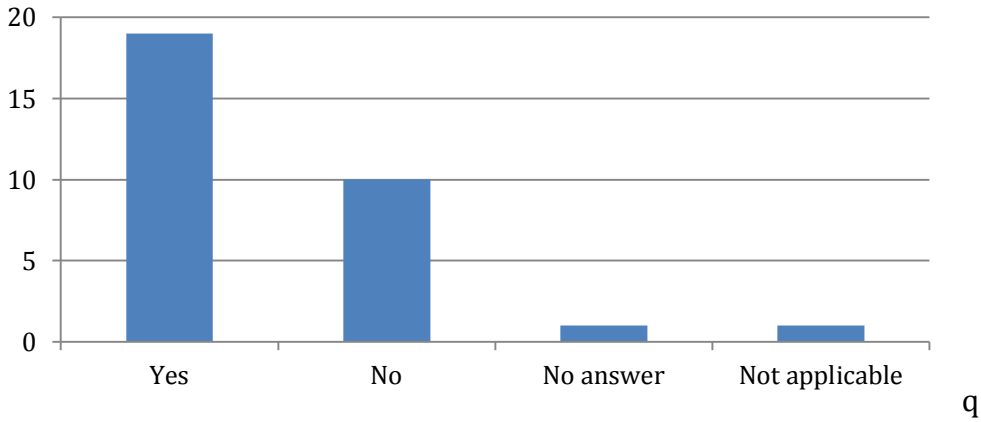


**Figure 16 Interviewees opinion on whether they apply their strategy, goals or objectives in the prioritizing of improvement work.**

### 4.2.3 Leadership

This part aims at describing the leadership at Powertrain. The managers' view of how they lead will be presented, both generally and when it comes to improvement work. This will also be complemented with what the respondents think about their own leaders.

Firstly respondents were asked how they viewed their role in the improvement work and the interviews showed that there is a consensus among the respondents that the leaders' main role is to support, coach, provide feedback, and when needed delegate responsibilities. Also, the group managers at Powertrain are highly operational, i.e. they should be billable seventy percent of their time, which might be another factor to why group managers take a less time-consuming role coordinating, instead of being more operative in CI. Of course there are differences throughout the organization. As a group manager states; "*My group consists of many experienced and specialized people so what I can contribute with is overview and support".* In other parts the share of newly employed people and external consultants is high and a more detailed support and management is needed. Another consensus among the managers is that time for improvement is scarce since the pressure to deliver into the different product development projects is high. However, managers and especially on group level believe that it is their responsibility to create time for improvement work. Another reoccurring opinion is that if managers do not follow up and give feedback on the work done CI will stagnate quickly.

Respondents were also asked about how they actually support improvement work in practice. Results from the group managers emphasize, once more, the difficulties of finding time to spend on improvement work. The respondents from the higher managerial levels talks more about strategic concerns such as creating concepts that guides the work, leading by showing which mindset that is right or providing context to the work.

Next, it was asked how managers give recognition to successful improvement work. The result is presented in Figure 17 and shows the most frequent answers. Occasional answers have been grouped together under Other and includes things such as movie tickets, business trips etc.

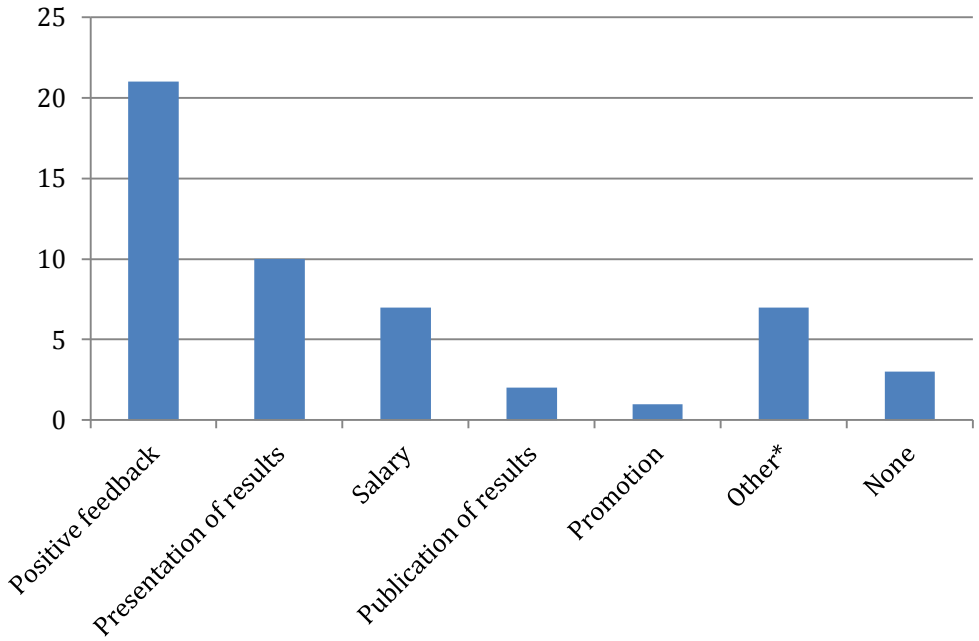


**Figure 17 How managers give recognition to successful improvement work.**

In Figure 18 respondents' opinions on to what extent recognition supports proactive work at Powertrain are shown. Here, managers have mostly given the answer based on their managers' behavior meaning that the result does not necessarily include a lot of self-criticism. However, the result is rather negative with around seventy percent of the respondents disagreeing or being neutral in the matter.

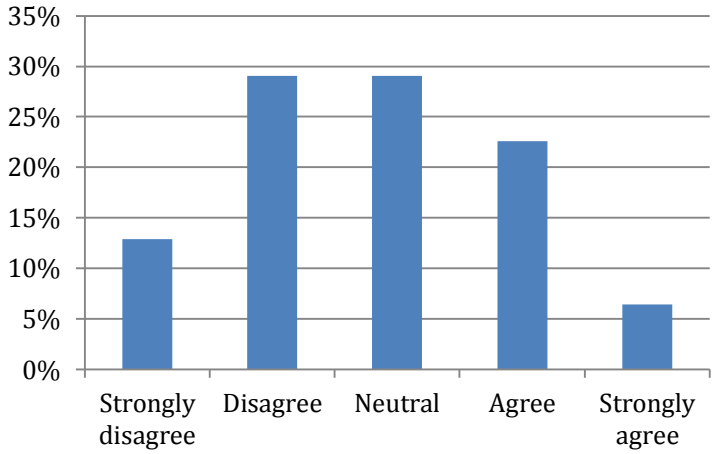


**Figure 18 To what degree respondents believe that rewards and recognition at Powertrain Engineering supports proactive improvement work.**

Next, a scale question along with open questions was asked about the general leadership style and direction on Powertrain. The scale question is presented in Figure 19 below. In the figure it can be seen that almost seventy percent disagrees or are neutral towards if the focus on CI at Powertrain is sufficient.

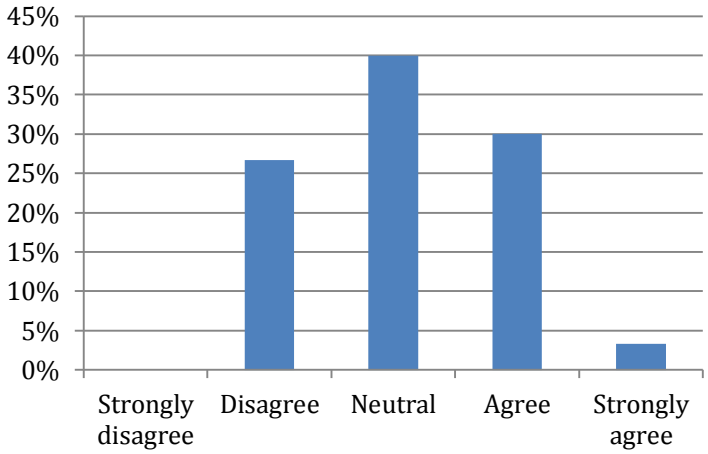


**Figure 19 To what extent respondent think there is sufficient focus on Continuous Improvement within Powertrain.**

Finally, respondents were asked what kind of leadership that is highly valued at Powertrain. This question showed interesting differences between the managerial levels. The group managers are quite precautious in their answers and seem to be rather satisfied with the leadership, even though some answers include that leaders sometimes focus on technical issues and not prioritizing other areas, However, on the PEMT GOT level, i.e. mostly section managers the answers have a different content. Answers include technical leadership, focus on a firefighting approach, and as long as you deliver on time you can lead as you want. One section manager actually anticipated the result that if you ask the co-workers they will answer an including leadership but that higher up in the organization there is another culture. G-PE members answered that the section managers' perception of Powertrain leadership is what used to be true but that this is now changing into a more delegating and including leadership. One respondent also shares his belief that project leaders are valued way too poorly making them escape the hard work in the PD projects for a more comfortable position in the line organization.

### 4.2.4 Problem solving

A number of questions concerning problem solving have also been asked to the respondents. The questions had the purpose of finding out how problems are solved, with what methodologies and what kind of problem solving that is rewarded at PE. Firstly, one result that show why this area is interesting and should be the target for studies is whether Powertrain's managers believe their company's ability to solve problems is efficient or not. The result of this question is presented in Figure 20.

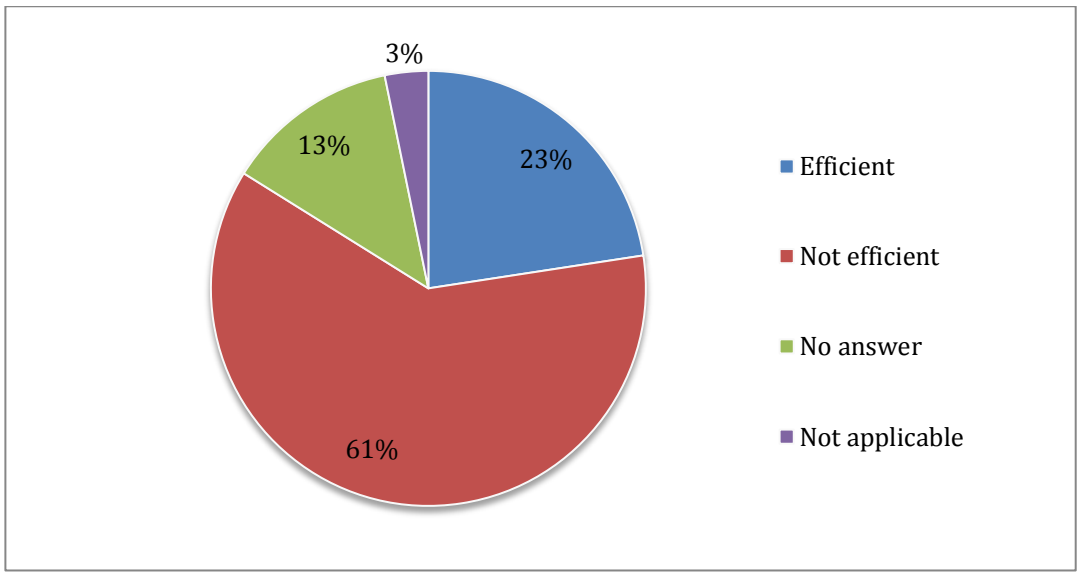


**Figure 20 Respondents' opinion regarding whether PE's problem solving is efficient or not.**

The result becomes even more interesting if it is broken down to the different managerial levels. It can be seen in Table 4 that while the group managers are divided into two essentially equal groups, Powertrain top management and the company's management team in Gothenburg are more negative.

**Table 4 Managers' perception of whether PE is good at managing knowledge**

| Responses | PEMT | | | |
|---|---|---|---|---|
| | G-PE | GOT | Group Managers | All |
| Efficient | 1 | 0 | 6 | 7 |
| Not efficient | 3 | 9 | 7 | 19 |
| No answer | 2 | 0 | 2 | 4 |
| Not applicable | 0 | 1 | 0 | 1 |
| **Total** | **6** | **10** | **15** | **31** |

Furthermore, the answers to the qualitative questions on this matter express that there are too many reoccurring problems, confusion regarding Powertrain's tools for supporting problem solving, that there is a lack of a statistical approach, and that too often resources are used to treat symptoms instead of finding the root cause to a problem. However, to balance this negative list of impressions there is also an understanding for that problems in product development can be cyclical and reoccurring to their natures since limits and demands are pushed to the edge over and over again. Among the group managers there are also some interesting opinions including that problem solving gets inefficient firstly when collaboration between different parts of the organization is needed and that Powertrain is not so good at making solutions last i.e. communicate and spreading best way of working. There are also some solutions on how to improve efficiency in the problem solving mentioned by the respondents. These include the use of design guidelines and a more structured approach towards problem solving.

Concerning a structured approach for problem solving Powertrain's 3C/PDCA methodology has previously been explained in section 4.1. The results presented in Figure 21 shows to what extent managers perceive that this methodology is applied throughout the organization.

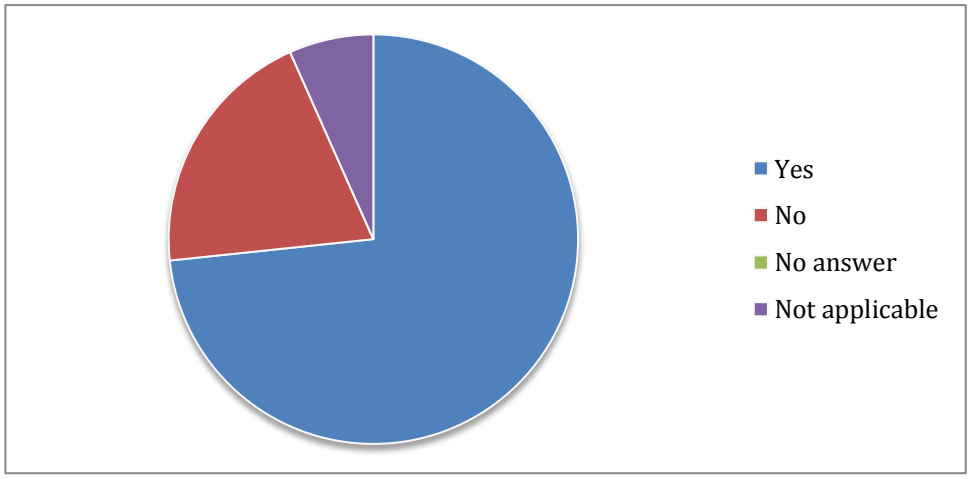


**Figure 21 Managers' perception of whether their organization, section or group applies 3C as a part of DTL.**

This result is rather uplifting for Powertrain with almost 75 percent using 3C, but it can be problematized since respondents also gave the answers presented in Figure 22. This result gives a more detailed picture on how the support for problem solving through tools at Powertrain works and even though it is not a catastrophic result, that around 50 percent of the organization utilizes the tools for problem solving is not sufficient. From this it can also be said that the link between the 3C/PDCA methodology and problem solving does not seem to be clear to everyone at Powertrain. There might also be the case of confusion when it comes to concepts. While 3C was originally the whole package with methodology, visual planning boards and a database, what is referred to when 3C is mentioned often seems to be the database.

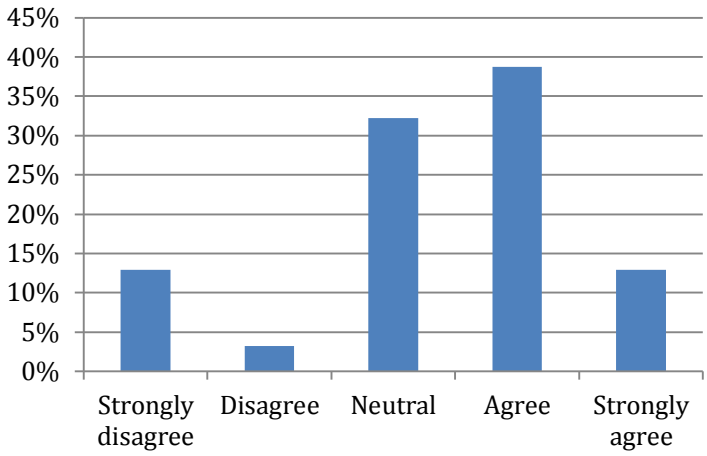


**Figure 22 Whether respondents' organization, section or group use some kind of tool when solving problems.**

### 4.2.5 Cross-functional interaction

The next topic discussed with the interviewees concerned cross-functional work within Powertrain, Volvo Group and also cross-company collaboration with customers and suppliers. Since the Volvo Group has a central supplier of IT services in Volvo Information Technology and Powertrain also collaborates with consulting firms in designing management tools a number of questions concerned whether managers could influence the design and functionality of tools, systems or other support were asked as well.

