PDSAT –
A New Product Development Self-Assessment Tool

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I hereby declare that I am the sole author of this thesis. No other sources than those indicated have been used in the accomplishment of this work.

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Abstract

The successful execution of complex PD projects still poses major challenges for companies. One approach companies can use to improve their performance is self-assessment to optimize their organization and processes. This thesis summarizes the current literature on PD-related self-assessment tools and derives tool requirements from an industry focus group (US aerospace and defense industry) as well as from interviews at a major American defense contractor. A gap analysis comparing these requirements to the previously identified tools is performed. The thesis concludes with the presentation of a new holistic self-assessment framework to be used in PD organizations. The framework includes a self-assessment questionnaire with 91 metrics, a formalized 9-step implementation process, tool customization guidelines, and mappings between the structure of the questionnaire and relevant process improvement approaches such as CMMI, Malcom Baldrige National Quality Award, Lean Management, and Six Sigma.

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1 Introduction

1.1 Motivation

The environment in which technology-oriented companies operate today changes rapidly. Companies have to face increased levels of competition, higher rates of technical obsolesce and shorter product life cycles (GRIFFIN 1997, P. 430). Both selling markets and buying markets have transformed into global markets (LEVITT 1993). Companies have to deliver their products and services faster, at cheaper prices and with better quality than their competitors in order to survive in more and more competitive sectors (NOBEOKA & CUSUMANO 1997; ULRICH & EPPINGER 2008). Firms also have to offer increasingly complex products in order to satisfy customer preferences. In today's market, bringing these complex products and services from the initial idea to delivery typically involves a number of different firms, often acting in supply chains. Companies acting in these dynamic environments face problems that cannot be easily resolved.

Hence, the pivotal question is: How can companies sustain their growth and profitability in the future? The literature highlights two main challenges that seem essential for success – to be *innovative* (UTTERBACK 1994) and to be *adaptive* (SENGE ET AL. 1999, KOTTER 1996).

The first challenge – to be *innovative* – implies more than just being inventive. Whereas invention is considered as the creation of a new idea, innovation includes the process of developing and implementing a new idea (VAN DE VEN ET AL. 1999, P. 9). Firms that are innovative continuously develop, produce and sell technical innovations, i.e., mainly technical and complex products and services. Many different functions are involved in the innovation process. However, the literature clearly recognizes the leading role of product development, which is regarded as the central part of the technical innovation process. BROWN & EISENHARDT (1995) refer to product development as the "nexus of competition" and "the central organizational process for adaption and renewal." (P. 375) They further describe product development as one of the essential processes for the success, survival, and renewal of organizations, particularly for firms in either fast-paced or competitive markets (BROWN & EISENHARDT (1995, P. 344). Although new products and services can contribute to quick successes, such as increasing stock prices, they are first and foremost a source of longer-term competitive and sustainable advantages (KUCZMARSKI 2000, P. 4).

The second challenge – to be *adaptive* – expresses the need for a company to constantly adapt to changing environments. Shifting environments encompass, for example, changing customers, suppliers, competitors, investors, labor markets, public infrastructure, or public opinion. A successful company has to make sure that it can react sufficiently fast to these changes. Beyond that, it should try to foresee structural changes and act rather than react.

In order to overcome these hurdles, research on innovation, new product development, organizational change, and change management has grown considerably during the last two decades (BROWN & EISENHARDT 1995; HELMS MILLS ET AL. 2009). This research aims at helping companies to be both *innovative* and *adaptive*. However, there is a considerable gap

between academic research results, on the one hand, and the actual application of these research findings in the companies, on the other hand.

An attempt to narrow this gap – a new self-assessment approach for product development – is presented in this thesis. The overall motivation for the development of a self-assessment tool is that a company needs information about the current state of its product development process before it can take action to become more *innovative* and *adaptive*. First of all, it needs to know how well it is currently performing in particular product development areas compared to both external competitors and internal divisions. Second, it needs to define its improvement goals based on the identified gaps, as well as the areas that should be addressed, when taking action in form of effective investments and efficient improvements.

Many tools have been developed that follow a self-assessment approach whose intent is to improve the business processes of firms. There are well-established macro-level national quality awards such as the European Quality Award (EFQM 2010) or the Malcom Baldrige National Quality Award (MBNQA 2009), as well as company-wide business improvement models such as the Capability Maturity Model Integration (CMMI 2006) or Six Sigma (PYZDEK & KELLER 2009). There are also self-assessment tools that focus on the in-depth investigation of micro-level areas, such as concurrent engineering (AINSCOUGH ET AL. 2003) or continuous improvement (CAFFYN 1999). In addition, a number of publications on product innovation self-assessment and new product development self-assessment have been discovered. However, no self-assessment tool has been identified that addresses product development to a sufficiently detailed extent. Therefore, a new holistic, integrated and application-oriented self-assessment approach is needed for suitably measuring a company's capability in being both *innovative* and *adaptive* in product development. This approach has to encompass the best practices for innovation and new product development to address the need for *innovativeness*, as well as the best practices for organizational change and change management to address the need for *adaptiveness*. Beyond that, it has to provide guidelines on how to implement self-assessment and link the self-assessment tool to process improvement approaches which already exist within the organization.

1.2 Thesis Goal

The goal of this thesis is the development of a new self-assessment approach that allows the assessment of the current state of a product development unit, as well as the identification of improvement opportunities. The self-assessment approach has to be based on an integrated product development model that allows the interdisciplinary product development activities and their outcomes to be sufficiently described. Practitioner's needs have to be strongly considered when defining the requirements of the new product development self-assessment approach.

1.3 Thesis Organization

The remainder of this thesis is structured as shown in Figure 1-1.

Chapter Two refers to the theoretical background of this thesis. It briefly explains the field of organizational change and narrows it down to the role of self-assessment in organizational change. A literature review presents and discusses a number of existing PD-related self-assessment tools. At the end of this chapter, the research gap is formulated.

Chapter Three introduces the research approach and explains the research methods used for this thesis.

Chapter Four presents the PDSAT Framework, including the product development model, the PDSAT Questionnaire and the formalized process of how to implement and customize the PDSAT. Furthermore, it demonstrates the way the PDSAT Questionnaire can be integrated with other business improvement approaches.

Chapter Five concludes the thesis with two subchapters – summary of research and future work.

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Figure 1-1: Structure of the thesis

2 Theoretical Background

2.1 Theory on Organizational Change

2.1.1 Field of Organizational Change

Today, change comes in all shapes, forms and sizes, and, thus affects all organizations in all industries (BY 2005). It is an ever-present feature of organizational life, both at an operational and strategic level (BURNES 2004). Hence, organizational change is regarded as part of the key management discourse today (HELMS MILLS ET AL. 2009). The leadership of organizational change is considered the primary task for management (BY 2005) and essential in order to keep a company on track and moving towards its vision and its objectives.

The growing number of uncertainties and changes in the environment of today's companies is recognized by the literature (KOTTER 1996, SENGE ET AL. 1999, BY 2005). This has resulted in the development of methods for managing organizational change (change management methods) and thus has led to a growing number of books and articles on this topic, particularly during the past twenty years. Figure 2-1 shows the number of organizational change books housed in the US Library of Congress between 1960 and 2005. The number moves from zero in 1960 to almost 3500 in 2005.

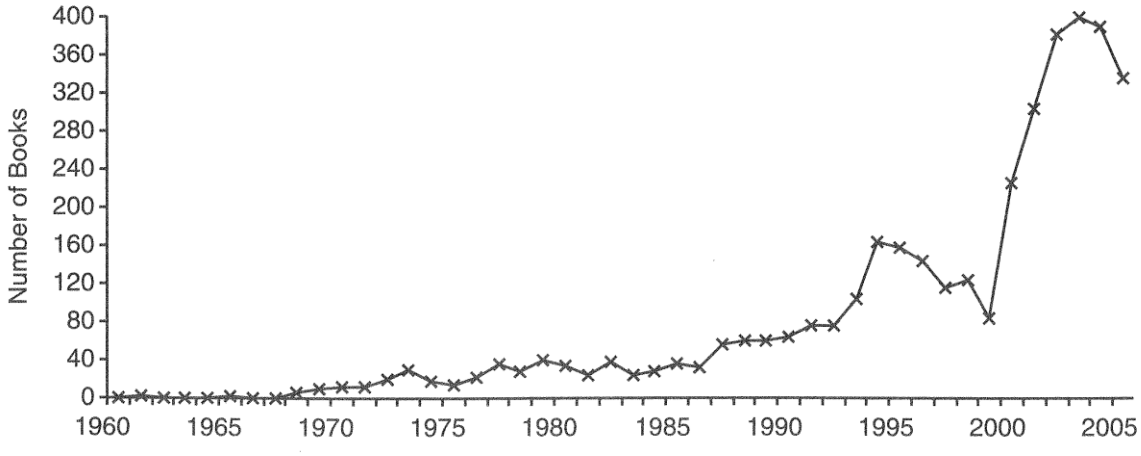

Figure 2-1: Organizational change books housed in the US Library of Congress (1960-2005)

Source: HELMS MILLS ET AL. (2009)

For this thesis, the following definition by HELMS MILLS ET AL. (2009, P. 4) for organizational change is used:

> *"[Organizational change is] an alteration of a core aspect of an organization's operation. Core aspects include the structure, technology, culture, leadership, goal or personnel of an organization. An alteration or change to any or all of these elements can range from the restructuring of a single department through to a restructuring of the entire company. […]"*

2.1.2 A Famous Example of an Organizational Change Model

In 1996, Harvard professor John Kotter presented an eight-step model (see Figure 2-2) for successful organizational change for firms. It is regarded as one of the most influential change management frameworks, and has been cited multiple times in the literature.

Kotter's change process is also linked with the well-known and frequently cited *Three-Step Change Process* by Kurt Lewin, one of the most important figures in the development of organizational change (LEWIN 1947; LEWIN 1951). The structure of Kotter's eight steps may be broken down into Lewin's three phases: *unfreezing*, *change*, and *refreezing*

Kotter's eight-step model can be briefly described as follows:

- **Step 1 – Establishing a Sense of Urgency:** According to John Kotter, one of the greatest barriers to change is complacency. By complacency he means, for example, the absence of a major and visible crisis, low overall performance standards, an organizational structure where employees focus on narrow functional goals, or simply too many pep talks from senior management (KOTTER 1996, P. 40). Therefore, increasing a sense of urgency among relevant people within the organization is the first essential step in a transformation process. The goal must be that "people start telling each other 'we must do something' about the problems and opportunities" (KOTTER & COHEN 2002). Kotter presents a list of methods that work:
    - Creating visible and artificial crises (KOTTER 1996, P. 45)
    - Showing others the need for change with a compelling object that can be seen, touched, and felt (KOTTER & COHEN 2002, P. 36)
    - Showing people valid and dramatic evidence from outside the organization that demonstrates that change is required (KOTTER & COHEN 2002, P. 36)
    - Eliminating obvious examples of success such as company-owned country club facilities, large air forces or gourmet executive dining rooms (KOTTER 1996, P. 44)
    - Setting revenues, productivity, and other goals so high that they cannot be reached by conducting business as usual (KOTTER 1996, P. 44)

  Once a certain urgency level among the employees is reached every activity must be conducted to continue that urgency during the change effort (KOTTER 1996, P. 132).

- **Step 2 – Creating the Guiding Coalition:** After complacency has been reduced to a low enough level, the next step is to form a strong team which guides change. Kotter argues that "no one individual, even a monarch-like CEO, is ever able to develop the right vision, communicate it to large numbers of people, eliminate all the key obstacles, generate short-term wins, lead and manage dozens of change projects, and anchor new approaches deep in the organization's culture" (KOTTER 1996, P. 51-52). In addition, he points out that "a guiding coalition that operates as an effective team can process more information, more quickly. It can also speed the implementation of new approaches because powerful people are truly informed and committed to key decisions" (KOTTER 1996, P. 55-56). However, a certain level of credibility, skills, connections, reputation, trust, and formal authority within the team is required in order to successfully lead a change effort (KOTTER & COHEN 2002, P. 4, P. 60).
- **Step 3 – Developing a Vision and Strategy:** The next step is to clarify and set the general direction of the change effort. A vision statement, as well as a strategy of how to achieve the goals within that statement, is essential for successfully directing the change effort. According to KOTTER (1996, P. 72), the vision has to be imaginable, desirable, feasible, focused, flexible and communicable. Customers, stockholders and employees should be involved in the definition process (KOTTER 1996, P. 74). Beyond that, a strategy has to be created that shows how the vision's "picture of the future" can be accomplished (KOTTER 1996, P. 75). Altogether, it is essential that vision, strategies, plans and budgets are sufficiently aligned (KOTTER 1996, P. 71).
- **Step 4 – Communicating the Change Vision:** After having created a clear vision and strategy for the change effort, the next step is to obtain the buy-in of as many people as possible. According to KOTTER (1996), "the real power of a vision is unleashed only when most of those involved in an enterprise or activity have a common understanding of its goals and direction" (P. 85). A selection of recommendations for effectively communicating a vision statement KOTTER 1996, P. 90; KOTTER & COHEN, P. 101) is presented here:
    - Communication has to be simple and jargon-free.
    - If possible, verbal pictures, metaphors and analogies should be used.
    - Vision is diffused most efficiently when using many different forums such as small or big meetings, newspapers, or posters.
    - Repetition. Convincing the employees to look at all their daily activities through the lens of the new vision.
    - Leadership by example.
    - Speaking to fears, confusion, and distrust.
- **Step 5 – Empowering Broad-based Action:** Usually, there are a number of obstacles preventing people from implementing their ideas which have to be dealt with or removed. These can be structural barriers (no alignment with the vision), a lack of necessary skills, discouraging bosses, poorly aligned information and personnel systems or wrong performance measurement and rewarding systems

(KOTTER 1996, P. 102, P. 115; KOTTER & COHEN 2002, P. 123). In summary, the issue is generally concerned with "removing obstacles" rather than "giving power" (KOTTER & COHEN 2002, P. 5).

Figure 2-2: John Kotter's eight steps

- **Step 6 – Generating Short-term Wins:** In the ideal case, highly motivated and empowered people are now working to produce change according to a new and clear vision. However, employees should concentrate less on the future, because, as KOTTER & COHEN (2002, P. 5) argue, short-term wins are critical for providing credibility, resources, and momentum to the overall change effort. Furthermore, they show evidence that all the sacrifices made in order to institute change are worth it and thus help to keep the supervisors on board (KOTTER 1996, P. 123). To be effective, short-term wins should have these three characteristics (KOTTER 1996, P. 121-122):
    - They should be visible to as many people as possible.
    - They should be unambiguous.
    - They should be clearly related to the overall change effort.

  The first short-term results should be accomplished within six to eighteen months, depending on the size of the company (KOTTER 1996, P. 122).
- **Step 7 – Consolidating Gains and Producing More Change:** After the first successes in form of short-term wins, it is time to celebrate – but minimally at this juncture. Instead, it is essential not to "let up", i.e., to "continue with wave after wave of change, not stopping until the vision is reality" (KOTTER & COHEN 2002, P. 159). Change leaders have to continually look for ways to maintain urgency and encourage employees to start more and bigger change projects (KOTTER & COHEN 2002, P. 159).

- **Step 8 – Anchoring New Approaches in the Culture:** "Cultural change comes last, not first" (KOTTER 1996, P. 155). Only in the best cases and after "making change stick" can a new culture with different norms of behavior and shared values arise (KOTTER & COHEN 2002, P. 5). When this occurs, it is important not to stop this process. The elements and polices of the new culture have to be continually exhibited, and the reasons the old one failed have to be demonstrated. Beyond that, promotion systems have to make sure that people who act according to new values and norms are placed in influential and visible positions (KOTTER & COHEN 2002, P. 177). Moreover, people have to be replaced if they are reluctant to change according to the new culture (KOTTER 1996, P. 157).

Kotter emphasizes the importance of finishing every step before proceeding with the next one.

2.2 Theory on Self-Assessment

2.2.1 Role of Self-Assessment in Organizational Change

The literature highlights the importance of differentiating between two general types of organizational change (FORD & EVANS 2001, P. 10-11). **Strategic change** is organizational change resulting from strategy development and implementation. This type of organizational change is generally externally focused and related to significant customer, market, product/service, or technological opportunities and challenges. **Process change** is organizational change resulting from self-assessment activities. This type of organizational change might be viewed as an operations exercise. Process change results from an examination of organizational processes and aims at changing organizational "infrastructures," i.e., the organizational processes for achieving results. Process change is often confined to a particular unit, division, or function of the organization (FORD & EVANS 2001, P. 11). Figure 2-3 compares the main differences between strategic and process change. It is important to mention that the Product Development Self-Assessment Framework (PDSAT Framework) presented in this thesis focuses primarily on process change.

Self-assessment (the term self-assessment as it is used in this thesis is defined in chapter 2.3.1) is a single event in the organizational change process. It is linked with two important process types in the field of organizational change. The first process type regards the firm-level organizational transformation processes on how to create and sustain organizational change, often with a time frame of years. A frequently cited example is John Kotter's eight-step process (see chapter 2.1.2). Self-assessment can play a decisive role in an organizational transformation process. However, it may have a different scope and different goals depending on the particular stage of a company in its organizational transformation process. The second process type regards problem solving processes for implementing improvement ideas. Their time frame is usually much shorter. Examples are the Six Sigma DMAIC Cycle (PYZDEK & KELLER 2009) or the Deming Cycle (DEMING 2000; SHEWHART 1986). The successful application of self-assessment may lead to a variety of different improvement ideas. Problem solving processes can be used for implementing these ideas

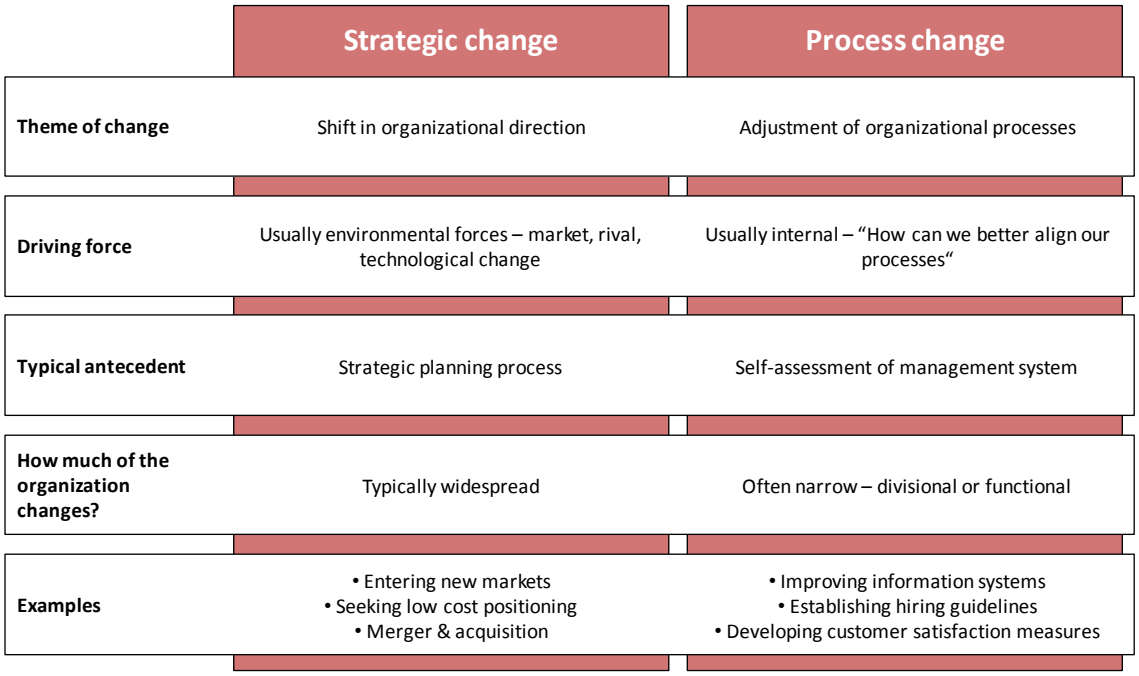

Figure 2-3: Strategic change versus process change (FORD & EVANS 2001)

Self-assessment activities belong to the category of organizational assessments. According to LAWLER ET AL. (1980) **organizational assessments** in general refer to the process of measuring the effectiveness of an organization from a behavioral or social-system perspective. The unit of analysis of organizational assessments is the organizational system and its relationship to performance. Hence, organizational assessments typically have a holistic perspective and do not focus on individual parts of the organization in most instances.

Like organizational assessments, **self-assessment activities** are aimed at increasing quality awareness, driving quality improvement activities, and improving business performance (VAN DER WIELE ET AL. 2000, P. 20). However, FORD & EVANS (2001, P. 9) indicate that, in contrast to organizational assessments, self-assessment activities are primarily governed by an organization's managers, although external consultants may be included to enhance objectivity. Self-assessment activities provide managers with process-oriented feedback that enables them to obtain a snapshot of how well organizational processes are functioning, and of where process improvements can be made (FORD & EVANS 2001, P. 14). Moreover, self-assessment activities provide an instrument to coordinate and define direction for quality improvement activities in the organization or parts of it (VAN DER WIELE ET AL. 2000, P. 15). Therefore, they drive the improvement of key managerial processes that affect organizational performance (FORD & EVANS 2001).

In their comprehensive survey study about self-assessment practices used by American Firms VAN DER WIELE ET AL. (2000) identified four main characteristics of self-assessment:

- Data gathering and scoring
- Discussing strengths and weaknesses
- Developing an improvement plan
- Linking the improvement plan to the business plan

The authors point out that that these four steps promote organizational learning on the basis of communication and feedback of the self-assessment results.

Additionally, the survey study found that companies utilizing self-assessment reported greater returns on sales than firms that did not utilize self-assessment. However, the authors do not believe that self-assessment alone accounted for this difference, but conclud that the adoption of self-assessment may indicate a level of development that heightens the probability of achieving such results (VAN DER WIELE ET AL. 2000).

A further finding from this survey study is that self-assessment generally led to better agreement about the organization's strengths and improvement opportunities, and better planning. Organizations utilizing self-assessment also appeared to realize better improvements in market share and profitability than organizations that did not practice self-assessment.

2.2.2 Reasons for Self-Assessment

In their study about organizational self-assessment practices used by American Firms VAN DER WIELE ET AL. (2000, P. 15) also investigated why companies use organizational self-assessment. By self-assessment the authors referred primarily to checklists and criteria defined with the own organization. However, they also numbered the Malcom Baldrige National Quality Award (MBNQA 2009), the European Quality Award (EFQM 2010) and other national quality awards among self-assessment.

The most important reasons for deciding to conduct the self-assessment found in their study were, in descending order:

- To achieve quality system registration (e.g., ISO 9000)
- To direct the improvement process
- To manage the business
- To find opportunities for improvement
- To provide new motivation for the improvement process
- To link quality management with strategic planning
- To strive for cost reduction

- To focus on the TQM (Total Quality Management) model of management
- Customers demand for evidence of self-assessment
- To benchmark against others
- Internal champion within the unit
- Pressure from headquarters
- To stimulate internal competition
- To pursue a quality award
- Competitors were using self-assessment

2.2.3 Benefits from Self-Assessment

The use of self-assessment leads to a number of benefits for the organization. Some of them have already been mentioned in introducing self-assessment in chapter 2.2. In the following three paragraphs additional self-assessment benefits found in the literature are briefly summarized.

TENNANT & ROBERTS (2003, P. 86) regard self-assessment as an ideal methodology for both performance measurement and knowledge transfer to identify new best practice and process re-engineering. However, they particularly consider the new product introduction process in their research.

FORD & EVANS (2001, P. 10) point out that anecdotal evidence suggests that self-assessment frequently leads to organizational change, stemming from managerial actions to improved management processes and practices based on assessment findings.

VAN DER WIELE ET AL. (2000, P. 20) mention five major benefits from self-assessment. First, self-assessment provides strategic direction for the dimensions of quality. Second, it helps to align quality processes and activities throughout an organization by defining quality in terms of principles that allow individual operating units of large organizations to use it as a means of setting goals and monitoring these. Third, self-assessment develops short- to medium-term targets for the organization and various business units. Fourth, it links quality to the strategic planning process. Finally, self-assessment serves to focus attention on the means of achieving better organizational performance. All this five statements about the benefits of self-assessment are based on the author's extensive survey study on the use of self-assessment in American companies.

2.2.4 Barriers to the Use of Product Development Self-Assessment Tools

A number of hurdles prevent companies from successfully using a self-assessment tool for product development. It is assumed that companies, in contrast to academia, often do not know about all the benefits of using self-assessment. In order to gain descriptive evidence

about what companies know and think about self-assessment in product development, and about why companies do or do not use assessment tools to evaluate their product development organization, an industry focus group (US aerospace and defense industry) survey was sent out. Details on the survey design and the survey objectives can be found in Chapter 3.5. Results from the survey are presented throughout this thesis.

The first significant result from the industry focus group survey is that only two out of thirteen respondents (about fifteen per cent) reported a use of product development assessment in their organization (see Figure 2-4). Given that the respondents work for well-known companies in the aerospace and defense industry (see Figure 3-3), this is a rather low percentage. In comparison, in their survey about self-assessment practices by selected American firms, VAN DER WIELE ET AL. (2000) indicated a much higher percentage of self-assessment use. Seventy-one percent of the all respondents (two-hundred and six respondents) revealed that their firms were using self-assessment. However, an important difference between these two surveys is that the industry focus group survey in this thesis focuses on product development assessment, whereas the survey by VAN DER WIELE ET AL. (2000) focuses on organizational assessment in general. Nevertheless, it is assumed that the barriers to organizational assessment and product development assessment are similar.

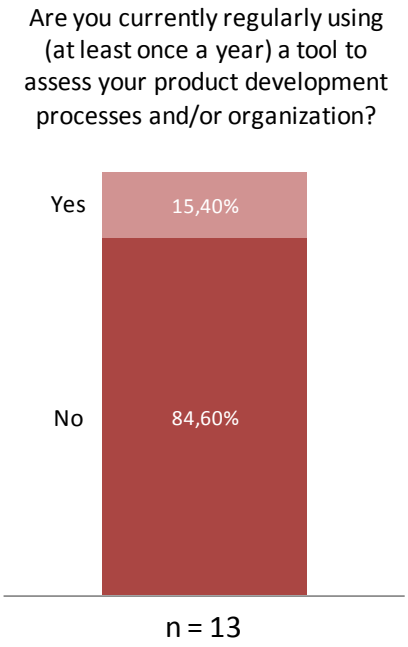

Figure 2-4: Use of PD self-assessment tools

Another part of industry focus group survey asked the respondents to rate different barriers to the use of self-assessment tools in product development on a scale from "does not apply at all" to "fully applies." Figure 2-5 shows the results.

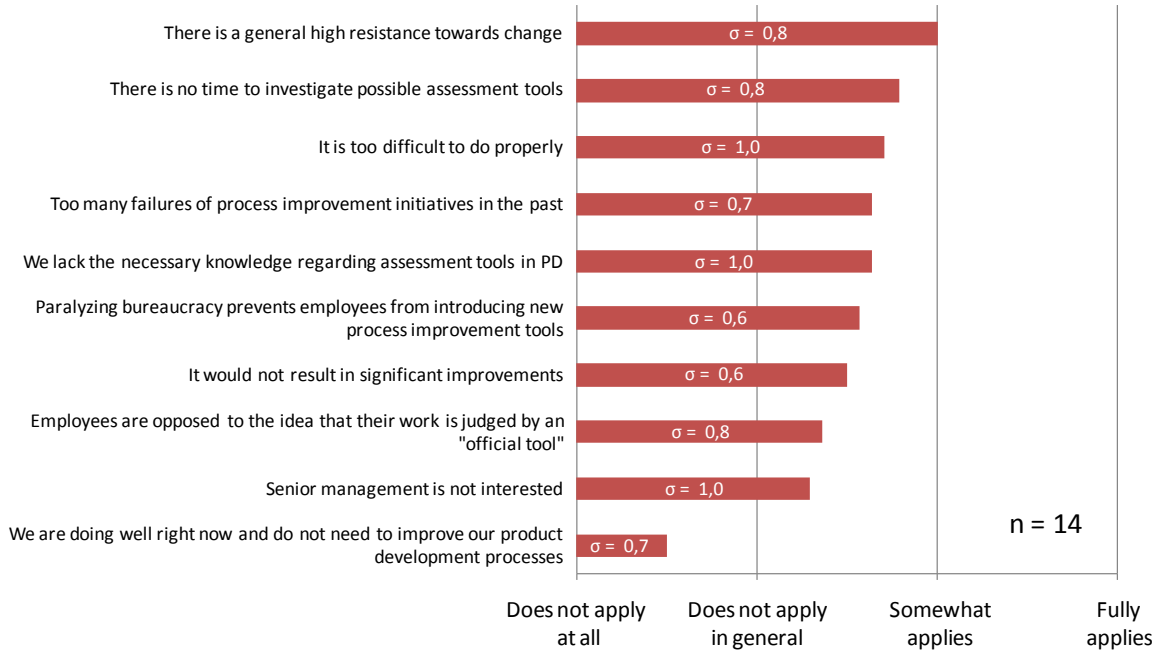

Figure 2-5: Barriers to the use of PD self-assessment tools

The statement that was agreed to most strongly was *"There is a general high resistance towards change."* This statement suggests evidence that in developing as well as using product development self-assessment tools, practices from the field of organizational change have to be taken strongly into consideration. The results of the self-assessment of the current state of a product development system have to be linked with ongoing business improvement processes. Moreover, the circumstances in the respective organization have to be considered. The second strongest agreement was suggested by the statement *"There is no time to investigate possible assessment tools."* The third strongest agreement was demonstrated in the statement *"It is difficult to do properly."* This is a significant response since it may lead to the assumption that companies expect a holistic and integrated PD self-assessment approach with helpful guidelines and formalized processes on how to use and implement the self-assessment tool in their particular environment.

The statement that applied least strongly was *"We are doing well right now and do not need to improve our product development processes."* This statement shows that the majority of respondents are not confident about the current state of their product development system. Other statements that did not apply in general were *"Senior management is not interested"* and *"Employees are opposed to the idea that their work is judged by an official tool."* These statements show that there is a general interest in improving product development processes, both among employees and senior management.

2.3 Theory on PD-Related Self-Assessment Tools

Since the main goal of this thesis is the development of a self-assessment tool for product development, the literature review in the chapters 2.3.1 and 2.3.2 focuses particularly on product development- and innovation management-related evaluation instruments. Twelve self-assessment tools could be identified in the literature, they are shown in Table 2-1 and Table 2-2). Chapter 2.4 presents the shortcomings of existing research as well as the research gap.

2.3.1 Self-Assessment Definitions from the Literature

Reviewing the literature on product development-related self-assessment tools, one of the first observations is that terms such as *audit*, *self-assessment audit*, *self-audit* or *self-assessment* are often used interchangeably and rarely clearly defined. However, this is not always the case. A few authors (AINSCOUGH ET AL. 2003, TENNANT & ROBERTS 2003) clearly differentiate between *audit* and *self-assessment*.

AINSCOUGH ET AL. (2003, P. 429), for example, regard continuous improvement through organizational learning as the main focus of self-assessment. Some authors criticize the more conventional and accepted audit and review approach as inadequate for achieving this objective and suggest self-assessment as a preferable alternative (TENNANT & ROBERTS 2003, P. 77; AINSCOUGH ET AL. 2003, P. 429).

In describing the application of the European Quality Award (EFQM 1995), the European Foundation for Quality Management provides a definition of *self-assessment audit*:

> *"[A self-assessment audit is] a comprehensive, systematic and regular review of an organization's activities and results referenced against a model of business excellence. [The] process allows the organization to discern clearly its strengths and areas in which improvements can be made and culminates in planned improvement actions which are monitored for progress. The process offers the organization the opportunity to learn."* (EFQM 1995)

CHIESA ET AL. (1996, P. 106) provide a definition of *audit*:

> *"Audit goes beyond measuring: it builds on this to identify gaps between current and desired performance, to identify where there are problems and needs, and to provide information that can be used in developing action plans to improve performance."*

AINSCOUGH ET AL. (2003, P. 426) are not in favor of the term *audit* and point out it that fosters a "pass the audit" mentality that does not encourage a culture of process improvement and organizational learning.