Figure 23 show managers' opinions on the extent of cross-functional work at Powertrain. Qualitative answers from the group managers give a picture of a situation that varies considerably between different groups and that some groups have natural links to other parts of the organization through global responsibilities or consulting services for other Volvo companies. However, there is a majority of the group managers that express lack of policies or structures for how collaborations are done and there are opinions that cross-functional projects often become burdensome and slow. Reasons given to this includes the complexity of the organization where the structural difference between the divisions inhibits effective collective work.

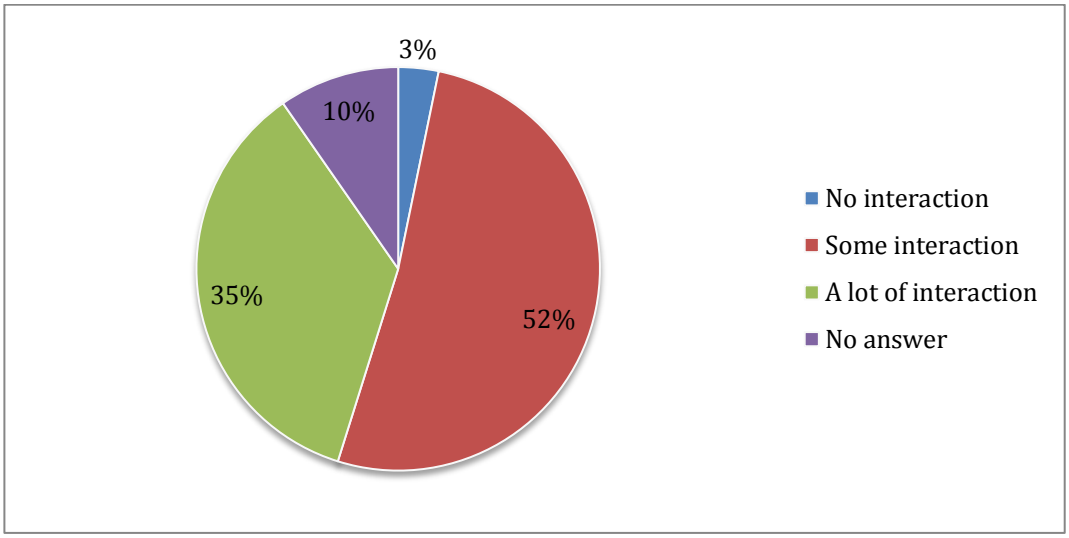


**Figure 23 Interaction across the Volvo Group organization in improvement work.**

PEMT GOT confirms what the group managers are saying. There is some interaction but the opinion is that Powertrain would benefit from an increase. However, there are also answers that state that structure is crucial to not end up in only arguing between departments or divisions. Also G-PE members are on the same page as the other two manager groups. Further, personal networks and their importance for successful cross-functional work are emphasized in the answers but also that Powertrain should be better at benchmarking against competitors and fellow Volvo companies. Again is the lack of structure an issue raised as inhibiting efficient ways of working. IT is also mentioned by a section manager as an area were closer collaboration with IT suppliers and thus mainly Volvo IT would be beneficial.

In Figure 24 and Figure 25 are the results from the questions if customers and suppliers are ever included in improvement work. As can be seen responses are about fifty-fifty, which is difficult to draw any conclusions from. However,

comments complementing the answers reveal a similar situation as with the cross-functional work. Customers and suppliers are included when there seems to be a need for them and on an ad hoc basis. Further, group managers often state that their situation places them far from the end customer, which is often experienced as non-beneficial and some respondents express a desire to come closer to the customer.

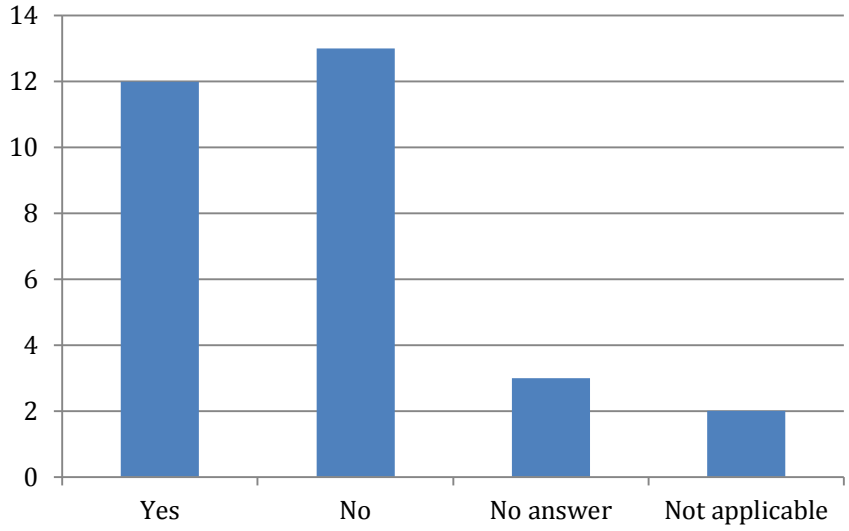


**Figure 24 Are customers included in improvement work?**

There are also some comments from the top managerial level that the customer requirements provided to Powertrain from Volvo Group level often are poor, incorrect or too general. Hence, some divisions generate products or components based on their own interpretation of the customers' wishes and demand. This interpretation and what it is based upon gets interesting due to the lack of customer contact expressed earlier.

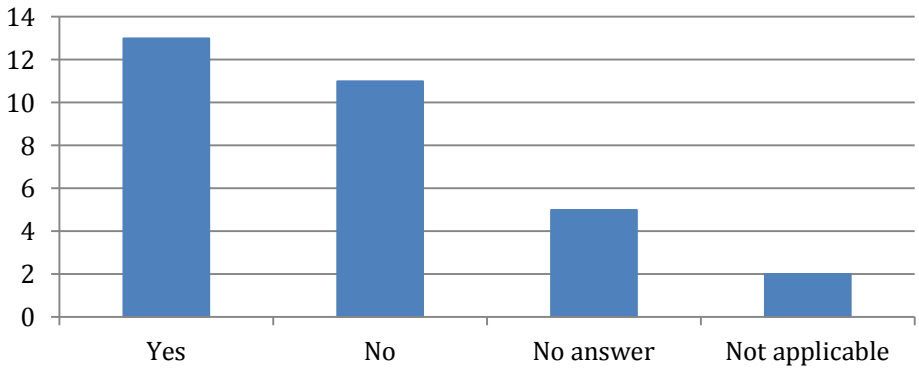


**Figure 25 Are suppliers included in improvement work?**

As mentioned earlier, IT has been mentioned as an area with opportunities for improvements and this leads to the next couple of questions, regarding tools, IT-systems and other support. However, these questions was easily interpreted by the respondents to include only IT-systems and in this area a lot of frustration could be seen. Respondents' views are normally that IT is something that should just work. Patience or understanding for malfunctions or lack of user friendliness is non-existing. But there are also some of the interviewees that bring up the

users' responsibility to provide specifications and user input that give programmer and system engineers a fair chance of succeeding.

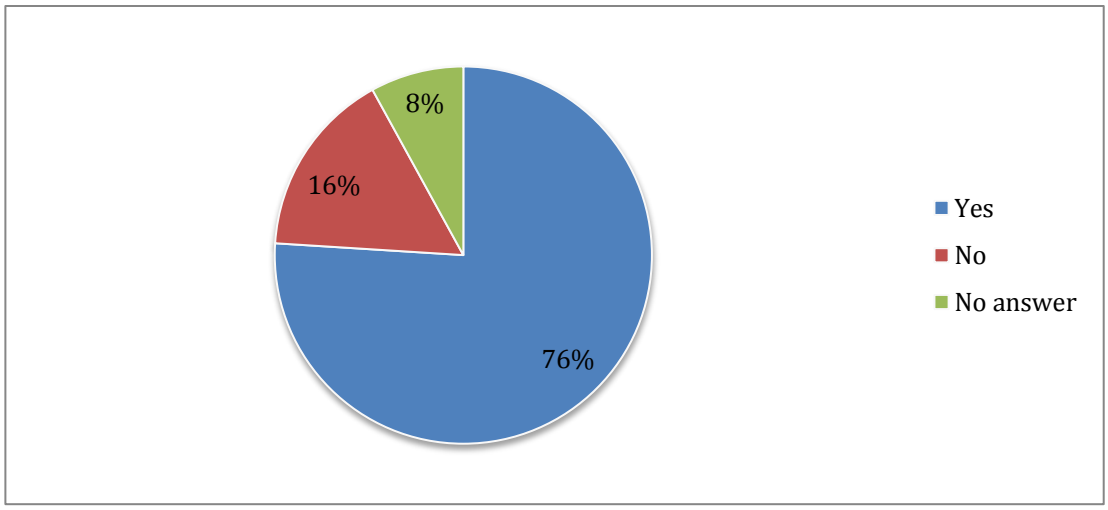


**Figure 26 Can managers influence the design and functionality on tools, IT-systems or other support used in the product development work?**

Further the group managers express a will that Powertrain's set of IT-tools should be more streamlined, i.e. removal of old systems when new ones are implemented. At the same time a smaller number of managers on all levels express that Powertrain is way too focused on the tools. According to some should time and energy be spent on improving the way of working instead of adjusting and refining the tools. Another opinion is that too little effort is spent on implementation of new tools, one manager express that tools can just arrive without anyone knowing how to handle them or even less knowing what good they are supposed to bring to the work. Besides the focus on IT-systems there some inputs regarding the CI system which was, by some people, perceived as inefficient. Finally on this matter, although the massive negative input on tools, IT-systems and support the majority of managers has the opinion that they can influence those that their organization utilizes. This result is presented in Figure 26.

### 4.2.6 Learning and knowledge management

This part presents the results from questions concerning knowledge management, which includes willingness to learn as well as capturing and sharing of knowledge throughout the company.

The first interesting result in this area concerns whether group and section managers believe that Powertrain are good at managing knowledge. The result was significantly negative as can be seen in Figure 27 and besides that it generates a number of additional questions it also validates this thesis's interest in the area.

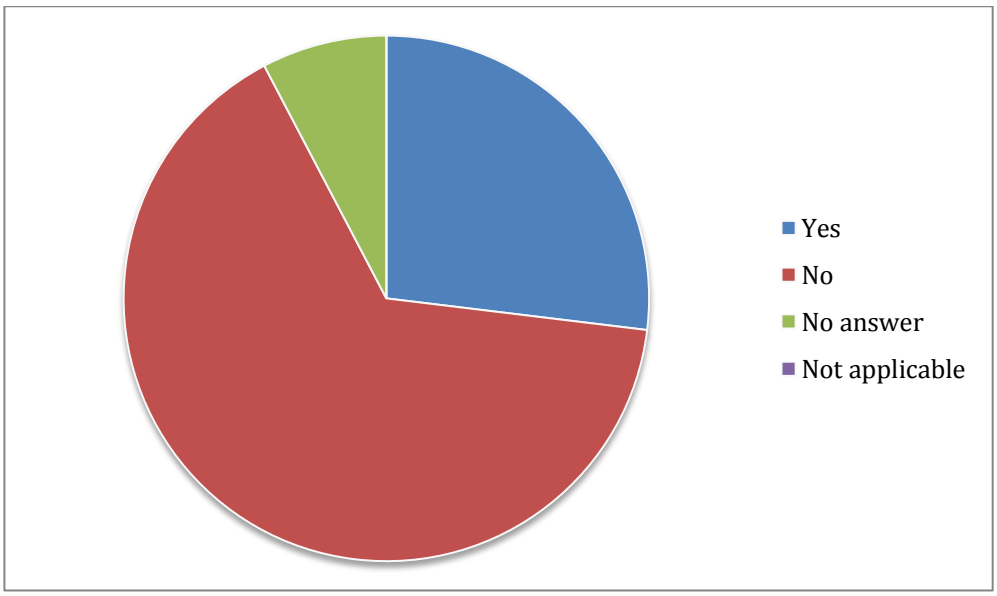


**Figure 27 Managers' perception of whether Powertrain is good at managing knowledge.**

A more positive result, seen from a Powertrain perspective was obtained when managers were asked if their co-workers spontaneously took part in or initiated activities for learning. The result is displayed in Figure 28. It can be noted that there was only one negative answer from one of the group managers on this question while the respondents that did not answer or the question applied to, had higher managerial roles than group manager.

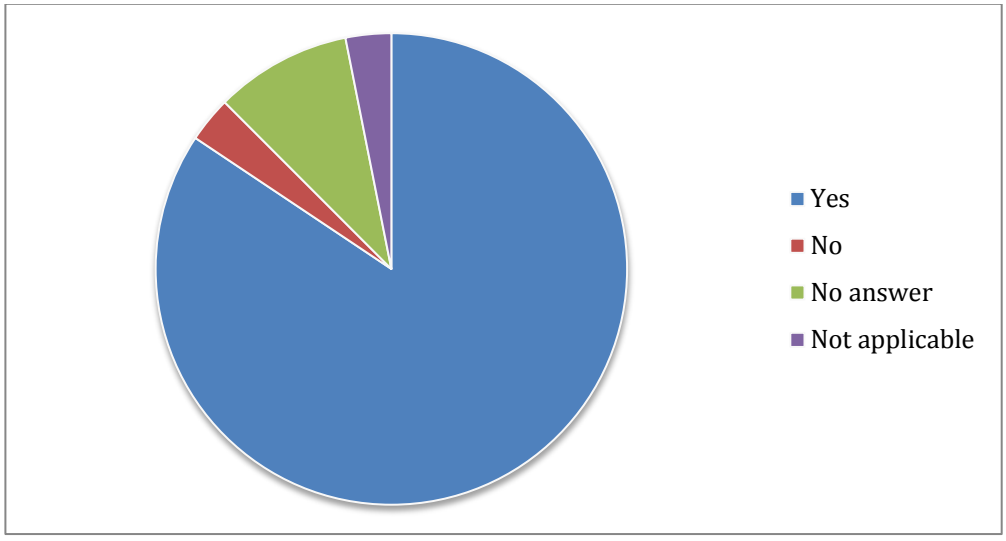


**Figure 28 Managers' opinion on whether co-workers take own initiatives for learning or training.**

Further, respondents were asked how knowledge acquired was captured by the organization. On this question the respondents were allowed and sometimes encouraged to give multiple answers. As can be seen in the results in Figure 29, IT-solutions were the most common answer on how knowledge is captured by Powertrain although answers were scattered across a lot of alternatives.

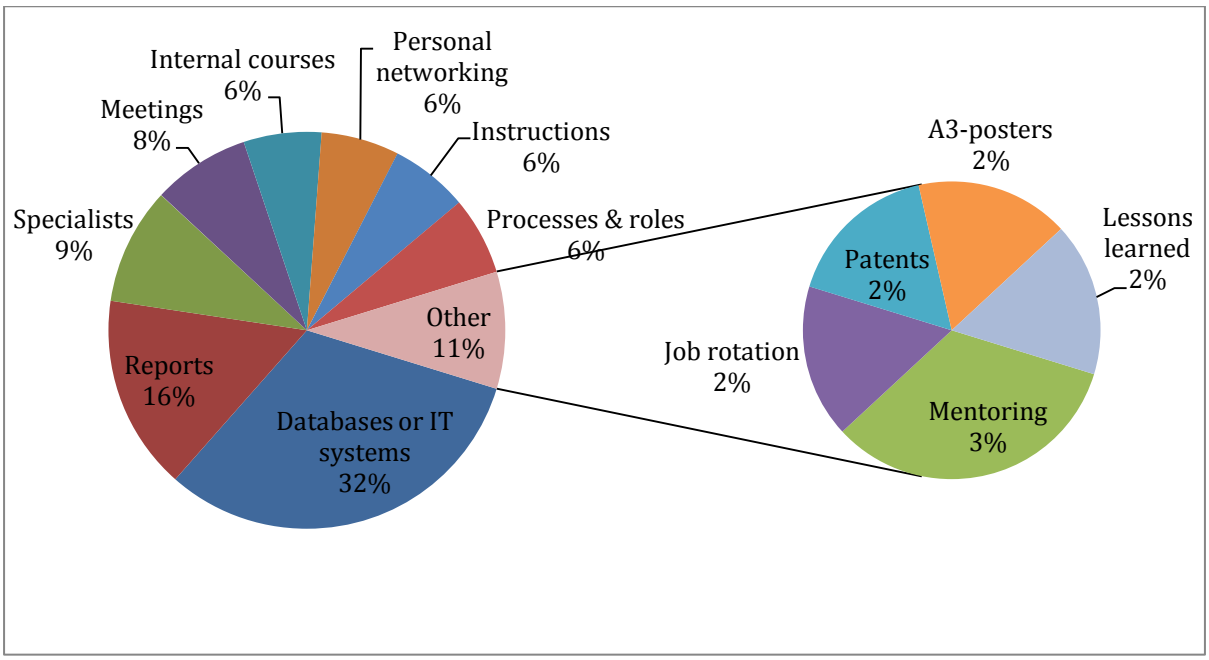


**Figure 29 Managers' perception of how knowledge is captured by their organization.**

Since Powertrain is a diverse company, it utilizes a variety of IT systems and databases both globally as well as locally or even group specific depending on the different needs throughout the organization. In this case, the global database DVG (Design Verification Guidelines) occurred most frequently in this group of answers but there were occasionally local solutions mentioned as well. DVG is a Wikipedia-like system where co-workers at Powertrain can contribute by sharing their specific knowledge about Powertrain's products. In the system each component that Powertrain works with gets its own headline to which descriptions, formulas, blueprints etc. can be amended. The second most common answer was reports and in this category, so-called Engineering Reports (ER) was the overwhelming majority. ER is a global Volvo standard on how to write technical reports and resembles academic reports. The third in rank of the responses, Specialists, is an alternative career path for technical specialists at Volvo. The people achieving this position get to spend 30% of their time to in-depth study their specialty.

If the previous question examined how Powertrain captures knowledge this next question deals with how this captured knowledge is then shared across the organization. Yet again multiple responses were given by most of the respondents and the results are shown in Figure 30. The differences of this result compared to the capturing of knowledge are vast, which is interesting. Further, due to the framing of the question there is a possibility that personal networking was neglected by some respondents since they were already thinking about formal initiatives for knowledge management following the previous question.

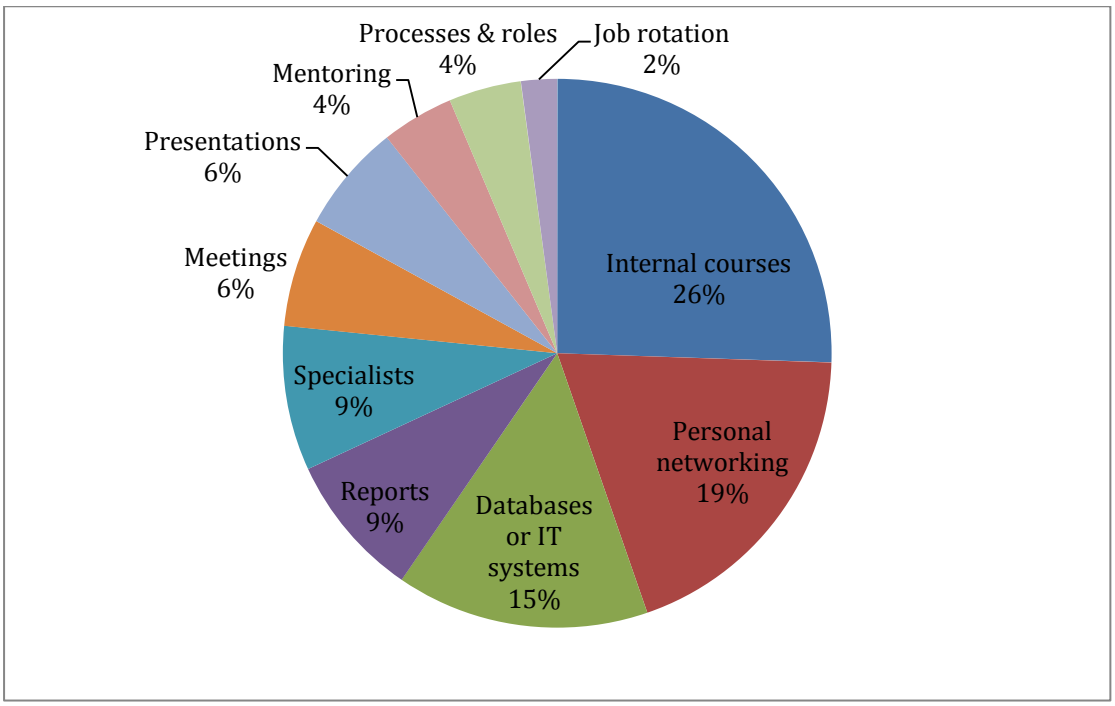


**Figure 30 Managers' opinion on how knowledge is shared at Powertrain.**

### 4.2.7 Maintenance of CI

This part concerns whether Powertrain has a structure for maintaining the CI system and if so, how it is used. As of today, there are bi-weekly reviews of the CI system with Powertrain GOT's improvement leader and Powertrain GOT's vice president for product development. The two, are influential over Powertrain's CI system but they have no direct ownership over the system as a whole. The CI system's ownership is portioned out with the different initiatives resulting in that no one has the complete ownership over the whole system. This is probably a result of the CI-system not being defined or visualized as a system, i.e. a collective perception of CI as a system like the illustration in Figure 6 is lacking. Instead, the separate initiatives have more or less randomly grown into a system with spontaneous connections.

At Powertrain there is basically one person working with an overview of the whole CI-system, the improvement leader. Before downturn 2008 there were also two internal consultants working with the CI system, assessing the organization's needs and capabilities in order to be able to proactively improve the CI-system. Today, CI system maintenance is reactive and deals with the most urgent problems. There is however an up and coming initiative that assesses the organization based on its performance according to the principles and modules in VPS-PDP. The initiative is called VPS-PDP assessment and it has gone through its first cycle of assessment which is carried out every other year.

Powertrain is ISO 9001 certified which basically implies that Powertrain needs to follow their processes. To stay certified and to maintain functional processes Powertrain review their processes. The aim of the process reviews however is not to aid in the CI-system and process compatibleness it is rather to maintain how processes and reality are compatible.

For, 3C, and DTL there is ongoing evaluation as the organization has new requests and matures. There are responsible system owners at Powertrain that make sure that the system is developing, and have the authority to do so. For OD however the ownership is located on a higher level making the ongoing evaluation less transparent.

## 4.3 Results overview

This chapter aims to summarize the findings in chapter 4 Empirical results. The results are describing how the CI-system at Powertrain looks like, the usage of it, and how it is supported.

Powertrain's CI-system, as it has been defined in this thesis, is visualized in Figure 6, in chapter 4.1. However, after interviewing thirty-one managers the perception of Powertrain's CI-system changed, some parts of the system seem to be less influential over CI at Powertrain than others. VPS-PDP, which aim to guide the organization towards operational excellence is in the top of the visualization. When asking the respondents about a quality culture and continuous improvements, which both are defined in VPS-PDP, no one referred to this model. This shows that the knowledge and the impact of VPS-PDP in the organization are low. Managers do however express a few things that align with VPS-PDP, such as G-PE level management emphasize customer demands as a part of quality culture. The impact of VPS-PDP however seem to be minimal thus customer demands has probably been a part of the quality culture requirements even before any theories on the topic where adopted or presented for Powertrain.

OD or operational development which is illustrated in the middle of Figure 31 is considered to be a functioning part of Powertrain's CI system. Interviewees state that OD is used, that it is reasonably easy to use, and that they understand the purpose of using it. They can further explain their strategy even though the strategies tend to be general, i.e. the effort when breaking-down the operative vision is modest.

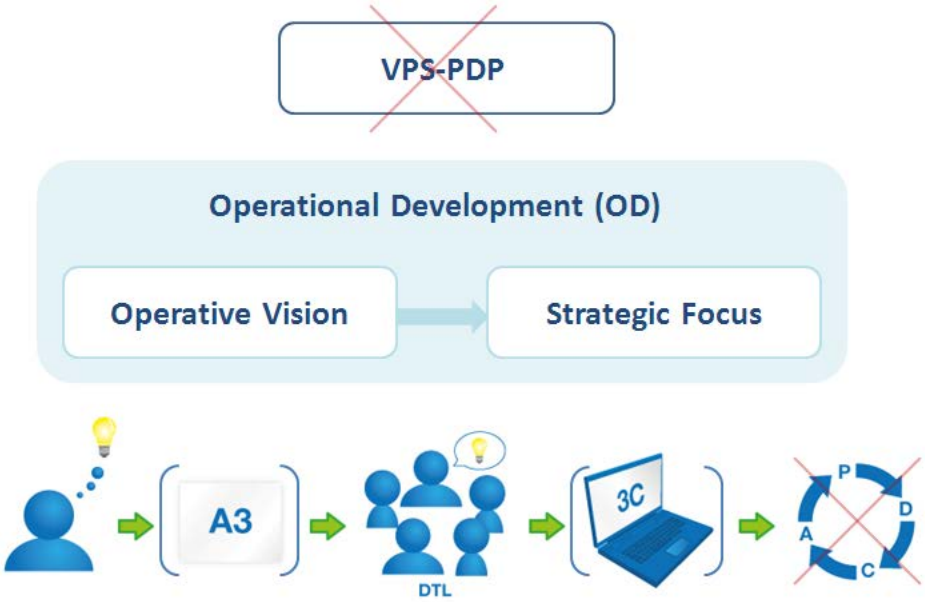


**Figure 31 The changed perception of Powertrain 's CI-system**

The last part, in the bottom of Figure 31, is the 3C process. This process manages the bottom-up ideas and as can be seen it has been defined as five steps. The second step and the fourth have been put into brackets, symbolizing that they are currently under development. Powertrain's lack of structure in the problem solving has led to redevelopment of the 3C tool and the implementation of a new tool for problem solving, namely the A3. Powertrain has chosen to emphasize the tools in developing their capability in CI, since they believe it is hindering them the most. The last step is a PDCA-cycle which illustrate the vision of the company to problem solve in a way that the learning is captured and shared and that processes are standardized etc. However, PE's problem solving method, 3C, emphasizes the plan stage and the do stage and neglect the check and act stage. Further, Powertrain has trouble with capturing and sharing learning and standardizing process improvements.

The CI-systems flaws and structure together with what theory defines as differences between manufacturing and product development CI sets the terms for the analysis. The main differences that have been taken into consideration are; cross-functional work, learning, measurement and creativity. The context in product development has expanded which puts pressure on cross-functional cooperation (Aloini, et al., 2011). Further, CI is something that needs to be developed within the company and not applied, which emphasize the importance of learning (Aloini, et al., 2011). Finally, product development is characterized by non-repetitive work while manufacturing is repetitive, leading to the last difference; creativity.

# 5 Analysis

*This chapter presents an analysis of the results from the data collection with help of the theoretical framework. The chapter is divided into six parts; Understanding, problem solving, cross-functional integration, learning and knowledge management, and maintenance of the CI-system. The chapter's aim is to analyze Powertrain Engineering's improvement work; the formal system for continuous improvement and the dispersion of this system throughout the organization along with the co-workers behaviors. This chapter is concluded with a brief summary of the key points.*

## 5.1 Understanding of the concepts

This thesis has argued that continuous improvement is an important part of achieving high quality. It has also argued that behaviors conforming to a set of values or principles for quality, such as TQM, can be referred to as having a quality culture. Hence, the first step towards a quality culture is to create awareness, understanding, and involvement for such behaviors and consequently for quality and CI. Further, if this focus can be maintained over time, knowledge and understanding will develop and the culture become established and enhanced. This part aims at analyzing the state of understanding and involvement in CI at Powertrain.

Quality culture is one out of four focus areas at Powertrain in 2012. Meaning that this area needs to be developed and significantly improved during the year. It is therefore crucial that the concept of quality culture is known to the organization. If a top-down perspective is applied on quality culture at Powertrain, it is clear that the VPS PDP model and the module Quality Culture is what should be guiding in every day work and especially in the work with this focus. The interviews though, show that below G-PE level there are essentially no references to or signs of impact of VPS PDP and its definition of what a quality culture should be to people at Powertrain. The results instead show that the organization does not know about VPS PDP in detail, it rather seems to be something that people accept being there in the fringes but pay no attention to. From a bottom up perspective it could be argued that the culture does not need to be something written in a model on a paper. A quality culture could be something prospering anyway, giving the organization a clear vision of where to go. However, the interviews show that there is no real consensus among the respondents in their elaborations on quality culture either. This shows that the understanding of what quality culture is for Powertrain is low and indicates that, the concept has been either poorly communicated or poorly defined and is not something that is "the way we do things around here". However, it can be argued that it is not needed for the employees to know the whole strategy, but that they can focus on an area of it that applies to them. Then the results show a different picture, where higher management is more customer focused and lower management is more focused on operations.

The results in Table 3 show that managers at PE are focused on the efficiency of CI and that the efficiency is the main collective view of the outcome of CI. However, CI and its close relation to quality culture do not reflect itself in the answers. Improved quality and the customer relation seem to be lost along the way and that there are other factors driving the thought process behind CI.

Another concern about everyone's understanding and involvement in CI is Powertrain's role descriptions. The involvement in CI activities is not reinforced by the employee role descriptions; by defining employee responsibilities or tasks. However, the interview respondents emphasize the involvement in CI as a crucial factor for success. This shows that there is an interest in improving, which a CI-system could be built on, although there is no structure in place to channel the interest into actions and responsibilities in a controlled way.

To further develop the employees perception of CI and quality and to gain a collective view of the concepts; employees at Powertrain would probably benefit from training. Caffyn (1997) states that training in the CI-system and related system and tools is crucial to develop capability in CI. At PE there is no initiative that provides courses or possibilities for learning about the company's CI-system, except when a new initiative is implemented. By not having any way of learning about the CI system, other than asking around, makes the process time consuming and burdensome. It also makes room for interpretations for how the system actually is supposed to function, leading to that there are as many ways of using the system as there are employees utilizing the CI-system.

Table 5 shows constituent behaviors needed to facilitate an understanding of CI. Figure 11 and Figure 12 show that managers think that people are involved in CI and also that the managers themselves are active in CI. The exceptions are HR and the business control division that are not actively involved. Further, Table 3 is showing the collective view of CI and that increased efficiency is the most anticipated outcome of CI mentioned by over 70 percent of the respondents. In the top three of the list is also competitive products with 61 percent and improved quality with 31 percent. This can be interpreted as people believe that their individual behavior really can have an impact on issues such as overall company performance and product competiveness. Hence, the respondents realize their responsibility in the CI process. Further, results also show that when an improvement activity needs to take on global proportions, it often becomes complex or burdensome, making people avoid initiating such activities. This is really outside the scope of this thesis but should be duly noted for future work. So, Powertrain can be said to be aligned with the first constituent behavior stated by Bessant et al. (2001). In conclusion, the first and third behavior can be seen as fulfilled from the results shown in Figure 11 and Figure 12.