TENNANT & ROBERTS (2003, P. 80) state that the purpose of using a self-assessment process *"(...) is to create an organisational culture where 'real time' learning to improve the process is a key objective through application of a rigorous approach and deployment."*

HALLGREN (2009) presents a completely new approach towards an innovation audit that is based on "high-involvement innovation."

Other authors present self-assessment or audit tools without formally defining these terms at all (GARDINER & GREGORY 1996, MCQUATER ET AL. 1998, CORMICAN & O'SULLIVAN 2004). Others do not explicitly use the prefix "self" for their approach, although their approach can be used in a self-administered way (PROBERT ET AL. 2000, CONN ET AL. 2009).

In summary, after reviewing the literature the difference between the two terms *audit* and *self-assessment* has not been made clearer. For this thesis, the two terms are used according to their public perception. *Audit* is seen as an expression for an assessment involving external assessors. *Self-assessment* is regarded as an assessment performed in a self-administered way within the company.

2.3.2 Literature Review on Relevant PD-Related Self-Assessment Tools

This subchapter compares twelve PD-related self-assessment tools (see Table 2-1 and Table 2-2) according to a number of relevant dimensions:

- Process scope
- Purpose
- Sources
- Measurement method
- Validation

The dimensions *innovativeness* and *adaptiveness* introduced in the motivation of this thesis are considered to be too general for a sufficient comparison.

2.3.2.1 Process Scope

Although the main topic of the twelve assessment tools listed in Table 2-1 and Table 2-2 can be subsumed under the heading of technology innovation management, the individual tools vary in their process scope. MCQUATER ET AL. (1998), RADNOR & NOKE (2002), CONN ET AL. (2009), and KAHN ET AL. (2006) present approaches that focus on the assessment of the new product development (NPD) process. TENNANT & ROBERTS (2003) and GARDINER & GREGORY (1996) have developed assessment methods with a very similar scope, but refer to new product introduction (NPI) as their application area. A frequently cited audit on a slightly higher level (Technical Innovation Management) has been developed by CHIESA ET AL. (1996). PROBERT ET AL. (2000) and CORMICAN & O'SULLIVAN (2004) have a similar scope to their approaches; however, they refer to technology management and product innovation management (PIM) as the application area of their assessment tools. AINSCOUGH ET AL. (2003) and CAFFYN (1999) address just one important aspect of the product development process (concurrent engineering and continuous improvement). An utterly different innovation audit based on high-involvement (participation and learning with a feedback mechanism) has been developed by HALLGREN (2009).

2.3.2.2 Purpose

The purpose of the twelve self-assessment tools can be summarized into three main types. The **identification of improvement opportunities**, i.e., highlighting problems and needs, and providing information that can be used in developing action plans for performance improvement, is the prevalent intent of the majority of the twelve compared tools (CHIESA ET AL. 1996, AINSCOUGH ET AL. 2003, CORMICAN & O'SULLIVAN 2004, TENNANT & ROBERTS 2003, CAFFYN 1999, MCQUATER ET AL. 1998, CONN ET AL. 2009, PROBERT ET AL. 2000, GARDINER & GREGORY 1996, RADNOR & NOKE 2002, KAHN ET AL. 2006). The second major purpose of using PD self-assessments is **business diagnosis**, i.e., assessing the current state and gap against an "ideal" state of a particular unit of analysis (project-level, program-level, firm-level) of a PD organization (CHIESA ET AL. 1996, AINSCOUGH ET AL. 2003, CORMICAN & O'SULLIVAN 2004, CAFFYN 1999, CONN ET AL. 2009, GARDINER & GREGORY 1996, RADNOR & NOKE 2002, KAHN ET AL. 2006). The third main purpose identified is **benchmarking**, either within a company or with other companies (CHIESA ET AL. 1996, AINSCOUGH ET AL. 2003, CORMICAN & O'SULLIVAN 2004, CONN ET AL. 2009, GARDINER & GREGORY 1996, RADNOR & NOKE 2002, KAHN ET AL. 2006). The self-assessment by HALLGREN (2009) can be regarded as an exception. Its main purpose is facilitating employee involvement and implementing employee-selected improvement projects.

2.3.2.3 Sources

The development of the assessment tools presented in Table 2-1 and Table 2-2 is based on a variety of different sources. Most of the tools draw from a literature review either on existing best-practice models, published papers, books or international conferences (CHIESA ET AL. 1996, AINSCOUGH ET AL. 2003, TENNANT & ROBERTS 2003, CONN ET AL. 2009, PROBERT ET AL. 2000, GARDINER & GREGORY 1996, KAHN ET AL. 2006). Authors such as MCQUATER ET AL. (1998) and RADNOR & NOKE (2002) use a combined case study and literature review approach to develop their tools. CORMICAN & O'SULLIVAN (2003) have developed a self-assessment tool that is solely based on their own research on product innovation management. The continuous improvement self-assessment tool created by CAFFYN (1999) is a research-based tool, too. The innovation audit based on high-involvement developed by HALLGREN (2009) uses material from traditional innovation audits and from literature on high-involvement innovation.

Title/Year/Authors	Process scope	Key characteristics	Sources	Measurement method	Field-tested in companies
"Development of a Technical Innovation Audit", 1996 V. Chiesa, P. Coughlan, C.A. Voss	TIM Technical Innovation Management	**1. Process Audit:** Innovation Scorecard with 4 scales and in-depth audit with open questions; 23 metrics **2. Performance Audit:** Only metrics; no scale; 40 metrics	Technological product and process innovation from a literature review	- Maturity/capability levels - Open questions - Best practices	Two companies
"A self-assessment tool for implementing concurrent engineering through change management", 2003 M. Ainscough, K. Neailey, C. Tennant	CE Concurrent Engineering	**1. CE Self-assessment model** - 6 main components - 32 metrics **2. Change management framework** - „Implementation Strategy Tool" - „Generic Planning and Guidance Tool" - „Tailoring Process" - „Generic Planning and Guidance Tool" - „Tailoring Process"	Literature on concurrent engineering and change management	- Best practices/Likert scale	One company
"Auditing best practice for effective product innovation management", 2004 K. Cormican, D. O'Sullivan	PIM Product Innovation Management	**1. PIM Best Practice Model** **2. PIM Scorecard** - 5 main components - 50 metrics	Based on the author's research which centers around product innovation management (PIM)	- Best practice/Likert scale	Eight companies
"The creation and application of a self-assessment process for new product introduction", 2003 C. Tennant, P. Roberts	NPI New Product Introduction	30 questions on primary, secondary and tertiary NPI best practice criteria	- Obtained copies of company procedures - Reviewed published papers within the IMVP study - Attended international conferences	- Open questions	One company
"Development of a continuous improvement self-assessment tool", 1999 S. Caffyn	CI Continuous Improvement	**1. CI capability model** **2. CI self-assessment tool** 32 page booklet Complicated measurement scale The tool enables the users to evaluate the extent to which each key CI behavior is present in the unit, both in terms of how developed the behavior is (superficial or mature) and how widespread.	- Research-based tool - Based on a model which seeks to address the underlying behaviors associated with successful continuous improvement	- Maturity/capability levels	Pilot testing at three companies
"The management and organisational context of new product development: Diagnosis and self-assessment", 1998 R.E. McQuater, A.J. Peters, B.G. Dale, M. Spring, J.H. Rogerson, E.M. Rooney	NPD New Product Development	NPD self-assessment methodology **5 main components** **43 open questions**	Combining case study evidence with the literature	- Open questions	Yes

Table 2-1: PD-related self-assessment tools – Part 1

Table 2-2: PD-related self-assessment tools – Part 2

Title/Year/Authors	Process scope	Key characteristics	Sources	Measurement method	Field-tested in companies
"Assessing the management of innovation with software tools: an application of innovationEnterprizer", 2009 S. J. Conn, M.T. Torkkeli, I. Bitran	NPD New Product Development But measures more PIM	**InnovationEnterprizer** NPD managerial decision making software Quantitative measurement with inbuilt algorithm Scale from 0 to 100 Measures how well a company is managing for innovation within each of the units on each of the dimensions	Scientific, academic and quality industry research resources	- Maturity levels	One company
„Development of a structured approach to assessing technology management practice", 2000 D. R. Probert, R. Phaal, C. J. P. Farrukh	TM Technology Management	**TMAP Procedure** Technology management assessment procedure based on a series of facilitated workshops	Based on a process model of technology management by M. J. Gregory	- No formal measurement system - Tool requires a series of facilited workshops	Eleven companies
An audit-based approach to the analysis, redesign and continuing assessment of a new product introduction system, 1996 G. S. Gardiner, M. J. Gregory	NPI New Product Introduction	**1.NPI process model** **2. Roles in NPI** **3. Good practice** question areas 100 statements 5 point Likert scale	Based on good practices identified from the literature, which have been compiled into a simple database	- Best practices/Likert scale	One company
Innovation Compass: A Self-audit Tool for the New Product Development Process, 2002 Z. J. Radnor, H. Noke	NPD New Product Development	**Innovation Compass** Circle A: quantitative benchmarking with 19 metrics Circle B: provides qualitative data on the 19 metrics (quotations from a case study) Circle C: provides qualitative context data (also from a case study)	- Previous audit tools - Detailed literature analysis	- Best practices/Likert scale	One company
How to Use an Innovation Audit as a Learning Tool: A Case Study of Enhancing High-Involvement Innovation, 2009 E. W. Hallgren	High Involvement Innovation	The audit is regarded as a process in which employee involvement and implementing employee-selected improvement projects are its main goals. Is a new perspective on innovation audits, building on a criticism of traditional ways of doing them.	- Literature on tradtitional innovation audits - Literature on high-involvement innovation	- No formal measurement system	One company
"PERSPECTIVE: Establishing an NPD Best Practices Framework", 2006 K. B. Kahn, G. Barczak, R. Moss	NPD New Product Development	**NPD best practices framework** - 6 main components - 6 metrics	Review of recent benchmarking studies of NPD best practices	- Maturity levels - Best practices	No

2.3.2.4 Measurement Method

By comparing the twelve assessment approaches three main measurement methods have been identified:

- **Capability/maturity scale**, i.e., different levels of maturity ranging from poor performance (lowest level) to exceptional performance (highest level). Each level is briefly described with a few sentences.
- **Likert scale**, i.e., the measurement of the level of agreement with a statement or best practice
- **Open questions**, i.e., asking detailed questions on a set of best practice categories in order to provide focus and address the specific circumstances of a respective PD organization

AINSCOUGH ET AL. (2003), CAFFYN (1999), CONN ET AL. (2009) and KAHN ET AL. (2006) have developed a real-capability or maturity-based measurement scale. CORMICAN & O'SULLIVAN (2003) and GARDINER & GREGORY (1996) use a Likert scale approach, i.e., they measure the level of agreement with a statement or best practice. TENNANT & ROBERTS (2003) and MCQUATER ET AL. (1998) use an utterly different approach; they ask open questions regarding the NPI/NPD process in order to focus on certain aspects. CHIESA ET AL. (1996) draw on a combination between capability measurement and open questions. The two publications of PROBERT ET AL. (2000) and HALLGREN (2009) provide no detailed information about the measurement method of their tools.

2.3.2.5 Validation

In their publication *Development of a Technical Innovation Audit*, CHIESA ET AL. (1996, P. 116) highlight that testing and issuing an audit/self-assessment approach usually proceeds through three phases:

- The first phase is **field testing**, which results in modifications and improvement.
- The second phase is **implementation in the field**.
- The third phase is **longer term testing**. This kind of testing requires companies that have already used the audit/self-assessment method for some time, have found improvement opportunities and have taken action. Therefore, it is possible to evaluate whether the improvement action has been successful or not.

None of the twelve assessment approaches presented in Table 2-1 and Table 2-2 underwent the third phase of testing. Some were implemented in the field, but the publications provide no information as to whether the companies are still using the approaches. All twelve assessment approaches, except the one presented by KAHN ET AL. (2006), were pre-tested in the field. Case study research (EISENHARDT 1989; EISENHARDT 1991; YIN 2009) was the most commonly used research approach for applying and adapting the assessment methods at one or more companies.

2.4 Formulation of the Research Gap

In this chapter a gap analysis is performed. Table 2-3 compares the twelve PD-related self-assessment tools in terms of four main requirements (see chapter 4.2). The requirements are: 1. Focus on proven PD best practices; 2. Formalized implementation process; 3. Tool customization guidelines; and 4. Integration with other process improvement approaches. These requirements have been derived from interviews at a major American defense contractor (see chapter 3.4) and from an industry focus group survey (US aerospace and defense) (see chapter 3.5).

Author(s) of the self-assessment tool	Focus on proven PD best practices	Formalized implementation process	Tool customization guidelines	Integration with other process improvement approaches
CHIESA ET AL. 1996	◐	○	○	○
AINSCOUGH ET AL. 2003	◐	◐	◐	○
CORMICAN & O'SULLIVAN 2004	◐	◐	○	○
TENNANT & ROBERTS 2003	●	●	○	○
CAFFYN 1999	◐	●	○	○
MCQUATER ET AL. 1998	◐	○	○	○
CONN ET AL. 2009	◐	○	○	○
PROBERT ET AL. 2000	◐	●	○	○
GARDINER & GREGORY 1996	●	◐	◐	○
RADNOR & NOKE 2002	●	○	○	○
HALLGREN 2009	◐	◐	○	○
KAHN ET AL. 2006	●	○	○	○

Legend: ○ = does not apply; ◐ = somewhat applies; ● = fully applies

Table 2-3: Comparison of twelve PD-related self-assessment tools along four main requirements

There are a number of shortcomings of existing self-assessment tools:

The first shortcoming regards the **process scope** of the majority of the assessment tools. One fourth of the twelve identified assessment approaches have a relatively high-level process scope on technical innovation management and thus do not address the product development process in a sufficient way (CHIESA ET AL. 1996; CORMICAN & O'SULLIVAN 2004; PROBERT ET AL. 2000). Other tools focus on very specific parts of the overall innovation process such as

the deployment of continuous improvement (CAFFYN 1999) or concurrent engineering (AINSCOUGH ET AL. 2003) and therefore address too small a part of the product development process. Four out of the twelve identified assessment approaches put an emphasis on new product development (NPD)/new product introduction (NPI) (GARDINER & GREGORY 1996; KAHN ET AL. 2006; RADNOR & NOKE 2002; TENNANT & ROBERTS 2003). However, only GARDINER & GREGORY 1996, RADNOR & NOKE 2002 and TENNANT & ROBERTS 2003 cover a broad and detailed enough extent of the product development process.

Second, most of the self-assessment tools found in the literature do not provide **guidelines and instructions of how to implement** them. Exceptions are CAFFYN (1999), PROBERT ET AL. (2000) and TENNANT & ROBERTS (2003). Although CAFFYN (1999) recognizes the importance of providing a formalized self-assessment implementation process (*"The process followed in carrying out the self-assessment is just as important as the end assessment scores."*) no tool has been found that consequently uses a truly integrated approach. From the author's point of view, providing a simple but sufficiently comprehensive and formalized process on how to use and implement the self-assessment within the company is the most promising lever in diffusing and promoting the use of self-assessment tools.

The third major shortcoming of the twelve self-assessment tools is the **lack of opportunity to customize** them according to specific needs. The vast majority of the tools are based on one model for every type of organization and do not provide opportunities to tailor them to an organization's specific circumstances. Two publications recognize the idea of customization. GARDINER & GREGORY (1996) mention the possibility of customization, AINSCOUGH ET AL. (2003) provide a very high-level tailoring process. The author of this thesis believes that a well formulated customization process will considerably improve most of the tools. Formal customization guidelines will enable a more focused and therefore a less extensive approach.

Fourth, a major weakness of all compared product development self-assessment tools is their **lack of integration with established and popular company-wide process improvement approaches**. Product development-related self-assessment tools are insufficiently classified, if classified at all, and linked to firm-level process improvement frameworks. Authors such as AINSCOUGH ET AL. (2003, P. 429) recognize this and point to company-wide holistic frameworks such as the Malcom Baldrige National Quality Award (MBNQA) or the European Quality Award (EFQM) as a prerequisite to effective self-assessment. However, no publication has been found that formally links product development self-assessment tools to company-wide assessment frameworks.

In summary, some authors of the twelve self-assessment tools have recognized parts of the shortcomings of existing self-assessment tools. Hence, there are PD-related self-assessment tools that address one or two of the four identified requirements highlighted in this paper. However, no tool has been found that addresses all four requirements.

3 Research Approach

This chapter highlights the research approach for developing the PDSAT Framework. Chapter 3.1 defines important key terms that are used throughout this thesis. Chapter 3.2 highlights the research approach. The subsequent chapters explain how different research methods (literature review, survey, interviews) were used and combined for developing the PDSAT Framework.

3.1 Definitions

Before outlining the research approach certain important key terms have to be defined:

- **Innovation:** Whereas invention is considered as the creation of a new idea, innovation is more encompassing, and includes the process of developing and implementing a new idea (VAN DE VEN ET AL. 1999, P. 9). Innovations can be differentiated by *technical innovations* (new technologies, products, services) and *administrative innovations* (new procedures, policies, organizational forms) (VAN DE VEN ET AL. 1999, P. 9).
- **Product development:** According to ULRICH & EPPINGER (2008) product development is *"(…) the set of activities beginning with the perception of a market opportunity and ending in the production, sale and delivery of a product"* (P. 2). They see product development as an interdisciplinary activity that involves nearly all functions of a firm. Central functions are marketing, design, and manufacturing (ULRICH & EPPINGER 2008, P. 3).
- **Self-assessment:** Self-assessment is "*[a comprehensive, systematic and regular review of an organization's activities and results referenced against a model of business excellence. [The] process allows the organization to discern clearly its strengths and areas in which improvements can be made and culminates in planned improvement actions which are monitored for progress. The process offers the organization the opportunity to learn."*(EFQM 1995)
- **Project:** *"A project is a temporary endeavor undertaken to create a unique product, service, or result."* (PMI 2004)
- **Program:** *"[A program is a] group of related projects managed in a coordinated way to obtain benefits and control not available from managing them individually. Programs may include elements of related work outside of the scope of the discrete projects in the program."* (PMI 2004)

3.2 Detailed Research Approach

A structured problem-solving approach is used to pave the way to a formalized development of the new PDSAT Framework. This problem-solving approach is called *The Munich Procedural Model* (LINDEMANN 2009) and shown in Figure 3-1.

The *Munich Procedural Model* was originally developed to support the planning of a development process. Another purpose was to provide assistance in the analysis and reflection of the development procedure. The *Munich Procedural Model* offers a structured approach to complex problem solving, on the one hand. On the other hand, it maintains the necessary flexibility to adapt to changes, which happen frequently, especially in product development.

The research approach for developing the PDSAT Framework is based on the *Munich Procedural Model (MPM)*. However, some parts of the *Munich Procedural Model* were adapted slightly in order to meet the requirements of academic problem solving.

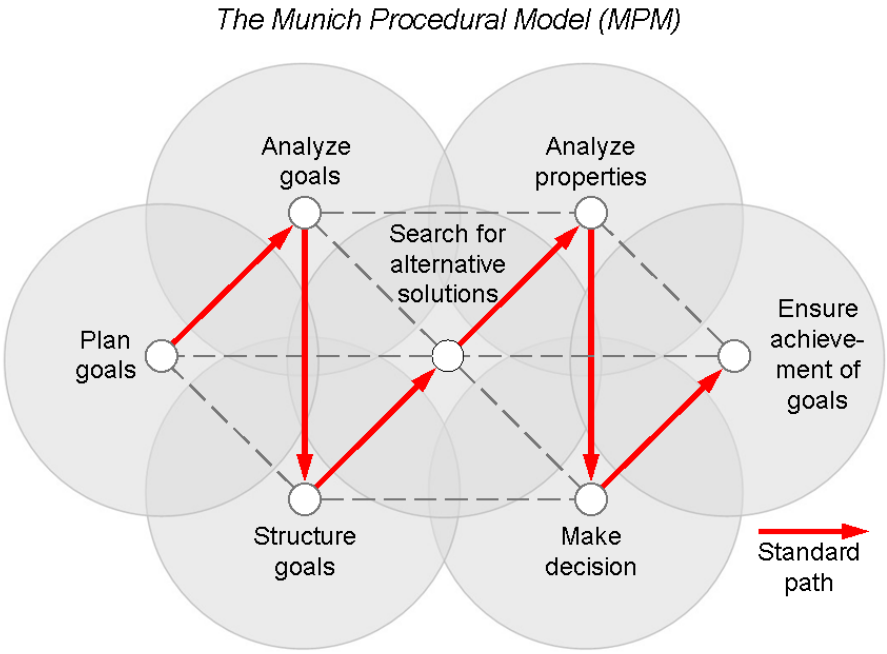

Figure 3-1: The Munich Procedural Model (MPM)

Figure 3-2 shows a graphical representation of the research approach. It highlights the seven steps of the *Munich Procedural Model* (on the left side) and the applied social research methods (on the right side). The dashed arrows indicate the influence of the applied social research methods (literature review, interviews, and survey) on particular stages of the problem-solving approach.

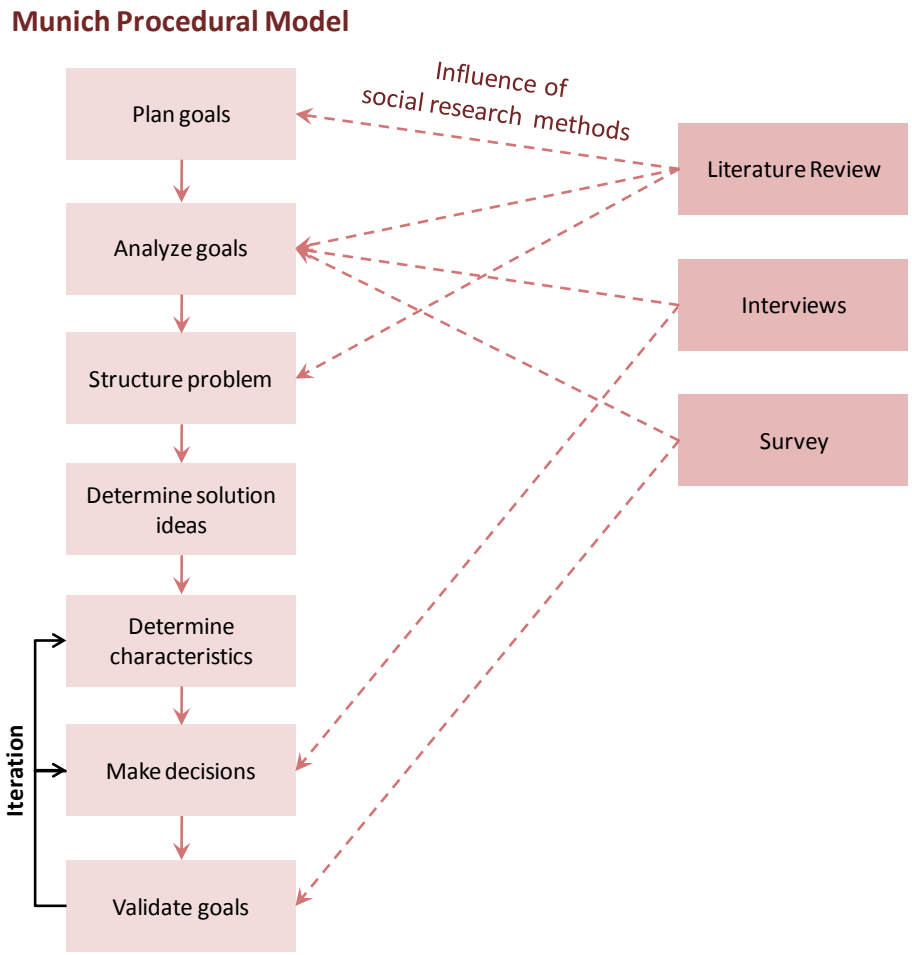

Figure 3-2: Research approach

In the following, the single steps of the research approach are described in detail. It is important to mention that the different steps overlap considerably in reality.

- **Plan Goals:** In order to become more familiar with the topic, the first step was to read about existing PD self-assessment tools and related areas such as (lean) product development, organizational change, and change management in the context of self-assessment. Subsequently, a more detailed and focused literature review with the main goal of identifying shortcomings of present product development self-assessment tools was accomplished. The literature also helped to understand the role and goals of self-assessment tools.
  Additionally, discussions with research assistants from the Lean Advancement Initiative at MIT helped to shape the view of how a more powerful and effective product development self-assessment tool would have to look. Thus, it was possible to establish first the target requirements for the PDSAT Framework at the end of this step.

- **Analyze Goal:** The main goal of this step was the formulation and documentation of requirements for the development of the PDSAT Framework. The requirements were mainly derived from two interview sessions (see chapter 3.4) at a major American defense contractor, as well as from an industry focus group survey (see chapter 3.5) with respondents from the US aerospace and defense industry. Beyond that, deliberations about the relationships between the different requirements were made. These deliberations served as preparation for designing a product development model, which would form the theoretical basis for the PDSAT Framework.
- **Structure Problem:** The main goal of this step was the development of a product development model serving as a basis for the new PDSAT Framework. Literature on strategic management theories was reviewed in order to guarantee a smooth integration of the new product development model in academia. At the end of this step, a model for product development was formally defined and documented.
- **Determine Solution Ideas:** The goal of the fourth step was to determine different solution ideas for the development of the PDSAT Framework. Existing academic work from LAI/MIT was analyzed in order to find out to what extent it could be used. Self-assessment tools such as the LESAT (LAI Enterprise Self-Assessment Tool), as well as product development-related surveys such as PERFORM (2003) and HOPPMANN (2009) were examined in detail. Suitable fragments were extracted and analyzed. Additionally, best practices on product development and change management from a wide collection of different sources found in the literature review were identified. Part of this step also involved analyzing how to combine and structure the different fragments into the new PDSAT Framework.
- **Determine Characteristics:** This step focused on the analysis of previously extracted fragments and identified best practices, as well as on the analysis of the structure that puts these fragments together. The results served as a basis for creating a first draft of the PDSAT Framework in the next step.
- **Make Decisions:** The goals of this step were to decide what the final PDSAT Framework should contain and how these items should be structured. However, a few iterations were run through before an ultimate decision was made.
  A first draft of the PDSAT Questionnaire and a formalized nine-step implementation process were generated. The PDSAT Questionnaire and the implementation process were discussed and interpreted in two meetings with employees from a major American defense contractor. Based on these discussions, the final structure of the PDSAT Questionnaire was defined. However, parts of the questionnaire and the implementation process were still refined at later dates.
- **Validate Goals:** The final version of the new PDSAT Framework has not been validated yet. However, it was presented and discussed at an LAI research seminar. Additionally, a survey was sent out to an industry focus group (see chapter 3.5) in order to get feedback on the proposed 9-step PDSAT Implementation Process (see chapter 4.5).
  The original plan was to implement the new PDSAT Framework with a couple of industry partners for a pre-test; however, this was not possible within this thesis.

After the original implementation plan was postponed twice, there was not enough time to do a pre-test of the PDSAT Framework since the time frame of this thesis was limited.

The overall development of the PDSAT Framework stemmed from a qualitative research approach, and mainly from a detailed literature review, interviews and an industry focus group survey. The following subchapters provide additional information on these three research methods.

3.3 Literature Review

The author did a comprehensive literature review on a number of different topics, such as success factors in product development, (Lean) product development, (self-)assessment tools, product development performance measurement, strategic management, organizational change, change management, case study research and survey research. The purpose of the literature review was to obtain knowledge in different research topics relevant to the development of a PD self-assessment tool at the beginning of the study. Furthermore, the literature also helped to develop sharper and more insightful research questions.

3.4 Interviews

Two interview sessions were held with employees of a major American defense contractor. The meetings took place at the office of the company and involved three employees from the staff organization. The employees had different backgrounds. One employee held the title of "Design for Six Sigma Lead"; the two other employees were from the "Engineering Process Group".

The interviews were carefully designed and conducted. Literature on case study research (EISENHARDT 1989; EISENHARDT 1991; YIN 2009) was reviewed before the meetings in order to make sure the interviews were conducted in a proper way. The interviews had three main goals:

- Obtain insightful information about what the company thinks about a new PD self-assessment approach in general
- Obtain insightful information about what the requirements for a new PD self-assessment approach are
- Obtain feedback on the proposed 9-step-model about how to implement the PDSAT Questionnaire (see chapter 4.5)

The two interview sessions revealed three main requirements for a new PD self-assessment tool, which were not addressed sufficiently either by an old internal assessment tool of the company or self-assessment tools found in the literature.

The first requirement regards the **focus on proven best practices for the entire PD process** of the tool. A self-assessment tool existed at the company. However, it has not been used for the last ten years because of its focus on the software development part of programs. Moreover, it was not detailed enough and needed to be updated. Discussions with the employees revealed that a more generic self-assessment tool focusing on best practices for the overall product development process would be very helpful for the engineering division of the company.

The second requirement regards the **integration** of a PD self-assessment tool with already existing process improvement processes. Since the company strongly relied on the Capability Maturity Model Integration (CMMI), linking a new PD self-assessment tool with this process improvement approach turned out to be of paramount importance. This is supported by the answers from the focus group survey.

The third important requirement regards a possible **customization** of the self-assessment tools, i.e., a process of tailoring the self-assessment tool according to the specific circumstances in an organization. A first version of the example PD self-assessment tool (see chapter 4.4, PDSAT Questionnaire) was presented and discussed with three employees from product development. The employees argued that there were certain areas which were either not important for their company or where there were no issues that had to be addressed. Moreover, it turned out that a number of metrics would have to be customized (e.g. selecting, adding, deleting, rephrasing, re-titling, or re-ordering certain metrics) in order to sharpen their focus on the specific circumstances of this company. The discussions revealed that a possible customization process would probably be a bigger step than expected. One main reason mentioned was that there were few people within the organization who had the expertise on the whole set of PD best practices covered by the PDSAT Questionnaire. Therefore, a formalized customization process would make sense.

The minutes of the two interviews are provided in Appendix B of this thesis.

3.5 Survey

Part of the research approach included an industry focus group survey with three main goals. The first objective was to acquire a broader knowledge about what companies generally think of product development assessment tools. The second objective was to obtain insightful information about the requirements of a possible PD self-assessment tool. The third objective was to acquire detailed feedback on the proposed 9-step-model as to how to implement and customize a possible product development assessment tool (see chapters 4.5 and 4.5.11).

After carefully balancing the benefits of different methods of data collection (FOWLER 1995; FOWLER 2009; NEUMAN 2006; REA & PARKER 2005), it was finally decided to use a web-based survey for a number of reasons. Web-based surveys have a low unit cost for data collection (no need for postage or paper supplies) and offer the potential for a high speed of returns (FOWLER 2009, P. 83). Moreover, they are convenient for both the survey creator and the respondents. The respondents are able to receive the questionnaire and complete it in the privacy of their home or office. Additionally, web-based surveys are particularly useful in

reaching specialized or well-identified populations whose e-mail addresses are readily available (REA & PARKER 2005, P. 11). This is the case for the population of this industry focus group survey.

While drafting the survey questionnaire, a number of references such as FOWLER (1995), FOWLER (2009) and NEUMAN (2006) were consulted. This literature was especially helpful for question phrasing and question formatting.

The questionnaire was pre-tested with three people, i.e., students and research assistants from MIT, before it was finally sent out. The pre-test was an important step since it assessed critical factors such as questionnaire clarity, comprehensiveness and acceptability (REA & PARKER 2005, P. 31). Minor changes to the survey questionnaire were made after the pre-test.

The final survey structure is shown in Table 3-1. It is comprised of sixteen pages and sixty-one questions. The survey structure is organized into six main sections. Two modes of questions are used: multiple choice and open-ended questions.