**Table 5 Ability number one, understanding CI (Bessant et al., 2001)**

| Ability | Constituent Behavior |
|---|---|
| Understanding CI – the ability to articulate the basic values of CI | 1. People at all levels demonstrate a shared belief in the value of small steps and that everyone can contribute, by themselves being actively involved in making and recognizing incremental improvements.<br>2. When something goes wrong the natural reaction of people at all levels is to look for reasons why etc. rather than to blame individuals. |
| Getting the CI habit – the ability to generate sustained involvement in CI | 3. People (as individuals and/or groups) initiate and carry through CI activities – they participate in the process.<br>4. People use measurement to shape the improvement process. |

When it comes to behavior two it can be concluded that Powertrain has a culture of rather looking for reasons than using scapegoats. However, a more interesting matter to discuss in this case is when problems are regarded as problems. Results show a tendency of denying problems until small ones has become urgent and critical. At this point, emergency measures such as a taskforce or similar has to be used to solve the problem. This behavior might come from that managers often tend to promote a firefighting type of leadership. A reason for doing so might be that respondents are proud of the way Powertrain's taskforces solve crises. It is a fact that expert engineers have many times saved the day when a deadline is closing. Respondents state that taskforce members are treated as heroes for their effort. Nevertheless, promoting reactive problem solving might be a step in the wrong direction and it shows a lack of understanding or focus for CI. It can be concluded that scapegoats are not common at Powertrain but when problems are dealt with they have sometimes snowballed into such proportions that there is no time to reflect or analyze causes. At this point a technical solution is what matters. Thus, the second constituent behavior is not present at Powertrain.

As stated in the beginning of this chapter; a quality culture can be seen as a culture conforming to TQM principles. This holds for Powertrain's definition of quality culture as well. A principle in TQM is to base decisions on facts (Bergman & Klefsjö, 2003). However, interviews show a lack of measurement and that measurement is focused on a set of KPI's measuring the pace of improvement work. The lack of measurement leads to that behavior four is unfulfilled.

## 5.2 Strategy for CI

The intention of this subchapter is to present to what extent the improvement work at Powertrain is impacted by company strategy. Powertrain's formal CI-system, which has been presented previously in chapter 4.1, includes a standardized way of deploying strategy, called Operational Development or just OD. The result of OD should be that all sections, groups and individuals have a clear vision of what they can do to contribute to fulfill the overall company strategy and the Volvo Group's operative vision. This means that it should also be clear what managers should found their prioritizing of improvement efforts on. Consequently, when looking strictly at the CI-system, it contains support for fulfilling the first three constituent behaviors presented in Table 6.

However, when mangers were asked on how they prioritize between ideas for improvement, only one single respondent referred to strategy. This is interesting since the results show that essentially all managers believe that using OD works well. Almost every manager can explain their organization, section or group's strategy in a satisfactory way. Further, almost two thirds of the respondents state that they apply their strategy when allocating resources to CI. Hence, there is a contradiction in the results since only one single person referred to strategy in the initial question on prioritizing of resources for CI. This has implications on the validity of these questions, since respondents seem to answer what is expected of them, not the reality. Hence, the first behavior in Table 6, shown below, can be said to not be fulfilled by Powertrain. The second behavior is closely linked to the argumentation above and results show that most managers are able to explain their strategy, goals or objectives. However, some of the respondents' answers show sloppiness with the OD work and interpretation of

strategic focuses. Sporadically it seems like the higher level's strategic focus is simply copied without further thoughts. Thus, behavior number two can be seen as mostly existent. Since strategy is seldom applied to CI efforts it can hardly be said that individuals or groups assess changes to strategic objectives making Powertrain not fulfilling behavior number three.

**Table 6 Abilities and corresponding behaviors concerning strategy, Bessant et al (2001)**

| Ability | Constituent Behavior |
|---|---|
| Focusing CI – the ability to link CI activities to the strategic goals of the company | 1. Individuals and groups use the organization's strategic goals and objectives to focus and prioritize improvements<br>2. Everyone understands (i.e. is able to explain) what the company's or department's strategy, goals and objectives are.<br>3. Individuals and groups (e.g. departments, CI teams) assess their proposed changes (before embarking on initial investigation and before implementing a solution) against departmental or company objectives to ensure they are consistent with them.<br>4. Individuals and groups monitor/measure the results of their improvement activity and the impact it has on strategic or departmental objectives.<br>5. CI activities are an integral part of the individual or groups work, not a parallel activity |

Before analyzing the fourth behavior it has to be said that measurements at Powertrain are done with so-called Key Performance Indicators or KPIs. These exist on two levels, globally and site by site. Hence, Powertrain GOT has its own KPIs. Still, these are high-level measures such as fault frequency on product, lead time in development projects etc.. Furthermore, there are no more official KPIs established for quality culture or improvement work on a global level that support monitoring or measuring results of CI. On site level Powertrain GOT is measuring improvement activities on section level and occasionally on group level. Thus, it is also impossible for individuals and groups to monitor their specific efforts in CI through Powertrain's KPI's. One measure that is known to around half of the respondents is how much time their organization, section or group spend on improvement work and the goal is to spend five percent on improvement work. This measure does not however, say anything about the amount or quality of improvements and respondents say that it is difficult to use these allocated hours since there is often more urgent things to take care of. Consequently, it can be concluded that Powertrain has no formal way for individuals or groups to monitor or see the progress of their improvements and hence, neither can the impact on company objectives be seen. Although and to the benefit of Powertrain is some of the improvement work documented in the 3C IT-tool. This data could possibly be used to improve performance in the area of monitoring and follow-up.

The fifth behavior could be seen as where Powertrain has gotten the furthest. In many of the interviews respondents express an opinion that they do not want to treat continuous improvement as something not incorporated in their everyday work. If this is the case it is positive but it could also be argued that saying that CI is incorporated in everyday work is just a way of hiding that there is not much activity at all. Since Powertrain has no good way of monitoring neither the amount nor quality of CI work, it is difficult to decide which case that is most true.

However, there is less uncertainty regarding that management expect improvements from all parts of Powertrain and that there exists no parallel organization, such as a quality department, taking the responsibilities for those issues. Instead, Powertrain has for some time worked with putting people with extensive knowledge in supportive roles where the organization can consult them when needed. Two examples of areas where support is possible to get is root cause analysis or the DTL methodology. Finally, the results are interpreted as where there is CI going on it is an integral part and not a parallel activity, thus fulfilling the fifth behavior.

According to Bessant et al (2001) the link between CI and company strategy is essential for a sustainable and successful CI work. Based on the analysis above it can be concluded that Powertrain does not fully succeed in linking their improvement work to the wider strategic concerns of the company. However, there is a foundation to build on in this area with a structure for strategic deployment and managers and co-workers that seems sincerely interested in connecting the dots to get better or more tangible results from their efforts.

## 5.3 Leadership

This part will be analyzing managers' perceptions of the leadership at Powertrain. In an article from 1997, Sarah Caffyn argues that to achieve sustained involvement in CI, leaders must show active commitment and leadership. The same idea is emphasized in TQM where committed leadership is one the corner stones for quality. The common notion among the managers that a leader's role is to coach, encourage and give co-workers opportunities to develop their ideas is consistent with theory and a promising approach. Managers also show the insight that without feedback or follow up, improvement work will stagnate. However, despite the good intentions Powertrain has a hard time fulfilling the behaviors connected to leadership and management of CI that are shown in Table 7.

**Table 7 CI behaviors connected to leadership**

| Ability | Constituent Behavior |
|---|---|
| Leading the way - the ability to lead, direct and support the creation and sustaining of CI behaviors | 1. Managers support the CI process through allocation of time, money, space and other behaviors.<br>2. Managers recognize in formal (but not necessarily financial) ways the contribution of employees to CI.<br>3. Managers lead by example, becoming actively involved in design and implementation of CI.<br>4. Managers support experiment by not punishing mistakes but by encouraging learning from them.<br>5. Closing the loop - ideas are responded to in a clearly defined and timely fashion – either implemented or otherwise dealt with. |

Constituent behavior one is about resources for CI. It is stated in the interviews that it is allowed to bill five percent of the total man hours on improvement work but the absolute majority of the organizations does not spend these hours. The respondents clearly state that it is unreasonable to believe that CI will get sufficient attention when the pressure to deliver into PD projects is constantly

high. Hence it is doubtful if management support of CI can be considered as sufficient.

Behavior two concerns recognition for contributions to CI. For this there is no formal mechanism aside individual salary, which in turn does not seem to be utilized to promote CI to the extent it was meant. Perhaps could the role descriptions bring structure into using salary as an incentive for CI. These exist for all positions and contain information about responsibilities and expectations. They are often used in recruitment and if they clearly state expectations about contributions in terms of improvement work it would be easier to relate efforts into an increase in salary. The result also clearly shows that CI is no career path at PE. If the different circumstances above are put together it becomes obvious that recognition for CI is not extensive and thus the second behavior not fulfilled.

Behavior three is more contradictive. On the one hand, since the respondents are all managers and more or less all of them state to be actively involved in CI, see Figure 12, that should mean many leading examples. On the other hand, results also show that many of the respondents do not think the focus on CI is sufficient.

Behavior four concerns managers' support of experimentation. As stated earlier in this chapter, scapegoats are not common at Powertrain, i.e. there is little fear of failing before engaging in activities. However, since people and equipment are often busy, opportunities for experimenting are rare and it is difficult to get time to reflect upon the results. In conclusion, if there were any experiments managers would encourage learning from them.

Regarding the fifth behavior there is an escalation process of improvement ideas within DTL. However, there are no signs of a structured way of how managers should respond to ideas. Because of this, managers have trouble supporting ideas and they have not been appointed responsibility or support in how to deal with ideas. It is also possible to escalate ideas to solve them on a higher managerial level. However, this can pose as a risk of overloading the organization, as one group manager expresses "*You have to be careful with how much you escalate, if you escalate too many issues, they will just end up not being done*". An idea management system could be structured in many ways.

## 5.4 Problem Solving

This part presents an analysis of the results from the questions concerning problem solving performance, methodologies, and rewards. Table 8 shows the two behaviors from the theoretical framework on this matter. As can be seen by the formulation of the behaviors, the emphasis is rather on that tools and methods are made available for employees than mindless uncompromised use.

**Table 8 The first ability with the behavior connected to problem solving as presented by (Bessant, et al., 2001).**

| Ability | Constituent Behavior |
|---|---|
| Understanding CI – the ability to articulate the basic values of CI | 1. People make use of some formal problem-finding and solving cycle. |
| Getting the CI habit – the ability to generate sustained involvement in CI | 2. People use appropriate tools and techniques to support CI. |

As stated in the results, managers are quite negative to the efficiency of the company's problem solving and even though problems tend to be cyclical in PD, Powertrain Engineering seems to be in somewhat of a vicious circle. Powertrain appears to have a too high focus on tools, too many tools, and a lack of problem analysis. Interestingly, Aloini et al. (2011) state that around ten years ago criticisms were raised towards that time's prevailing view of CI as way too much focused on tools. Since Volvo's CI-system started to develop around that time it is possible that the tool focus was built-in from the beginning. Regardless of how many tools Powertrain has in its toolbox, results clearly shows that none of them are commonly used to support problem solving and only half of the respondents believe any tool is used at all. When it comes to the CI-system of today Powertrain uses the 3C process; described in 4.1.3 A3 and 3C. 3C is basically a version of Plan, Do, Check, Act (PDCA) where the Plan-phase is heavily emphasized, which has resulted in that reflection and standardization of the solution is often missed and thus the purpose with a learning cycle is missed as well. However, the system requirement of having a problem solving cycle can be said to be fulfilled anyway. Moreover, the methodology seems to have had problems to get established in the organization, perhaps due to a flawed design, lack of training for the users or both. The results does however show that most groups use 3C but this does most probably refer to the database and not the use of a PDCA methodology. Consequently it can be concluded that the first behavior in Table 8 is not satisfactory fulfilled by Powertrain. Moreover, there is a strong belief that the tools are the central part of CI at Powertrain. However, the tools are not the root cause, eventhough some are poorly designed as in the example of 3C. What is truly missing at Powertrain is the mind-set that a tool does not become useful until it is put into a relevant context, provided by for example PDCA. This leads to the conclusion that focus might have to be shifted from the tools to higher level principles or methodologies to provide structure and purpose in the use of tools.

Another finding supporting that solving problems at Powertrain is troublesome is that many of the respondents emphasize problem analysis before looking for solutions. Although, it seems as when a problem does occur, the tendency of directly focusing on solutions is high. One example of this is the KPI on lead time for quality journals, i.e. defects on the products that directly affect the users. A KPI like this that only take into consideration the time spent on finding a solution does not promote a thorough problem analysis. Of course the user should have a functioning product as quickly as possible but the work does not end there. Just because *one* solution to a technical problem was found quickly it does not mean it was the best solution. To really find the root to the problem and design long-term solutions a thorough problem analysis and a problem solving methodology based on experience is important. Today, Powertrain does not apply this.

Another interesting thing that shows in the results is that small problems do not get much attention from management before they have turned into severe problems. For example, if a group manager tells his manager that a delivery to a project will be late, no actions for making the best of the situation is taken, such as allocating more resources or at least notifying other involved in the project that their deliveries can be postponed. Instead the deadline comes and if the

delivery is still late, emergency measures, such as task forces or other firefighting modes have to be applied to finalize the delivery as quickly as possible. This approach probably creates a lot of waste for Powertrain and also risks the development work to fall in the trap described in the previous paragraph, neglecting proper analysis.

## 5.5 Cross-functional interaction

This subchapter includes an analysis of how Powertrain collaborates across internal borders, with other companies in the Volvo Group as well as with customers and suppliers. It is pointed out in the theory chapter that cross-functional interaction becomes more important when dealing with CI in product development in order to create a holistic understanding of the PD process throughout the organization (Aloini, et al., 2011). According to Bessant et al. (2001) in order to develop a company's capability in CI, the ability and behaviors' displayed in the complex organization that is Powertrain it cannot be asked from the individual engineer to always have a clear picture of what is best for the entire organization in a given situation. Instead, this falls within managements responsibilities and from the results presented it can be said that Powertrain lacks clear structures and confidence in how to approach problems and to solve them efficiently.

The constituent behaviors in Table 9 are said to develop company specific benefits from process development with customers and suppliers. Departments as well as customers and suppliers get knowledge on each other's work, receiving insights in the strive towards innovation.

**Table 9 Ability number six, shared problem-solving (Bessant et al., 2001)**

| Ability | Constituent Behavior |
|---|---|
| 6. Shared problem-solving - the ability to move CI activity across organizational boundaries | 1. People co-operate across internal divisions (e.g. cross-functional groups) in CI as well as working in their own areas.<br>2. People understand and share a holistic view (process understanding and ownership).<br>3. People are oriented towards internal and external customers in their CI activity.<br>4. Specific CI projects with outside agencies - customers, suppliers, etc. - are taking place.<br>5. Relevant CI activities involve representatives from different organizational levels. |

At Powertrain there are some internal collaboration and some with other departments, suppliers, and customers. These relations are built on an ad-hoc basis and are often initiated bottom-up. Respondents state that there is no structure in handling or forming these relations. Based on this it is difficult to really say if Powertrain fulfills behavior number one in a satisfactory way. Managers at Powertrain do however think that a structure supporting the collaboration could be beneficial and that there could be benefits with extending cooperation with other parts of the company and parties outside the company. The answers from our questions show no indication that there is any part of Powertrain that interacts more than the other. Most existing relations seem to be due to a special need for a specific relation in a specific matter. The importance

of collaboration on a larger inter-organizational setting is a difference between CI in manufacturing versus CI in PD. It becomes more important in PD and the under-emphasis on such collaboration derived from adopting CI from manufacturing is obvious at Powertrain. Thus, it can be stated that all of behavior three, four, and five needs to be developed at Powertrain.

Regarding the second behavior it can be argued that it is in its nature to be an ever ongoing process. The processes are much longer in PD, more complex, and more difficult to understand. This leads to a stronger argumentation for cross-functional work within PD to create holistic views. The results show that the organizational complexity is perceived as hindering cross-functional initiatives, which could be seen as a lack of understanding for the development process at Powertrain. Meaning that if an increased understanding for the process was gained, the organization would be perceived as less complicated, facilitating CI through less resistance towards cross-functional work. To summarize, since there is a lack of understanding that cross-functional cooperation is essential to facilitate improvements in PD , this area needs to further emphasized.

One of the most criticized suppliers is Volvo IT. The collaboration with Volvo IT has interfaces everywhere and is taking place every day at Powertrain Gothenburg. As can be understood from the name, Volvo IT is a part of the Volvo Group and it has been the provider of IT services for the group since its origination. Even though the organizational proximity, there are problems in the collaboration between Powertrain Gothenburg and Volvo IT. One reason could be the view upon the collaboration that it is not a regular customer and supplier relationship, i.e. lack of customer respect. It could also be that there are poor specifications of the needs leading to confusion when trying to fulfill them.

## 5.6 Learning and knowledge management

This part presents the analysis on Powertrain's ability to move knowledge across the organization and how learning is encouraged and captured. The development loops have been getting shorter in the last decade and to stay competitive companies have to get increasingly innovative. Thus, the importance of sharing and capturing knowledge is also getting increasingly important. Furthermore, literature states that in a PD context learning and the handling of knowledge become even more important since PD is really a process of accumulating knowledge. Or as Bartezzaghi et al (1997) puts it; "*Knowledge is the basis for developing and continuously improving capability in product development*".

Table 10 shows the constituent behaviors from the theoretical framework concerning learning or knowledge management. The first behavior is naturally difficult to generalize over an organization with eight hundred employees. The impression is however that Powertrain has a culture where prestige does not obstruct learning and people willingly share insights with each other. Something mentioned numerous times in the interviews and perhaps is a significant difference to a manufacturing setting is that the vast majority of co-workers at Powertrain are highly specialized engineers. It lies in the nature of these people to be curious and eager to learn, especially when it comes to their area of expertise. Thus, behavior number one is fulfilled. Behavior number two touch upon the same issue and it is consistent with the result shown in Figure 28.

Based on this perception by managers it is concluded that the willingness to learn at Powertrain is high.

Behavior number three is like the first one difficult to generalize. However, the leadership analysis does conclude that Powertrain is transitioning from an omniscient leadership culture to a more including and delegating one. This indicates that insights from co-workers could be providing more and more impact. Thus, it is not the managers' leadership in this sense that stands in the way of efficient management of knowledge at Powertrain.

**Table 10 The framework's ability concerning a learning organization (Bessant et al., 2001)**

| Ability | Constituent Behavior |
|---|---|
| 8. The learning organization - generating the ability to enable learning to take place and be captured at all levels. | 1. People learn from their experiences, both positive and negative.<br>2. Individuals seek out opportunities for learning / personal development (e.g. actively experiment, set their own learning objectives).<br>3. Managers accept and, where necessary, act on all the learning that takes place.<br>4. Individuals and groups at all levels share (make available) their learning from *all* work experiences.<br>5. The organization articulates and consolidates (captures and shares) the learning of individuals and groups.<br>6. People and teams ensure that their learning is captured by making use of the mechanisms provided for doing so.<br>7. Designated individual(s) use organizational mechanisms to deploy the learning that is captured across the organization. |

Next the theory presents three behaviors, numbers four to six, connected to knowledge at the organizational level. If results were positive regarding learning on the individual level, they are quite the opposite on the organizational level. This is shown by the result in Figure 27. Concerning the behaviors, number four demands a lot from the co-workers and perhaps even more a streamlined structure for sharing and capturing knowledge. In the empiric chapter 4.2.6, it is explained how managers perceive that Powertrain is sharing and capturing knowledge. As can be seen in the graphs; Figure 29 and Figure 30, are the ways of sharing versus capturing knowledge distinctly different. This implies a lack of a holistic view on the role of knowledge and continuous learning and perhaps also that it is not a primary concern to the organization. Even though the two questions regarding sharing and capturing was asked as a pair, respondents did not reflect over the difference in their answers. This shows that using separate ways for sharing and capturing seems to be accepted as a part of the culture. It could also be an implication of that Powertrain management has either failed in communicating or, even worse, not understood, the underlying purposes of their mechanisms for knowledge management. Hence it is concluded that neither is there a sufficient structure for capturing and sharing knowledge nor is there spontaneous behaviors compensating for the lack of organizational mechanisms. Hence, none of the three behaviors can be seen as fulfilled.

The tendencies of handling sharing and capturing of knowledge separate ways has shown itself outside of the interviews as well. If someone needs to know something, they firstly ask their colleagues. It is the employees that possess the knowledge i.e. what they have learned from previous projects etc. In fact, the companies most successful at knowledge management carefully manage individuals that possess valuable experience (Bartezzaghi, et al., 1997). At

Powertrain, some parts of the organization have experimented with this more social approach to knowledge sharing, such as senior advisors or mentorships and they are mostly positive. Formally, Powertrain also works with a specialists-program that provides a person, with specific knowledge of an area, with time to expand that knowledge and with the obligation to share it with the rest of the organization. It could be of interest to Powertrain to develop the co-workers' personal networks further, incorporating specialists, mentors, and senior-advisors into them. However, concerning the behaviors of mechanisms for knowledge and the use of them it can be said that they are present but are not functioning satisfactory. Consequently, managers express their discontent over the lack of usage of knowledge databases and documents, such as project documentation and Design and Verification Guidelines (DVG). According to Bartezzaghi et al. (1997) the benefits of using such documentation and databases can often be marginal, due to the time consuming interpretation of unstructured knowledge. There are however a lot of investments that have been put into these efforts that probably is the source of managers' discontent.

The last behavior aims to find out if the mechanisms for a functioning system are used to deploy learning. Even though there are responsible individuals using these mechanisms and which are deploying learning, the usage of the deployed learning is low. This leads to that these peoples' efforts with databases etc. do not have the impact they could have.

Finally, a quote from one of the managers is rather descriptive: "*When we started this last project we looked into what information there was from previous projects of the concerned product, we found nothing*". The citation illustrates how frustrating the lack of knowledge can be for a project manager. The project managers status is something that results showed might be too low, leading to that the turnover of project managers is high. A possible situation for Powertrain could therefore be inexperienced project managers with little knowledge about the products. Further, Bartezzaghi et al. (1997) state that CI has emerged as a way of gaining competitive advantage through innovation and the most successful or most innovative companies use company specific, creative, and unexpected forms for sharing and capturing knowledge. It is clear that Powertrain has work to do on this matter, but if they can succeed, an important step in organizational development has been taken and opportunities to outrun competition might be the result.

## 5.7 Maintenance of CI

This section analyses the maintenance of the CI-system, including whom that are involved in the maintenance and what activities there are to maintain the CI-system. As described in the empirical chapter there is a lack of a defined CI-system at Powertrain and the different parts making up the system, as it is defined in this thesis, lacks coordination and a holistic approach to CI. Thus, maintenance of the system is difficult because there is not a defined entity to maintain. However, based on the abilities and behaviors in Table 11, there are still some aspects of the different elements of the system that are interesting to look into.

**Table 11 Abilities and behaviors connected to maintaining the CI system. (Bessant, et al., 2001)**

| Ability | Constituent behaviors |
|---|---|
| Aligning CI - the ability to create consistency between CI values and behavior and the organizational context (structures, procedures, etc.) | 1. Ongoing assessment ensures that the organization's structure and infrastructure and the CI system consistently support and reinforce each other.<br>2. The individual/group responsible for designing the CI system designs it to fit within the current structure and infrastructure.<br>3. Individuals with responsibility for particular company processes/systems hold ongoing reviews to assess whether these processes/systems and the CI system remain compatible.<br>4. People with responsibility for the CI system ensure that when a major organizational change is planned its potential impact on the CI system is assessed and adjustments are made as necessary. |
| Continuous improvement of continuous improvement - the ability to strategically manage the development of CI | 5. The CI system is continually monitored and developed; a designated individual or group monitors the CI system and measures the incidence (i.e. frequency and location) of CI, the development of CI activity, and the results of CI activity.<br>6. There is a cyclical planning process whereby (a) the CI system is regularly reviewed and, if necessary, amended (single-loop learning).<br>**7.** There is periodic review of the CI system in relation to the organization as a whole which may lead to a major regeneration (double-loop learning).<br>8. Senior management makes available sufficient resources (time, money, personnel) to support the ongoing development of the CI system. |

Firstly, Operational Development or OD is an initiative where the responsibilities and ownerships lie outside of Powertrain and are common for the whole Volvo Group, thus making it difficult for Powertrain to adjust or develop OD according to only their own needs. Also, recent years' decline in use and strategic impact of OD could perhaps be partially explained with this reasoning. Due to the ongoing reorganization of Volvo Group there are expectations that the OD work will gain momentum again once the new structure has had some time to become established.

As described in the empirics; the participants in the forum for assessing the parts of the CI-system which are called DTL and 3C, are primarily Powertrain GOT's vice president and the improvement leader at the site. This part of the system is probably the best maintained one and arguably because the improvement leader, who is the owner of DTL and 3C, is situated within the organization. However, DTL and 3C also provide an example of the difficulties that arise with global initiatives, e.g. the new IT support for 3C improvement projects. The IT solution has been ready for a number of months but is still waiting to be rolled out since it needs to be globally approved and all sites have problems agreeing on the design of the solution. Further concerning maintenance of DTL and 3C a new set of training sessions will be carried out, complementing the training done during the implementation phase back in 2009 and 2010.

There is also an attempt to assess the organization; with a lean perspective through VPS PDP. The VPS PDP assessment, as it is called, assesses the whole

product development organization in its effort to evaluate VPS PDP practices and modules. The assessment is a relatively new initiative and there has only been one carried out but from now on it is supposed to be held every other year. However, the results and impact of the assessment has not been that encouraging but the initiative is a step in the right direction in trying to assess the organization. The first behavior, shown in Table 11, is however still perceived to not be fulfilled since the assessment has not fulfilled its purpose and generated any harmonization between Powertrain's structure and its CI-system.

As for the second behavior; there is no individual or group with the absolute responsibility of the CI-system. The responsibility is spread over the different initiatives that add up the CI-system. The different initiatives and their owners might have agendas that do not align and take input from separate parts of the organization, leading to that the total effect on the CI-system is unknown. The same reasoning for behavior two can be applied to behavior three and four. Even though behavior three is not fulfilled, there is some structure to this behavior. As Powertrain is ISO 9001 certified they are working within the area of process reviews, the reviewing done today just has another aim than continuous improvement.

For the fifth behavior there is not much Powertrain is doing to continually develop and monitor the CI-system. As stated earlier, the improvement leader at Powertrain is monitoring his part of the system and Powertrain is able to develop and monitor the usage of DTL and 3C and have done so since the ownership lies within the Powertrain organization. The last part of the behavior; to measure the results of activities in CI is something that is nonexistent at Powertrain. The lack of measurements at Powertrain is further described in chapter 5.2.

Behavior six, seven, and eight relies on similar reasoning as previous points; there is no holistic ownership of the CI-system, which leads to that there is no one with the overview to plan for the development of the whole system. There are however parts of the system that can be amended at situations. In total are the behaviors not present at Powertrain. Interviewees stated that Powertrain tend to solve problems by adding more and more tools or methods and never take away any of the old or obsolete ones, i.e. Powertrain has trouble to double-loop learn when developing a system and its supporting tools and methods. For behavior eight the resources are spread among the separate initiatives. This could lead to a lack of resources managing the interfaces. In the interviews it was also stated that there is a lack of resources to proactively manage the CI-system.

## 5.8 Analysis summary

To summarize this analysis chapter it can be said that Powertrain has a long tradition of applying a continuous improvement approaches but the work seems to have difficulties in gaining momentum. Compared to the theoretical framework Powertrain is not really performing well in any of the areas and from a CI-system perspective it is only the strategy deployment mechanism OD that stands out as a facilitator for a number of behaviors important to improvement work. However, the interpretation and experience is that this is not the whole truth as Powertrain possesses a number of soft factors that, if managed effectively, could be turned into strengths from a CI perspective. For example,

there is a genuine interest in wanting to improve and a culture where knowledge is gladly shared and for everyone in the company to benefit from. See Table 12 for a list of strengths and weaknesses based on this analysis chapter.

**Table 12 Strengths and weaknesses identified in Powertrain's improvement work.**

| Strengths | Weaknesses |
|---|---|
| **Understanding of the concepts:** | |
| Genuine interest in improvements | Holistic view of CI |
| | Training in CI |
| **Leadership:** | |
| Managers are positive towards OD | Direction of management attention |
| | Idea management |
| | Recognition of improvement work |
| | The use of measurements |
| **Strategy for CI:** | |
| Operational Development (OD) | The impact of strategy on improvement work |
| Awareness of strategy | |
| **Problem solving:** | |
| Root cause analysis specialists | Tool focus |
| | Product to process connection |
| | Problem denial |
| **Cross-functional interaction:** | |
| | Organizational complexity |
| | Structure for collaboration |
| **Learning and knowledge management:** | |
| Willingness to learn | Databases |
| Networking culture | Project management knowledge |
| DVG (component database) | |
| Specialists | |
| Willingness to share knowledge | |
| PE School | |
| **Maintenance of CI:** | |
| Process reviews | CI-system definition |
| DTL and 3C | CI-system ownership |
| | Improvement work assessment |

Table 12 is divided into seven different areas, which follows the structure of this chapter. The table also includes the differences between manufacturing and product development which are stated in theory. The differences are: the use of measurement, learning and knowledge management, cross-functionality, and creativity. Even though Powertrain shows several distinctive strengths, it can be

seen that many of the areas where Powertrain is lacking capability are connected to the differences between PD and manufacturing. For example, there is a lack of effective measurements in the CI-system and Powertrain does not have any structure for cross-functional work and there is a fear of improvement work escalating out of proportions, i.e. the increased complexity that arises when projects become global. Learning and knowledge management is also possible to problematize, for example the heavy focus that is put onto documenting knowledge. Finally, organizational creativity is seemingly something that is not in focus at Powertrain. Hence, it is likely that Powertrain suffers from the fact that many of the components of its CI-system were designed for manufacturing and are not optimal for a product developing organization. Further, top management commitment at Powertrain seems to be directed at other things than CI for the moment. In conclusion, altering and optimizing the CI-system will most probably be a challenge for Powertrain but as laid out in the beginning of this thesis, improving continually is an important part of shaping a quality culture. As such, CI becomes strategically important for Powertrain, not least to secure the success of future projects and products. Different aspects and dimensions of this reasoning are explored in the next chapter.

# 6 Concluding discussion

*This chapter aims to conclude and discuss the findings of this thesis. The analysis chapter shows, with help of theory, that Powertrain has strengths but also weaknesses connected to its improvement work. This chapter starts by concluding that improvement work at Powertrain does not generate the desired outcomes but there is lots of unused potential within the company. A visualization is presented of what the underlying causes to the identified weaknesses could be. Then, step by step, every major area is discussed from the perspective of how the improvement work can be improved and subsequently contribute to the quality culture, effective ways of working and better products and services.*

Firstly however, to be able to carry on with a focused discussion, the topic of *lack of time* has to be dealt with. Lack of time is a common inhibiting factor for improvements within product development (Caffyn, 1997). The common notion with continuous improvement is that something with poor quality can be enhanced until it becomes something with better quality. However, in the case of Powertrain and Volvo this notion is not as simple, since quality is a non-negotiable requirement in Volvo products. This situation imposes a risk of creating a vicious circle. With a constantly high focus and demand of improving the products, less energy is spent on improving the ways working. Thus, it could be argued that the consistency in quality between products and processes decreases with the result that more money and more resources have to be spent in ineffective processes in order to develop the next generation of products. Alternatively, the rate of innovation could be leveling out, meaning that the company maintains its current products rather than inventing new and better ones. Throughout the work with this thesis, this vicious circle has shown through managers constantly stating that it is difficult to find time for CI. For example, Powertrain company policy says that five percent of everyone's time should be devoted to improvement work and this is included in budgeting. However, the organization fails at spending these allocated resources, which clearly indicates

that the focus on CI from management cannot be sufficient. Spenley (1995) states that "*I don't have the time*" for improving processes is a common attitude characterized by short term thinking and long term extinction. To break the circle is the responsibility of management, to find a way of focusing on improving the ways of working while simultaneously maintaining high quality products.