The introduction provides information about the survey purpose, the background on PD assessment and the time required to complete the questionnaire. Moreover, it includes an informed consent and the contact information of the author. The second part contains general questions, e.g., about barriers to the use and goals of PD assessment. The third part addresses the customization process of tailoring a PD assessment according to the specific needs of companies. The fourth part explains the 9-step PDSAT Implementation Process. The fifth part asks the respondents about their opinion on each of the nine steps of the PDSAT Implementation Process. The survey ends with general questions about the respondent's position and about the particular company he or she is working for.

The survey was e-mailed to eighty-one respondents, all employees in the product development area of member companies in the LAI Consortium. All respondents indicated they worked for firms operating in the aerospace and defense sector (see Figure 3-3). Fourteen responses were received in the first run; a reminder was not sent out. That means a response rate of little more than seventeen percent. Seventy-two percent of the respondents were part of the functional organization of their company. All of the respondents worked for companies with at least one thousand employees. Forty-three percent indicated they were employed at firms with more than fifty thousand employees.

In summary, the industry focus group survey found three essential requirements for product development self-assessment tools. The first requirement regards the **implementation** of the tools. A number of statements shown in Figure 2-5 (*"There is a general high resistance towards change"*; *"It's too difficult to do properly"*, *"Too many failures of process improvement initiatives in the past"*, *"We lack the necessary knowledge regarding assessment tools in PD"*) indicate that the respondents need more detailed and formalized guidelines and help in implementing such an instrument. The second requirement considers the organizational **integration** of PD self-assessment tools. The vast majority of the industry focus group already uses process improvement tools, mainly on firm-level. They explicitly highlighted the importance of linking a PD self-assessment tool to already established process improvement approaches (see Figure 4-20). Moreover, this requirement is supported by a number of statements shown in Figure 2-5 (*"It's too difficult to do properly"*, *"Too many failures of process improvement initiatives in the past"*, *"We lack the necessary knowledge*

regarding assessment tools in PD"). The third requirement regards the **customization** of the tools. The respondents were asked to rate four proposed customization dimensions (see chapter 4.6 and Figure 4-18) according to their relevance. All four dimensions were rated between "somewhat relevant" and "relevant". Moreover, a number of respondents provided further customization dimensions to support the process of tailoring the tools to the specific needs of particular organizations.

Structure of the Survey	Number of pages	Number of questions	Mode of questions
Introduction to the Survey			
• Purpose of the survey • Background on PD self-assessment • Time required to complete the survey • Informed consent • Contact information	1	-	-
General Questions about PD Assessment			
• Barriers to the use of product development assessment • Goals of product development assessment • Responsible person for product development assessment • Link to company-wide process improvement activities • Use of PD assessment in general	3	7 + 1	Mult. Choice + Open Ended
Customization of the PD Assessment			
• Short description of the customization • Relevance of customization dimensions • Additional comments or ideas	1	1 + 2	Mult. Choice + Open Ended
Overview of the Implementation Process			
• Presentation of the 9-step-model of the PDSAT Implementation and Customization	1		-
Feedback on Step 1-9 of the PDSAT Implementation Process			
• Short description of the step • Feedback questions about the step • Additional comments or ideas	9 x 1	9 x 4 + 9 x 1	Mult. Choice + Open Ended
Company Information			
• Industrial sector • Number of employees • Respondent's position	1	4 + 1	Mult. Choice + Open Ended
Total	**16**	**61**	**-**

Table 3-1: Structure of the survey sent out to the LAI Consortium Members

The survey study is limited to some extent. First, the industry focus group survey results are based on a rather small sample of fourteen responses. Moreover, a couple of the eight-one e-mail addresses belonged to the same company; however, it is not known to which department or division. Second, the survey represents the aerospace and defense industry only. Figure 3-3

clearly points out the industrial sector of the respondents. Sixty-four percent were from aerospace companies, and thirty-six percent from defense contractors. The companies involved were generally private. However, one respondent answered the survey from the perspective of a government organization.

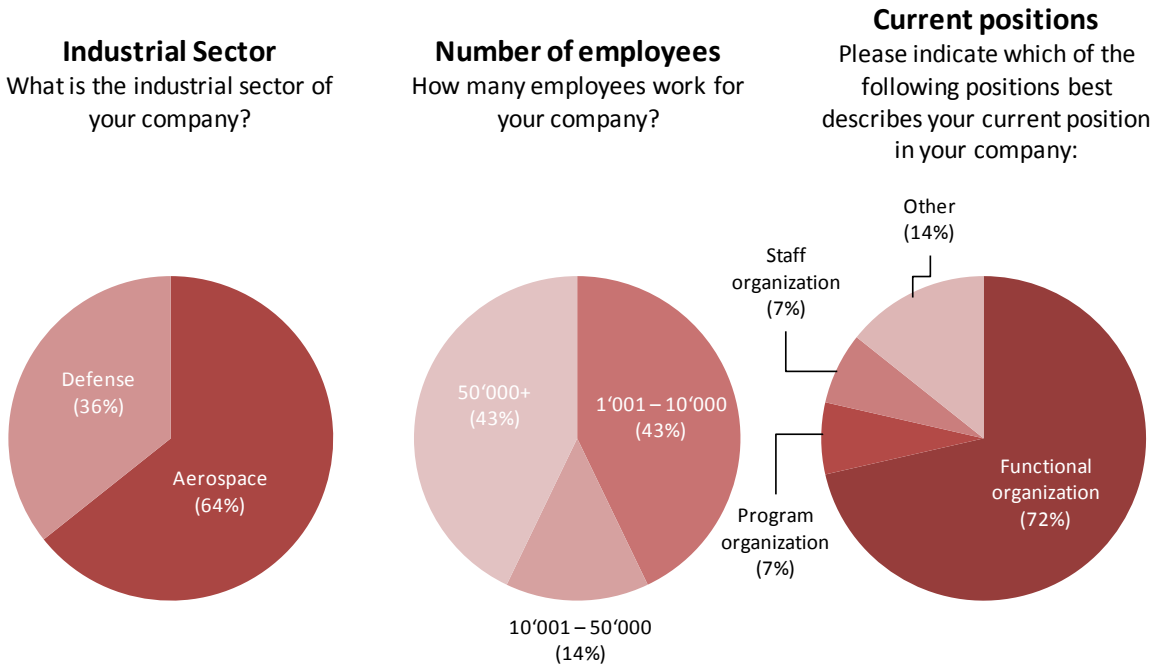

Figure 3-3: Information about the survey respondents

The results of the industry focus group survey are presented throughout this thesis. This includes chapter 2.2.4, chapter 4.5 with the subchapters 4.5.1, 4.5.3, 4.5.10, chapter 4.5.11, chapter 4.7, as well as Appendix A.

4 Presentation of the PDSAT Framework

4.1 PDSAT Framework Overview

The new product development self-assessment framework consists of five main parts: the Product Development Model, the PDSAT Questionnaire (the actual "tool"), the PDSAT Implementation, the PDSAT Customization and the PDSAT Integration (see Figure 4-1).

The PDSAT Framework was designed for companies that develop complex products that can be described as engineered, discrete, and physical (see ULRICH & EPPINGER (2008, P. 2)). The main "customers" of the PDSAT Framework are typically employees from the functional organization, such as the head of product development or the head of engineering, as well as program leaders, project leaders, or change agents from the staff organization. The PDSAT Framework is applicable at different levels of analysis, such as project-level, program-level or firm-level.

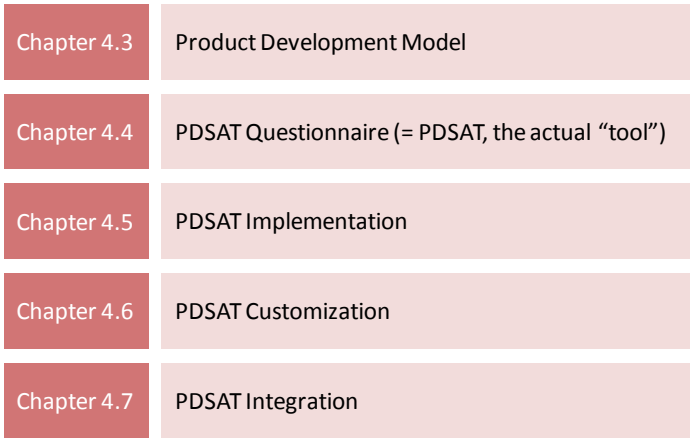

Figure 4-1: Parts of the PDSAT Framework

4.2 Requirements for the PDSAT Framework

The requirements were derived from two interview sessions at a major American defense contractor (see chapter 3.4 and Appendix B) as well as from an industry focus group survey (see chapter 3.5 and Appendix A). Four general requirements could be identified. These are:

- Focus on proven PD best practices
- Formalized implementation process
- Tool customization guidelines
- Integration with other process improvement approaches

4.3 Model for Product Development

4.3.1 The PD Model in the Context of Business Strategy Theories

The new PDSAT Tool presented in this thesis is based on a PD model describing the interdisciplinary product development activities and their outcomes.

The PD model is smoothly integrated into the academic field of strategic management. The structure of this PD model stems from well-established theoretical frameworks, mainly from the *resource-based-view (RBV)* and the *dynamic capability-view* of the firm.
The following paragraphs provide background information about several influential strategic management frameworks.

One main pivotal question of strategic management theories is to identify and understand the sources of sustainable competitive advantage. TEECE ET AL. (1997) summarizes four main paradigms that address this question:

- Competitive forces (PORTER 1980)
- Strategic conflict (SHAPIRO 1989)
- Resource-based perspective (WERNERFELT 1984, BARNEY 1991)
- Dynamic capability perspective (TEECE ET AL. 1997, EISENHARDT & MARTIN 2000, WINTER 2003, HELFAT & PETERAF 2003)

In determining the competitive advantage of firms, the first two paradigms (*competitive forces* and *strategic conflict*) focus on the external and industrial elements of the firm. They analyze predominantly the relationship of companies to their environment, i.e., the product and market side of companies. In the *competitive forces theory* of PORTER (1980), the key aspect of a company's environment is the industry or industries in which it competes. Porter provides a theoretical framework that helps companies define their right position within an industry. In the competitive forces theory, having a privileged market position is one of the main generators of competitive advantage.

SHAPIRO (1989) highlights the emergence of game theory models for analyzing the competition between rival companies (*strategic conflict*). The motivation behind this approach is to find out how a firm can influence the behavioral actions of rival companies and therefore the market environment. One of the key ideas is manipulating the market environment in order to increase profits (TEECE ET AL. 1997, P. 511).

However, for this thesis the two latter strategic paradigms (*resource-based view (RBV)* and *dynamic capability view*) play a more decisive role.

The *resource-based view (RBV)* of the firm (WERNERFELT 1984) is an influential theory for explaining the competitive advantage of companies. It has a more internal focus and analyzes the firm in terms of resources rather than in terms of its products and its market environment. The *RBV* sees companies generating a competitive advantage mainly through the application of superior and specific bundles of *resources*. EISENHARDT & MARTIN (2000) describe *resources* as specific physical, human, and organizational assets for implementing value-creating strategies. According to WERNERFELT (1984, P. 172) these *resources* can be anything which could be thought of as a strength or a weakness of a company, for example, brand names, in-house knowledge of technology, employment of skilled personnel, trade contacts, machinery, efficient procedures or capital. BARNEY (1991) presented a theoretical framework for analyzing the usefulness of specific *resources* in generating a sustainable competitive advantage. The framework comprises four empirical indicators (VRIN indicators) and states that – in the ideal case – resources are *valuable*, *rare*, *inimitable* and *not-substitutable*. Barney's framework assumes that a firm's *resources* have to be heterogeneous and immobile in order to create a competitive advantage.

AMIT & SCHOEMAKER (1993) and MAKADOK (2001) highlight the need to distinguish between the terms *resources* and *capabilities*. *Resources* serve as a basis for building *capabilities* which are seen as firm-specific, in contrast to *ordinary resources* (MAKADOK 2001, P. 388-389). Therefore, a firm's *capabilities* can only generate economic profit after the necessary *resources* are acquired. A formal definition of the term *capability* can be found in MAKADOK (2001):

> *"A capability is defined as a special type of resource – specifically, an organizationally embedded nontransferable firm-specific resource whose purpose is to improve the productivity of the other resources possessed by the firm"* (P. 389).

In order to address firms operating in dynamic environments of rapid technological change, TEECE ET AL. (1997) coined the term *dynamic capability*. The *dynamic capabilities view* is closely associated with the *resource-based view*. However, in contrast to the rather static *resource-based view*, its emphasis is on dynamics (EASTERBY-SMITH ET AL. 2009). Consequently, there is a difference between *ordinary capabilities* and *dynamic capabilities*. In contrast to *ordinary capabilities*, *dynamic capabilities* are concerned with change and adaption (WINTER 2003, HELFAT & PETERAF 2003). A formal definition is provided by TEECE ET AL. (1997). They define *dynamic capabilities* as

> *"(...) the firm's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments. Dynamic capabilities thus reflect an organization's ability to achieve new and innovative forms of competitive advantage given path dependencies and market positions."* (P. 516)

EISENHARDT & MARTIN (2000) see *dynamic capabilities* as *"the drivers behind the creation, evolution, and recombination of other resources into new sources of competitive advantage"* (P. 1107). They provide the following definition:

> *"(Dynamic capabilities are the) firm's processes that use resources – specifically the processes to integrate, reconfigure, gain and release resources – to match and even create market change. Dynamic capabilities thus are the organizational and strategic routines by which firms achieve new resource configurations as markets emerge, collide, split, evolve, and die."* (P. 1107)

According to TEECE ET AL. (1997, P. 510), one of the benefits of the *dynamic capability approach* is that it addresses and integrates newer sources of competitive advantage which are often viewed as outside the traditional boundaries of strategy, and thus have not been incorporated into existing economic approaches to strategy issues. Examples of such sources of competitive advantage are the management of R&D, product and process development, technology transfer, intellectual property, human resources, and organizational learning. Hence, *dynamic capabilities* emphasize the development of management capabilities, and difficult-to-imitate combinations of organizational, functional and technological skills (TEECE ET AL. 1997, P. 510).

The PD model serving as the theoretical framework for the PDSAT Questionnaire stems from the idea of describing the product development activities through competencies and capabilities. Thus, it draws from the business strategy theories of the *resource-based view (RBV)* and the *dynamic capabilities view*. However, the level of analysis is a different one. The main focus of the PD model in this thesis lies on product development. Hence, the PD model defines a set of competencies and capabilities for sufficiently describing an ideal product development process of a company. On the one hand, it provides a selection of *PD Competencies* which focus on the technological and methodological tasks in product development. On the other hand, it presents a selection of *PD Dynamic Capabilities* addressing the ability to change and thus considers dynamic environments of rapid technological change. A more comprehensive explanation of the PD model is given in the following chapters.

4.3.2 Overview of the PD Model

Most existing PD-related self-assessment tools (GARDINER & GREGORY 1996, KAHN ET AL. 2006, RADNOR & NOKE 2002, TENNANT & ROBERTS 2003) are based on a rather static and functional structure of PD best practices. In contrast, the PD model presented in this thesis (see Figure 4-2) draws upon a collection of a large variety of different competencies and capabilities for product development. Therefore, it exhibits the dynamic and interdisciplinary character of product development much better than a functionally-structured PD model. The PD model upon which the PDSAT Questionnaire is based consists of three main parts:

- PD Competencies
- PD Dynamic Capabilities
- PD Results

The motivation for this thesis (see chapter 1.1) indicates that companies have to be both *innovative* and *adaptive* in order to sustain their competitive advantage in the future. Consequently, the new PD model has to address both of these challenges.

PD Competencies address the need to be *innovative*. They comprise innovation-related and product-development-related best practices. The author formally defines PD Competencies as

> *"the firm's proficiency to combine different resources in order to successfully create value by developing engineered, discrete and physical products. In short, PD Competencies can be considered as a set of the most important PD best practices."*

PD Dynamic Capabilities address the need to be *adaptive* by placing a heavy emphasis on organizational change and change management topics. They encompass a set of important change-management-related best practices. The author formally defines the set of PD Dynamic Capabilities as

> *"the firm's ability to change and adapt. This includes the capabilities to build, extend, integrate or reconfigure PD Competencies in order to address rapidly changing environments. PD Dynamic Capabilities can be considered 'change management best practices'."*

Putting both together allows the interdisciplinary activities of product development in a rapidly changing environment to be sufficiently described. The new model not only provides a framework for assessing how well a PD system is operating at the moment, but also for assessing how good it is at improving itself. Depending on whether and to what extent the proposed PD Competencies and PD Dynamic Capabilities are implemented in a PD system, it achieves either good or bad outcomes, referred to as **PD Results**.

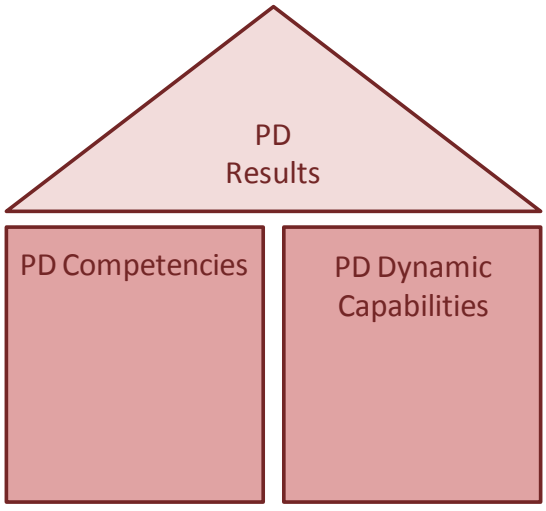

Figure 4-2: Product Development Model

4.4 PDSAT Questionnaire

The new PDSAT Questionnaire, in short PDSAT, is a powerful and integrated instrument for companies seeking help in assessing and improving their product development processes.

The following subchapters describe the PDSAT structure (chapter 4.4.1), its level of analysis (chapter 4.4.2), its measurement system (chapter 4.4.3) and its sources (chapter 4.4.4). Additional subchapters explain the set of PD Competencies (chapter 4.4.5), PD Dynamic Capabilities (chapter 4.4.6) and PD Project Results (chapter 4.4.7).

4.4.1 Structure

The PDSAT Questionnaire is based on the structure of the PD model explained in chapter 4.3.2. One important difference concerns the PD Results part of the model. In the PDSAT Questionnaire, the PD Results part focuses particularly on product development project results.

The PDSAT Questionnaire is structured into different competencies and capabilities for product development. Thus, its structure facilitates the customization process (see chapter 4.5.11) of selecting those PD Competencies and PD Dynamic Capabilities for the assessment that specifically address the environment and circumstances or a particular unit of analysis.

4.4.2 Level of Analysis

The PDSAT Questionnaire is applicable to different levels of analysis. It is possible to evaluate the maturity of PD Competencies and PD Dynamic Capabilities in units such as PD projects, PD programs or the entire engineering division. In smaller companies, it may be reasonable to assess the entire PD organization. However, in most cases it is useful to tailor the PDSAT Questionnaire according to the specific unit of analysis. The PDSAT framework includes guidelines on how to create and customize the PDSAT Questionnaire in order create a perfect fit. Details on this process are provided in chapter 4.5 and chapter 4.5.11.

4.4.3 Measurement Method

The measurement method of the PDSAT Questionnaire is based on a five-level maturity scale. An example of a PDSAT metric is shown in Figure 4-3. The maturity levels range from Level 1 (poor performance) to Level 5 (excellent performance). The highlighted areas in magenta (below the description of the five maturity levels) are related with the PDSAT Customization Process. Further information on this process is provided in chapter 4.5.11.

PDC 15	1.4.2	Transition to sales							
Competence Level Description:	Sales presence is completely absent during the PD cycle.	Sales organization develops sales plans when PD "releases" to sales. Readiness takes great effort. Sales presence is largely absent during PD cycle except when the product is tossed "over the wall."		Sales participates in all key review checkpoints during PD. Sales has reviewed and critiqued the product specs and prototypes during PD.		Product is validated with lead users and beta customers with sales groups as full-fledged team members. Sales is confident of the product and its ability to perform in customer environment.		Product readiness is a non-issue. Sales has been a co-developer from the concept development stage. Product issues from sales are resolved as they arise throughout development.	
Competence Level:	**Level 1 (poor)**	**Level 2 (fair)**		**Level 3 (good)**		**Level 4 (very good)**		**Level 5 (excellent)**	
	Functional area:	Product Design Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
	Organizational role:	Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
	Level of analysis:	Individuals	Teams	Projects Programs	Organization				
	Specific Lean Management Practice:	Specific Lean	Not specific Lean						

Figure 4-3: Example of a PDSAT metric – PD Competence No. 15: Transition to sales

Figure 4-4 provides generic definitions of all five maturity levels. Each maturity level is briefly described and thus highlights the practices that have to be satisfied to score a certain level. It is important to note that all elements of a particular level have to be satisfied in order to progress to the next higher level.

Level 1 (poor)	poor performance; goals are not satisfied at all
Level 2 (fair)	not necessarily incompetence or worst performance; it gets the job done, albeit with weak results, or in a way you do not want to repeat
Level 3 (good)	reflects a competent practice or characteristic
Level 4 (very good)	very good performance, but one that can be achieved with substantial experience, diligence, or training; good practice
Level 5 (excellent)	"exceptional" performance that is very hard to achieve and only a small subset are capable of reaching that level; well-defined and innovative approach; best practice

Figure 4-4: PDSAT Measurement Scale

Alignment with other business improvement models such as CMMI (Capability Maturity Model Integration) or self-assessment tools such as the LESAT (LAI Enterprise Self-Assessment Tool) has been considered a significant requirement in the development of the PDSAT. That is why, like the LESAT and CMMI, the PDSAT uses a five-level maturity scale.

It is important to mention that a company does not necessarily have to attain Level 5 in all PDSAT metrics. As every company is different, some competencies and capabilities are more important than others. Management has to decide individually what to focus on. The decisions should reflect the specific circumstances and the environment of the company as well as its strategic objectives.

4.4.4 PDSAT Sources

In developing the PDSAT Questionnaire, a number of fragments and best practices from different sources were synthesized. Figure 4-5 presents an overview of the main sources that contributed to the final version of the PDSAT Questionnaire.

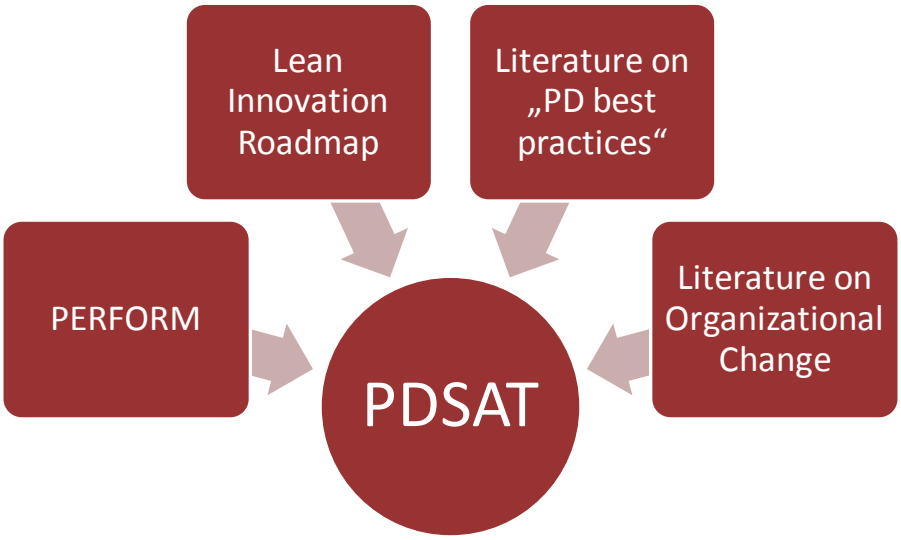

Figure 4-5: PDSAT Sources

One of the key sources was the **Perform Tool** (PERFORM 2003) developed at MIT by TANG ET AL. (2005). Perform is a PD capability assessment instrument for evaluating PD organizational capability. It builds on previous academic research, industry practices and company surveys. The authors first collected 1106 enabling factors contributing to successful product development and then gradually reduced the number to 44 enabling factors. The final version of Perform consisted of 51 enabling factors and 23 specific project outcomes. Perform was tested and validated at an industrial field site (KELLAM 2004). For the PDSAT Questionnaire, Perform served as a main source, especially for the PD Competencies section. Almost all PD factors from Perform were incorporated into the PDSAT Questionnaire. However, they were structured in a fundamentally different way and, if necessary, rephrased as well as expanded.

Another main source was the **Lean Innovation Roadmap** by HOPPMANN (2009). In his work, Hoppmann reviewed the literature on Lean Product Development and finally came up with a list of eleven Lean components and forty-four Lean characteristics. Parts of these Lean

components and Lean characteristics were incorporated into the PDSAT Questionnaire.

A **literature review on PD best practices** was conducted in order to gain additional evidence besides the success factors from Perform and the Lean Innovation Roadmap.

A **literature review on the topic of organizational change** was conducted in order to identify the most important best practices for successful and sustainable change management. The results of this literature review formed the basis for the PD Dynamic Capability section of the PDSAT Questionnaire and thus particularly address the rapidly changing environment in which companies compete today.

A mapping between the final structure of the PDSAT and the different sources is provided in Figure 4-6, Figure 4-7, Figure 4-8 and Figure 4-9. It highlights the different sources of each PDSAT metric, i.e., PD Competencies, PD Dynamic Capabilities and PD Project Results.

			Perform	Lean Innovation Roadmap	Literature on PD best practices	Literature on organizational change
1. PD Competencies	**1.1 Customer Focus Competence**	1.1.1 Customer relationships (PDC 1)	Perform 2.2.3		Ulrich & Eppinger (2008)	
		1.1.2 Customer satisfaction data (PDC 2)	Perform 4.2.2		Otto & Wood (2001)	
	1.2 Product Concept and Design Competence	1.2.1 Product architecture (PDC 3)	Perform 5.2.2		Ulrich & Eppinger (2000)	
		1.2.2 Linkage to corporate objectives (PDC 4)	Perform 5.1.3			
		1.2.3 Product's functional content (PDC 5)	Perform 5.2.3		Ulrich & Eppinger (2000)	
		1.2.4 Definition of product attributes and their values (PDC 6)	Perform 6.3.2		Ulrich & Eppinger (2000)	
		1.2.5 Concept development (PDC 7)	Perform 5.2.1	Hoppmann (2009) (Characteristic No. 5)	Otto & Wood (2001)	
		1.2.6 Set-based concurrent engineering (PDC 8)		Hoppmann (2009) (Characteristic No. 37, No. 38, No. 39, No. 40)	Liker et al. 1996 Sobek et al. 1999 Ward et al. 1995	
		1.2.7 Product variety management (PDC 9)		Hoppmann (2009) (Characteristic No. 21, No. 22, No. 23, No. 24)	Ulrich & Eppinger (2000)	
		1.2.8 Re-use of physical and design assets (PDC 10)	Perform 4.1.2		Ulrich & Eppinger (2000)	
		1.2.9 Make-buy decision (PDC 11)	Perform 5.5.1			
	1.3 Product Validation Competence	1.3.1 Prototypes (PDC 12)	Perform 6.3.1		Kahn et al. (2005) Ulrich & Eppinger (2008)	
		1.3.2 Rapid prototyping, simulation, testing (PDC 13)		Hoppmann (2009) (Characteristic No. 29, No. 30, No. 31, No. 32)	Kahn et al. (2005) Ulrich & Eppinger (2008)	
	1.4 Product Delivery Competence	1.4.1 Release to manufacturing ramp-up (PDC 14)	Perform 7.1	Hoppmann (2009) No. 7		
		1.4.2 Transition to sales (PDC 15)	Perform 7.2			
		1.4.3 Organizational readiness for sales (PDC 16)	Perform 7.3			
		1.4.4 Service and support complexity (PDC 17)	Perform 7.4			
		1.4.5 Product service processes (PDC 18)	Perform 5.5.2			
	1.5 Project and Portfolio Management	1.5.1 Schedule planning and control (PDC 19)	Perform 6.5.1	Hoppmann (2009) (Characteristic No. 2, No. 6)	Otto & Wood (2001)	
		1.5.2 Time to market (PDC 20)	Perform 6.5.2		Kahn et al. (2005)	
		1.5.3 PD project financial goals (PDC 21)	Perform 6.4.2		Kahn et al. (2005)	
		1.5.4 Portfolio of product opportunities (PDC 22)	Perform 5.1.2		Cooper et al. (2001) Kahn et al. (2005)	
		1.5.5 End-of-life strategy (PDC 23)	Perform 5.2.4		Kahn et al. (2005)	
		1.5.6 Risk management analysis (PDC 24)	Perform 4.2.4		Kahn et al. (2005)	
	1.6 Execution Competence	1.6.1 Project leader's responsibilities and power (PDC 25)	Perform 1.3	Hoppmann (2009) (Characteristic No. 9, No. 10, No. 11, No. 12)	Morgan & Liker (2006)	
		1.6.2 Project leader's experience (PDC 26)	Perform 1.2		Morgan & Liker (2006)	
		1.6.3 Concurrent development (PDC 27)	Perform 6.5.3	Hoppmann (2009) No. 6	Kahn et al. (2005)	
		1.6.4 Internal task coordination (PDC 28)	Perform 6.5.4			
		1.6.5 Workload leveling (PDC 29)		Hoppmann (2009) (Characteristic No. 13, No. 14, No. 15, No. 16)	Morgan & Liker (2006)	
		1.6.6 Development process (PDC 30)	Perform 6.1			
		1.6.7 Supplier integration (ties between PD and suppliers) (PDC 31)	Perform 2.2.4	Hoppmann (2009) (Characteristic No. 25, No. 26, No. 27, No. 28)	Morgan & Liker (2006)	
	1.7 PD Staff Competence	1.7.1 PD staff competency (PDC 32)	Perform 3.1			
		1.7.2 Multi-disciplinary staffing (PDC 33)	Perform 3.2		Smith & Reinertsen (1997) Ulrich & Eppinger (2008)	
		1.7.3 Specialist career path (PDC 34)		Hoppmann (2009) (Characteristic No. 17, No. 18, No. 19, No. 20)	Morgan & Liker (2006)	

Figure 4-6: Sources of PD Competencies – Part 1

			Perform	Lean Innovation Roadmap	Literature on PD best practices	Literature on organizational change
1. PD Competencies	**1.8 Data Management Competence**	1.8.1 Use of project performance metrics (PDC 35)	Perform 4.2.3		Kuczmarski (2000)	
		1.8.2 Productivity metrics (PDC 36)	Perform 6.4.1			
		1.8.3 System of data collection, management and usage (PDC 37)	Perform 4.2.1			
		1.8.4 Knowledge management system (PDC 38)	Perform 4.1.3	Hoppmann (2009) (Characteristic No. 4)	Alavi & Leidner (1999) Morgan & Liker (2006)	
	1.9 Technology Competence	1.9.1 Technology readiness (PDC 39)	Perform 5.4.2		Ulrich & Eppinger (2008)	
		1.9.2 Investments in PD methods, tools and databases (PDC 40)	Perform 4.1.1			
		1.9.3 Technology forecasting (PDC 41)	Perform 5.4.1		Ulrich & Eppinger (2008)	
	1.10 Marketing Competence	1.10.1 Product positioning (PDC 42)	Perform 5.1.1		Kahn et al. (2005)	
		1.10.2 Knowledge of market potential (PDC 43)	Perform 5.3.1		Kahn (2005) Kahn et al. (2005)	
		1.10.3 Product pricing strategy (PDC 44)	Perform 5.3.2			
	1.11 Social Responsibility Competence	1.11.1 Social responsibilities (PDC 45)	Perform 6.6			