Further, the reasoning in this thesis has been built on the positive impact continuous improvement can have on product quality as well as in facilitating the establishment of a quality culture. Further, the theoretical framework presents a number of areas where continuous improvement initiatives in product development often fails due to that they have been adopted from or inspired by a manufacturing setting. Powertrain fits well into this picture since many of the underlying ideas on how to continually improve have been adopted from the manufacturing parts of Volvo. As a consequence, Powertrain lacks capabilities in the following areas; learning and knowledge management, cross-functional interaction, promotion of creativity, and measurements. Moreover, this thesis shows signs of additional weaknesses in Powertrain's improvement system. These are visualized as causes in Figure 32 and the rest of this chapter discusses them one by one. On the other hand, the cultural context at Powertrain is promising from a CI perspective. This thesis argues that through n clarification and subsequently an adaptation of the CI-system, to better fit Powertrain's cultural context, an enhanced quality culture could be achieved.

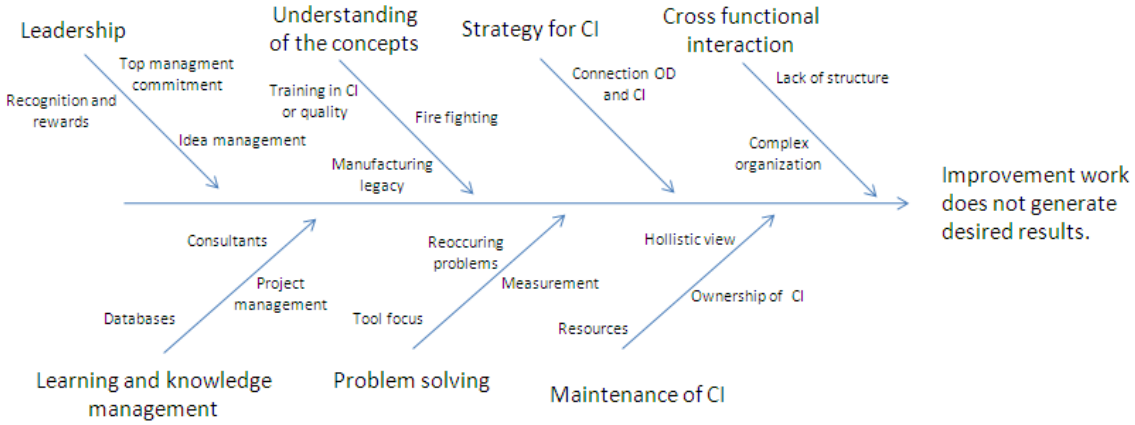


**Figure 32 Illustration of causes to the unsatisfactory results from improvement work**

## Leadership

Management commitment in CI is crucial since it is a prerequisite for improvement work. An illustration of management's importance to a number of quality dimensions is shown in Figure 33. Without commitment from top management there is absolutely no point in adopting any quality improvement processes (Spenley, 1995). As most companies, the Volvo Group and Powertrain experienced a dramatic change in its business environment during the financial crisis 2008 to 2010. For improvements of Powertrain's ways of working this had the consequence that practically all resources and initiatives were discontinued. Only a small part of these have then been reinstated. Instead, top management has focused on that the development of Powertrain's products is too expensive compared to competitors and that excessive costs need to be cut. It is the notion

of this thesis that such a focus, heavily emphasizing efficiency might be too narrow and although it might generate higher margins in the short term it might cause harm in the long run. Further, this approach cannot be seen as aligned with neither the Volvo Group or GTT policies, presented in chapter 4.1., nor the link between quality and lowered costs presented within TQM.


**Figure 33 Visualization of the central role of management for the business. Adapted from Spenley (1995).**

There are reasons to believe that creativity and innovative ideas not get their fair share of attention at Powertrain. Executives at Powertrain show discontent over that the development work costs too much and fail to deliver accordingly. The notion is that the organization has to be made more slim and streamlined. On the other hand it can be argued that when an organization is put under high demands to constantly deliver solutions to development projects, the energy does not suffice to also self-improve or pursue unconventional ideas (Caffyn, 1997). Put in other words, people might not have the time to think outside the box.

The process for managing ideas and suggestions at Powertrain is the 3C process, thoroughly described in section 4.1.3. This process is considered as a rather formal process, giving co-workers at Powertrain a strict way in how to treat their ideas and relatively early involve a manager with decision-making authority. Besides, due to time constraints there is not much interest in this process. However, this design exclude co-workers from responsibility and authority and instead makes group managers the ones responsible for spotting good improvements and perhaps even radical innovations. This is a heavy burden for persons that are expected to be managers only thirty percent of their time and practice technical development the rest. A suiting example can be loaned from Steve Wozniak who built one of the first desktop PCs. Of loyalty to his employer, Hewlett Packard, Wozniak firstly showed his computer to his manager there. Although impressed, the manager responded that this was not a product that fit into HP's high quality market segments and it was nothing they could develop. Consequently, Wozniak went on to co-founding Apple Computer and the desktop PC came to change society (Isaacson, 2011). This example shows, that it can be

difficult to appreciate really good and innovative ideas and as it seems, Powertrain need to adjust its approach to spot the good ideas.

Steiber & Alänge (2012) builds upon a study of Google's innovativeness and concludes that for TQM companies, such as Powertrain, an update of the mental model in how to manage and organize people is needed to sustain continuous innovation. This notion is also consistent with the view that to successfully manage knowledge, companies must carefully manage the individuals with the knowledge (Bartezzaghi, et al., 1997). This thesis has reasons to believe that the engineers in product development at Powertrain are not so different from the ones at Google, e.g. co-workers are regarded as a key asset to the innovativeness of the company. Based on this, it is the notion of this thesis that Powertrain perhaps could also benefit from trying a less structured approach towards handling ideas and the improvement of their ways of working. Further, more mature industries than the one in which Google operates will in the future become more dynamic (Steiber & Alänge, 2012). Hence, trying out a less structured approach towards innovation might show as a foresighted measure for Powertrain.

Another interesting concept on the matter of creativity is that of serendipity, which means approximately; finding something while not specifically searching for it. There are ways for companies to encourage and create possibilities for serendipity through personal networking or in the design of the workplace. Steve Jobs for example, co-founder of Apple, emphasizes in a biography by Walter Isaacson (2011) face-to-face meetings and that creativity comes from spontaneous encounters. Consequently, the headquarters of Pixar, where Jobs was CEO, was designed with serendipity as a central theme and to get people out of their offices and into the big atrium in the middle of the building to interact with each other. Tricks used for achieving that effect was that the front doors went straight into the atrium as well as the location of the café, mailboxes, and rest rooms (Isaacson, 2011).

### Learning and knowledge management

Again, since this thesis is carried out in a product development setting it is necessary to especially emphasize the role of learning and knowledge management in CI. The empirics and analysis show that the situation at Powertrain today is not sufficiently good although a number of activities have been done in the past. On the other hand has a number of strengths connected to learning been identified in the quality culture at Powertrain. Bartezzaghi et al. (1997) state that the most successful or most innovative companies use company specific, creative, and unexpected forms for sharing and capturing knowledge. Thus, Powertrain has to figure out their preferences and how they can be used to turn learning into a strength.

In product development, learning is naturally occurring every day. Besides the spontaneous will of learning new things among co-workers at Powertrain there are some good examples on how Powertrain is trying to promote learning further. Firstly, there is the alternative career path of technical specialists, called Specialists. This enables in-depth knowledge and understanding of the fields and technologies that make up Powertrain's products. What is believed as important to this initiative aside from the individual learning is to make these senior

technicians available to the organization, utilizing their knowledge. Secondly there is the PE School. The PE School is interesting from two points of view. On the one hand it is education of co-workers enhancing understanding of technologies and the product but also giving an improved holistic view of the company's operations. On the other hand, since courses are held by Powertrain engineers, these engineers are required to articulate and visualize their specialty and everyday work. Through this kind of efforts the engineer's knowledge evolves and provides the engineer with insights he or she would not have gained if not teaching a course.

This thesis argues that it is not the behavior of Powertrain's co-workers that seems to be the major problem in knowledge management but rather the mechanisms and systems provided to them. Building on the quote by Bartezzaghi et al above, the main conclusion in this area is that Powertrain's focus is on documenting knowledge for people to read when needed. However, this thesis has shown that when knowledge is documented and stored in a database it is seldom reused. Reasons might be that it is difficult to interpret written information, or that in an organization like Powertrain, the amount of written information quickly accumulates to something impossible to overview. At that point search engines become crucial, but if these do not return what was sought after, the documented knowledge becomes practically useless. The conclusion here is not that databases are useless, for example the Design and Verfication Guideline database DVG seems to be a promising idea for covering the documentation needed when it comes to the technical dimension of Powertrain's products. Hence, databases definitely fill a purpose in providing technical information but perhaps they are not the whole solution. Instead, Powertrain could focus more on the interaction between co-workers. Knowledge is spontaneously shared between people at Powertrain and personal networks are already an important part of the knowledge sharing. It is quite clear that people rather use their connections to acquire knowledge than utilizing the organizational mechanisms e.g. databases provided for that. This study has seen some initiatives that try to utilize this cultural preference, for example, mentors. However, this could be done in a much more structured way.

Further, the real weakness in knowledge management at Powertrain is project knowledge, e.g. knowledge about problems that occurred during the project, how these were solved, what decisions that were taken and why. Powertrain relies upon project documentation where lessons learned are documented but based on the interviews this does not seem like an effective way of moving knowledge among the relevant people. Another aspect is the high turnover of project leaders, leading to the lack of senior managers in this area for newer ones to learn from. From a knowledge perspective this is unfortunate because, when experience and skill has been built up it disappears and the project organization can no longer benefit from it. Further, Caffyn (1997) states that a high turnover of personnel is an inhibiting factor for CI in PD. One other similar phenomena is Powertrain's consultancy policies, generating a lot of short term assignments; leading to that the capturing and sharing of knowledge is constantly interrupted. In the long term there could be a risk of not having enough senior engineers, which means undermining the entire knowledge base of the company.

### Understanding of the concepts

Another facilitator for successful improvement work is a common understanding and direction. To be able to develop capabilities in CI co-workers need to be trained in CI and the CI-system (Caffyn, 1997). Today, Powertrain only provides possibilities for learning when rolling out new initiatives. This implies a problem with sustaining understanding. It is therefore concluded that Powertrain could benefit from supplying courses on quality culture and the CI-system at Powertrain. Further, a lack of understanding shows itself in how Powertrain uses measurements to shape the improvement process. In order to create a Quality Culture that is aligned with company values, i.e. VPS-PDP, Powertrain needs to monitor the impact of its activities and base its decisions on facts. It is important to use measurements in order to develop CI (Bessant & Caffyn, 1997). To conclude, there is an absence of reliable measurements shaping the improvement process at Powertrain.

### Cross-functional interaction

Having co-workers involved in cross-functional activities, including both vertical and lateral cooperation, is important for enhancing the understanding of the development process as a whole (Bartezzaghi, et al., 1997). This understanding is important from an improvement perspective. The holistic understanding prevents the sections from turning into silos without interaction with each other. The behavior of being able to work cross-functionally also facilitates spontaneous knowledge transfer (Bartezzaghi, et al., 1997). This is important for Powertrain since one of its strengths is the ability to share knowledge by using the co-workers' personal networks.

Powertrain has no way of identifying improvements in need of cross-functional collaboration, there is no structure for how to handle cross-functional work, and when occasional cross-functional work occurs it seems to be on an ad-hoc basis or by management decision. Powertrain managers do however express a need to be able to improve cross-functionally. The ability to collaborate cross-functionally is a main difference between CI in PD compared to CI in manufacturing since the processes in PD tend to be more complex and with longer lead times. To be able to succeed in this area there must be an understanding for other areas of the company and to willingly contribute, even though the improvement results will show elsewhere in the organization. There must be a culture where it is possible to delegate responsibility to other parts of the company to improve but also take the responsibility to help them in their efforts. Today, employees hesitate to initiate improvement work fearing that the improvement will escalate in proportions, from local to global. This seems to be due to the ineffectiveness of collaborating globally, as respondents state that it is burdensome to carry though these kinds of projects. Today, Powertrain is emphasizing this area by addressing a few improvement projects regarding processes. The need of cross-functional collaboration has therefore surfaced. It is however important that the focus in these projects is not solely on solving the problem, falling into taskforce behavior, but also to learn how to address and make visible these problems in the future.

### Strategy for improvement work

Strategy is what should provide Powertrain with a direction in its CI work; it should also be the explaining link to why CI is important and benefits the business. Thus, motivating the organization to prioritize and drive improvement work. The analysis shows that the strategy deployment mechanism, OD is functioning, even though it has seen a decrease in importance the last couple of years. This is probably due to the downturn in the economy, which crippled the CI work. Nevertheless, most managers can describe their strategic objectives, however, what they do not do in most cases is relating strategy to the CI work. This makes the CI work uncoordinated between groups and sections and constitutes a risk of increasing complexity in the cross-functional work. It might also cause strategies to be only partially, or not at all, fulfilled which in the long run might undermine the attention paid to strategies, since they are never fulfilled anyway. Instead of being rooted in strategy, improvement efforts are based on economic reasoning or simply the most apparent flaws in the organization. Neither is there any measurements and follow-up of CI work, making it impossible to evaluate and know what the results of the activity were even though there is no resistance in the organization towards connecting CI to strategy or monitor the work done. It is rather that it has been poorly communicated and that there has not been enough support and resources to establish these kinds of behavior in the organization.

Another aspect of strategy is how to create momentum in the improvement work. Then it is important to not overwhelm the organization with improvement projects. During 2012 the management team for Powertrain in Gothenburg has specified 26 improvement activities. This does not include and perhaps give no space for ideas coming bottom-up through DTL escalation or in other ways. According to Palermo (1994) it is said that between four to eight company level improvement projects at the same time is enough. As stated in the beginning of this chapter there is a culture of wanting to improve at Powertrain. This is essentially positive but if the enthusiasm to start up activities leads to that the organization is overloaded and does not manage to complete any activities, the CI work risks to implode. Hence, managers must be clear on which ideas that are turned into activities, which are put on hold until resources are available and which that will not be pursued. This communication also constitutes an act of balance. If carried out to strictly, it risks suffocating bottom-up ideas. This is something that Powertrain really does not need since another way of creating momentum in improvement work is through co-worker interest and involvement. This thesis gives a number of recommendations on how the status of CI can be improved, for example loosening of manager interference in the innovation process, connections between salary and career and skills in improvement work, less documentation, and chances to show off good results.

### Problem solving

The analysis points out that PE has a substantial improvement opportunity in its problem solving. Bessant et al. (2001) state that there is a major criticism of CI literature because it is assuming a connection between performance enhancement and tool utilization. Further, Aloini et al. (2011) state that Corso et al. (2007) found that CI performance improvements cannot be derived from increased utilization of tools. Hence, applying tools in the right way is important

but before going further into that there are some more general notions that have to discussed.

The unsatisfactory problem solving process shows in the untimely fashion problems are dealt with. The empirical results show that it can be difficult to get through to managers if solving a problem demands additional resources. Thus, problems at Powertrain seem to have a tendency of growing until they reach a critical state, i.e. when there are possible consequences directly affecting the customer. Again, the strive for efficiency generates apparently short-sighted behaviors and the problem solving is prolonged to a later stage of development, and thus risks extending the development lead time and drive up the cost as well. Figure 34 shows a characteristic pattern of management intervention in product development projects, which illustrates the notion that Powertrain's approach to problem solving is reactive. A more favorable approach would be to recognize problems at an early state by emphasizing and recognize proactive efforts instead of neglecting them.

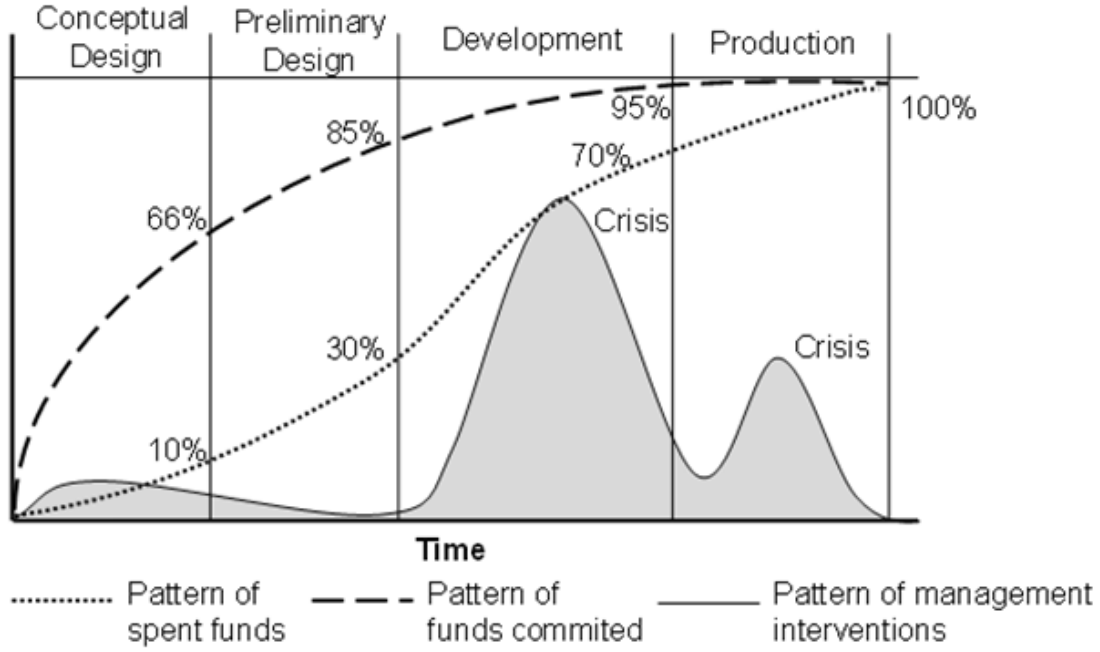


**Figure 34 Illustration of late management interventions in product development. Adapted from Wheelwright & Clark (1992).**

Complementing the argument about postponed problem solving above, one last argument can be made about the connection between products and processes. In PE's work with malfunctioning products there are basically two types of feedback; one in the testing and verification phase called PROTUS and one for products that have been launched in the market, called QJ. These two feedback loops and the activities for resolving the problems get attention by the whole organization. However, solely the technical solution is not always satisfactory since the core of the problem could derive from a malfunctioning process. To exemplify:

> Product testing has a timeframe. In this timeframe designers have to specify the product. However, the specification and testing take more time than is given by the process. Designers are therefore making

qualified guesses on the design of the product, send it to testing, and then realize that the wrong product has been tested since there were some changes to it. Resulting in that the tested design is not the same as the final one.

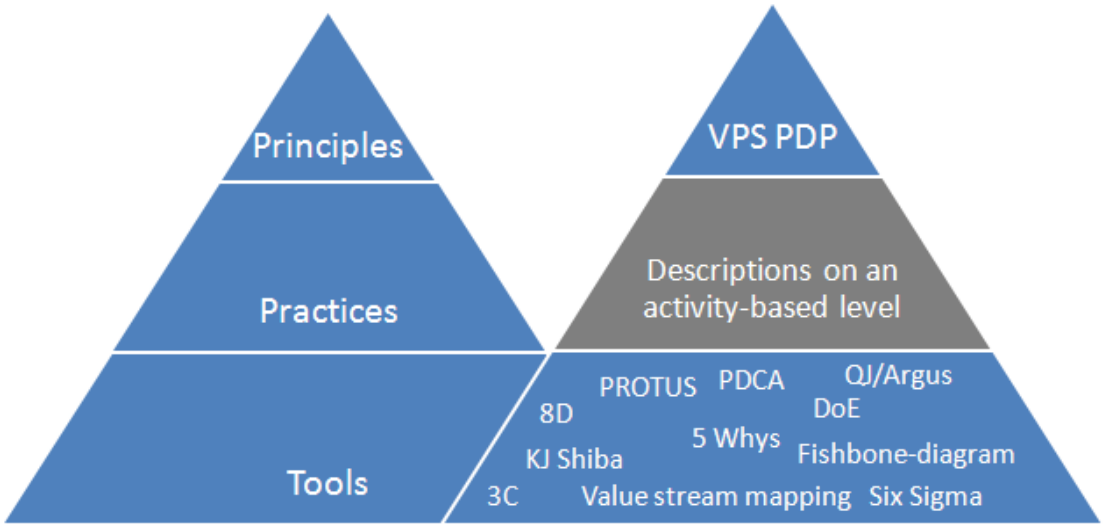


**Figure 35 Illustration of a model for the establishment of methodologies for problem solving. Adapted from (Gremyr & Hasenkamp, 2011)**

Gremyr & Hasenkamp (2011) utilize a model consisting of principles, practices and tools to visualize how practices, or methodologies such as PDCA, can be used to connect the use of tools to the general principles of their existence. A connection that is often lost at Powertrain. This model is shown in Figure 35 on the left hand side and on the right hand side is an interpretation of the current situation at Powertrain. This figure perhaps includes a couple of reasons for the frustration regarding the tools. Firstly, Powertrain has tried to establish practices but they have rather been perceived as tools. This has the consequence that the practices are not something characterizing the problem solving but instead applied on an ad-hoc basis. An easier way of relating tools and practices to each other would be if Powertrain applied a view more consistent with Figure 36. Here the methodologies have been lifted one level and distinguished from the tools making it more clear that practices prescribe appropriate tools for each phase in the problem solving and hence, provide guidance in how to approach different problems. Important to note on this matter is that, for example a PDCA approach to problem solving, works equally fine in dealing with product improvements as with process improvements.

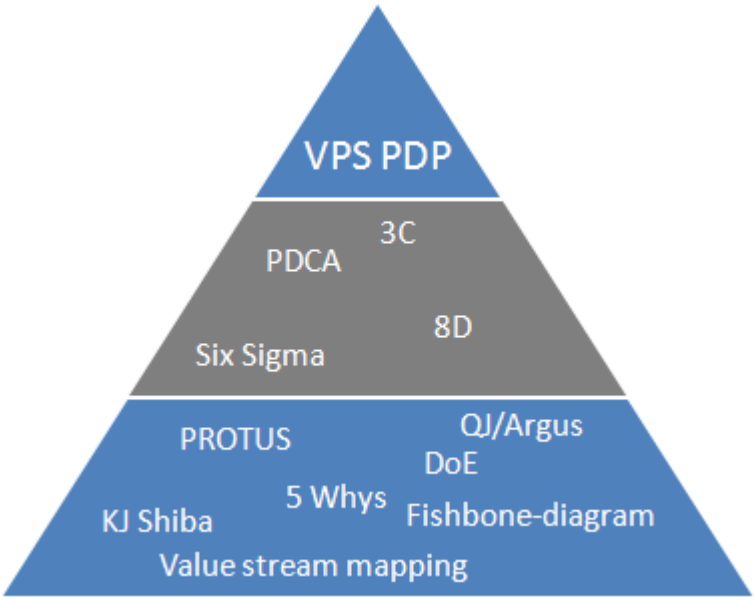


**Figure 36 An interpretation of Powertrain's set of principles, practices, and tools grouped according to the theory by Dean & Bowen (1994)**

To finalize this discussion on how to approach the use of tools through practices, the 3C process has to be mentioned. This practice is based on PDCA but emphasizes the initial Plan phase, thus drawing focus from the important phases later in the process, namely Check and Act which include making lasting, long-term solutions, follow-up results and communicate solutions to the relevant people. This weakness in the 'CA'-phases (reflection and standardizing) in the 3C model also leads to the lack of connection between product malfunctions and process improvements.

According to Powertrain's own evaluations of the previously mentioned PROTUS and QJ processes, the ability to produce process improvements once the technical problem is solved is weak. Instead there seems to be a tendency of wanting to dig into the next technical issue. One possible reason for this could be that the leadership has a technical background and what is considered to be fun is solving technical problems, not making sure the same problem will not reoccur.

Finally, results and analysis reveal that managers believe that there are too many tools available and that this could lead to confusion. It seems that Powertrain has a view of a tool to be something that has to be used, not something that is chosen to aid in the problem solving. This leads to anxiety since co-workers at PE imagine the effort of utilizing all tools instead of choosing one that fits the identified problem. It is probable that a high focus on tools represents a rather obsolete perception of CI which needs to be actively intervened against in order to gain energy and momentum in the improvement work.

### Maintenance of the CI-system

The CI-system, as it has been described in this thesis, consists of several initiatives. These initiatives, have appointed ownerships but there is no ownership of the whole CI-system. This contributes to increased complexity for the users. A holistic view is needed for the employees to understand the

processes and connections between the initiatives leading to a more efficient usage of the system. The development and maintenance is lagging since there is no collective agenda for the system. It has led to a lack of resources allocated to the maintenance of the CI-system as well as forced interfaces between the initiatives. It should also be emphasized that even though there is a lot for PE to do and improve within the frame of their improvement efforts, there is probably not much to win without thorough, long-term commitment from management. This does not just include group managers but all levels of management within Powertrain. With the genuine interest that to a high extent exists at Powertrain, together with a holistic view of CI, there are possibilities to strengthen the improvement work and consequently the building of a company quality culture. These two behaviors are part of the framework presented by Bessant et al (2001), it is concluded that the behaviors that Bessant et al. (2001) present to build capabilities in CI also can improve quality culture. Ultimately this will most likely show also in improved quality in the engines, gearboxes and other products developed at Powertrain Engineering in Sweden.

## Future Research

Finally, a short comment on interesting questions that this thesis has generated that could be of interest for future research and some brief comments on the theory chosen for this thesis.

Future research

- Measurements
- Project knowledge wiki
- How to establish a product to process connection in problem solving
- What time for reflection does to a innovativeness

It is believed that the framework for CI developed by CIRCA in the 1990s and presented in its final form by Bessant et al. (2001) complemented with more modern literature and the special characteristics of product development has been a good choice. Since the framework and the origin of PE's CI work dates back to approximately the same time it is interesting to see the vast differences, even though PE has had ten years to develop their capabilities. The analysis shows that PE has or has had initiatives in all areas of the framework but PE obviously has problems in completing and sustaining the improvement initiatives they start. Once again it can be argued that the most important component missing is probably management commitment but also consistency. What could perhaps have been interesting would have been to shift the analysis more towards continuous innovation, i.e. both continuous improvement and radical innovation. This could possibly have generated other and more drastic results and recommendations than the rather incremental ones which this thesis presents. On the other hand, PE is a company with a firm structure in a mature industry deeply rooted in TQM values and perhaps too pervasive recommendations would probably be considered by Powertrain as not rooted in reality and gain no impact on the organization.

# 7 Recommendations

*This chapter presents the recommendations of this thesis and starts off by elaborating on recommendations in the area of innovation. Further are the areas of learning, cross-functional interaction, measurements, and finally leadership revised. These areas are identified as areas with major differences between improvement work in manufacturing versus that in product development and they are also key areas within Total Quality Management. The chapter further present additional recommendations derived from using the theoretical framework, such as how to increase understanding and awareness for continuous improvement and more efficient problem solving.*

The notion of both this thesis and the interviewees that has contributed to it is that continuous improvement is essential to stay competitive and stay in business. The concluding discussion pinpoints that an adaptation of Powertrain's improvement system, to better fit the current quality culture would strengthen improvement work and consequently have a positive impact on the quality culture itself leading continual enhancement of it. The rest of this chapter is devoted to propose, motivate, and discuss changes of the improvement system.

### Innovativeness

First off, the fundamental prerequisite for great improvement work is great ideas. This means that Powertrain has to think about how such ideas are generated and taken care of. The concluding discussion glances at Google in this area. When mature industries and the companies therein move towards more dynamic conditions it is probable that also improvement and innovation systems of these firms need to adapt. One example of how Powertrain adapts to increased dynamic conditions is the company's increasing rate of consultants. Hiring consultants instead of permanent employees is one way of achieving a flexible organization that quickly can adjust to changes in workload etcetera. Another way of making Powertrain less rigid and to stir innovativeness could include giving individual engineers more freedom. Such an approach, where engineers are empowered to a higher extent, could also include letting engineers to some extent choose if they want to spend their time on process or product innovation. From a leadership perspective, focus needs to be shifted to providing clear goals for the work and encourage spontaneous sharing of knowledge e.g. through personal networks across divisions and presentations. There are no reasons to believe that the engineers at PE would not deliver under such circumstances as long as there is a sincere interest from management in the results. Perhaps this kind of approach could attract more innovative and involved co-workers, at least that is one of Google's main reasons for giving their engineers more free hands (Steiber & Alänge, 2012).

Regarding the idea management system at Powertrain, which has been discussed throughout this thesis, the design could be done in a lot of different ways. Powertrain has an escalation process of ideas in place but it is not sufficiently reliable, ideas that go into the process might be put on hold or not dealt with at all. One idea to improve this process is to raise tougher requirements on managers to respond on ideas. A timeframe could be set for responding to ideas, for example a week or at the next improvement meeting, if a response has not been given the originator is free to escalate the idea to the next level of

management. Such an approach would probably encourage dialogue and speed in the process of handling ideas for improvement. Spenley (1995) states that a structure, criteria, time and top management engagement for escalating ideas are needed. Powertrain has criteria and the structure for escalating ideas, what is needed is engagement and time put into the structure.

Today, serendipity is hardly a concept frequently discussed by management at Powertrain and even though the company already holds nice buildings, out ruling a re-design, some ideas could be interesting to try out. For example, more common spaces where people could go and work or socialize, getting some variety from their ordinary offices. Today, offices are cramped and common spaces seen as something necessary but evil. Bearing in mind the cost of an engineer, Powertrain should try and get the most out of them. Powertrain also holds an archive of old reports etc., perhaps a library focusing on Volvo or engine history could be a place people naturally met. Another important common space is the dining rooms, it is recommended to Powertrain to really apply a serendipity perspective when renovating their facilities in the future. Many swedes also love to sit outside when the weather is nice, why not take advantage of this and create possibilities for eating or working outside. Thus, people from different sections or divisions would come in contact, which they normally would not and Powertrain could possibly draw benefits from serendipity. Why not try to take advantage of this and draw benefits from serendipity, as described by Isaacson (2011), for example through outside patios where people actually want to sit and work. Other methods could be to encourage or sponsor hobby or sport societies formed by the co-workers. Finally, there is an opinion at Powertrain that top management is rather invisible and difficult to get in touch with. Perhaps these managers should be more available to the organization and show themselves out in the office landscapes from time to time. Perhaps they would find something they were not expecting.

### Learning

Bartezzaghi et al. (1997) state that the most successful or most innovative companies use company specific, creative, and unexpected forms for sharing and capturing knowledge. For the sharing and capturing Powertrain is experimenting with different databases and has been doing so for several years. Even though databases seem good in theory, e.g. the Design and Verification Guidelines database, Powertrain has had troubles drawing substantial benefits from the documented knowledge. An important reason might be that sharing knowledge at Powertrain is mainly done via personal networks. These networks are concluded to be a strength of Powertrain and their benefits and development should be put more in focus. New employees do not have access to a personal network and while the culture at Powertrain relies upon these networks to function, it is crucial that they are incorporated in to these as quickly as possible. One natural way for Powertrain to achieve such quick and social introduction processes would be through assigning mentors to all new employees. Today this is applied on an ad-hoc basis but it is believed to become more beneficial if it was more rigorously applied. An especially important task for the mentors would be to make the new person meet and befriend the colleagues that will become most important to him or her. In this way a functioning personal network, where useful knowledge is flowing, could be functional within days of a new person's

arrival. Another way to create networks could be the introduction courses given for new employees within the scope of PE School. Today these courses focus a lot on lecturing and give little time for discussions, mingling and getting to know each other. Exercises or activities with focus on the latter would probably give more in-depth understanding of the teaching as well as providing participants with 'connections' in the same situation as themselves.

When talking about courses and training, CI training at Powertrain today consists of; training in new initiatives and in updates of existing initiatives. This means that Powertrain does not provide any way to continually learn about the CI-system and of learning about what is a Powertrain quality culture. It is therefore recommended that Powertrain uses the existing PE School as a foundation for CI and quality culture courses. In this way the perception of Powertrain's improvement-system could be harmonized and management gets a focused channel for what they would like to communicate in the area of improvement and quality.