Figure 4-7: Sources of PD Competencies – Part 2

			Perform	Lean Innovation Roadmap	Literature on PD best practices	Literature on organizational change
2. PD Dynamic Capabilities	**2.1 Communication and diffusion channels**	2.1.1 Communication of vision, strategy and plans (PDDC 1)	Perform 1.1			Kotter (1996) Lewis (1997)
		2.1.2 Communication and change diffusion barriers (PDDC 2)				Kirkpatrick (2001)
		2.1.3 Formal change diffusion in PD (meetings) (PDDC 3)	Perform 2.2.2			Kotter & Cohen (2002) Senge et al. (1999)
		2.1.4 Informal change diffusion in PD (PDDC 4)	Perform 2.2.2			Senge (1999) Senge et al. (1999) Turner (1999)
	2.2 Vision, strategy & plans	2.2.1 Establishing a vision (PDDC 5)				Kahn et al. (2005) Kotter (1996) Lewis 1997
		2.2.2 Establishing a strategy (PDDC 6)				Hamel (1996) Klein (2004) Kotter (1996) Lewis (1997) Senge et al. (1999)
		2.2.3 Short term wins (PDDC 7)				Kotter (1996) Kotter & Cohen (2002)
	2.3 PD Corporate culture	2.3.1 Understanding and leveraging organizational culture (PDDC 8)	Perform 2.1.1			Harvey (2001) Klein (2004) Senge et al. (1999)
		2.3.2 Teamwork culture (PDDC 9)	Perform 2.2.1			Harvey (2001) Kotter (1996)
		2.3.3 Work environment (PDDC 10)	Perform 3.4			Kirkpatrick (2001) Kotter & Cohen (2002) Senge et al. (1999)
	2.4 People for change	2.4.1 Core change team composition (PDDC 11)				Harvey (2001) Kotter (1996) Kotter & Cohen (2002)
		2.4.2 Teambuilding efforts (PDDC 12)				Connor & Lake (1994) Kotter (1996)
		2.4.3 Roles, responsibilities and empowerment (PDDC 13)	Perform 6.2			Kirkpatrick (2001) Kotter (1996) Kotter & Cohen (2002) Senge et al. (1999)
	2.5 Helping, training & education	2.5.1 Mentoring & coaching (PDDC 14)				Klein (2004) O'Brien et al. (1999) Smith & Ross (1999)
		2.5.2 Attitude education (PDDC 15)				Connor & Lake (1994) Kotter (1996) Smith & Ross. (1999)
		2.5.3 Technical training (PDDC 16)	Perform 3.3			Kirkpatrick (2001)
	2.6 Human resources for product development	2.6.1 PD rewarding & promotion (PDDC 17)				Beer & Nohria (2000) Ledford & Heneman (2000) Kotter (1996) Wruck (2000)
		2.6.2 PD recruiting & hiring (PDDC 18)				Klein (2004)
	2.7 Openness to improvements	2.7.1 Raising and maintaining urgency level for change (PDDC 19)	Perform 2.1.2			Kirkpatrick (2001) Kotter (1996) Kotter & Cohen (2002)
		2.7.2 Motivating breakthrough ideas (PDDC 20)	Perform 2.3.1			
	2.8 Learning	2.8.1 Pursuit of organizational learning (PDDC 21)	Perform 2.3.2			
		2.8.2 Cross-project knowledge transfer (PDDC 22)		Hoppmann (2009) (Characteristic No. 41, No. 42, No. 43, No. 44)		

Figure 4-8: Sources of PD Dynamic Capabilities

			Perform	Lean Innovation Roadmap	Literature on PD best practices	Literature on organizational change
3. PD Project Results	**3.1 Project Financial and Market Results**	3.1.1 Project IRR and NPV (PDR 1)	Perform 8.1.1			
		3.1.2 Product volumes (PDR 2)	Perform 8.1.2			
		3.1.3 Product revenues (PDR 3)	Perform 8.1.3			
		3.1.4 Product costs (PDR 4)	Perform 8.1.4			
		3.1.5 Product SG&A (PDR 5)	Perform 8.1.5			
		3.1.6 Product's market share in revenue (PDR 6)	Perform 8.1.6			
	3.2 Project Customer Satisfaction and Loyalty Results	3.2.1 Customer loyalty (PDR 7)	Perform 8.2.1			
		3.2.2 Satisfaction with price for value (PDR 8)	Perform 8.2.2			
		3.2.3 Satisfaction with product function and performance (PDR 9)	Perform 8.2.3			
		3.2.4 Satisfaction with service and support (PDR 10)	Perform 8.2.4			
	3.3 Organizational Effectiveness Results	3.3.1 Strategic intent (PDR 11)	Perform 8.3.1			
		3.3.2 Development time and slip rate (PDR 12)	Perform 8.3.2			
		3.3.3 Development budget and schedule (PDR 13)	Perform 8.3.3			
		3.3.4 Partner satisfaction and loyalty (PDR 14)	Perform 8.3.4			
		3.3.5 Project team morale (PDR 15)	Perform 8.3.5			
		3.3.6 Productivity (PDR 16)	Perform 8.3.6			
		3.3.7 Contribution to knowledge assets (PDR 17)	Perform 8.3.7			
	3.4 Product Results	3.4.1 Functions and performance versus specifications (PDR 18)	Perform 8.4.1			
		3.4.2 Industry awards (PDR 19)	Perform 8.4.2			
		3.4.3 Core technology newness (PDR 20)	Perform 8.4.3			
		3.4.4 Platforming extent (PDR 21)	Perform 8.4.4			
		3.4.5 Manufacturing complexity (PDR 22)	Perform 8.4.5			
		3.4.6 Sales and service complexity (PDR 23)	Perform 8.4.6			
	3.5 Project Benchmarking	3.5.1 Benchmarks (PDR 24)	Perform 8.5			

Figure 4-9: Sources of PD Project Results

4.4.5 PD Competencies

For this thesis, PD Competencies are formally defined as (see chapter 4.3.2):

> *"the firm's proficiency to combine different resources in order to successfully create value by developing engineered, discrete and physical products. In short, PD Competencies can be considered as a set of the most important PD best practices."*

The PD Competencies comprise 45 metrics that are described in the following subchapters. All PD Competencies are presented in Appendix C.

4.4.5.1 Customer Focus Competence

Customer relationships (PDC 1)

Beyond identifying customer needs, companies should try to involve customers throughout the product development process. ULRICH & EPPINGER (2008, P. 54) highlight the importance of engineers and industrial designers who interact with customers and experience the use environment of the product. Ideally, users and customers are co-developers throughout the PD cycle and critics during field operations (PERFORM 2003). They should review development specs, field manuals, and key functional strategies. Moreover, they should be consulted regularly about product and lifecycle requirements (service, updates, availability, etc.) (PERFORM 2003). That is especially important since customers' expectations, incomes, or tastes may change over time (ULRICH & EPPINGER 2008, P. 323). These changes "may be independent or may be driven by new conditions in markets for complementary or substitute products" (ULRICH & EPPINGER 2008, P. 323).

Customer satisfaction data (PDC 2)

OTTO & WOOD (2001, P. 112) point out that considering customers' desires will push product development into better directions and amplify success. Therefore, the PD organization should make sure to continually collect customer satisfaction data and keep it up to date. Web sites can support these goals in an important way because they make it easy to capture customer feedback. Additionally, warranty and repair data should be documented and structured, and made available in reports or online (PERFORM 2003). That makes it easy for product development teams and functional groups to gain access.

4.4.5.2 Product Concept and Design Competence

Product architecture (PDC 3)

ULRICH & EPPINGER (2000) define the architecture of a product as the "scheme by which the functional elements of the product are arranged into physical chunks and by which the chunks interact" (P.183). By "chunks" they mean major physical building blocks which organize different physical elements of a product.

According to PERFORM (2003) product architecture should be a strategy issue and address all key functions of the firm. Furthermore, it should consider future upgrades and derivative

products, and not be limited to a single product.

Linkage to corporate objectives (PDC 4)

The benefits of a certain project, program or product should always be explicitly and comprehensively mapped onto key quantifiable business goals, objectives, and business initiatives (PERFORM 2003).

Product's functional content (PDC 5)

"A product can be thought of in both functional and physical terms. […] The functional elements of a product are the individual operations and transformations that contribute to the overall performance of the product. […]. The physical elements of a product are the parts, components, and sub-assemblies that ultimately implement the product's functions" (ULRICH & EPPINGER 2000, P.182-183).

The definition process of the product's functional content is a central part of the concept development phase. It should be based on repeatable methods and be largely driven by market segment needs, strategic positioning, product architecture, and input from benchmarks (PERFORM 2003).

Definition of product attributes and their values (PDC 6)

The definition of product attributes and their values is a critical starting point in the definition and planning process of a new product. A good product definition process includes customer inputs and customer preferences for establishing the requirements as well as a validation of the specifications with lead users and suppliers (PERFORM 2003).

ULRICH & EPPINGER (2000, P. 82) point out that for technology-intensive products it makes sense to establish the specifications at least twice. Immediately after identifying the customer needs, *target specifications* should be set. After establishing the constraints of the product technology, the *final specifications* can be set.

Concept development (PDC 7)

OTTO & WOOD (2001, P. 414) emphasize that the goal of the concept generation process is to develop as many ideas as possible. In the ideal case, brilliant people with proven track records are given unconstrained freedom to create concepts. In addition, the concept space should be large and "down-selection-systematic." Furthermore, concept development should rely on broad participation, such as manufacturing, quality assurance and purchasing (PERFORM 2003, HOPPMANN 2009).

Set-based concurrent engineering (PDC 8)

There are two fundamentally different approaches in how to design a product (WARD ET AL. 1995; LIKER ET AL. 1996; SOBEK ET AL. 1999):

- Point-based design
- Set-based concurrent engineering

Point-based design is the traditional approach. It begins with designing a variety of possible solutions to solve a particular problem. At an early stage in the design process, engineers have to select the most promising alternative. Then they further develop this alternative until they find – after a couple of iterations – a final solution (LIKER ET AL 1996, P.165, P.167).

Rather than choosing a promising solution early in the design process, the *set-based concurrent engineering approach* propagates to consider broad sets of solutions and gradually narrows them down to a final solution. Instead of choosing a promising solution early in the design process, "design participants reason about, develop, and communicate sets of solutions in parallel and relatively independently. As the design progresses, they gradually narrow their respective sets of solutions based on additional information from development, testing, the customer, and other participant's sets" (SOBEK ET AL. 1999, P. 70).

There are a number of benefits (WARD ET AL. 1995; LIKER ET AL. 1996; SOBEK ET AL. 1999) from using a set-based concurrent engineering approach in product development. However, it has to be considered that this approach was first discovered at Toyota, which has an engineering culture that is in many ways unique (e.g., chief engineer, specialist career path) compared to that of most other companies (SOBEK ET AL. 1999, P. 72).

Product variety management (PDC 9)

According to ULRICH & EPPINGER (2000), product variety "refers to the range of product models the firm can produce within a particular time period in response to market demand" (P. 187).

HOPPMANN (2009, P.41) mentions four major characteristics of product variety management: use of commodities, reuse of parts, definition of modules and definition of product platform. Details of these four characteristics can be found in his thesis.

In the ideal case there is a common understanding among all the staff responsible for product development about the use of off-the-shelf components within a product and about the reuse of product parts among different modules, products and product families. Components of products should be modular, have standardized interfaces and be based on the platform idea (PERFORM 2003).

Re-use of physical and design assets (PDC 10)

Physical and design assets are, for example, electrical and mechanical design, software, packaging, purchased parts, test programs and test equipment (PERFORM 2003).

The main idea behind the re-use of physical and design assets is that in creating subsequent

products only a few functional elements have to be changed while the rest of the product retains intact (ULRICH & EPPINGER 2000, P. 187).

Re-use also includes the use of subsystems and their ability to interoperate (PERFORM 2003).

Make-buy decision (PDC 11)

The make-buy decision should be considered a strategic decision and involve cross-functional teams to ensure that architecture, IP, manufacturing, finance, strategic and competitive implications to the product are considered. The customer and partners should be informed as well (PERFORM 2003).

4.4.5.3 Product Validation Competence

Prototypes (PDC 12)

ULRICH & EPPINGER (2008) define a prototype as "an approximation of the product along one or more dimensions of interest" (P. 247). This is a rather wide definition as it includes different forms of prototypes such as concept sketches, mathematical models, simulations or fully functional preproduction versions of a product (ULRICH & EPPINGER 2008, P. 247). In contrast, KAHN ET AL. (2005) provide a more narrow definition. According to them, a prototype is "a physical model of the new product concept. Depending upon the purpose, prototypes may be nonworking, functionally working, or both functionally and aesthetically complete" (KAHN ET AL. 2005, P. 604).

In contrast to Kahn's definition, ULRICH & EPPINGER (2008, P. 247) emphasize the difference between *physical* (tangible artifacts that look and feel like the product) and *analytical* (non-tangible, usually mathematical or visual artifacts) prototypes. Moreover, they highlight the difference between *focused* (only one or a few dimensions are implemented) and *comprehensive* (most, if not all, attributes are implemented) prototypes.

Prototypes can be used for a variety of different purposes. ULRICH & EPPINGER (2008, P. 250-253) mention four of them:

- Learning
- Communication
- Integration
- Milestones

Finally, ULRICH & EPPINGER (2008, P. 253-257) indicate several principals of good prototyping:

- Analytical prototypes are generally more flexible than physical prototypes
- Physical prototypes are required to detect unanticipated phenomena

- A prototype may reduce the risk of cost iterations
- A prototype may expedite other development steps
- A prototype may restructure task dependencies

This PD Competence (PDC 12) focuses on *physical* and *comprehensive* prototypes, i.e., alpha prototypes, beta prototypes or preproduction prototypes.

Rapid prototyping, simulation, testing (PDC 13)

This Dynamic Capability refers to more *focused* and *analytical* prototyping methods, such as rapid prototyping, simulation, and testing.

Rapid prototyping is a technology that allows physical prototypes to be built based on an existing 3D CAD model within hours or days rather than weeks. The prototypes are generally made from plastics, wax, paper ceramics or metal (ULRICH & EPPINGER 2008, P. 258). They are used to quickly test a product's technical feasibility or consumer interest (KAHN ET AL. 2005, P. 605).

Simulation and testing refers to a variety of different methods used in product development. Examples include 3D CAD models (including digital assembly and digital mock ups), finite element analysis of thermal flow or stress distribution, virtual crash testing and the kinematic and dynamic motion of complex mechanisms (ULRICH & EPPINGER 2008, P. 257).

In the ideal case, designs are tested and simulated throughout the product development process. Moreover, there is a very close interaction between prototype specialists, production engineers, designers and quality assurance experts throughout the product development process (HOPPMANN 2009, P. 44).

4.4.5.4 Product Delivery Competence

Release to manufacturing ramp-up (PDC 14)

In an ideal product development process, the release to manufacturing is a "non-event", i.e., manufacturing and development have proceeded in parallel development with suppliers to ensure a smooth manufacturing ramp-up (PERFORM 2003). Moreover, there should be a formalized process for evaluating design proposals regarding manufacturing and assembly compatibility (HOPPMANN 2009).

Transition to sales (PDC 15)

In order to ensure a smooth transition to sales, it is necessary that sales participates in all key review checkpoints during product development and reviews of the product specifications and prototypes. Moreover, products should be validated with lead users and beta customers with sales groups as full-fledged team members. In the ideal case, sales is a seen as a "co-developer" from the concept development stage (PERFORM 2003).

Organizational readiness for sales (PDC 16)

Organizational readiness for sales means that sales persons, systems, campaigns, and service and support are all coordinated. Sales should be an integral part of the product development process along with other key functions (PERFORM 2003).

Service and support complexity (PDC 17)

In order to ensure that the service and support groups are ready for the product, cross-functional teams, which include customers, should start working on this issue early in the product development process. Service and support should be part of the beta prototype testing with lead users to refine service and support strategies and plans. The project leader should support service and support issues during all stages of the product development process (PERFORM 2003).

Product service processes (PDC 18)

In an ideal product development process, product service processes have a high priority. A cross-functional team, which includes customers and partners, should work together in order to ensure that product design, manufacturing, and finance address serviceability and support (PERFORM 2003).

4.4.5.5 Project and Portfolio Management

Schedule planning and control (PDC 19)

OTTO & WOOD (2001, P.76) point out that the original schedule of a project should be continually monitored for progress and be graphed as a function of time and resources. All key functions, i.e., development, manufacturing, quality assurance and purchasing, should be informed frequently about the status of delays (HOPPMANN 2009). The use of standardized project planning tools like Gantt charts, critical paths methods (CPM) or program evaluation and technical reviews (PERT) is highly recommended (HOPPMANN 2009).

Time to market (PDC 20)

KAHN ET AL. (2005) defines time to market as "the length of time it takes to develop a new product from an early initial idea for a new product to initial market sales" (P. 611). However, they also point out that "precise definitions of the start and end point may vary from one company to another, and may vary from one project to another within the company." (P. 611) Time to market should be addressed by concurrent development and co-development with customers and partners. The flexibility to cut functions in order to meet a defined schedule is recommended (PERFORM 2003).

PD project financial goals (PDC 21)

Financial success is the "extent to which a new product meets its profit, margin, and return on investment goals" (KAHN ET AL. 2005, P.587). Product development should be part of a formal multi-functional group that addresses financial issues. Moreover, it should be responsible for its budget and product costs. In addition, product development should participate in a group that addresses sales, distribution, and service expense strategies and tactics (PERFORM 2003).

Portfolio of product opportunities (PDC 22)

KAHN ET AL. (2005) defines a product portfolio as "the set of products and product lines the firm has placed in the market" (P.603). The management of a product portfolio "is about balance: about the optimal investment mix between risk versus return, maintenance versus growth, and short-term versus long-term strategies. […] In this process, new projects are evaluated, selected, and prioritized. Existing projects may be accelerated, killed, or deprioritized. […]" (COOPER ET AL. 2001, P. 3)

Portfolio decisions should drive new product development. Portfolio planning should be linked to market, business, and functional strategies. Its methods should be quantitative and qualitative as well as engage senior executives and PD managers (PERFORM 2003).

End-of-life strategy (PDC 23)

An end-of-life (EOL) or exit strategy is "a preplanned process for deleting a product or product line from the firm's portfolio. At a minimum it includes plans for clearing inventory out of the supply chain pipeline at a minimum of losses, continuing to provide for after-sales parts supply and maintenance support, and converting customers of the deleted product line to a different one" (KAHN ET AL. 2005, P. 586).

An end-of-life (EOL) strategy of current products within the product portfolio should be set by business strategy and corporate goals. Product architecture, and technology forecast and pricing, should be involved in the EOL of products. It has to be ensured that new products are ready at the earliest sign of technology maturation, deceleration of sales and profit, and increasing competitive pressure (PERFORM 2003).

Risk management analysis (PDC 24)

The Product Development & Management Association (PDMA) defines risk as "an event or condition that may or may not occur, but if it does occur [it] will impact the ability to achieve a project's objectives. In new product development, risks may take the form of market, technical, or organizational issues" (KAHN ET AL. 2005, P. 606).

Risk management is "the process of identifying, measuring, and mitigating the business risk in a product development project" (KAHN ET AL. 2005, P. 606).

A good risk management process characterizes key uncertainties and risks, and uses formal methods such as sensitivity analysis in order to identify key sources of risk. Based on this,

plans are formed to ensure robustness (PERFORM 2003).

4.4.5.6 Execution Competence

Project leader's responsibilities and power (PDC 25)

In the ideal case, the project leader has the final say on all project tradeoffs. Senior executives should clearly communicate their trust and confidence in the project leader. Moreover, they should not be able to easily subvert or slow down the project (PERFORM 2003).

The Toyota Product Development propagates "strong project leaders" (MORGAN & LIKER 2006, P. 131), who have more responsibility than they have authority to carry out projects. Some of the important responsibilities of "strong project leaders" are:

- Defining the product concept and advocating the customer value
- Leading the product development project from concept to market
- Choosing the technology and making major component choices
- Setting the project time frame and controlling adherence to it

Project leader's experience (PDC 26)

Besides his formal authority, a project leader should have informal authority. Informal authority can be gained, for example, by exceptional technical or personal experience. The program leaders at Toyota, called "Chief Engineers," are good models of highly experienced leaders. MORGAN & LIKER (2006, P. 119) point out some characteristics of "Chief Engineers":

- A visceral feel for what customers want
- Exceptional engineering skills
- Intuitive yet grounded in facts
- Innovative yet skeptical of unproven technology
- Visionary yet practical
- A hard-driving teacher, motivator, and disciplinarian, yet a patient listener

Besides these characteristics, project leaders should have track records of delivering complex technical projects, and understanding in their complexity business, financial, and customer issues (PERFORM 2003).

Concurrent development (PDC 27)

According to KAHN ET AL. (2005) concurrent development (also called simultaneous engineering) takes place "when product design and manufacturing process development occur concurrently in an integrated fashion, using a cross-functional team, rather than sequentially by separate functions" (P. 579). This includes frequent review meetings with development, manufacturing, quality assurance and purchasing (HOPPMANN 2009). In addition, the strong cross-functional team should be led by an experienced project leader who should be supported by motivated and skilled functional participation (PERFORM 2003).

Internal task coordination (PDC 28)

Internal task coordination between different functional silos should include detailed walkthroughs of specs, functions and dependencies. Formal specs and formal cross-functional meetings should be used to discuss dependencies, timing, and content of task coordination. Results should be reflected in extended task mapping documents (PERFORM 2003).

Workload leveling (PDC 29)

According to MORGAN & LIKER (2006) workload leveling begins "with product portfolio planning and resource scheduling, which occurs prior to execution" (P. 83). The idea of workload leveling is to create an even and constant use of product development resources. These resources (financial, technical, and human) should be planned on a cross-project basis. Different projects should be classified, staggered and launched in constant intervals. All resources should be flexibly adapted in case of occurring bottlenecks (HOPPMANN 2009). It is important that the project leader is constantly aware of the gap between actual and planned capacity utilization.

Development process (PDC 30)

This competence characterizes the development process from a high-level perspective. An ideal development process is standardized, i.e., well-defined go/no-go criteria exist. Moreover, it is redesigned for the current project by the project champion and core team who have proven competence and a successful track record (PERFORM 2003).

Supplier integration (ties between PD and suppliers) (PDC 31)

As products are becoming more and more complex, companies increasingly concentrate on their core competencies and outsource parts, modules or subsystems of their products to suppliers that have specialized in particular areas. What is important is to have real partners instead of a high number of poorly integrated suppliers. MORGAN & LIKER (2006) recommend using a small number of high-capability suppliers for critical parts throughout the PD cycle. These suppliers can be regarded as co-developers. They are responsible for the definition of a number of development specifications and functional strategies. Ideally, both formal and informal ties exist, and the company and its suppliers work together collaboratively. Emphasis

should be put on mutual trust and respect (PERFORM 2003).

4.4.5.7 PD Staff Competence

Core PD staff competency (PDC 32)

Skilled staff is an important factor for success in product development. In the ideal case, the core staff for product development has advanced degrees from top institutions and years of experience in their field. Moreover, the staff has demonstrated capability in many previous breakthrough concepts (PERFORM 2003).

Multi-disciplinary staffing (PDC 33)

In their book *Developing Products in Half the Time: New Rules, New Tools*, SMITH & REINERTSEN (1997) recommend seven criteria for ideal team staffing that have proven to be successful. One of the criteria is multi-disciplinary staffing of development teams. A team should at the least include members from marketing, design and manufacturing. ULRICH & EPPINGER (2008, P. 6) argue that successful development requires many different skills and talents. Thus, development teams should involve people with a wide range of different training, experience, perspectives, and personalities.

Specialist career path (PDC 34)

Companies following lean principles have been found to use a fundamentally different approach to defining the career paths of their engineers than most traditional firms do. This new idea is called "specialist career path" (HOPPMANN 2009, P. 27). A "specialist career path" provides a well-defined and accepted advancement path for technical specialists in product development and throughout the organization. Technical expertise and knowledge are the main criteria for promotion. Therefore, engineers stay much longer within their technical position than in traditional companies.

Toyota, as an example of a company that heavily relies on a "specialist career path" for its engineers, only promotes its engineers to first-level management positions after being with the company ten to twelve years (MORGAN & LIKER 2006, P. 171-172). In addition, engineers are typically mentored and supported by more experienced managers. Furthermore, their performance is regularly evaluated and discussed in feedback meetings (MORGAN & LIKER 2006, P. 171-172).

4.4.5.8 Data Management Competence

Use of project performance metrics (PDC 35)

KUCZMARSKI (2000) indicates that one of the first steps in managing new product innovation is to "develop common, consistent standards for measuring all aspects of the innovation investment across as many dimensions and business units as possible" (P. 186). Moreover, he

points out that metrics should be tailored to each company, and be organic, i.e., new metrics can be added over time. Furthermore, performance metrics should be available online and always be measured and reviewed against corporate objectives. Key customers and partners should be frequently informed of changes or updates in those metrics (PERFORM 2003).

Productivity metrics (PDC 36)

As mentioned in the previous paragraph (PDC 35 – Use of project performance metrics), having an established performance measurement system is of paramount importance. One important metric is productivity. It should be measured and tracked with analytical and predictive models. Moreover, information should be available online for management and key team members' review and queries. In addition, this information should also be linked to other functional systems for a complete picture of project productivity (PERFORM 2003).

System of data collection, management and usage (PDC 37)

A standardized IT system should be used for data collection, management and usage. This system should be highly integrated with learning, knowledge, information tools and processes (PERFORM 2003).

Knowledge management system (PDC 38)

It is recommended that the knowledge assets of projects are systematically captured and catalogued (ALAVI & LEIDNER 1999, MORGAN & LIKER 2006). Knowledge assets are, for example, best practices that have proven to be successful or lessons learned from previous projects. Standardized documents should be used for collecting these knowledge assets (HOPPMANN 2009, P. 127). Past project info should be easily accessible. Formal knowledge communities should exist and be available to share and expand knowledge (PERFORM 2003). However, it is of primary importance that engineers accept the knowledge management system, really enter their "lessons learned" and use it. ALAVI & LEIDNER (1999) point out that "the success of knowledge management systems may be more related to organizational culture than to organizational structure" (P. 24).

4.4.5.9 Technology Competence

Technology readiness (PDC 39)

Adopting a new technology to a product is a key process in the product planning phase. Therefore, it is essential to make sure that the technology used for new product development is robust. ULRICH & EPPINGER (2008) point out that "a proven, robust technology can be integrated into products much more quickly and reliable" (P. 45). Hence, technology readiness should be determined by the actual application of the technology in the final form in a stressed system and in actual customer environments. Internal simulation and application in prototype systems should support this process. Technology readiness should be a joint process

between engineering, technologists, and manufacturing. Customers and partners should be consulted as well. (PERFORM 2003).

Investments in PD methods, tools and databases (PDC 40)

Products have become increasingly complex in the last decades. The use of standardized methods, tools and databases in the product development process are a means of coping with that. To ensure maximum applicability, the IT infrastructure should be tailored for specific projects and continuously improved. IT support should be dedicated to the projects, and not vice versa (PERFORM 2003).

Forecasting technology (PDC 41)

One key factor in managing technology for new product development is technology forecasting. A common method for aligning technology development with product planning is a technology roadmap. ULRICH & EPPINGER (2008) describe a technology roadmap as "a way to represent the expected availability and future use of various technologies relevant to the product being considered" (P. 41). Besides using methods for forecasting technology, it is important to validate the technology finally used in lead user application environments (PERFORM 2003).

More detailed insights in technology roadmaps are provided in the book *Product Design and Development* by ULRICH & EPPINGER (2008).

4.4.5.10 Marketing Competence

Product positioning (PDC 42)

According to the Product Development and Management Association (KAHN ET AL. 2005), product positioning is about "how a product will be marketed to customers. The product positioning refers to the set of features and value that is valued by (and therefore defined by) the target customer audience, relative to competing products" (P. 603).

In the ideal case, the product and its derivatives are targeted for new market creation in the industry. Therefore, the product has to be "unique," i.e., there should be no competitive products or precedents (PERFORM 2003).

Knowledge of market potential (PDC 43)

The market potential of a firm can be defined as the "maximum estimate of total market volume reasonably attainable under a given set of conditions" (KAHN 2005, P. 363).

Market research can be helpful in order to determine knowledge of the market potential for a certain product. The Product Development and Management Association refer to market research as "the information about the firm's customers, competitors, or markets" (KAHN ET AL. 2005, P. 594). This information may come from secondary sources (already published and

publicly available) or primary sources (from customers themselves) and may be qualitative or quantitative (KAHN ET AL. 2005, P. 594).

In the ideal case, companies use products to create a new market. In this situation, knowledge of market growth and acceleration may be more important than knowledge about the potential size of a market (PERFORM 2003).

Product pricing strategy (PDC 44)

Pricing is also an important part of a new product strategy, for example, targeting customers. The goal is to price a product according to its customer value. The use of methods such as EVA (Economic Value Added) or conjoint studies can be helpful in this process (PERFORM 2003).

Validation of the product pricing strategy should involve lead users within their business processes. In addition, pricing consistency with the overall strategic intent of the product should be guaranteed (PERFORM 2003).

4.4.5.11 Social Responsibility Competence

Social responsibilities (PDC 45)

Addressing social responsibility issues has become more and more important in recent years. Today, it is expected that companies aim not only to maximize their earnings but also to contribute to the welfare of society. Companies should try not only to adhere to legal requirements but proactively address social responsibility issues that are not yet in statutes or regulations (PERFORM (2003).

4.4.6 PD Dynamic Capabilities

For this thesis, PD Dynamic Capabilities are formally defined as (see chapter 4.3.2):

> *"the firm's ability to change and adapt. This includes the capabilities to build, extend, integrate or reconfigure PD Competencies in order to address rapidly changing environments. PD Dynamic Capabilities can be considered 'change management best practices'."*

The PD Dynamic Capabilities comprise 22 metrics that are described in the following subchapters. All PD Dynamic Capabilities are presented in Appendix D.

4.4.6.1 Communication and Diffusion Channels

Communication of vision, strategy and plans (PDDC 1)

In his book *Leading Change,* John Kotter presented a model that highlights the importance of alignment between a company's vision, its strategy, its plans, and its budgets (KOTTER 1996, P. 71). The idea behind this model is that in order to create a successful and sustainable transformation, vision, strategy, plans and budgets have to be inter-coordinated and harmonized (see Figure 4-10). A change strategy without a direct link to a shared vision significantly increases the potential for failure (LEWIS 1997, P. 6).

KOTTER (1996) points out that "a vision can be mundane and simple, at least partially, because in a successful transformation it is only one element in a larger system that also includes strategies, plans and budgets" (P. 71). He adds, that the "real power of a vision is unleashed only when most of those involved in an enterprise or activity have a common understanding of its goal and direction" (KOTTER 1996, P. 85).

Hence, it is highly important to have effective communication mechanisms (see PDDC 2, PDDC 3, PDDC 3). Communication should be as simple as possible and use metaphors, analogies and examples (KOTTER 1996, P. 90). Furthermore, multiple forums (e.g., big meetings, small meetings, memos, newspapers, formal and informal interaction) should be actively used as communication channels (KOTTER 1996, P. 90). Another success factor is repetition – change ideas sink in deeply only after they have been heard many times (KOTTER 1996, P. 90).

Furthermore, it is essential that executives and senior management actively communicate the company's vision and strategy. This should be reinforced by visible actions, rewards and incentives so that consistent messages arrive at all levels (PERFORM 2003). In addition, managers have to encourage employees to look at all their daily activities through the lens of the current vision and strategy.

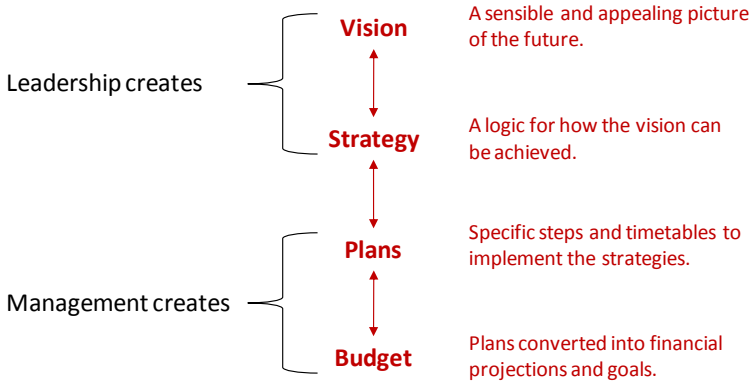

Figure 4-10: Alignment between vision, strategy, plans and budgets

Communication and change diffusion barriers (PDDC 2)

In his book *Managing Change Effectively*, Donald L. Kirkpatrick names three keys to successful change (KIRKPATRICK 2001, P. 77):

- Empathy
- Communication
- Participation

This PD Dynamic Capability focuses on the second key – communication – which plays an important role in the management of change. Kirkpatrick points out that communication means more than "telling" and is predominantly about "creating understanding" (KIRKPATRICK 2001, P. 47).