Interviews unraveled a high project management turnover at PE. This leads to a situation where project knowledge is lost. A manager states "*When we started this last project we looked into what information there was from previous projects of the concerned product, we found nothing*". Further, to successfully manage knowledge, companies must carefully manage the individuals with the knowledge (Bartezzaghi, et al., 1997). It is therefore recommended to look into why the turnover is so high and how skilled project leaders can be kept in those roles within the organization. Based on limited data on this issue this thesis cannot discuss this problem in depth. However, a qualified guess is that the workload is too high and the status and salary too low to make project leader a job where people want to stay and pursue a career. It is recommended that Powertrain looks further into this problem area and addresses the issue with concrete activities to not end up with a totally excavated project organization. Finally on the matter of learning, the DVG, which stores knowledge about Powertrain's components, was mentioned as a theoretically sound initiative that has had some difficulties in gaining momentum. The knowledge storage for project knowledge is document archiving, a method that both theory and reality regards as pretty much useless. Instead it would be interesting if Powertrain dwelled upon how an accumulating knowledge bank, such as the Design and Verification Guideline database, DVG, could be designed for the project organization as well.

### Cross-functional interaction

The cross-functional improvement work is lagging at Powertrain. There is a fear of initiating improvements due to the risk of the scope escalating out of proportions. The cross-functional work has been recognized as a key area of improvement at PE in the year of 2012. A few chosen projects have been initiated to analyze key processes. It is recommended to use these projects as pilots in how to structure the cross-functional work. By evaluating how these projects were progressing, what obstructed the work, and what facilitated the work, PE could get the knowledge needed for structuring cross-functional CI.

Another interesting thing Powertrain could do in the area of cross-functionality is to make mandatory for all aspiring managers to spend some time working in

the quality department. This would probably increase the managers' understanding of why the quality dimension is important and where the difficulties lie in managing quality. It would also mean for the quality department to have a constant flow of ambitious and driven individuals, giving energy and skill to the quality work.

Virtual Oobeya Room is an initiative ongoing at Powertrain studying possibilities of communicating globally. A way of supporting the cross-functional improvement could be by utilizing the technology at Powertrain's Virtual Oobeya rooms. The methodology of Oobeya is not important for cross-functional improvements but the technology can be used. The technology is basically touch screens shared between members of the meeting, displaying whatever needed and the members can communicate via direct links as in a regular meeting. This technology enables quicker and more frequent communication in comparison to today where much collaboration relies upon traveling and face-to-face meetings. However, the culture at Powertrain shows tendencies of overly focusing on tools. It is therefore recommended that firstly look into other ways of stimulating the cross-functional work by incorporating a culture where employees willingly engage in cross-functional collaborations without immediate benefits to their own part of the corporation.

### Strategy for CI

Operational development (OD) is PE's initiative for strategy deployment. Managers are often involved and active in the OD work which makes it capable to achieve its purpose. However, the strategy set by the Volvo Group CEO might be too vague in guiding the organization towards a specific goal. It is therefore recommended to look into how more specific goals could guide the improvement work. This notion is based on the finding that managers know their strategy and can elaborate upon it. However, they do not seem to use it in their prioritization of improvement resources, which could lead to that the strategic objectives are not reached. Hence, it is recommended to increase the connection between the strategy deployment and actual prioritization. This probably requires training for the managers. Interviews do however reveal that OD is emphasized by the new organization and that respondents believe that the OD work will gain momentum and get an increased emphasis by management in the future. It is also recommended to not overload the organization with too many improvement activities but to focus on a few at the same time to make sure that there is time for escalated bottom-up initiatives. It is further recommended to measure how improvements influence the fulfillment of strategy. Caffyn (1997) states that a lack of measurement points and performance indicators act as an inhibiting factor for CI within PD. The present measurement regarding CI work is basically a KPI monitoring the progress in number of closed 3C issues. To improve the measurement philosophy and attitude towards CI, it is recommended to provide some kind of measurement points for CI teams in their CI work. It is also recommended to measure the benefits of CI and its impact on strategy. This could be done with a prioritization matrix. The purpose is to pick a few improvement projects that affect the overall strategy the most. The priority matrix should display how activities affect different strategic goals and which of them are most important (Palermo, 1994). However, in this thesis it has not been

investigated how these measurement points and KPI's should be formulated and it is something that Powertrain should look further into.

Another recommendation for the OD and strategy deployment work is for management to share a view of the strategy and goals of the organization. It is important to communicate a shared vision for how Powertrain's improvement work should progress. Olofsson & Sandquist (2012) emphasize the importance of agreement in the management team when pursuing improvements. It is therefore recommended that the management team gains agreement on the strategy formulated. The agreement should be by the majority of management e.g. sixteen out of nineteen, and should be signed by the participants to build commitment (Olofsson & Sandquist, 2012). It is further recommended that the strategy is printed displayed outside the management office for everyone to see in order to increase commitment even further (Spenley, 1995). Gremyr & Hasenkamp (2011) state that to make the organization understand the implications of an initiative management should prepare "elevator pitches". These are short speeches that explain the whats, hows and whys with an initiative. This could be applicable for strategy but also for other initiatives, such as VPS-PDP. People in the organization need to know why the initiative is important, what they need to do, with the help of what. This is a way of showing commitment and a shared view of the direction Powertrain is going.

### Problem solving

Concerning recommendations for problem solving, there is an exaggerated tool focus at PE that seems to derive from a general overconfidence in tools. The tools themselves are facilitating problem solving and not supposed to solve the specific problem. This again shows that Powertrain has not entirely understood the role of tools, a suitable tool is chosen for a specific problem, and there is no need for everyone to use every tool. It is therefore recommended for Powertrain to reduce their inventory of tools. This could be done through investigating which tools that are utilized along with which tools that have a quality level that justifies their existence. Further, Powertrain should contemplate how to create consistency in its problem solving. Perhaps a stronger link between principles and tools through practices for problem solving could help providing purpose, direction and focus in problem solving. Today, PDCA, 8D, A3 and probably other practices as well are applied throughout Powertrain. However, understanding of the practices' purpose and design, e.g. to guide in what tools to use, is often lacking and results in frustration and a view of practices as time consuming and redundant. To gain benefits from applying practices in problem solving it is recommended to Powertrain to choose one practice and focus its efforts on educating and increase the understanding of why and how that practice is important to use. Most favorably would be if a demand for using a practice as aid in problem solving could be created.

Moreover on this matter, root cause analysis has been identified by Powertrain as an important ability in problem solving and the company has appointed specialists to support and coach the organization in using RCA. This is probably a good first step in establishing a practice like PDCA. However, RCA as applied by Powertrain, is very product focused and does not include reflection and improvements to the ways of working nor sharing of what was learnt to the rest

of the company. Currently, there is unfortunately no idea or plan on how to realize the Act-phase. However, there are probably other methodologies that could help shaping additional abilities as well and these should perhaps be treated the same way as RCA. Examples could be Robust Design or Design for Six Sigma. These senior problem solvers could also be educated and then help to disperse the practices recommended above.

### Maintenance of the CI-system

Support of CI in the form of resources is something that the analysis pinpointed as inadequate. Gladly though, Powertrain has already taken action in this matter and will complement the sole person responsible for coaching in OD, DTL, and 3C with one group manager per section with coaching responsibilities. It remains however to see if these group managers are relieved from other responsibilities. If not, this initiative runs a great risk getting no effect whatsoever.

It is recommended to consolidate the ownership of the CI-system, developing it as a whole. The interfaces are somewhat strained at times which makes the process less easy to manage. The situation could also lead to skewed resource allocation due to bureaucracy, leading to that some parts may develop accordingly while others are stagnate. The consolidated ownership could also help facilitating communicating a holistic view of the CI-system to the PE employees, which is recommended.

### Leadership

A lot of recommendations have been discussed above and naturally there is one group of people that is responsible for making things happen, the managers. Thus are the last paragraphs of this master thesis devoted to leadership and how improvement work can become more central for Powertrain.

Given that there are great improvement ideas, it takes leadership that knows how to spot, promote and recognize them for gaining momentum in the improvement work. The recommendations concerning leadership aim at enhancing managers' involvement and focus on CI in order to make improvements to the ways of working more central for the whole organization. Further, just executing CI as required by duty cannot be seen as enough, in order to become really successful personal engagement from managers is critical. This could be achieved in two steps. Firstly, and in the short term perspective, top level management need to agree upon a direction and clearly communicate this to the organization and also be perceptive towards feedback or criticism. Secondly, and in a long term perspective, improvement or quality skills and interest could be taken more into consideration when appointing new managers. The latter would become more natural if a higher focus was put on improvement work in the job descriptions. PE has role descriptions for all positions and it would not take much effort to update these with expectations and responsibilities within CI.

Further, updated job descriptions including expectations on improvement efforts would also make it more convenient to promote and recognize improvement work through salary. Other types of recognition that could help promote CI to co-workers are presentations or seminars where people get to present and show

their work and what results that has been generated. This is also an important part of the final stages of the PDCA cycle that should not be neglected (Bergman & Klefsjö, 2003). The notion of this thesis is that such presentations become most efficient if they are incorporated into the everyday work. Probably are ten minutes at a DTL meeting or ten minutes at the management team meeting seen as sufficiently awarding. When it comes to monetary awards it is recommended to be very careful, there might be a risk of alienating CI from everyday work if people are awarded prizes. On the other hand, it could be seen as a sign of management emphasizing this kind of work and function as a motivator for CI. The recommendation is however that it is better to emphasize that improvement ideas and efforts are expected from everyone and if a special award is to be given it should be for something extraordinary and to a group effort.

Figure 37 visualizes the recommendations given above on a time line and with whom that has to be responsible for driving the change. Naturally, all recommendations cannot be implemented at once and thus a simple classification of now, soon and later has been applied. It is also important to note that even though someone is responsible for driving the implementation of these recommended changes the whole organization has to become involved in order to create a sustainable change.

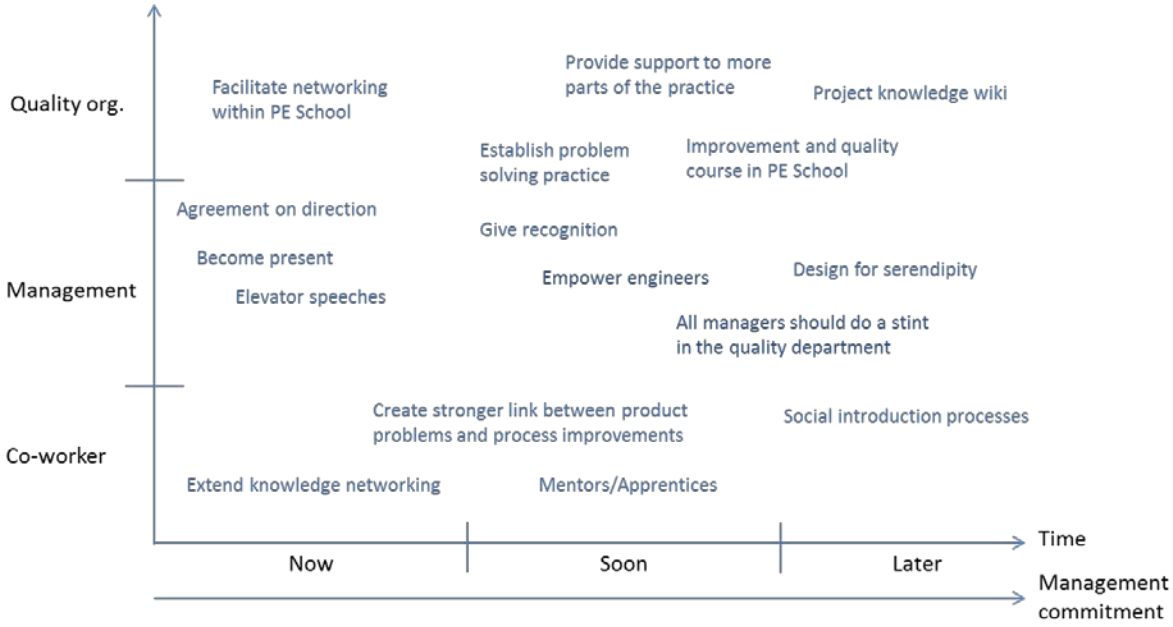


**Figure 37 Recommendations visualized on a time-line and with whom that has to be driving the change.**

It is the notion of this thesis that the recommendations above, based on the review of Powertrain's improvement work is an effective and efficient way of enhancing the company's quality culture. In a practical sense this would mean; a better focus in order to follow through improvement initiatives, a higher pace in the improvement work, and over time an improved capacity to continuously improve, learn and solve more complex issues. Consequently, this would likely mean improved product quality as well as improved financial performance even though resources have to be increased now to create benefits further down the line.

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# Appendix I

## Interview guide

1. Can you explain what a Quality Culture is to you?
2. Can you explain what Continuous Improvement is to you?
3. Can you mention the three most important factors to why improvement work is important?
4. Who do you think is responsible for driving improvement work?
    a. How big is the share of people in your organization that is involved in improvement work?
    b. Is there anyone coordinating the improvement activities?
5. How do you choose among different improvement alternatives?
    a. Can you explain your organization's/section's/group's strategy, goals and objectives?
    b. Do you use your strategy, goals and objectives for prioritizing and choosing improvements?
    c. Do you think it is possible to break down a more aggregated strategy into something useful for your organization/section/group?
6. Are you personally involved in some kind of structured improvement work?
    a. How do you, as a manager, view your role in the quality/improvement work?
    b. How do you support improvement work, time, money, space?
    c. How do you give recognition to good improvement work?
7. Please explain how your organization/section/group solves problems?
    a. Are you aware of the PDCA cycle
        i. Can you explain what the C means?
    b. Group Managers only
        i. Have your group started to use the 3C process and is it being monitored within DTL?
        ii. Is your group using DTL to follow up Protus as deliveries, i.e. are they written in black on the DTL board?
        iii. Is your group using DTL to follow up QJs as deliveries, i.e. are they written in black on the DTL board?
    c. How do you know if your problem solving actually solves the origin of the problem and not just the consequences?
    d. Would you say that the problem solving is efficient?
    e. Do you measure or follow up in some way?
        i. Do you follow up how much time that is spent on OD or equivalent work?

8. To what extent is there interaction with other parts of Volvo in the improvement work?
    a. What is your opinion on the systems, tools and materials etc. provided to your organization/section/group?
    b. Can you influence the design of such systems, tools or material?
    c. Are customer representatives ever included in improvement work?
    d. Are supplier representatives ever included in improvement work?
9. How is knowledge that is acquired by your organization/section/group managed?
    a. Do people take own initiatives for learning/training?
10. How do your organization/section/group share knowledge?
    a. Do you think Powertrain consolidate and present knowledge in a good way?

**5-point Likert scale:**

- Strongly agree
- Agree
- No opinion
- Disagree
- Strongly disagree

Powertrain Engineering has a common direction towards creating a Quality culture.

Your organization/section/group use some kind of tool when solving problems.

Rewards and recognition at Powertrain Engineering supports proactive improvements.

People in your organization/section/group are aware about how the process they operate within looks like.

People in your organization/section/group feel responsible for the processes they operate within.

You think that you have sufficient knowledge within the area of continuous improvement.

You think that you get sufficient coaching within the field of continuous improvement.

You think there is sufficient focus on Continuous Improvement within Powertrain.

You think there is sufficient focus on Continuous Improvement within your organization/section/group.

**Open questions:**

- How would you describe the Quality Culture within your organization/section/group?
- If you could do anything, what would you do to improve the quality culture within your organization/section/group?
- Name a few success factors for creating a Quality Culture and improvement culture.
- Is there anything hindering Powertrain Engineering from creating a quality culture and improvement culture?
- What type of leadership is highly valued at Powertrain Engineering?
- What are the contributing characteristics that make Powertrain Engineering and Volvo successful?

Continuous Improvement in Product Development
An action research study for enhancing quality culture
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