Big change ideas have to be dispersed throughout the organization in order to create successful and sustainable change. Therefore, information has to be available openly to everyone in the organization. Furthermore, it is essential to communicate to the right people. Talking to the most relevant key people is not enough. Those who are concerned as well as those who are involved have to be informed about ongoing changes (KIRKPATRICK 2001, P. 49).

KIRKPATRICK (2001, P. 48-49) distinguishes between sender barriers and receiver barriers in communication activities. He provides fourteen sender barriers and twelve receiver barriers in his book *Managing Change Effectively*. He further points out the importance of feedback as an essential part of the communication process.

Formal change diffusion in PD (meetings) (PDDC 3)

Communication of change ideas can be divided into two main parts:

- Formal change diffusion (e.g., meetings)
- Informal change diffusion (e.g., "communities of practice")

Formal meetings play an important role in diffusing change ideas among the organization. People get together regularly in meetings in almost every company. However, most meetings seem to be organized quite ineffectively or inefficiently and employees often complain that they are too time-consuming. The literature on organizational change suggests a number of simple recommendations in order to improve the outcomes of meetings. A small selection is presented in the following:

KOTTER & COHEN (2002, P. 57), for example, point out that the key to successful meetings is focus and discipline. They argue that one topic per meeting is enough and that this topic should be discussed intensively. In addition, participants should include employees from different functional areas. SENGE ET AL. (1999, P. 71) suggest letting people schedule themselves and rewarding them for the results they produce, instead of holding "visible" meetings. Finally, communication should be open, direct and honest (PERFORM 2003).

Informal change diffusion in PD (PDDC 4)

Informal networks foster spreading new ideas and innovative practices in and across PD projects and the whole organization (SENGE 1999, P. 17). They are often called *communities of practice*. *Network leaders* are participators and leaders in *communities of practice*.

Communities of practice have no name, no formal membership and no status (TURNER 1999, P. 478). They can be described as webs of relationship that are created in order to bring people together in ways that encourage them to get to know each other informally (SENGE ET AL. 1999, P. 479). Examples of *communities of practice* can be a group of smokers, people who have the same hobbies or people who meet for lunch. SENGE ET AL. (1999, P. 49) point out that such informal networks are generally superior to hierarchical channels for dispersing new innovations. These groups have the advantage of organizing themselves. They don't have to have a schedule to meet or a hierarchical set of relationships to get things done (TURNER 1999, P. 479).

Network leaders are participators and leaders in *communities of practice*. Good examples may be internal consultants, people in training or executive development departments (SENGE 1999, P. 17). *Network leaders* are a natural counterpart to local line leaders (SENGE 1999, P. 17). They disseminate new practices and change ideas. They establish connections with others. They assist the people working in the line organization. They often work behind the scenes, which enables them to encourage people in a different way than executives. Often, it is their lack of hierarchical authority that makes them effective (SENGE 1999, P. 17).

Due to the numerous advantages of informal change diffusion as a method for communication, it is recommended that the PD organization sets incentives for building informal networks. PD employees should not only understand and acknowledge the

importance of informal networks but also constantly try to spread the idea and importance of "communities of practice" among the organization.

4.4.6.2 Vision, Strategy & Plans

Establishing a vision (PDDC 5)

KOTTER (1996) refers to a vision as "a picture of the future with some implicit or explicit commentary on why people should strive to create that future" (P. 68). The Product Development and Management Association provide a definition which focuses more on product development. They characterize vision as "an act of imagining, guided by both foresight and informed discernment that reveals the possibilities as well as the practical limits in new product development. It depicts the most desirable future state of a product or organization" (KAHN ET AL. 2005, P. 613).

To create an effective vision which is shared among a high number of employees within an organization and with customers and suppliers, a list of numerous recommendations have to be kept in mind (KOTTER 1996, P.72-79). In short, an official vision statement should be

- Imaginable
- Desirable
- Feasible
- Focused
- Flexible
- Communicable
- Ambitious
- Appealing to customers and stockholders
- Take advantage of fundamental trends
- Have moral power

To create the vision, it is essential that everyone from key executives to first-level employees within the organization buy into it. In addition, buy-ins from board members and stakeholders outside the organization such as investors, customers and suppliers are necessary (LEWIS 1997, P. 113). Everything from the structure of the organization to the leadership style, management methods, and action plans has to be designed to support the vision.

If all these suggestions from the literature are considered and successfully transformed into a final vision statement, the vision can significantly help companies in their organizational change. A vision can have a great effect on the organization and push it towards the future. It provides a framework that guides all decision making, planning and action (LEWIS 1997, P. 11). Moreover, the vision is a key driving force in producing useful change by helping to direct, align, and inspire the actions of different people. In addition, for the people of an

organization, a shared vision provides motivation, meaning and direction for work (LEWIS 1997, P. 11).

Establishing a strategy (PDDC 6)

According to LEWIS (1997), "vision is what the organization wants to become, strategy is how it wants to get there" (P. 70) KOTTER (1996, P. 75) underscores this statement by arguing that a strategy provides both a logic and the first level of detail to show how a vision can be accomplished.

The approach of creating a strategy has changed during the past decades. Crafting a company's strategy has traditionally been the domain of the top management and of strategy consultants. However, today a number of authors suggest involving new parties in this process. HAMEL (1996), for example, recommends the participation of three groups in the strategy definition process. These are young employees, people at the organization's geographic periphery, and newcomers. Hamel argues that young people live "closer to the future," people at the organization's geographic periphery reflect the "international voice" of the organization, and newcomers "have not yet been co-opted by an industry dogma" (P. 76-77). Additionally, KLEIN (2004, P. 53) states that different functional groups should work collaboratively in order to achieve the firm's strategic objectives.

Normally, a strategy is based on a variety of assumptions about the future environment in which the company acts. It is essential that these assumptions are continually exposed and tested. Strategic planning methods such as scenario thinking (SENGE ET AL. 1999, P. 496) can help in doing that.

Short term wins (PDDC 7)

Besides having an elevated statement about a future vision as well as a strategy on how to achieve it, short term wins are another essential part in a sustainable transformation process. However, short term wins differ considerably from vision and strategy statements. Most significantly, their time horizon is focused on the near future. KOTTER (1996, P. 120) points out that the first performance improvements in a company-wide organizational change effort should be accomplished in six to eighteen months, depending on the company size.

Short-term wins are wins that can be achieved cheaply and easily, even if they seem small compared with the overall change vision (KOTTER & COHEN 2002, P. 141). Achieving the first improvements sufficiently fast is their main role. Furthermore, they should provide credibility and momentum to the overall change effort. More importantly, their task is to undermine cynics and resisters within the company, keep the supervisors on board (KOTTER 1996, P.123) and speak to other powerful players whose support is not yet guaranteed (KOTTER & COHEN 2002, P. 141).

KOTTER (1996, P. 121-122) mentions three characteristics of good short-term wins:

- Visibility – The first positive results should be visible to as many employees as possible. People who make wins possible should be visibly recognized and rewarded.

- Unambiguity – Wins should be meaningful to the employees
- Clear relation to the overall change effort – Alignment with vision and strategy

4.4.6.3 PD Corporate Culture

Understanding and leveraging organizational culture (PDDC 8)

In her book *True Change*, KLEIN (2004, P. 30) reveals that the most admired companies typically have strong organizational cultures. She further points out that these cultures are what align the organization and help employees make daily decision efficiently. KLEIN (2004, P. 31) explains that cultures are made up of a set of underlying assumptions about how organizational members are expected to behave. These cultural assumptions drive the behavior of employees.

For this reason, it is essential to understand a company's organizational culture for creating profound and sustainable change. KLEIN (2004, P. 75) highlights the importance of working within the existing organizational culture and underscores that personalities and change approach have to fit the respective organizations. HARVEY (2001, P. 33) states that change that runs counter to the organizational norms will be resisted, and therefore it has to fit into the already established culture. Additionally, SENGE ET AL. (1999) reveal that the "fundamental flaw in most innovators' strategies is that they focus on their innovation, on what they are trying to do – rather than on understanding how the larger culture, structures, and norms will react to their efforts" (P. 26). They further point out that in order to create sustainable change, one has to understand why and how the organization as a system "pushes back," i.e., how it reacts to changes. Systematic strategies for sustaining profound change should be developed only after understanding the organization as a system.

Understanding the organizational culture is also very helpful for disseminating information and change ideas. SENGE ET AL. (1999, P. 427) suggest using accepted informal webs of people in an organization for diffusing knowledge and information. KLEIN (2004, P. 52) explains that knowledge transfer happens by personal contact. Furthermore, she points out that although most organizations have extensive knowledge management systems, many people first ask a friend or work associate for help before searching data repositories or contacting an expert they have never met (KLEIN 2004, P.152).

Teamwork culture (PDDC 9)

Teamwork culture can be regarded as an essential part of the overall organizational culture. HARVEY (2001, P. 129) points out that the most effective change endeavors are team efforts. He argues that a team approach expands available resources, e.g., time and energy, and, hence, the potential scope of the change effort. Thus, a lack of teamwork is a major barrier to change KOTTER (1996, P. 20). The PD organization should therefore foster its teamwork culture as much as possible. Incentives for forming self-organized cross-functional networks (formal and informal, with customers and with partners) should be established for actively promoting problem solving in PD-related areas (PERFORM 2003).

Work environment (PDDC 10)

The right work environment plays an important role especially for creating organizational change. The work environment should provide surroundings and incentives which foster empathy, trust and personal reflection among the PD employees — all key factors for successful and sustainable organizational change (SENGE ET AL. 1999; KOTTER & COHEN 2002; KIRKPATRICK 2001). Furthermore, the organization's policy should address workplace, systems, and programs for PD employee well-being and satisfaction (PERFORM 2003).

4.4.6.4 People for Change

Core change team composition (PDDC 11)

KOTTER (1996, P. 55) argues that in rapidly changing environments single individuals cannot be successful at implementing changes due to a variety of factors. First of all, they rarely have all the information they need; secondly, an individual seldom has the credibility and the time to convince all the other employees who are needed to make change sustainable. KOTTER (1996, P. 55) concludes that only teams can be successful and underscores his statement with the argument that they can process information more quickly and make decisions faster. HARVEY (2001, P. 129) also points out that every change effort should be pursed through a collaborative team process. However, he mentions that in his experience existing groups rarely function as the most effective strategists for change and indicates that most successful change teams are formed for a particular reason and exist solely for that change effort.

A powerful change guiding team should be made up of people with the appropriate skills, the leadership capacity, the organizational credibility and reputation, and the connections to handle the organizational change effort (KOTTER & COHEN 2002, P. 439; KOTTER 1996, P. 57). It should typically consist of five to twelve members (HARVEY 2001, P. 130).

KOTTER & COHEN (2002, P. 46-47) describe the typical process of creating a change guiding coalition. Usually, it is a single individual who feels great urgency for a certain change and pulls in the first people. Based on his ideas, this individual creates a first team that selects certain employees with the right combination of capabilities (knowledge, credibility, connections, authority, etc.). Over time, the team changes by pulling additional people in and sporadically pushing people out. As change progresses throughout the organization, additional teams are formed at lower levels (KOTTER & COHEN 2002, P. 46-47). These groups help to drive the change effort within their units. At this stage, the initial "guiding team" has transformed into a real "guiding coalition."

Teambuilding efforts (PDDC 12)

The importance of teamwork has been pointed out several times in this thesis (see PDDC 9, PDDC 11) Therefore, it is essential that an organization supports teambuilding by providing the right environment and offering incentives.

CONNOR & LAKE (1994, P. 100) indicate that teambuilding activities aim at doing two things. First, they enhance the effectiveness and satisfaction of individuals who work in groups or

teams. Second, they promote overall group or team effectiveness. Preferably, teambuilding efforts should be an organization-wide activity, beginning at the top and eventually reaching the lower levels of the organization (CONNOR & LAKE 1994, P. 100). KOTTER (1996, P. 61- 63) mentions a few additional recommendations that should be considered in teambuilding efforts:

- Teambuilding meetings should be planned carefully, preferably involving internal staff or external consultants in the planning efforts
- Teambuilding efforts have to create trust among employees in order to foster collaborative teamwork
- Teambuilding efforts should be preferably organized as blocked meetings. One off-site three-day meeting is usually more effective than three one-day meetings (KOTTER 1996).

Roles, responsibilities and empowerment (PDDC 13)

Most of the literature found about the roles of employees, their responsibilities and their empowerment is based on the idea of participative management (KIRKPATRICK 2001, SENGE ET AL. 1999, KOTTER 1996, KOTTER & COHEN 2002).

KIRKPATRICK (2001) quotes an executive vice-president who describes participative management as "a way of releasing the natural, inherent enthusiasm and creativity of the entire organization" (P. 62). KIRKPATRICK (2001, P. 60) further explains that in order to get participation – one of his three keys to successful change besides empathy and communication – involvement is needed not only from those who are concerned but also from those who are affected by the change. He emphasizes that an effective participative program must be based on a philosophy that the input of employees can contribute to the effectiveness of an organization (KIRKPATRICK 2001, P. 63). In his opinion, the most significant aspect of participation is that managers really want the input and are not merely going through the motions of asking for it, i.e., they really have to believe that the employees' input contributes to the effectiveness of the organization (KIRKPATRICK 2001, P. 63, 69).

To create lasting and sustainable change, the right level of empowerment of employees has to be found for every organization. True change can only happen when it involves and convinces the majority of the people. SENGE (1999, P. 13) points out that planned change efforts have to be built around commitment and not just compliance. However, KIRKPATRICK (2001, P. 65) argues that empowerment is only useful when the subordinates are qualified and interested in having responsibility (KIRKPATRICK 2001, P. 65). Furthermore, top management really has to believe in a participative philosophy (KIRKPATRICK 2001, P. 63).

In the ideal case, the responsibilities of team members are determined via extensive discussions at all levels and with participation from suppliers and partners. Extensive power is delegated to the project leader. Moreover, team members must have a desire to go beyond their job descriptions and know their role and responsibilities relative to key functions (PERFORM 2003).

4.4.6.5 Helping, Training & Education

Mentoring & coaching (PDDC 14)

A mentoring relationship always consists of a mentor and a protégé. KLEIN (2004, P. 148) describes mentors as coaches or advisors who guide their protégés through a pulling change process and help them to expand their networks. She adds that in most cases, mentors are more senior and experienced than their mentees. Regarding the relationship between mentor and mentee, O'BRIEN ET AL. (1999, P. 130) argue that a fruitful mentoring relationship has to be based on mutual trust and respect. KLEIN (2004, P. 162) adds that the best coaching relationship is that between people who like and respect one another.

Having an established company-wide mentoring program can help companies in many ways, e.g., in learning the culture or establishing internal networks. Mentors usually offer valuable advice, help define goals, supply information on developments, and provide visibility and recommendations for their mentees (KLEIN 2004, P. 163). Additionally, mentors usually coach their mentees about how to leverage the organizational culture (KLEIN 2004, P. 160). SMITH & ROSS (1999, P. 109) point out that high quality coaches not only provide their feedback but enjoy seeing people develop.

However, mentoring can also have negative aspects. KLEIN (2004, P. 162) points out the risk of overreliance on the guidance and goodwill of mentors, which can lead to a loss of independent thinking.

Attitude education (PDDC 15)

CONNOR & LAKE (1994, P.91) describe training as an activity that is aimed at upgrading people's knowledge, skills, attitudes and even beliefs. The framework presented in this thesis distinguishes between training attitude and training technical skills.

This PD Dynamic Capability focuses on attitude education. To prepare an organization for change, it is important to train employees not only in terms of their skills but also their attitudes. KOTTER (1996, P. 108) explains that very often training is provided, but it focuses on technical skills rather than on social skills or attitudes. In terms of educating the staff about their attitude towards their work, he suggests offering courses to employees not only before they start their jobs but also as follow-ups to help them with problems while performing their jobs (KOTTER 1996, P.108). SMITH & ROSS (1999, P.107) recommend that senior executive leaders should participate in teaching the culture of the company and key business processes.

To sum up, it is recommended that organizations underscore the importance of attitude education among its PD staff. Employees at all levels, regardless their experience, should attend regular courses. The attitude training should be designed to facilitate both the understanding of the organization's vision and its cultural values.

Technical training (PDDC 16)

Training technical skills has always been important and will become even more important in the future. KIRKPATRICK (2001, P. 9) argues that rapid technological change will call for more training and retraining among employees. Therefore, it is essential that an organization's culture values technical proficiency. Commitment for training efforts should be shared by senior executives, functional managers and project managers. Training should be fully funded and never be an issue. Moreover, product delivery pressure should never circumvent training efforts (PERFORM 2003).

4.4.6.6 Human Resources for Product Development

PD rewarding & promotion (PDDC 17)

According to BEER & NOHRIA (2000, P. 267), there are virtually no fundamental changes in organizations that do not also involve some changes in the reward system. KOTTER (1996, P. 157) also points out that reward and promotion systems are an important incentive for organizational change. He mentions that if promotion processes are not changed to be compatible with the new practices in the system, the old culture will reassert itself.

There are a number of different approaches that can be summarized under the general term reward system. According to BEER & NOHRIA (2000, P. 267), reward systems range from informal and intangible rewards, such as recognition and political support, to more formal arrangements, such as the promotion and financial incentive system.

A good rewards system offers a number of benefits. WRUCK (2000, P. 274) point out that today researchers generally agree that compensation systems encourage individuals to engage in more behaviors that are rewarded and fewer behaviors that are punished. They further argue that an effective compensation system improves the motivation and productivity of employees (WRUCK 2000, P. 270). For example, they mention that a well designed and focused reward system can help overcome organizational inertia and opposition to change (WRUCK 2000, P. 270).

There are a number of recommendations from authors on how to design effective reward systems. LEDFORD & HENEMAN (2000, P. 310) recommend using extrinsic rewards (such as pay) as well as intrinsic rewards (such as job designs), and that both should be congruent and consistent. Moreover, they highlight the importance of details of the design, and the implementation and the administration that determines success or failure of the reward system (WRUCK 2000, P. 275-276). If the reward system is deliberately used as part of an organizational transformation, the system redesign should be implemented early in the change process (WRUCK 2000, P. 270). KOTTER (1996, P. 56) suggests the promotion of teams instead of individuals. Finally, it is important that managers and employees fully understand how the compensation system functions. They must be kept up to date about any changes to the system.

PD recruiting & hiring (PDDC 18)

It is important to align the recruiting and hiring system with the change vision, change strategy and change plans of the company. The human resources department has to be continually updated about ongoing change efforts, so it can continually adjust its employee selection criteria. PD employees should be selected based not only on their technical skills and experience, but also on behavioral interviews which are held in order to ensure the "cultural fit" of new PD employees (KLEIN 2004, P. 145).

4.4.6.7 Openness to Improvements

Raising and maintaining the urgency level for change (PDDC 19)

It is widely believed that people by nature are opposed to changes that affect their environment. There are a number of barriers that negatively affect change initiatives (KOTTER 1996, P. 20):

- Inwardly focused cultures
- Paralyzing bureaucracy
- Parochial politics
- Low level of trust
- Lack of teamwork
- Arrogant attitudes
- Lack of leadership in middle management
- General human fear of the unknown

KIRKPATRICK (2001, P. 20-21, P. 26-27) provides a more detailed list as to why people resist change or accept and welcome it.

Overcoming these barriers to change is essential in creating successful, profound and sustainable change. One of the first steps of a change effort is to create a sense of urgency among the affected and involved employees. That means reducing the complacency, fear, and anger that prevent change from being initiated (KOTTER & COHEN 2002, P. 36). A list of nine sources of complacency is presented in KOTTER (1996, P. 40).

By far the biggest mistake people make when trying to move an organization ahead is to fail to instill a sufficient sense of urgency in both managers and employees (KOTTER 1996, P. 4). A number of factors have to be considered. One is creativity and providing something visually compelling, dramatic, attention grabbing and memorable (KOTTER & COHEN 2002, P. 35) in order to get people "off their couch, out of a bunker, and ready to move" (P. 3). Looking continually for inexpensive and easy ways to reduce complacency is also recommended. Furthermore, KOTTER & COHEN (2002, P. 26) also point out that one should never underestimate how much complacency, fear, and anger exists, even in good organizations.

In his book *Leading Change*, KOTTER (1996, P. 44) presents a list of nine ways to raise the urgency level.

Motivating breakthrough ideas (PDDC 20)

Having a management system and culture that promotes fresh ideas is recommended. Innovation should be prized and rewarded, especially from sources outside an employee's normal expertise (PERFORM 2003)

4.4.6.8 Learning

Pursuit of organizational learning (PDDC 21)

Learning from past projects is an important part of the product development process. The organization should provide formal and informal incentive mechanisms for organizational learning. Moreover, it should take advantage of lessons from its latest project and encourage its key people to learn how to apply those lessons to new projects (PERFORM 2003).

Cross-project knowledge transfer (PDDC 22)

Best practices and lessons learned from previous projects should be documented, reviewed and continually updated by the engineers. Moreover, the knowledge collected should be frequently simplified, reorganized and generalized. Methods and devices to collect information on successful procedures, tools and designs across projects can support this process. However, probably the most essential part of cross-project knowledge transfer is to ensure that employees have access to the centralized knowledge database and regularly use the system (HOPPMANN 2009).

Moreover, it is important to not only collect best practices and lessons learned from previous projects, but also to transfer this knowledge across different projects.

4.4.7 PD Project Results

For this thesis, PD Project Results are formally defined as:

> *"metrics to measure actual results of projects from multiple dimensions."*

The PD Project Results comprise 24 metrics that are listed in the following subchapters. All PD Project Results are presented in Appendix E.

4.4.7.1 Project Financial and Market Results

- **Project IRR and NPV (PDR 1)**
- **Product volumes (PDR 2)**
- **Product revenues (PDR 3)**
- **Product costs (PDR 4)**
- **Product SG&A (PDR 5)**
- **Product's market share in revenue (PDR 6)**

4.4.7.2 Project Customer Satisfaction and Loyalty Results

- **Customer loyalty (PDR 7)**
- **Satisfaction with price for value (PDR 8)**
- **Satisfaction with product function and performance (PDR 9)**
- **Satisfaction with service and support (PDR 10)**

4.4.7.3 Organizational Effectiveness Results

- **Strategic intent (PDR 11)**
- **Development time and slip rate (PDR 12)**
- **Development budget and schedule (PDR 13)**
- **Partner satisfaction and loyalty (PDR 14)**
- **Project team morale (PDR 15)**
- **Productivity (PDR 16)**
- **Contribution to knowledge assets (PDR 17)**

4.4.7.4 Product Results

- **Functions and performance versus specifications (PDR 18)**
- **Industry awards (PDR 19)**

- **Core technology newness (PDR 20)**
- **Platforming extent (PDR 21)**
- **Manufacturing complexity (PDR 22)**
- **Sales and service complexity (PDR 23)**

4.4.7.5 Project Benchmarking

- **Benchmarks (PDR 24)**

4.5 PDSAT Implementation

A self-assessment tool only becomes a powerful instrument if it is well-understood, widely accepted and properly used. However, the literature review in this thesis identified missing implementation guidelines as a main shortcoming of existing product development-related assessment tools (see chapter 2.4). Hence, this thesis presents a formalized 9-step-model on how to use and conduct the PDSAT Questionnaire. Its main purpose is to provide sufficient guidance and help in executing the self-assessment for achieving the best possible results from this process.

The 9-step-model of how to implement the PDSAT Questionnaire (see Figure 4-11) was developed from scratch. It has not yet been validated. However, the author discussed this 9-step-model in depth in two interviews with employees from a major American defense contractor (Company X). Additional feedback was gathered by the survey sent out to the LAI Consortium Members.

The following subchapters briefly explain each of the nine steps. After that, evidence from the interviews as well as the survey is presented.

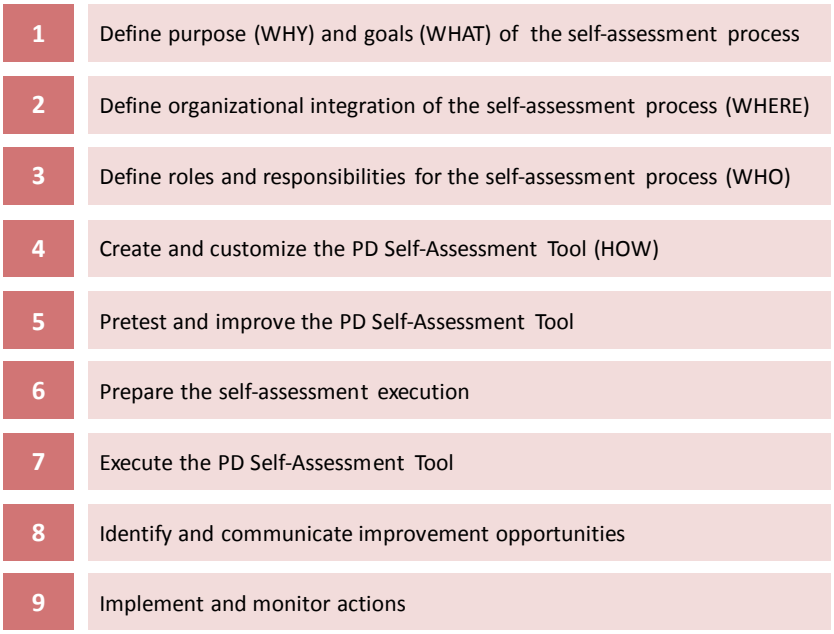

Figure 4-11: 9-Step-Model for the implementation of PDSAT

In applying the PDSAT Questionnaire, the first step is to commit to the timing of the assessment (WHEN). Conducting the PDSAT Questionnaire on an annual basis may be a reasonable idea for most companies. Whenever possible, the PDSAT Questionnaire should be conducted a few months prior to the annual business planning. This allows enough time to establish formal improvement plans in product development and thus leads to a stronger position in the annual budget negotiations.

4.5.1 Step 1 – Define Purpose (WHY) and Goals (WHAT) of the Self-Assessment Process

Since there is a considerable overlap in discussing the content of the first three steps of the 9-step-model, an official kick-off meeting with senior management and key employees from product development should be planned to discuss these three interrelated steps.

The execution of step 1 is essential for developing an appropriate understanding of the purpose and the goals of a possible self-assessment application in a specific organization. A group discussion among responsible key employees from product development is a meaningful approach for developing and sharing ideas about a possible self-assessment application. Two essential questions dealing with the PDSAT purpose and the PDSAT goals have to be considered:

The first question is: **Why** does the organization intend to use a product development self-assessment approach? This question refers to the purpose of the PDSAT application. Possible purposes may be, for example:

- Identification of improvement opportunities in an existing PD organization and its PD processes
- Business diagnosis: Assessing the current state of an existing PD organization and its PD processes as well as the gap against the "ideal" state
- Benchmarking of a project/program/organization within a firm
- Benchmarking of a project/program/organization with other firms

The second question is: **What** are the specific goals of using a product development self-assessment approach in a particular organization? To answer this question, the specific circumstances in the respective organization have to be taken into consideration. Group discussions among different employees from product development help to clarify the current situation and allow for a broader consideration of different ideas. It is then essential to focus on a few clear and simple goals which have to be aligned with each other as well as with overall business goals. Aligning them with ongoing organizational change efforts is fundamental as well. At the end of step 1, a first target timeline should be established.

The feedback survey sent out to the LAI Consortium Members revealed the “identification of improvement opportunities” and “business diagnosis” as the two main purposes of product development assessments (see Figure 4-12). Benchmarking both within and with other companies seemed to be of minor importance (see Figure 4-12). One respondent stated that “[his] primary goal would be to establish a quantitative link between PD improvements and financial results, requiring correlation analysis of assessment data.”

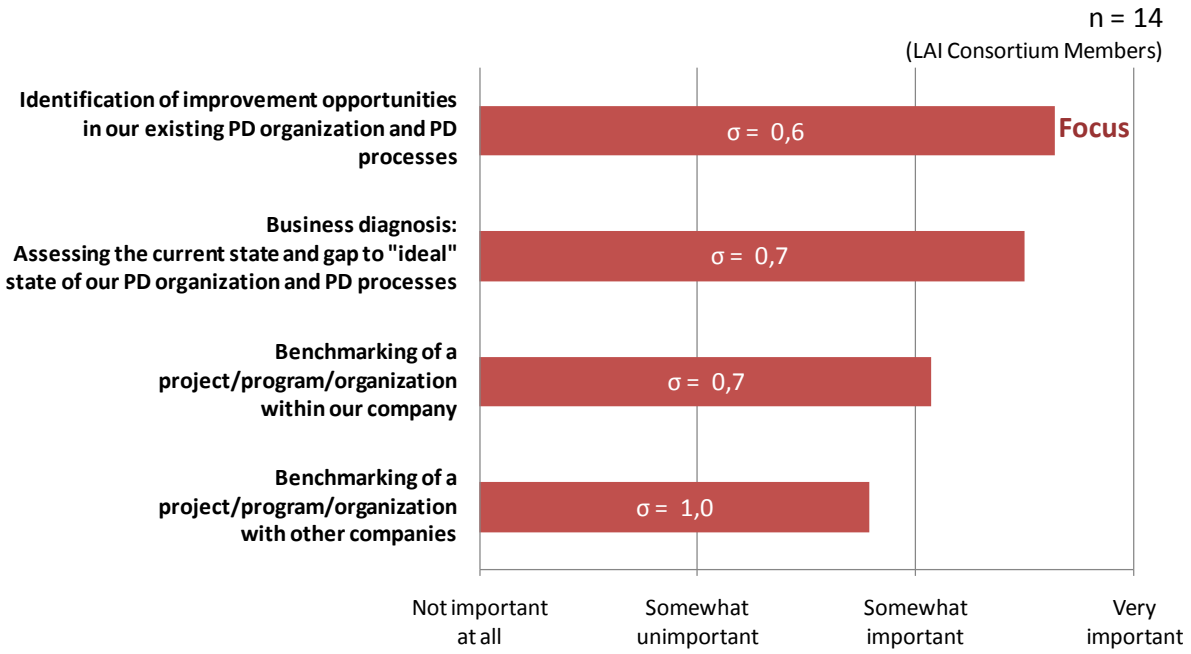

Figure 4-12: Purposes of PD Assessment

4.5.2 Step 2 – Define Organizational Integration of the Self-Assessment Process (WHERE)

Besides the purpose and the goals of the PDSAT application, two further questions regarding the organizational integration of the PDSAT have to be considered:

- Where should the self-assessment take place (project, division, etc.)?
- Is there a company-wide organizational change approach or process improvement approach in place, such as CMMI, Malcolm Baldrige National Quality Award, etc? If yes, how is the PDSAT to be integrated with these approaches?

The first bullet point refers to the level of analysis. Key employees from product development have to select either a certain project or division where they want to apply the PDSAT. In smaller companies it may make sense to assess, for example, the whole engineering division. Furthermore, in most cases it may be meaningful to focus on the development of a certain product or a product line.

The second bullet point refers to the integration of the PDSAT with previously implemented process improvement approaches. Integration in this context means the process of embedding the PDSAT into already established business improvement processes (e.g., CMMI) within the company. Because this integration process involves almost every function of the company, it is essential to invite not only key employees from product development and other relevant

functions, but senior management as well, to this discussion.

This thesis provides a number of different mappings between the PDSAT Questionnaire and other process improvement instruments (LESAT, CMMI, Malcom Baldrige National Quality Award) which provide helpful information for executing this step. For details see chapter 4.7.

4.5.3 Step 3 – Define Roles and Responsibilities for the Self-Assessment Process (WHO)

The main objective of Step 3 is to select a facilitator who is responsible for the whole administration and coordination of the PDSAT implementation. The facilitator has to be familiar with the firm's organizational structure and well-informed about ongoing company-wide business improvement processes both inside and outside of product development. In short, he or she is responsible for a variety of duties:

- First, it is the facilitator who should lead the discussion about defining the goals of the PDSAT implementation. In doing that, he or she is the direct contact person for senior management.
- Second, the facilitator is the contact person officially responsible for any questions about the PDSAT implementation process.
- Third, the facilitator is accountable for the creation and customization of the PDSAT Questionnaire, i.e., the tailoring process of adapting the PDSAT Questionnaire so that it best suits the previously defined purpose of the PD self-assessment. Furthermore, the facilitator has to decide whether he or she can do this step by him or herself or needs to involve key employees from other functions. In the latter case, it is reasonable to set up a separate meeting for creating and customizing the firm-specific PDSAT Questionnaire.
- Fourth, after the customization of the PDAST Questionnaire, the facilitator has to select, inform and officially invite the employees who are needed to evaluate the appropriate PDSAT metrics.
- Fifth, the facilitator is responsible for collecting enough reliable data for sufficiently evaluating the appropriate PDSAT metrics.

The industry focus group survey sent out to the LAI Consortium Members asked the respondents which part of the company should be responsible for conducting a PD assessment (see Figure 4-13). Almost two-thirds (sixty-four percent) indicated the functional organization as the main responsibility. Twenty-two percent thought that the staff organization should be in charge, and seven percent indicated the program organization. However, before generalizing these results, it should be taken into consideration that the respondents' background, i.e., their positions in their companies (see Figure 3-3), was very similar to their answers (see Figure 4-13).

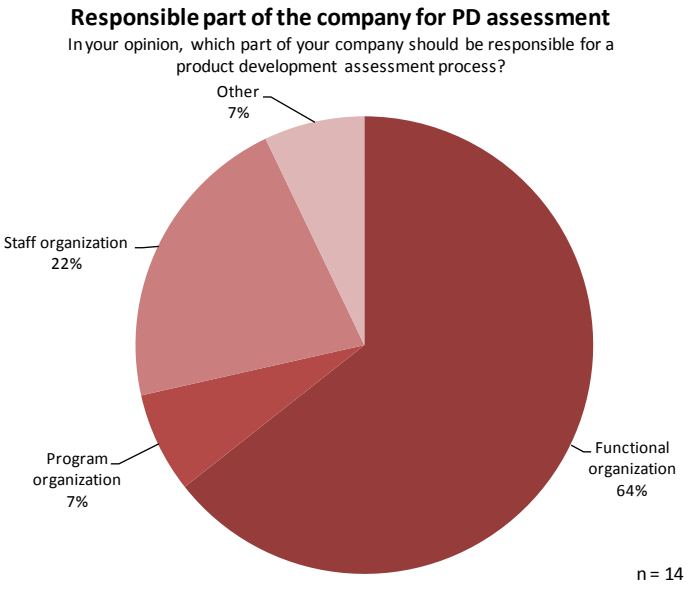

Figure 4-13: Responsible part of the company for PD assessment

4.5.4 Step 4 – Create and Customize the PD Self-Assessment Tool (HOW)

It may not always be meaningful to evaluate all 91 PDSAT metrics. In the majority of cases, it may make more sense to adapt the PDSAT Questionnaire according to the specific circumstances of a particular organization or unit of analysis. This process is called "Creation and Customization of PDSAT". Its purpose is to tailor and adapt the PDSAT Questionnaire so that it better fits the unit of analysis (project, program, engineering, etc.) addressed by the self-assessment approach.

The process of creating and customizing the PDSAT Questionnaire is different at every company. The first step may be to select all the PDSAT metrics which show a link to the specific product development processes of an organization. Furthermore, adding new metrics may be meaningful if important product development process areas of an organization are not addressed by the PDSAT metrics at all. Rephrasing certain PDSAT metrics in order to sharpen their focus on the respective products and processes of the organization may create an easier solution in other cases. If the PDSAT metrics do not apply to an organization's products and processes, they can be deleted. In certain cases it may be meaningful to obtain senior management's approval after the creation and customization of the PDSAT Questionnaire.

Senior management should also participate in the process of deciding whether a cross-functional group should evaluate the PDSAT metrics together or the PDSAT metrics should

be sent out and evaluated individually by the appropriate employees. This decision often depends on the self-assessment purpose. If the purpose is to discover improvement, evaluating the PDSAT metrics together in a group may make more sense. For assessing the current state of a PD system, evaluating the PDSAT metrics or parts of them individually and anonymously by sending questions out, such as in a survey, will be a more neutral and unbiased approach. If the PDSAT metrics are evaluated in a group, the facilitator has to make sure that the attendants are provided with the questions beforehand. That enables them to skim through the questions before the group meeting and thus saves time.

4.5.5 Step 5 – Pre-test and Improve the PD Self-Assessment Tool

After the PDSAT Questionnaire has been tailored to fit an organization's specific circumstances, it has to be pre-tested and, if necessary, improved. This is especially important if it is sent out as a survey to a high number of employees. The main purpose of pre-testing the customized PDSAT Questionnaire is to verify that employees understand the metrics they have to evaluate and are capable of evaluating them. The pre-test should be conducted with a number of employees after the self-assessment customization process. It is reasonable to select employees from different functions. At least three employees should participate in the pre-test of the customized PDSAT Questionnaire.

4.5.6 Step 6 – Prepare the Self-Assessment Execution

Before actually executing the PDSAT Questionnaire, a few preparations have to be made. The facilitator has to prepare and send out an introductory statement which informs the employees about the purpose of the PDSAT implementation in their organization. The introductory statement has to explain the structure of the PDSAT Questionnaire and define special vocabulary used in describing the different PDSAT metrics. If the PDSAT Questionnaire is sent out as a survey, the introductory statement has to make clear that the employees can anonymously evaluate the metrics assigned to them. Having senior management members sign the introductory statement makes sense in individual cases. Senior management's commitment is especially useful in creating a sense of urgency, i.e., motivating the PD employees in actively participating in the self-assessment process.

4.5.7 Step 7 – Execute the Self-Assessment

The actual execution of the self-assessment, i.e., evaluating the PDSAT metrics, can be conducted in two different ways:

- Evaluating the customized PDSAT metrics together in a group with key employees from product development and other functions
- Sending out the customized PDSAT Questionnaire to the respective experts and/or employees similar to a survey

In the first case, the facilitator has to invite the respective people to a half-day or day-long meeting for evaluating the selection of the customized PDSAT metrics. The PDSAT Questionnaire provides "customization fields" below the corresponding PDSAT metrics (see chapter 4.6) that should help in choosing and inviting the right employees. In the meeting itself, the facilitator should act as a moderator who asks questions to the group of experts and collects and documents their ideas and evaluations.

In the second case, the facilitator has to send out a set of PDSAT metrics to individuals who have the expertise in a particular area to answer them. The facilitator is responsible for selecting the PDSAT metrics and assigning them to the individual employees. He or she has to make sure that the employees are capable of evaluating their set of PDSAT metrics. One possible approach would be to send out a standard set of questions to all employees of the organization and other more specific questions to experts in certain areas.

4.5.8 Step 8 – Identify and Communicate Opportunities for Improvement

After measuring the set of PDSAT metrics and condensing the results, the current state of a particular product development process is known. The next step is to interpret the results and to define areas in which improvements are most urgently needed and reasonable to enact. For this reason a separate meeting with senior management and key employees from product development and other key functions should be set up. The objective of such a meeting is to identify improvement opportunities in product development as well as to define the desired levels of the assessed PD Competencies, PD Dynamic Capabilities and PD Results. Although the main goal of the organization should be to score as high as possible in the PDSAT metrics, this may not make sense for every company. Also, some of the PD Competencies and PD Dynamic Capabilities provided may not be important or applicable to certain organizations. Therefore, it is of paramount importance to prioritize the improvement ideas and to focus on the most urgent and promising ones. For this reason, the organization has to consider its vision, its strategic goals in product development and other functions, its core competencies, its available resources and many other factors. If the company is regularly using an assessment tool on the level of the firm (e.g., LESAT, CMMI, etc.) or a national quality award (Malcom Baldrige National Quality Award, EFQM, etc.) it may be meaningful to align the improvement objectives documented from using these instruments with the improvement objectives on the product development level identified in conducting the PDSAT Questionnaire. At the end of Step 8, it has to be clear where to take action in form of improvements of the product development process.

One of the respondents of the survey sent out to the LAI Consortium Members stated that Step 8 is "the most value added portion on any assessment." He referred to group discussions of the current state, addressing gaps and finding opportunities for improvements as the main steps.

4.5.9 Step 9 – Take Action

Once key employees from different functions and senior management have agreed on a future improvement plan, action can be taken in the particular areas of product development. The literature provides a number of formalized processes that guide practitioners in translating improvement ideas into successful change implementations. Two examples are the Deming Cycle (DEMING 2000; SHEWHART 1986) and the DMAIC Cycle (PYZDEK & KELLER 2009).

4.5.10 Survey Feedback on the 9-Step PDSAT Implementation Process

All survey respondents were asked to answer two questions:

- "For organizational assessments, do you execute process Steps 1-9 in your company?"
- "Do you believe Steps 1-9 are relevant for your company?"

When respondents indicated the execution of a certain step, they were asked to rate two additional statements on a scale from "does not apply at all" to "fully applies."

- "Our organization is successful in executing Steps 1-9."
- "It is easy to execute Steps 1-9 in our organization."

The results of these four questions are shown in Figure 4-14, Figure 4-15, Figure 4-16 and Figure 4-17. Additional results are presented in Appendix A of this thesis.

As Figure 4-14 shows, about fifty percent of the respondents indicated that their companies execute Steps 1-3 and Steps 6-9. Only about twenty percent, however, indicate executing Step 4 ("Create and customize the PD self-assessment tool"). About thirty percent pre-test their tool before they use it for evaluation (Step 5). Figure 4-15 shows that all nine steps of the proposed PDSAT Implementation Process are perceived to be relevant. Figure 4-16 presents the respondents' rating of how successful their company is at executing Steps 1-9. Again, Step 4 ("Create and customize the PD self-assessment tool") and Step 5 ("Pretest and improve the PD self-assessment tool") seem to be the weak points. Moreover, there is improvement potential in Step 8 and Step 9, which deal with the implementation of the improvement ideas found from conducting the assessment. Figure 4-17 presents the respondents' rating of how easy it is to execute Steps 1-9. The steps that appear to be most hard to implement are Step 2 ("Define organizational integration of the self-assessment process") and Step 4 ("Create and customize the PD self-assessment tool"), as well as Step 8 and Step 9.

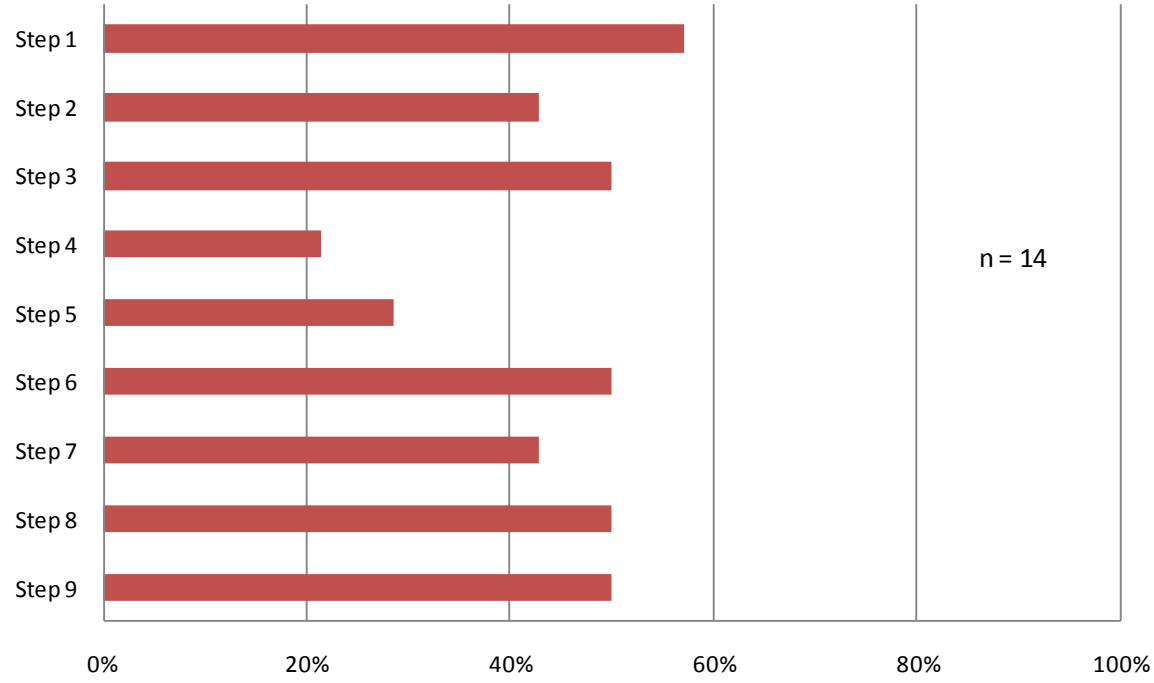

Figure 4-14: Percentage of companies which execute the single steps of the PDSAT Implementation Process in their organizational assessments

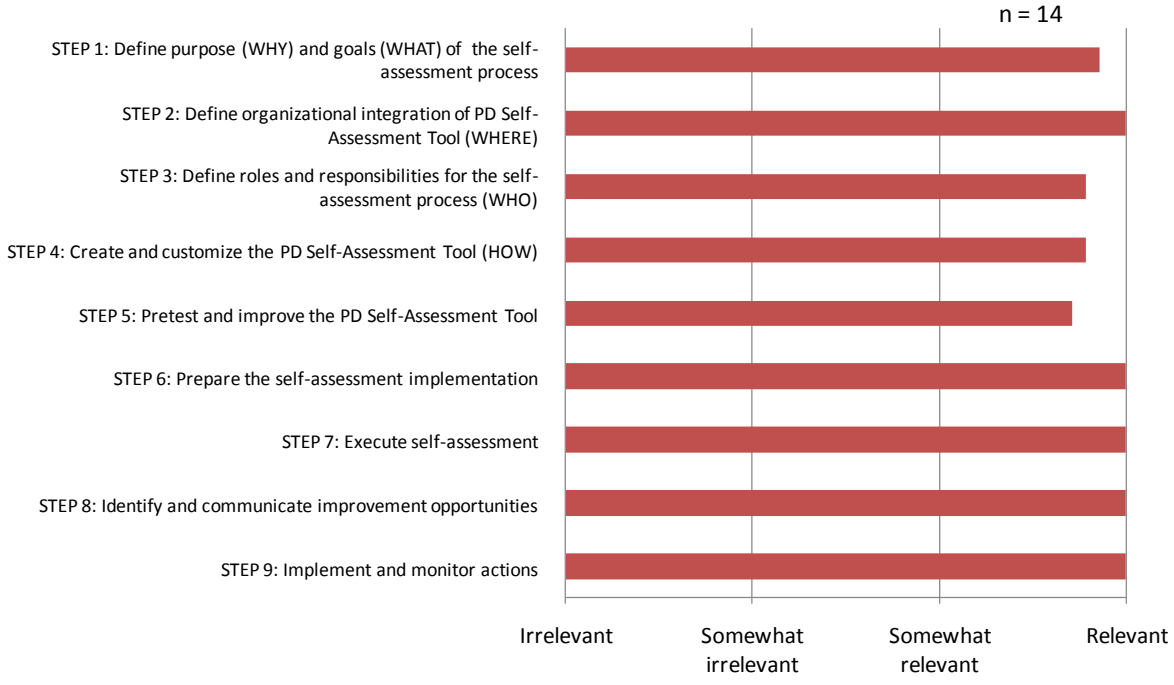

Figure 4-15: Respondents' perceived relevance of the nine steps of the PDSAT Implementation Process

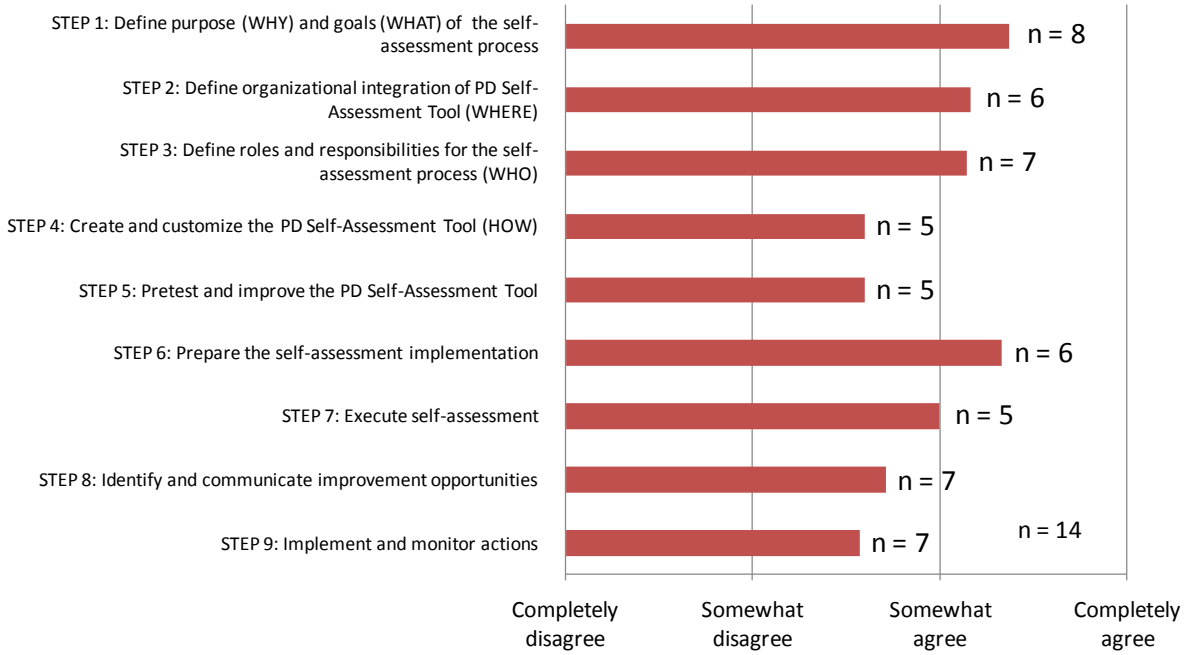

Figure 4-16: Respondents' rating of: "Our company is successful at executing Steps 1-9."

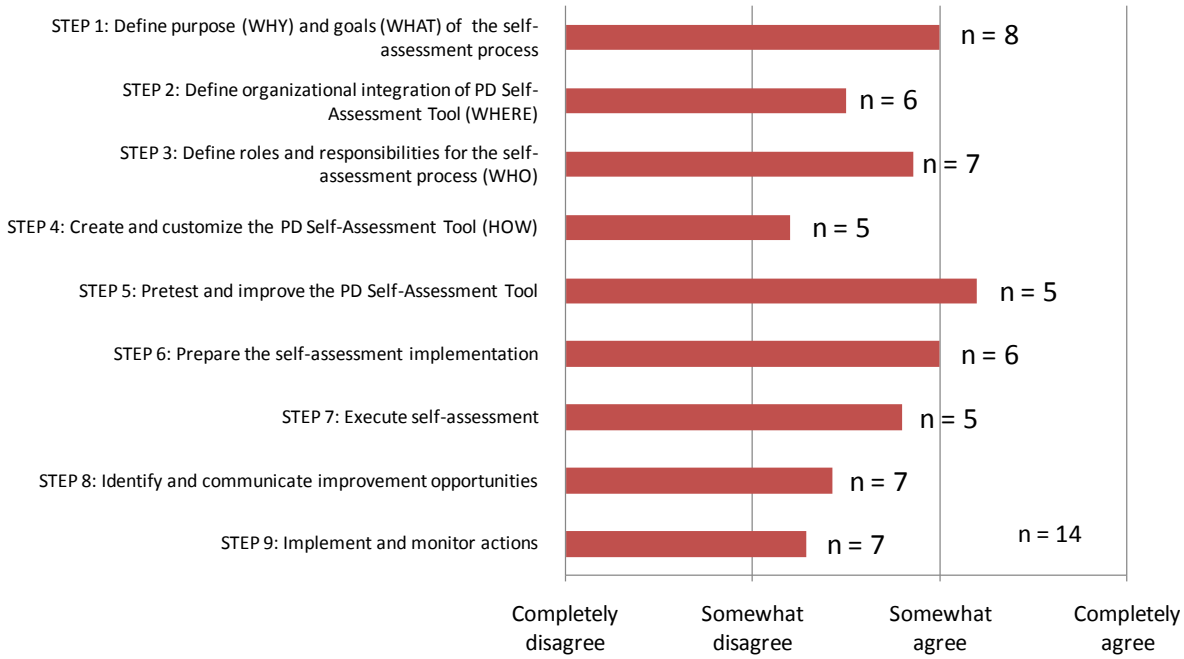

Figure 4-17: Respondents' rating of: "It is easy to execute Steps 1-9 in our organization."

4.5.11 Feedback Interviews at Company X

The 9-step PDSAT Implementation Process was discussed in depth at two interview sessions at Company X. Based on these discussions a number of changes were made to the original process. The minutes of the two meetings are presented in Appendix B in this thesis.

4.6 PDSAT Customization

In the ideal case, a PD assessment tool would measure the practices of a certain product development process against a standard model for product development. Thus, comparisons across firms could easily be made. However, a standard PD assessment tool is not suitable across all companies since every company is unique. This fact was the motivation for considering the possibility of customizing the PDSAT Questionnaire.

The PDSAT framework provides a process of customizing and therefore directly addresses a part of the research gap highlighted in chapter 2.4. As already explained in this thesis, customization is the process of tailoring and adapting the PDSAT Questionnaire to better fit the selected unit of analysis (project, program, or engineering) of a specific firm. This process can involve the following tasks:

- **Selecting** the PDSAT metrics that apply to the respective product development system to be assessed
- **Adding** new metrics, if important product development processes in the respective organization are not addressed by the PDSAT metrics
- **Re-phrasing** certain PDSAT metrics in order to sharpen their focus on the respective products and processes of an organization
- **Deleting** certain PDSAT metrics if they do not apply to an organization's products and processes or address an area where there are no problems
- **Re-titling** certain PDSAT metrics
- **Re-ordering** certain PDSAT metrics into a different structure

In order to facilitate the customization process all PD Competencies and PD Dynamic Capabilities are characterized along a number of dimensions such as functional area affected by the metric, organizational role affected by the metric, level of analysis, and Lean management related metric. These four customization dimensions are shown in the example metric (Transition to Sales) in Figure 4-3. The highlighted areas in magenta either characterize the particular metric (level of analysis, specific Lean management practice) or are especially important for implementing the specific PD best practices (functional area, organizational role).

The four customization dimensions should help the facilitator in tailoring the PDSAT Questionnaire. They are briefly described below:

- **Functional area** affected by the PDSAT metric (R&D, Quality, HR, Marketing, etc.). This dimension is especially useful for the process of inviting key employees from different functions. The facilitator acquires a quick overview of the different functions affected by the metric.
- **Organizational role** affected by the PDSAT metric (project leader, CI-organization, etc.). This dimension is especially useful for the process of inviting key employees from different functions. The facilitator acquires a quick overview of the different organizational hierarchies affected by the metric.
- **Level of analysis** (individuals, teams, projects, organization). This dimension is especially useful in the customization process of selecting certain PDSAT metrics. The dimension indicates for which level of analysis a certain PDSAT metric can be used. Minor re-phrasing may be necessary for adapting the PDSAT metric to the chosen level of analysis.
- **Lean management related metric** (specific Lean management practice or not). This dimension classifies the PD Competencies and the PD Dynamic Capabilities into "specific Lean management related metrics" and "not specific Lean management related metrics." Such a classification allows "Lean best practices" to be quickly identified.

The survey sent out to the LAI Consortium Members asked the respondents about their opinion on the four customization dimensions (see Figure 4-18). In general, all four customization dimensions were perceived as useful. However, the Lean management-related customization dimension didn't seem to be as relevant as the other three dimensions.

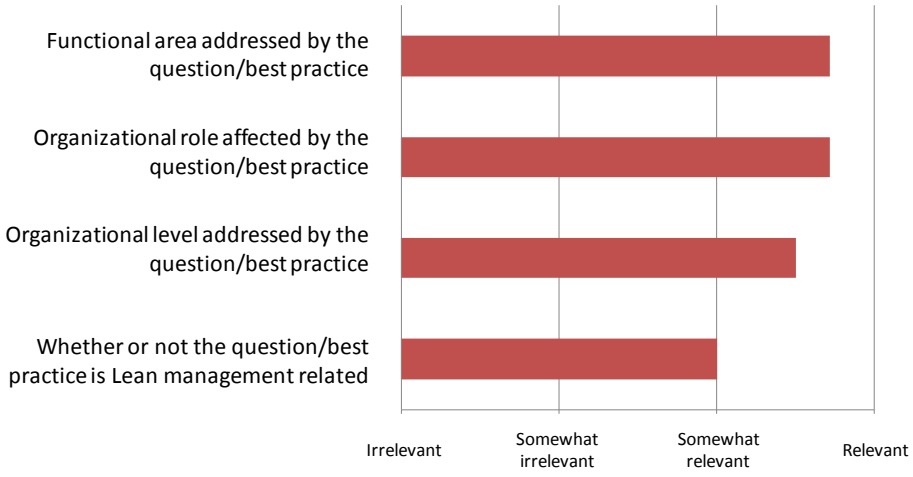

Figure 4-18: Survey respondents' opinion about the relevance of the customization dimensions

4.7 PDSAT Integration

Today most companies have established one or more standardized process improvement approaches which aim at helping them to improve their performance. It is therefore very important to consider all these business improvement processes already in use when introducing a new approach.

Figure 4-19 shows the most popular process improvement approaches implemented by the LAI Consortium companies (evidence from the industry focus group survey). As the figure reveals, all of the companies have implemented at least one business improvement approach. The Capability Maturity Model Integration (CMMI 2006) and Lean Management (WOMACK & JONES 1996, MORGAN & LIKER 2006, HOPPMANN 2009) are by far the two most common approaches. Thirteen out of fourteen respondents pointed out that their company was using CMMI. Eleven out of fourteen respondents stated that their company was employing Lean Management. Six Sigma (PYZDEK & KELLER 2009) and the Malcom Baldrige National Quality Award (MBNQA 2009) seemed to be popular process improvement approaches as well. Six out of the fourteen respondents indicated a use of Six Sigma. Two respondents pointed out that their company was employing the Malcom Baldrige National Quality Award. There were many more additional process improvement approaches used by the LAI Consortium Members. However, they do not seem to be as prevalent as the four approaches already mentioned.

Figure 4-19: Process improvement approaches of participating companies

The survey respondents were also asked their opinion about linking product development assessment tools with existing company-wide process improvement approaches. Their answers are shown in Figure 4-20. The vast majority of the respondents (eighty-six percent) think that it is "important" to link a product development assessment tool to already existing business improvement approaches. Only seven percent indicate that it is "somewhat important." Another seven percent consider this link to be "somewhat unimportant."

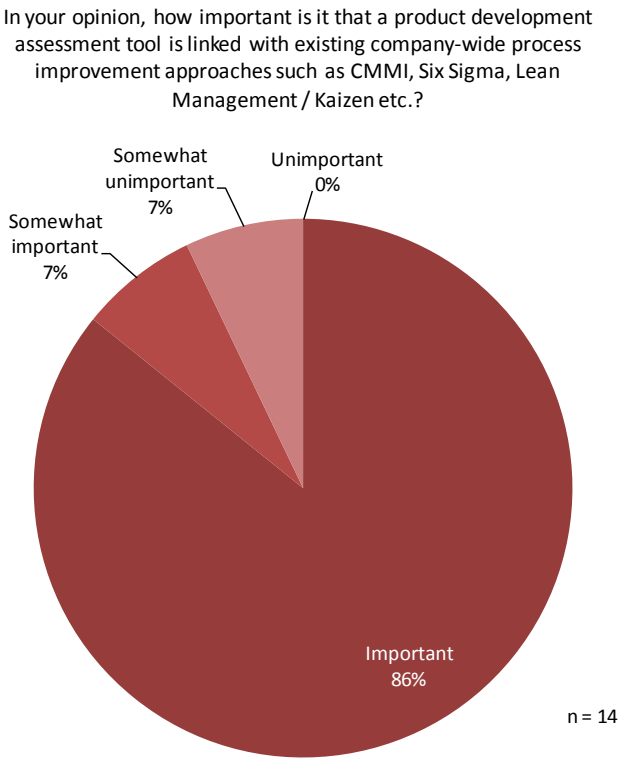

Figure 4-20: Perceived importance of link with other process improvement frameworks

The survey results indicate how important it is to consider other process improvement approaches when developing a product development assessment tool. Hence, the link between the PDSAT Questionnaire and the most common company-wide approaches is addressed in this thesis. Detailed mappings between the PDSAT Questionnaire and approaches such as CMMI, the LAI framework including the LESAT, the Malcom Baldrige Quality Awards, Six Sigma and Lean Management are presented in the following subchapters. The mappings are solely based on the author's opinion.

4.7.1 Integration of PDSAT into the LAI Enterprise Transformation Roadmap

The Lean Advancement Initiative (LAI) is a collaborative effort among industry and government organizations, MIT, and other academic institutions.

The LAI Enterprise Transformation Roadmap is a formalized model of how to plan an enterprise-level transformation. It comprises three main cycles: the strategic cycle, the planning cycle and the execution cycle, see Figure 4-21.

In integrating the PDSAT into the Enterprise Transformation Roadmap, the planning cycle in particular has to be considered. The planning cycle deals with critical activities associated with creating the current and future state enterprise analysis along with the creation of a prioritized transformation plan (ESAT 2010). The first step in the planning cycle is "Understand[ing] the current state of the enterprise" (P. 9). The next step indicates that the future enterprise has to be "envisioned and designed." The author suggests using both the LESAT (LAI Enterprise Self-Assessment Tool) and the PDSAT (Product Development Self-Assessment Tool) within the execution of these two steps (see Figure 4-21).

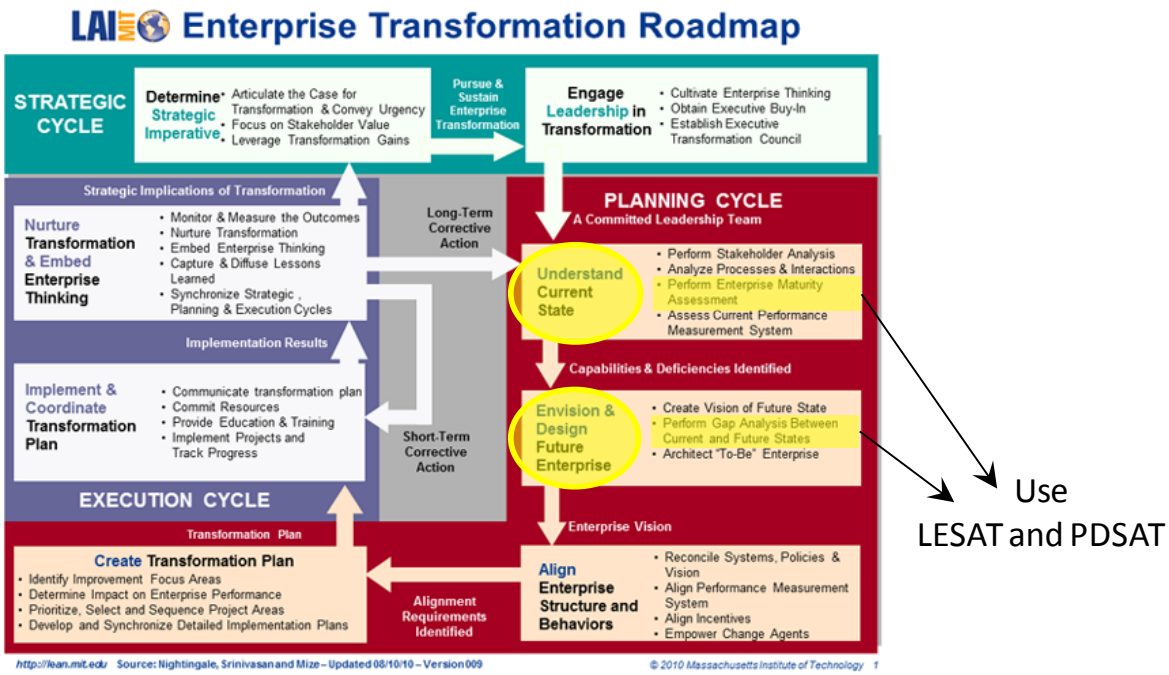

Figure 4-21: Integration of PDSAT into the LAI Enterprise Transformation Roadmap

4.7.2 Mapping between the LESAT and the PDSAT

The LESAT is LAI's Enterprise Self-Assessment Tool (LESAT 2010). In contrast to the PDSAT, it is focused at the enterprise level of assessment. The LESAT is a tool for self-assessing the present state of leanness of an enterprise and its readiness to change. It is organized into three main assessment sections:

- **Lean transformation/leadership:** This section contains those lean practices pertinent to the lean transformation process, with an emphasis on enterprise leadership and change management.
- **Life cycle processes:** This section contains those lean practices pertinent to the "life cycle processes" of an enterprise, i.e., those processes involved in product realization.
- **Enabling infrastructure:** This section contains those lean practices pertinent to the infrastructure support units.

Each of these three sections contains diagnostic questions, lean practices, five capability levels, and lean indicators. The tool is supported by a Facilitator's Guide as well as a LESAT Calculator.

Using both the LESAT and the PDSAT may result in assessing two related metrics twice. Figure 4-22, Figure 4-23 and Figure 4-24 present a mapping between the LESAT and the PDSAT that classifies the PDSAT metrics into "additional PD-specific metrics" and "overlapping metrics (with LESAT)". "Additional PD-specific metrics" are those metrics that focus especially on PD-related processes, and are not addressed in the LESAT. "Overlapping metrics (with LESAT)" are those metrics that have a broader focus on enterprise leadership and change management, and are addressed in the LESAT.

			Additional PD-specific Metric	Overlapping Metric
I. Enterprise Transformation/Leadership	I.A Determine Strategic Imperative	I.A.1 Integrate Enterprise Transformation into Strategic Planning Process		PDDC 5: Establishing a vision PDDC 6: Establishing a strategy
		I.A.2 Focus on Stakeholder Value	PDC 1: Customer relationships PDC 2: Customer satisfaction data	
		I.A.3 Articulate the Case for Transformation		PDDC 1: Communication of vision, strategy and plans
	I.B Engage Enterprise Leadership in Transformation	I.B.1 Cultivate Enterprise Thinking		PDDC 8: Understanding and leveraging organizational culture
		I.B.2 Obtain Senior Leadership Commitment		
		I.B.3 Establish Executive Coordination and Oversight		(PDDC 1: Communication of vision, strategy and plans)
	I.C Understand Current Enterprise State	I.C.1 Perform Stakeholder Analysis		
		I.C.2 Analyze Enterprise Processes & Interactions		
		I.C.3 Ensure Stability and Flow Within and Across the Enterprise		
	I.D Envision and Design the Future Enterprise	I.D.1 Envision the Enterprise State		(PDDC 5: Establishing a vision)
		I.D.2 Designing the Future Enterprise		
		I.D.3 Develop Enterprise Organizational Structure		PDDC 2: Communication and change diffusion barriers
	I.E Develop Enterprise Structure and Behavior	I.E.1 Reconcile systems, policies and vision		
		I.E.2 Align Performance Measurement System	all PD Project Results (PDR 1 to PDR 24)	
		I.E.3 Align Incentives	PDC 34: Specialist career path PDDC 18: PD recruiting & hiring	PDDC 17: PD rewarding & promotion
		I.E.4 Empower Change Agents		PDDC 4: Informal change diffusion in PD PDDC 11: Core change team composition
		I.E.5 Promote Relationships Based on Mutual Trust		PDDC 10: Work environment (fostering empathy, trust, personal reflection) PDDC 9: Teamwork culture
		I.E.6 Establish Open and Timely Communications		PDDC 3: Formal change diffusion in PD (meetings)
		I.E.7 Empower Employees		PDDC 13: Roles, responsibilities and empowerment
		I.E.8 Encourage Initiative		PDDC 19:Raising and maintaining urgency level for change PDDC 20: Motivating breakthrough ideas
	I.F Create Transformation Plan	I.F.1 Enterprise Level Transformation Plan		
		I.F.2 Communication Plan		(PDDC 1: Communication of vision, strategy and plans)
	I.G Implement and Coordinate Transformation Plan	I.G.1 Develop Detailed Plans Based on the Enterprise Plan		PDDC 7: Short term wins
		I.G.2 Commit Resources for Transformation Efforts		
		I.G.3 Provide Education and Training	PDC 32: PD staff competency PDC 33: Multi-disciplinary staffing PDDC 12: Teambuilding efforts PDDC 14: Mentoring & coaching PDDC 15: Attitude education PDDC 16: Technical training	
		I.G.4 Tracking Detailed Implementation	PDC 20: Time to market PDC 35: Use of project performance metrics PDC 36: Productivity metrics PDC 37: System of data collection, management and usage	
	I.H Nurture Process and Embed Enterprise Thinking	I.H.1 Monitor Transformation Progress		
		I.H.2 Nurturing the Transformation		(PDDC 1: Communication of vision, strategy and plans)
		I.H.3 Capture and Diffuse Lessons Learned	PDC 38: Knowledge management system PDDC 22: Cross-project knowledge transfer	
		I.H.4 Impact Enterprise Strategic Planning		PDDC 21: Pursuit of organizational learning (PDDC 7: Short term wins)
		I.H.5 Embed Enterprise Thinking Throughout the Organization		
		I.H.6 Institutionalize continuous Improvement		

Figure 4-22: Mapping between the LESAT and the PDSAT – Part 1

			Additional PD-specific Metric	Overlapping Metric
II. Life Cycle Processes	II.A Business Acquisition and Program Management	II.A.1 Leverage Lean Capability for Business Growth		(PDDC 8: Understanding and leveraging organizational culture)
		II.A.2 Optimize the Capability and Utilization of Assets	PDC 29: Workload leveling	
		II.A.3 Provide Capability to Manage Risk, Cost, Schedule and Performance	PDC 21: PD project financial goals PDC 22: Portfolio of product opportunities PDC 23: End-of-life strategy PDC 24: Risk management analysis PDC 25: Project leader's responsibilities and power PDC 26: Project leader's experience PDC 19: Schedule planning and control (PDC 35: Use of project performance metrics) (PDC 36: Productivity metrics) PDC 42: Product positioning PDC 43: Knowledge of market potential PDC 44: Product pricing strategy	
		II.A.4 Allocate Ressources for Program Development Efforts	(PDC 29: Workload leveling)	
	II.B System Engineering	II.B.1 Establish a Engineering Process to Optimize Lifecycle Value	PDC 6: Definition of product attributes and their values PDC 4: Linkage to corporate objectives PDC 5: Product's functional content PDC 9: Product variety management PDC 8: Set-based concurrent engineering	
		II.B.2 Utilize Knowledge from the Extended Enterprise to Optimize Future	PDC 39:Technology readiness PDC 41: Technology forecasting	
	II.C Develop Product/Service and Process	II.C.1 Incorporate Customer Value into Design of Products and Processes	(PDC 1: Customer relationships) (PDC 2: Customer satisfaction data)	
		II.C.2 Incorporate Downstream Stakeholder Values (Manufacturing, Support,…) into Products and Processes	PDC 7: Concept development PDC 12: Prototypes PDC 14: Release to manufacturing ramp-up PDC 15: Transition to sales PDC 16: Organizational readiness for sales PDC 17: Service and support complexity PDC 18: Product service processes	
		II.C.3 Integrate Product and Process Development	PDC 3: Product architecture PDC 11: Make-buy decision PDC 13: Rapid prototyping, simulation, testing PDC 27: Concurrent development PDC 28: Internal task coordination	
	II.D Manage Supply and Service Chain	II.D.1 Define and Develop Supplier and Service Network	PDC 31: Supplier integration (ties between PD and suppliers)	
		II.D.2 Optimize Network-Wide Performance		
		II.D.3 Foster Innovation and Knowledge-Sharing Throughout the Supplier Network		
	II.E Produce Product and Service	II.E.1 Utilize Production Knowledge and Capabilities for Competitive Advantage		
		II.E.2 Establish and Maintain Enterprise Capabilities		
	II.F Distribute and Service Product	II.F.1 Match Capacity to Demand		
		II.F.2 Distribute Product and Service Effectively		
		II.F.3 Enhance Value of Delivered Products and Customer Support Services		
		II.F.4 Provide Post Delivery Service, Support and Sustainability		

Figure 4-23: Mapping between the LESAT and the PDSAT – Part 2

			Additional PD-specific Metric	Overlapping Metric
III. Enabling Infrastructure	III.A Organizational Enablers	III.A.1 Enterprise Performance Measurement System Supports Enterprise Transformation		
		III.A.2 Enterprise Stakeholders Pull Required Metrics		
		III.A.3 Promulgate the Learning Organization	(PDC 38: Knowledge management system) (PDDC 22: Cross-project knowledge transfer)	(PDDC 21: Pursuit of organizational learning)
		III.A.4 Enable the Enterprise with Information Systems and Tools	(PDC 40: Investments in PD methods, tools and databases)	
		III.A.5 Integration of Environmental Protection, Health and Safety into the	PDC 45: Social responsibilities	
	III.B Process Enablers	III.B.1 Process Standardization	PDC 30: Development process	
		III.B.2 Common Tools and Systems	PDC 10: Re-use of physical and design assets (PDC 40: Investments in PD methods, tools and databases)	
		III.B.3 Process Variation Reduction		

Figure 4-24: Mapping between the LESAT and the PDSAT – Part 3

4.7.3 Mapping between the PDSAT and Lean Management

The term "Lean" was first coined by WOMACK ET AL. (1990) in their publication of *The Machine that Changed the World*. In this book, the authors thoroughly explained the thought process of "Lean," which has its roots in the automobile manufacturing process of the Japanese company Toyota. WOMACK ET AL. (1990) investigated in great detail the differences between leading western automobile manufacturers and Toyota. They came to the conclusion that the Toyota Production System (TPS) was fundamentally superior to and different from traditional ways of mass manufacturing.

The Machine that Changed the World paved the way for a number of subsequent academic investigations of the "Toyota phenomenon." Over the years, a new way of thinking about the entire enterprise called "Lean Thinking" emerged. Six years after releasing *The Machine that Changed the World*, WOMACK & JONES (1996) published a subsequent volume, titled *Lean Thinking*. In this book they presented five major principles of Lean Thinking:

- Specification of customer value
- Identification of the value stream
- Creation of a continuous flow
- Pull of the value
- Striving for perfection

Today, Lean Management can be regarded as a new concept of organizing and conducting business operations for the entire enterprise. Lean initiatives have expanded and address not only manufacturing, but also product development, distribution, construction, services, healthcare, and even practices in the government.

HOPPMANN (2009) intensively investigated and synthesized the literature on Lean Management related to product development. He came up with a classification of eleven Lean components and forty-four Lean characteristics. The eleven Lean components are:

- Process Standardization
- Simultaneous Engineering
- Strong Project Manager
- Workload Leveling
- Specialist Career Path
- Product Variety Management
- Supplier Integration
- Rapid Prototyping, Simulation and Testing
- Responsibility-based Planning and Control
- Set-based Engineering

- Cross-project Knowledge Transfer

Hoppmann's classification was used as a basis for drawing a map that rates whether the PDSAT metrics are Lean Management-related or not. This map is shown in Figure 4-25 and Figure 4-26. It is especially useful for the practitioners who want to acquire a quick overview of "Lean-specific" PDSAT metrics.

PDSAT Structure			Lean Management-related PD Competencies
PD Competencies	Customer Focus Competence	1.1.1 Customer relationships (PDC 1)	
		1.1.2 Customer satisfaction data (PDC 2)	
	Product Concept and Design Competence	1.2.1 Product architecture (PDC 3)	
		1.2.2 Linkage to corporate objectives (PDC 4)	
		1.2.3 Product's functional content (PDC 5)	
		1.2.4 Definition of product attributes and their values (PDC 6)	
		1.2.5 Concept development (PDC 7)	(X)
		1.2.6 Set-based concurrent engineering (PDC 8)	X
		1.2.7 Product variety management (PDC 9)	X
		1.2.8 Re-use of physical and design assets (PDC 10)	(X)
		1.2.9 Make-buy decision (PDC 11)	
	Product Validation Competence	1.3.1 Prototypes (PDC 12)	
		1.3.2 Rapid prototyping, simulation, testing (PDC 13)	X
	Product Delivery Competence	1.4.1 Release to manufacturing ramp-up (PDC 14)	(X)
		1.4.2 Transition to sales (PDC 15)	(X)
		1.4.3 Organizational readiness for sales (PDC 16)	(X)
		1.4.4 Service and support complexity (PDC 17)	
		1.4.5 Product service processes (PDC 18)	
	Project and Portfolio Management	1.5.1 Schedule planning and control (PDC 19)	(X)
		1.5.2 Time to market (PDC 20)	
		1.5.3 PD project financial goals (PDC 21)	
		1.5.4 Portfolio of product opportunities (PDC 22)	
		1.5.5 End-of-life strategy (PDC 23)	
		1.5.6 Risk management analysis (PDC 24)	
	Project Execution Competence	1.6.1 Project leader's responsibilities and power (PDC 25)	X
		1.6.2 Project leader's experience (PDC 26)	X
		1.6.3 Concurrent development (PDC 27)	X
		1.6.4 Internal task coordination (PDC 28)	
		1.6.5 Workload leveling (PDC 29)	X
		1.6.6 Development process (PDC 30)	(X)
		1.6.7 Supplier integration (ties between PD and suppliers)	X
	PD Staff Competence	1.7.1 PD staff competency (PDC 32)	
		1.7.2 Multi-disciplinary staffing (PDC 33)	
		1.7.3 Specialist career path (PDC 34)	X
	Data Management Competence	1.8.1 Use of project performance metrics (PDC 35)	
		1.8.2 Productivity metrics (PDC 36)	
		1.8.3 System of data collection, management and usage (PDC	
		1.8.4 Knowledge management system (PDC 38)	(X)
	Technology Competence	1.9.1 Technology readiness (PDC 39)	
		1.9.2 Investments in PD methods, tools and databases (PDC 40)	
		1.9.3 Technology forecasting (PDC 41)	
	Marketing Competence	1.10.1 Product positioning (PDC 42)	
		1.10.2 Knowledge of market potential (PDC 43)	
		1.10.3 Product pricing strategy (PDC 44)	
	Social Responsibility Competence	1.11.1 Social responsibilities (PDC 45)	

X = related with Lean components identified by Hoppmann (2009) ; (X) = implicitly related with Lean Product Development

Figure 4-25: Mapping between the PDSAT and Lean Management – Part 1

PDSAT Structure			Lean Management-related PD Dynamic Capabilities
PD Dynamic Capabilities	Communication and diffusion channels	2.1.1 Communication of vision, strategy and plans (PDDC 1)	
		2.1.2 Communication and change diffusion barriers (PDDC 2)	
		2.1.3 Formal change diffusion in PD (meetings) (PDDC 3)	
		2.1.4 Informal change diffusions in PD (PDDC 4)	
	Vision, strategy & plans	2.2.1 Establishing a vision (PDDC 5)	
		2.2.2 Establishing a strategy (PDDC 6)	
		2.2.3 Short term wins (PDDC 7)	
	Corporate culture	2.3.1 Understanding and leveraging organizational culture	
		2.3.2 Teamwork culture (PDDC 9)	
		2.3.3 Work environment (fostering empathy, trust, personal	
	People for change	2.4.1 Core change team composition (PDDC 11)	
		2.4.2 Teambuilding efforts (PDDC 12)	
		2.4.3 Roles, responsibilities and empowerment (PDDC 13)	
	Helping, training & education	2.5.1 Mentoring & coaching (PDDC 14)	(X)
		2.5.2 Attitude education (PDDC 15)	(X)
		2.5.3 Technical training (PDDC 16)	(X)
	Human resources for product development	2.6.1 PD rewarding & promotion (PDDC 17)	(X)
		2.6.2 PD recruiting & hiring (PDDC 18)	
	Openness to improvements	2.7.1 Raising and maintaining urgency level for change (PDDC 19)	(X)
		2.7.2 Motivating breakthrough ideas (PDDC 20)	
	Learning	2.8.1 Pursuit of organizational learning (PDDC 21)	(X)
		2.8.2 Cross-project knowledge transfer (PDDC 22)	X

X = related with Lean components identified by Hoppmann (2009) ; **(X)** = implicitly related with Lean Product Development

Figure 4-26: Mapping between the PDSAT and Lean Management – Part 2

4.7.4 Mapping between CMMI® for Development and the PDSAT

The Capability Maturity Model® Integration (CMMI 2006) for Development is a widely adopted process improvement reference model for the development of products and services. It can be regarded as a collection of best practices that address the product's life cycle from conception through delivery and maintenance. CMMI® for Development is applicable at different levels of analysis, such as the project level, division level or organizational level. Its main purpose is to help organizations improve their development and maintenance processes for both products and services.

CMMI® for Development is structured into four main categories (Project Management, Process Management, Engineering, and Support) and twenty-two process areas (see Figure 4-27). Each of these process areas includes a purpose statement, introductory notes and a short description of related process areas. Beyond that, the components of each process area are classified into:

- **Required components**: These components describe what the organization has to achieve to satisfy a certain process area. The two required components are called *specific goals* and *generic goals* in CMMI.
- **Expected components**: These components describe what an organization may implement to achieve a required component. The two expected components are called *specific practices* and *generic practices*.
- **Informative components**: These components provide additional help for the organization to achieve the required and expected components. They include subpractices, typical work products, amplifications, generic practice elaborations, goal and practice titles, and goal and practice notes and references.

CMMI® for Development offers two improvement paths:

- **Continuous representation (capability levels)**: This representation enables an organization to incrementally improve processes according to (an) individual process area(s) selected by the organization. The selection of the process area(s) is based on improvement objectives. The five capability levels are:
    - Incomplete (Level 0)
    - Performed (Level 1)
    - Managed (Level 2)
    - Defined (Level 3)
    - Quantitatively managed (Level 4)
    - Optimizing (Level 5)
- **Staged representation (maturity levels)**: This representation enables an organization to improve a set of related processes by incrementally addressing successive sets of process areas. The staged representation can be seen as a model-based improvement path for the whole organization. It suggests sets of process areas

that need to be improved in order to achieve the next maturity level. The selection of the process area(s) is based on previously reached maturity levels. The five maturity levels are:

- N/A (Level 0)
- Initial (Level 1)
- Managed (Level 2)
- Defined (Level 3)
- Quantitatively managed (Level 4)
- Optimizing (Level 5)

All the information provided in this subchapter was extracted from CMMI (2006).

A mapping between the twenty-two CMMI process areas and the PDSAT metrics is presented in Figure 4-27, Figure 4-28, Figure 4-29 and Figure 4-30. Since there is a considerable overlap between the CMMI structure and the PDSAT structure, the tables show all related PDSAT metrics for each CMMI process area.

CMMI						PDSAT
No.	**Process Area**	**Purpose**	**Abb.**	**Category**	**Maturity Level**	**related measures in PDSAT**
1.	Causal Analysis and Resolution	The purpose of Causal Analysis and Resolution (CAR) is to identify causes of defects and other problems and take action to prevent them from occurring in the future.	CAR	Support	5	the whole PDSAT Tool: PDC 1 - PDC 45 PDDC 1 - PDDC 22
2.	Configuration Management	The purpose of Configuration Management (CM) is to establish and maintain the integrity of work products using configuration identification, configuration control, configuration status accounting, and configuration audits.	CM	Support	2	PDC 3: Product architecture PDC 4: Linkage to corporate objectives PDC 5: Product's functional content PDC 6: Definition of product attributes and their values PDC 9: Product variety management PDC 10: Re-use of physical and design assets PDC 11: Make-buy decision PDC 14: Release to manufacturing ramp-up PDC 15: Transition to sales PDC 16: Organizational readiness for sales PDC 17: Service and support complexity PDC 18: Product service processes PDC 21: PD project financial goals PDC 23: End-of-life strategy PDC 39: Technology readiness PDC 40: Investments in PD methods, tools and databases
3.	Decision Analysis and Resolution	The purpose of Decision Analysis and Resolution (DAR) is to analyze possible decisions using a formal evaluation process that evaluates identified alternatives against established criteria.	DAR	Support	3	PDC 7: Concept development PDC 8: Set-based concurrent engineering PDC 9: Product variety management PDC 10: Re-use of physical and design assets PDC 11: Make-buy decision PDC 24: Risk management analysis PDC 25: Project leader's responsibilities and power PDC 27: Concurrent development PDC 28: Internal task coordination PDC 29: Workload leveling PDC 30: Development process PDDC 13: Roles, responsibilities and empowerment
4.	Integrated Project Management + IPPD	The purpose of Integrated Project Management (IPM) is to establish and manage the project and the involvement of the relevant stakeholders according to an integrated and defined process that is tailored from the organization's set of standard processes. IPPD-Addition: For IPPD, Integrated Project Management +IPPD also covers the establishment of a shared vision for the project and the establishment of integrated teams that will carry out objectives of the project.	IPM + IPPD	Project Management	3	PDC 1: Customer relationships PDC 4: Linkage to corporate objectives PDC 7: Concept development PDC 8: Set-based concurrent engineering PDC 9: Product variety management PDC 13: Rapid prototyping, simulation, testing PDC 14: Release to manufacturing ramp-up PDC 15: Transition to sales PDC 16: Organizational readiness for sales PDC 17: Service and support complexity PDC 18: Product service processes PDC 19: Schedule planning and control PDC 20: Time to market PDC 21: PD project financial goals PDC 22: Portfolio of product opportunities PDC 23: End-of-life strategy PDC 24: Risk management analysis PDC 25: Project leader's responsibilities and power PDC 26: Project leader's experience PDC 27: Concurrent development PDC 28: Internal task coordination PDC 29: Workload leveling PDC 30: Development process PDC 31: Supplier integration (ties between PD and suppliers) PDC 34: Specialist career path PDC 37: System of data collection, management and usage PDC 38: Knowledge management system PDDC 1: Communication of vision, strategy and plans PDDC 5: Establishing a vision PDDC 6: Establishing a strategy PDDC 7: Short term wins PDDC 8: Understanding and leveraging organizational culture PDDC 9: Teamwork culture PDDC 10: Work environment (fostering empathy, trust, personal reflection) PDDC 11: Core change team composition PDDC 12: Teambuilding efforts PDDC 13: Roles, responsibilities and empowerment PDDC 14: Mentoring & coaching PDDC 15: Attitude education PDDC 17: PD rewarding & promotion PDDC 22: Cross-project knowledge transfer

Figure 4-27: Mapping between CMMI and the PDSAT – Part 1

CMMI						PDSAT
No.	Process Area	Purpose	Abb.	Category	Maturity Level	related measures in PDSAT
5.	Measurement and Analysis	The purpose of Measurement and Analysis (MA) is to develop and sustain a measurement capability that is used to support management information needs.	MA	Support	2	PDC 2: Customer satisfaction data PDC 4: Linkage to corporate objectives PDC 19: Schedule planning and control PDC 20: Time to market PDC 21: PD project financial goals PDC 24: Risk management analysis PDC 35: Use of project performance metrics PDC 36: Productivity metrics PDC 37: System of data collection, management and usage PDC 38: Knowledge management system PDDC 22: Cross-project knowledge transfer
6.	Organizational Innovation and Deployment	The purpose of Organizational Innovation and Deployment (OID) is to select and deploy incremental and innovative improvements that measurably improve the organization's processes and technologies. The improvements support the organization's quality and process performance objectives as derived from the organization's business objectives.	OID	Process Management	5	PDC 41: Technology forecasting PDDC 2: Communication and change diffusion barriers PDDC 3: Formal change diffusion in PD (meetings) PDDC 4: Informal change diffusion in PD PDDC 10: Work environment PDDC 11: Core change team composition PDDC 13: Roles, responsibilities and empowerment PDDC 17: PD rewarding & promotion PDDC 18: PD recruiting & hiring PDDC 19: Raising and maintaining urgency level for change PDDC 20: Motivating breakthrough ideas
7.	Organizational Process Defintion + IPPD	The purpose of Organizational Process Definition (OPD) is to establish and maintain a usable set of organizational process assets and work environment standards. IPPD-Addition: For IPPD, Organizational Process Definition +IPPD also covers the establishment of organizational rules and guidelines that enable conducting work using integrated teams.	OPD + IPPD	Process Management	3	PDC 14: Release to manufacturing ramp-up PDC 15: Transition to sales PDC 16: Organizational readiness for sales PDC 17: Service and support complexity PDC 18: Product service processes PDC 25: Project leader's responsibilities and power PDC 27: Concurrent development PDC 30: Development process PDC 38: Knowledge management system PDDC 5: Establishing a vision PDDC 6: Establishing a strategy PDDC 9: Teamwork culture PDDC 10: Work environment (fostering empathy, trust, personal reflection) PDDC 11: Core change team composition PDDC 13: Roles, responsibilities and empowerment PDDC 22: Cross-project knowledge transfer
8.	Organization Process Focus	The purpose of Organizational Process Focus (OPF) is to plan, implement, and deploy organizational process improvements based on a thorough understanding of the current strengths and weaknesses of the organization's processes and process assets.	OPF	Process Management	3	PDC 14: Release to manufacturing ramp-up PDC 15: Transition to sales PDC 16: Organizational readiness for sales PDC 17: Service and support complexity PDC 18: Product service processes PDC 27: Concurrent development PDC 30: Development process PDC 35: Use of project performance metrics PDC 36: Productivity metrics PDC 37: System of data collection, management and usage PDC 38: Knowledge management system PDDC 1: Communication of vision, strategy and plans PDDC 9: Teamwork culture PDDC 21: Pursuit of organizational learning PDDC 22: Cross-project knowledge transfer
9.	Organizational Process Performance	The purpose of Organizational Process Performance (OPP) is to establish and maintain a quantitative understanding of the performance of the organization's set of standard processes in support of quality and process-performance objectives, and to provide the process performance data, baselines, and models to quantitatively manage the organization's projects.	OPP	Process Management	4	PDC 35: Use of project performance metrics PDC 36: Productivity metrics PDC 37: System of data collection, management and usage

Figure 4-28: Mapping between CMMI and the PDSAT – Part 2

CMMI						PDSAT
No.	**Process Area**	**Purpose**	**Abb.**	**Category**	**Maturity**	**related measures in PDSAT**
10.	Organizational Training	The purpose of Organizational Training (OT) is to develop the skills and knowledge of people so they can perform their roles effectively and efficiently.	OT	Process Management	3	PDC 26: Project leader's experience PDC 32: PD staff competency PDC 33: Multi-disciplinary staffing PDC 34: Specialist career path PDC 26: Project leaders experience PDC 38: Knowledge management system PDDC 14: Mentoring & coaching PDDC 15: Attitude education PDDC 16: Technical training PDDC 18: PD Recruiting & hiring PDDC 21: Pursuit of organizational learning
11.	Product Integration	The purpose of Product Integration (PI) is to assemble the product from the product components, ensure that the product, as integrated, functions properly, and deliver the product.	PI	Engineering	3	PDC 3: Product architecture PDC 9: Product variety management PDC 12: Prototypes PDC 13: Rapid prototyping, simulation, testing
12.	Project Monitoring and Control	The purpose of Project Monitoring and Control (PMC) is to provide an understanding of the project's progress so that appropriate corrective actions can be taken when the project's performance deviates significantly from the plan.	PMC	Project Management	2	PDC 2: Customer satisfaction data PDC 19: Schedule planning and control PDC 20: Time to market PDC 21: PD project financial goals PDC 24: Risk management analysis PDC 35: Use of project performance metrics PDC 36: Productivity metrics PDC 37: System of data collection, management and usage PDC 40: Investments in PD methods, tools and databases
13.	Project Planning	The purpose of Project Planning (PP) is to establish and maintain plans that define project activities.	PP	Project Management	2	PDC 1: Customer relationships PDC 19: Schedule planning and control PDC 20: Time to market PDC 21: PD project financial goals PDC 22: Portfolio of product opportunities PDC 23: End-of-life strategy PDC 24: Risk management analysis PDC 28: Internal task coordination PDC 29: Workload leveling PDC 31: Supplier integration (ties between PD and suppliers) PDC 42: Product positioning PDC 43: Knowledge of market potential PDC 44: Product pricing strategy PDDC 2: Communication and change diffusion barriers PDDC 3: Formal change diffusion in PD (meetings) PDDC 4: Informal change diffusions in PD PDDC 7: Short term wins PDDC 19: Raising and maintaining urgency level for change
14.	Process and Product Quality Assurance	The purpose of Process and Product Quality Assurance (PPQA) is to provide staff and management with objective insight into processes and associated work products.	PPQA	Support	2	PDC 36: Productivity metrics PDC 37: System of data collection, management and usage PDC 40: Investments in PD methods, tools and databases
15.	Quantitative Project Management	The purpose of Quantitative Project Management (QPM) is to quantitatively manage the project's defined process to achieve the project's established quality and process-performance objectives.	QPM	Project Management	4	PDC 4: Linkage to corporate objectives PDC 19: Schedule planning and control PDC 20: Time to market PDC 21: PD project financial goals PDC 35: Use of project performance metrics PDC 36: Productivity metrics PDC 37: System of data collection, management and usage PDC 40: Investments in PD methods, tools and databases
16.	Requirements Development	The purpose of Requirements Development (RD) is to produce and analyze customer, product, and product component requirements.	RD	Engineering	3	PDC 1: Customer relationships PDC 2: Customer satisfaction data PDC 3: Product architecture PDC 5: Product's functional content PDC 6: Definition of product attributes and their values PDC 42: Product positioning PDC 43: Knowledge of market potential PDC 44: Product pricing strategy

Figure 4-29: Mapping between CMMI and the PDSAT – Part 3

CMMI						PDSAT
No.	**Process Area**	**Purpose**	**Abb.**	**Category**	**Maturity Level**	**related measures in PDSAT**
17.	Requirements Management	The purpose of Requirements Management (REQM) is to manage the requirements of the project's products and product components and to identify inconsistencies between those requirements and the project's plans and work products.	REQM	Engineering	2	PDC 1: Customer relationships PDC 2: Customer satisfaction data PDC 7: Concept development PDC 14: Release to manufacturing ramp-up PDC 15: Transition to sales PDC 16: Organizational readiness for sales PDC 17: Service and support complexity PDC 18: Product service processes
18.	Risk Management	The purpose of Risk Management (RSKM) is to identify potential problems before they occur so that risk-handling activities can be planned and invoked as needed across the life of the product or project to mitigate adverse impacts on achieving objectives.	RSKM	Project Management	3	PDC 24: Risk management analysis
19.	Supplier Agreement Management	The purpose of Supplier Agreement Management (SAM) is to manage the acquisition of products from suppliers.	SAM	Project Management	2	PDC 31: Supplier integration (ties between PD and suppliers)
20.	Technical Solution	The purpose of Technical Solution (TS) is to design, develop, and implement solutions to requirements. Solutions, designs, and implementations encompass products, product components, and product-related lifecycle processes either singly or in combination as appropriate.	TS	Engineering	3	PDC 3: Product architecture PDC 7: Concept development PDC 8: Set-based concurrent engineering PDC 9: Product variety management PDC 10: Re-use of physical and design assets PDC 11: Make-buy decision PDC 12: Prototypes PDC 13: Rapid prototyping, simulation, testing PDC 14: Release to manufacturing ramp-up PDC 39: Technology readiness PDC 40: Investments in PD methods, tools and databases
21.	Validation	The purpose of Validation (VAL) is to demonstrate that a product or product component fulfills its intended use when placed in its intended environment.	VAL	Engineering	3	PDC 12: Prototypes PDC 13: Rapid prototyping, simulation, testing
22.	Verification	The purpose of Verification (VER) is to ensure that selected work products meet their specified requirements.	VER	Engineering	3	PDC 12: Prototypes PDC 13: Rapid prototyping, simulation, testing

Figure 4-30: Mapping between CMMI and the PDSAT – Part 4

4.7.5 Mapping between Malcom Baldrige National Quality Award and the PDSAT

The Malcom Baldrige National Quality Award is an annual reward for US companies which achieve performance excellence (MBNQA 2009). It is based on a generic model that can be used for the award application by all types of organizations, whether they are large or small, manufacturing or service, private or public (VAN DER WIELE ET AL. 2000, P. 9).

The requirements of the 2009-2010 Criteria for Performance Excellence are classified into seven categories, as follows:

- Leadership
- Strategic Planning
- Customer Focus
- Measurement, Analysis, and Knowledge Management
- Workforce Focus
- Process Management
- Results

Figure 4-31 and Figure 4-32 present a one-to-one mapping between the Malcom Baldrige National Quality Award and the PDSAT. In this mapping all 91 PDSAT metrics are assigned to the seven MBNQA categories.

	related PDSAT metrics
1. Leadership	PDC 45: Social responsibilities PDDC 1: Communication of vision, strategy and plans PDDC 5: Establishing a vision PDDC 20: Motivating breakthrough ideas
2. Strategic Planning	PDC 4: Linkage to corporate objectives PDC 21: PD project financial goals PDC 22: Portfolio of product opportunities PDC 23: End-of-life strategy PDC 41: Technology forecasting PDDC 6: Establishing a strategy PDDC 7: Short term wins
3. Customer Focus	PDC 1: Customer relationships PDC 2: Customer satisfaction data
4. Measurement, Analysis, and Knowledge Management	PDC 35: Use of project performance metrics PDC 36: Productivity metrics PDC 37: System of data collection, management and usage PDC 38: Knowledge management system PDC 39: Technology readiness PDC 40: Investments in PD methods, tools and databases

Figure 4-31: Mapping between MBNQA and the PDSAT – Part 1

	related PDSAT metrics
5. Workforce Focus	PDC 25: Project leader's responsibilities and power PDC 26: Project leader's experience PDC 32: PD staff competency PDC 33: Multi-disciplinary staffing PDC 34: Specialist career path PDDC 2: Communication and change diffusion barriers PDDC 3: Formal change diffusion in PD (meetings) PDDC 4: Informal change diffusion in PD PDDC 8: Understanding and leveraging organizational culture PDDC 9: Teamwork culture PDDC 10: Work environment (fostering empathy, trust, personal reflection) PDDC 11: Core change team composition PDDC 12: Teambuilding efforts PDDC 13: Roles, responsibilities and empowerment PDDC 14: Mentoring & coaching PDDC 15: Attitude education PDDC 16: Technical training PDDC 17: PD rewarding & promotion PDDC 18: PD recruiting & hiring PDDC 19: Raising and maintaining urgency level for change
6. Process Management	PDC 3: Product architecture PDC 5: Product's functional content PDC 6: Definition of product attributes and their values PDC 7: Concept development PDC 8: Set-based concurrent engineering PDC 9: Product variety management PDC 10: Re-use of physical and design assets PDC 11: Make-buy decision PDC 12: Prototypes PDC 13: Rapid prototyping, simulation, testing PDC 14: Release to manufacturing ramp-up PDC 15: Transition to sales PDC 16: Organizational readiness for sales PDC 17: Service and support complexity PDC 18: Product service processes PDC 19: Schedule planning and control PDC 20: Time to market PDC 24: Risk management analysis PDC 27: Concurrent development (PDC 28: Internal task coordination PDC 29: Workload leveling PDC 30: Development process PDC 31: Supplier integration (ties between PD and suppliers)
7. Results	PDR 1 - PDR 24

Figure 4-32: Mapping between MBNQA and the PDSAT – Part 2

4.7.6 Linking the PDSAT Implementation with the Six Sigma DMAIC Cycle

Six Sigma (PYZDEK & KELLER 2009) is a business management strategy concept originated by Motorola Inc. in the mid- 1980s. Today, it is widely used in many different sectors of industry. Six Sigma aims at improving the quality of business processes by continually identifying and reducing defects in the organization. Therefore, it uses a set of quality management methods, including statistical methods. This also includes the DMAIC Cycle, a method for solving problems with an unknown solution to improve existing business processes. DMAIC consists of five phases: define, measure, analyze, improve and control (KWAK & ANBARI 2006; LINDERMAN ET AL. 2003).

The DMAIC Cycle can be used for implementing the improvement ideas generated from a PDSAT Self-Assessment. Figure 4-33 shows a DMAIC cycle adapted for use in combination with the 9-step PDSAT Implementation Process. Figure 4-34 shows the relationship and the overlap between the PDSAT Implementation Process and the DMAIC Process.

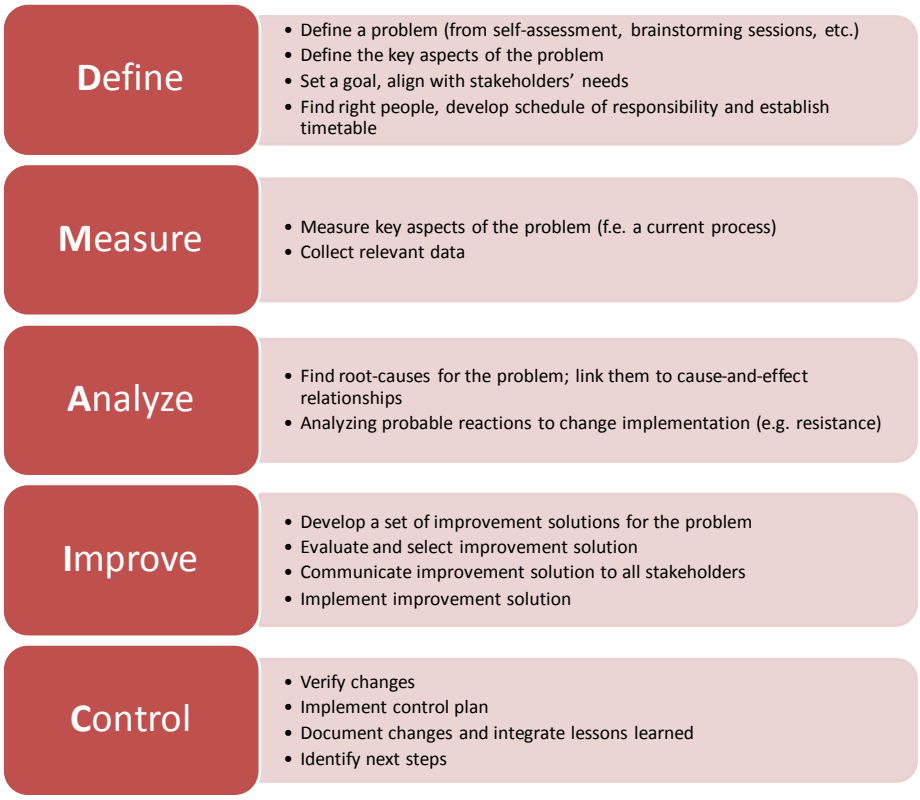

Figure 4-33: DMAIC Cycle, adapted for PDSAT from LINDERMAN ET AL. (2003)

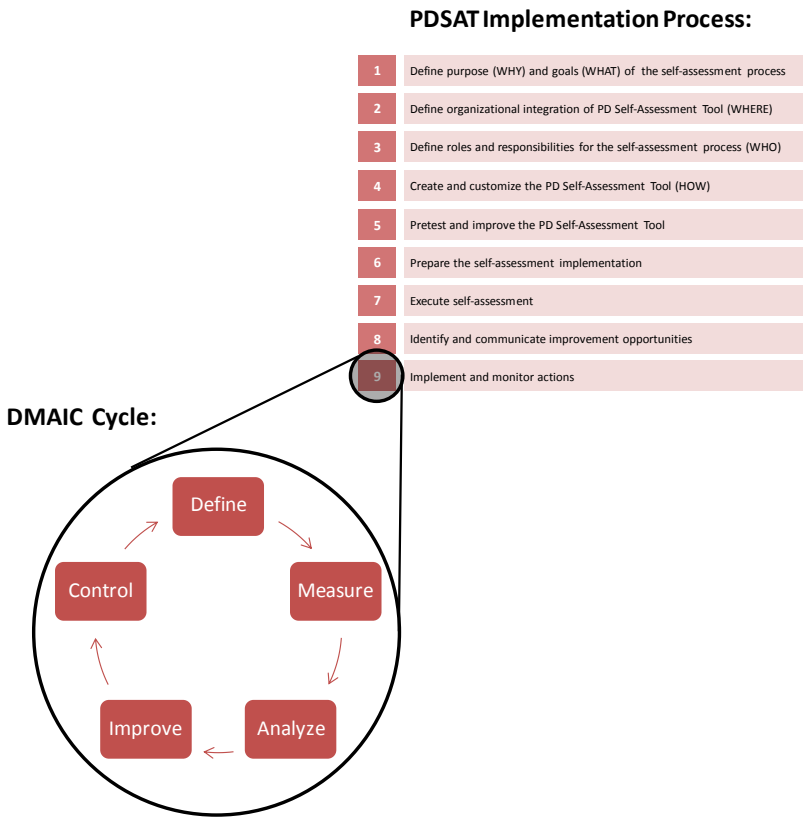

Figure 4-34: Relationship between the PDSAT Implementation Process and the DMAIC Cycle

4.7.7 Comments on the Mapping Process

The process of mapping and correlating the structures of the PDSAT Questionnaire with other process improvement framework, which finally led to the results presented in the previous subchapters, was solely based on the author's subjective opinion. This chapter provides reflections on the mapping process.

The mapping between the LESAT and the PDSAT Questionnaire (see chapter 4.7.2) was perceived as an unproblematic and straightforward process. Most PDSAT metrics could be allocated into "additional PD-specific metrics" and "overlapping metrics (with LESAT)". For a small sample of the PDSAT metrics, it was not possible to do a one-to-one mapping. Therefore, these PDSAT metrics were mapped two or more times with certain LESAT metrics. In summary, the more general organizational change metrics (in PDSAT: PD Dynamic Capabilities) in PDSAT and LESAT are very similar. This shows that these organizational change metrics are relatively generic and important both for product development as well as the whole company. The PD Competencies, which focus especially on product development, are "additional PD-specific metrics" throughout. They are not addressed in the LESAT. Therefore, it is recommended to use PDSAT, if the scope of the self-assessment process is the product development organization.

The mapping process between Lean Management and the PDSAT Questionnaire (see chapter 4.7.3) was perceived as unproblematic as well. The Lean Product Development classification by HOPPMANN (2009) was used to rate whether a PDSAT metric is "Lean Management-related" or not. Eight of the PD Competencies and six of the PD Dynamic Capabilities are not directly mentioned in Hoppmann's classification. However, they are implicitly related with Lean Product Development, i.e., they use a similar idea or are based on a similar idea.

The mapping process between CMMI® for Development and the PDSAT Questionnaire (see chapter 4.7.4) was perceived as relatively hard. A one-to-one mapping between the CMMI® structure and the PDSAT structure was not achievable, mainly because of the redundancy in the CMMI® structure; the CMMI® Process Areas showed a considerable overlap. For this reason, the author decided to show the relationship between the CMMI® and the PDSAT Questionnaire for every CMMI® Process Area separately, i.e., each CMMI® Process Area is mapped with all PDSAT metrics.

The mapping process between the Malcom Baldrige National Quality Award and the PDSAT Questionnaire (see chapter 4.7.5) was perceived as straightforward again. The author had no problems in allocating the 91 PDSAT metrics into the seven MBNQA categories.

4.8 Reflections and Limitations

This chapter critically analyzes the PDSAT Framework presented in the previous chapters. The PDSAT Framework is analyzed in terms of the five dimensions introduced in chapter 2.3.2, as well as in terms of the four requirements postulated in chapter 4.2.

Regarding the **process scope**, the PDSAT Framework clearly focuses on the new product development (NPD) process. On the one hand, the PDSAT Questionnaire addresses PD-related best practices with a higher level of detail than most of the tools compared in chapter 2.3. On the other hand, it also addresses the important topic of change management, which becomes more and more important in every business function in today's rapidly changing environment. The main **purpose** of the PDSAT Framework is the identification of improvement opportunities in the product development area of companies. However, it can also be used for business diagnosis, i.e., assessing the current state and gap against "ideal" state of a particular unit of analysis (project-level, program-level, firm-level) of a PD organization, or benchmarking, either within a company or with other companies. The **sources** of the PDSAT Questionnaire are the Perform Tool (PERFORM 2003), the Lean Innovation Roadmap (HOPPMANN 2009), as well as literature on PD best practices and change management best practices (for details see chapter 4.4.4). The PDSAT Questionnaire relies on a capability/maturity scale as a **measurement method**, i.e., different levels of maturity ranging from poor performance (lowest level) to exceptional performance (highest level) can be assessed. The highest levels implicitly include best practices for product development and organizational change. The PDSAT Questionnaire has been developed rigorously; it is based on proven best practices and a number of discussions with experts in the field of product development, as well as PD employees from the aerospace and defense industry. However, it has not been **validated** yet. Future work could aim at implementing the PDSAT Questionnaire in the field and longer term testing.

Chapter 2.4 has identified four main shortcomings of existing product development self-assessment tools. In chapter 4.2 these shortcomings are transformed into four main requirements for product development-related self-assessment tools. The PDSAT Framework addresses all these four requirements. First, it **focuses on proven best practices for the entire PD process**. Second, it provides a **formalized implementation process**. This 9-step-process provides the user with sufficient guidance and help in executing the self-assessment for achieving the best possible results from this process. Third, the PDSAT Framework offers **tool customization guidelines**. Therefore, it is possible to tailor the PDSAT Questionnaire according to specific circumstances of a respective unit of analysis. Fourth, the PDSAT Framework is **integrated with other process improvement approaches**. Mappings between the PDSAT Questionnaire structure and the structure of other approaches facilitate the introduction of the PDSAT Framework within an organization.

However, there are still a number of limitations:

The first limitation regards the derivation of the requirements. Both the industry focus group survey and the interviews represent the aerospace and defense industry only. In addition, the survey results are based on a rather small sample of fourteen responses.

Furthermore, it has to be mentioned that the PDSAT Framework does not classify the forty-five PD Competencies and the twenty-two PD Dynamic Capabilities. It is assumed that certain competencies/capabilities are more important than others. However, it is unknown to what extent the different competencies/capabilities are correlated. Moreover, the provided PDSAT Implementation Process does not suggest where to start with the improvements. This has to be decided in discussions with experts in the respective organizations.

Another limitation regards the measurement method. The different capability levels (see chapter 4.4.3) are described with a number of sentences, which explain what has to be implemented in order to score a certain level. For this reason, there may be situations where a certain unit of analysis scores “between” two capability levels, i.e., certain practices from one level and certain practices from another level are implemented.

Regarding the PDSAT Integration (see chapter 4.7) it has to be mentioned that all the mappings between the PDSAT Questionnaire structure and the structure of other process improvement approaches are based on the subjective opinion of the author.

Finally, the PDSAT Framework has not been validated yet in industry. Future work could aim at field testing the PDSAT Framework with different companies in different industries.

5 Summary of Research and Future Work

5.1 Summary of Research

This thesis presents a new self-assessment approach for product development. It enables to measure how *innovative* and *adaptive* the product development processes of a particular unit of analysis within a company are.

A detailed literature review is conducted in order to classify existing PD-related self-assessment tools. Twelve PD-related self-assessment tools are analyzed. Furthermore, the requirements for self-assessment tools to be used in PD organizations are investigated. Four main requirements are derived from an industry focus group survey and from interviews at a major American defense contractor: 1. Focus on proven PD best practices; 2. Formalized implementation process; 3. Tool customization guidelines; 4. Integration with other process improvement tools. The twelve PD-related self-assessment tools found in the literature review are analyzed in terms of these four requirements. A number of shortcomings are identified. Although there are tools that meet parts of the requirements, none of the twelve tools addresses all four requirements listed above.

The new PDSAT Framework presented in this thesis addresses all four requirements. It consists of a questionnaire with ninety-one metrics, a formalized 9-step process on how to use and implement the questionnaire, guidelines and instructions of how to customize the questionnaire, and mappings between the questionnaire structure and the structure of relevant process improvement approaches, which facilitate the introduction and integration of the questionnaire within the organization.

The PDSAT Questionnaire is structured into three main categories and comprises 91 metrics, all based on a five-scale maturity-level measurement method. The questionnaire evaluates to what extent product development best practices (45 metrics) and change management best practices (22 metrics) are implemented. Furthermore, it consists of 24 metrics which measure actual results of PD projects from multiple dimensions. The PDSAT Questionnaire was developed mainly for assessing projects. However, it can be customized for the application on different levels of analysis such as PD programs or the whole PD organization. The 91 metrics are drawn from four main sources. A main part of the metrics is based on the PERFORM Tool (PERFORM 2003), an already validated PD capability assessment instrument. Moreover, the metrics comprise a selection of the most important factors for Lean Product Development identified by (HOPPMANN 2009). Furthermore, the questionnaire includes additional best practices both on product development and change management identified from the literature.

A formalized 9-step process for implementing the PDSAT Questionnaire was developed and intensively discussed with employees of a major American defense contractor. Furthermore, feedback from an industry focus group survey was collected and used for improving the process. The final process includes the following steps: 1. Define purpose (WHY) and goals (WHAT) of the self-assessment process; 2. Define organizational integration of the self-

assessment process (WHERE); 3. Define roles and responsibilities for the self-assessment process (WHO); 4. Create and customize the PD Self-Assessment Tool (HOW); 5. Pretest and improve the PD Self-Assessment Tool; 6. Prepare the self-assessment execution; 7. Execute PD Self-Assessment Tool; 8. Identify and communicate improvement opportunities, and 9. Implement and monitor actions.

The PDSAT Framework provides guidelines and instructions on how to customize the PDSAT Questionnaire according to specific circumstances of different companies. The forty-five PD Competencies and the twenty-two PD Dynamic Capabilities are characterized along a number of dimensions such as functional area affected by the metric, organizational role affected by the metric, level of analysis, and Lean management related metric.

In order to facilitate the integration of the PDSAT Questionnaire with existing process improvement frameworks, all ninety-one metrics were mapped in table form with the structure of the Capability Maturity Model Integration (CMMI), the Malcom Baldrige National Quality Award, the Lean Product Development Components by HOPPMANN (2009) and the LESAT, an enterprise self-assessment tool. Moreover, the 9-step implementation process was linked with the DMAIC Process from Six Sigma.

5.2 Future Work

The PDSAT Framework presented in this thesis has not been implemented yet. Future research could aim at field-testing the framework with a number of different companies from different industries. This would lead to insightful evidence whether the specifications of the new self-assessment framework – in particular the formalized implementation and customization process, as well as the integration with other process improvement frameworks – improved the self-assessment process. Beyond that, longer term testing will be necessary to evaluate whether the improvement actions derived from the PDSAT implementation are successful or not. By nature, this kind of testing requires organizations that have already used the PDSAT Framework for some time, have found improvement opportunities and have taken action.

A significant improvement opportunity regards the PD Project Results. As the title reveals, the current PD Project Results section mainly considers results of product development projects. Promising suggestions for a more generic approach can be found in ROTH (1999).

Furthermore, the PDSAT Questionnaire can be used for academic research. Assessment data collected by sending out the PDSAT Questionnaire to a number of different companies in different industries would enable to establish a quantitative link between PD Competencies/PD Dynamic Capabilities and PD Project Results.

6 References

AINSCOUGH ET AL. 2003
Ainscough, M.; Neailey, K.; Tennant, C.: A Self-Assessment Tool for Implementing Concurrent Engineering through Change Management.
In: International Journal of Project Management, 2003, Vol. 21, No. 6, p. 425-431

ALAVI & LEIDNER 1999
Alavi, M.; Leidner, D. E.: Knowledge Management Systems: Issues, Challenges, and Benefits.
Atlanta: Communications of the Association for Information Systems 1999, Vol. 1, No. 7, 1999

AMIT & SCHOEMAKER 1993
Amit, R.; Schoemaker, P.J.H.: Strategic Assets and Organizational Rent.
In: Strategic Management Journal, 1993, Vol. 14, No. 1, p. 33-46

BARNEY 1991
Barney, J.B.: Firm Resources and Sustained Competitive Advantage.
In: Journal of Management, 1991, Vol. 17, No. 1, p. 99-120

BEER & NOHRIA 2000
Beer, M.; Nohria, N.: Breaking the Code of Change.
Boston: Harvard Business School Press 2000.

BROWN & EISENHARDT 1995
Brown, S. L.; Eisenhardt, K. M.: Product Development: Past Research, Present Findings, and Future Directions.
In: Academy of Management Review, 1995, Vol. 20, No. 2, p. 343-378

BURNES 2004
Burnes, B.: Managing Change: A Strategic Approach to Organisational Dynamics. Fourth Edition.
Harlow: Prentice Hall 2004

BY 2005
By, R.T.: Organisational Change Management: A Critical Review.
In: Journal of Change Management, 2005, Vol. 5, No. 4, p. 369-380

CAFFYN 1999
Caffyn, S.: Development of a Continuous Improvement Self-Assessment Tool.
International Journal of Operations & Production Management, 1999, Vol. 19, No. 11, p. 1138-1153

CHIESA ET AL. 1996
Chiesa, V.; Coughlan, P.; Voss, C. A.: Development of a Technical Innovation Audit.
In: Journal of Product Innovation Management, 1996, Vol. 13, No. 2, p. 105-136

CMMI 2006
CMMI Product Team: CMMI® for Development. Improving Processes for Better Products, Version 1.2
Available: http://www.sei.cmu.edu/
Pittsburgh: Carnegie Mellon Software Engineering Institute 2006.

CONN ET AL. 2009
Conn, S. J.; Torkkeli, M. T.; Bitran, I.: Assessing the Management of Innovation with Software Tools: An Application of innovationEnterprizer.
In: International Journal of Production Economics, 2009, Vol. 8, No. 2, 2008, p. 142-153

CONNOR & LAKE 1994
Connor, P. E.; Lake, L. K.: Managing Organizational Change. Second Edition.
Westport: Praeger Publishers 1994.

COOPER ET AL. 2001
Cooper, R. G.; Edgett, S. J.; Kleinschmidt E. J.: Portfolio Management for New Products. Second Edition.
New York: Basic Books 2001

CORMICAN & O'SULLIVAN 2004
Cormican, K.; O'Sullivan, D.: Auditing Best Practice for Effective Product Innovation Management.
In: Technovation, 2004, Vol. 24, No. 10, p. 819-829

DEMING 2000
Deming, W.: Out of the Crisis
Cambridge: MIT Press 2000

EASTERBY-SMITH ET AL. 2009
Easterby-Smith, M.; Lyles, M. A.; Peteraf, M. A.: Dynamic Capabilities: Current Debates and Future Directions.
In: British Journal of Management, 2009, Vol. 20, p. 1-8

EFQM 1995
European Foundation for Quality Management: Self-Assessment.
Brussels: EFQM 1995.

EFQM 2010
EFQM Team: The EFQM Excellence Model.
Available: http://www.efqm.org, 2010

EISENHARDT 1989
Eisenhardt, K.M.: Building Theories from Case Study Research.
In: Academy of Management Review, 1989, Vol. 14, No. 4, p. 532-550

EISENHARDT 1991
Eisenhardt, K.M.: Better Stories and Better Constructs: The Case for Rigor and Comparative Logic.
In: Academy of Management Review, 1991, Vol. 16, No. 3, p. 620-627

EISENHARDT & MARTIN 2000
Eisenhardt, K. M.; Martin, J. A.: Dynamic Capabilities: What are they?
In: Strategic Management Journal, 2000, Vol. 21, No. 10-11, p.1105-1121

ESAT 2010
Nightingale, D.; Stanke, A.; Bryan, F.T.: Enterprise Strategic Analysis and Transformation
Available: http://lean.mit.edu/products/enterprise-strategic-analysis-for-tranformation-esat

FORD & EVANS 2001
Ford, M.W.; Evans, J.R.: Baldrige Assessment and Organizational Learning: The Need for Change Management.
In: Quality Management Journal, 2001, Vol. 8, No. 3, p. 9-25

FOWLER 1995
Fowler, F.J.: Improving Survey Questions. Design and Evaluation.
Thousand Oaks: SAGE Publications 1995.

FOWLER 2009
Fowler, F.J.: Survey Research Methods. Fourth Edition.
Thousand Oaks: SAGE Publications 2009.

GARDINER & GREGORY 1996
Gardiner, G.S.; Gregory, M.J.: An Audit-Based Approach to the Analysis, Redesign and Continuing Assessment of a New Product Introduction System.
In: Integrated Manufacturing Systems, 1996, Vol. 7, No. 2, p. 52-59

GRIFFIN 1997
Griffin, A.: PDMA Research on New Product Development Practices: Updating Trends and Benchmarking Best Practices
In: Journal of Product Innovation Management, 1997, Vol. 14, No. 6, p. 429-458

HALLGREN 2009
Hallgren, E.W.: How to Use an Innovation Audit as a Learning Tool: A Case Study of Enhancing High-Involvement Innovation
In: Creativity and Innovation Management, 2009, Vol. 18, No. 1, p. 48-58

HAMEL 1996
Hamel, G.: Strategy as Revolution.
In: Harvard Business Review, July-August 1996, Vol. 74, No. 4, p. 69-82

HARVEY 2001
Harvey, T. R.: Checklist for Change. A Pragmatic Approach to Creating and Controlling Change. Second Edition.
Lanham: Scarecrow Press 2001

HELFAT & PETERAF 2003
Helfat, C. E.; Peteraf, M. A.: The Dynamic Resource-based View: Capability Lifecycles. In: Strategic Management Journal, 2003, Vol. 24, No. 10, p. 997-1010

HELMS MILLS ET AL. 2009
Mills, J.; Dye, K.; Mills, A. J.: Understanding Organizational Change. New York: Routledge 2009.

HOPPMANN 2009
Hoppmann, J.: The Lean Innovation Roadmap – A Systematic Approach to Introducing Lean in Product Development Processes and Establishing a Learning Organization. Diploma Thesis. Technische Universitaet Braunschweig (2009)

KAHN 2005
Kahn, K.B.: Approaches to New Product Forecasting
In: Kahn, K.B. (Ed.); Castellion, G.; Griffin, A.: The PDMA Handbook of New Product Development. Second Edition.
Hoboken: John Wiley & Sons 2005

KAHN ET AL. 2005
Kahn, K.B. (Ed.); Castellion, G.; Griffin, A.: The PDMA Handbook of New Product Development. Second Edition.
Hoboken: John Wiley & Sons 2005

KAHN ET AL. 2006
Kahn, K.B.; Barczak, G.; Moss, R.: Perspective: Establishing an NPD Best Practices Framework
In: Journal of Product Innovation Management, 2006, Vol. 23, No. 2, p. 106-116

KELLAM 2004
Kellam, B.A.: The Use of Process Metrics to Evaluate Product Development Projects. Master Thesis. Massachusetts Institute of Technology (2004)

KIRKPATRICK 2001
Kirkpatrick, D. L.: Managing Change Effectively. Approaches, Methods, and Case Examples. Woburn: Butterworth-Heinemann 2001

KLEIN 2004
Klein, J. A.: True Change. How Outsiders on the Inside Get Things Done in Organizations. San Francisco: Jossey-Bass 2004.

KOTTER 1996
Kotter, J. P.: Leading Change.
Boston: Harvard Business School Press 1996.

KOTTER & COHEN 2002
Kotter, J. P.; Cohen, D. S.: The Heart of Change.
Boston: Harvard Business School Press 2002.

KUCZMARSKI 2000
Kuczmarski, T. D.: Managing New Products. Using the MAP™ System to Accelerate Growth. Third Edition.
Chicago: The Innovative Press 2000

KWAK & ANBARI 2006
Kwak, Y.H.; Anbari, F.T.: Benefits, Obstacles, and Future of Six Sigma Approach.
In: Technovation, 2006, Vol. 26, No. 5-6, p. 708-715

LAWLER ET AL. 1980
Lawler, E.E. III; Nadler, D.A.; Cammann, C. (Ed.): Organizational Assessment: Perspectives on the Measurement of Organizational Behavior and the Quality of Work Life.
New York: John Wiley & Sons 1980

LEDFORD & HENEMAN 2000
Ledford, G.E.; Heneman, R.L.: Compensation: A Troublesome Lead System in Organizational Change.
In: Beer, M. (Ed.); Nohria, N. (Ed.): Breaking the Code of Change.
Boston: Harvard Business School Press 2000.

LESAT 2010
LAI: LAI Enterprise Self-Assessment Tool
Available: http://lean.mit.edu/products/lean-enterprise-self-assessment-tool-lesat?task=view

LEVITT 1993
Levitt, T.: The Globalization of Markets.
In: Aliber, R.Z. (Ed.); Click, R.W. (Ed.): Readings in International Business. A Decision Approach.
Cambridge: MIT Press 1993

LEWIN 1947
Lewin, K.: Frontiers in Group Dynamics.
In: Human Relations, 1947, Vol. 1, No. 1, p. 5-41

LEWIN 1951
Lewin, K.: Field Theory in Social Science.
New York: Harper & Row 1951

LEWIS 1997
Lewis, C. P.: Building a Shared Vision. A Leader's Guide to Aligning the Organization.
Portland: Productivity Press 1997.

LIKER ET AL. 1996
Liker, J. K.; Sobek II, D. K.; Ward, A. C.; Cristiano, J. J.: Involving Suppliers in Product Development in the United States and Japan: Evidence for Set-Based Concurrent Engineering.
In: IEEE Transactions on Engineering Management, Vol. 43, No. 2, 1996, p. 165-178

LINDEMANN 2009
Lindemann, U.: Methodische Entwicklung technischer Produkte. Methoden flexibel und situationsgerecht anmelden. 3., korrigierte Auflage.
Berlin: Springer 2009

LINDERMAN ET AL. 2003
Linderman, K.; Schroeder, R.G.; Zaheer, S.; Choo, A.S.: Six Sigma: A Goal-Theoretic Perspective.
In: Journal of Operations Management, 2003, Vol. 21, No. 2, p. 193-203

MAKADOK 2001
Makadok, R.: Toward a Synthesis of the Resource-based and Dynamic-capability Views of Rent Creation.
In: Strategic Management Journal, 2001, Vol. 22, No. 5, p. 387-401

MBNQA 2009
Baldrige National Quality Program. 2009-2010 Criteria for Performance Excellence.
Gaithersburg: National Institute of Standards and Technology 2009.

MCQUATER ET AL. 1998
McQuater, R. E.; Peters, A. J.; Dale, B. G.; Spring, M.; Rogerson, J. H.; Rooney, E. M.: The Management and Organizational Context of New Product Development: Diagnosis and Self-Assessment.
In: International Journal of Production Economics, Vol. 55, No. 2, 1998, p. 121-131

MORGAN & LIKER 2006
Morgan, J. M.; Liker, J. K.: The Toyota Product Development System. Integrating People, Process, and Technology.
New York: Productivity Press 2006

NEUMAN 2006
Neuman, W. L.: Social Research Methods. Qualitative and Quantitative Approaches. Sixth Edition.
Boston: Pearson 2006

NOBEOKA & CUSUMANO 1997
Nobeoka, K.; Cusumano, M.A.: Multiproject Strategy and Sales Growth: The Benefits of Rapid Design Transfer in New Product Development.

O'BRIEN ET AL. 1999
O'Brien, B.; Collins, P.; Hogan, J.; Rowe, M.: Precepts for Mentors…and for those being mentored.
In: Senge, P.; Kleiner, A.; Roberts, C.; Ross, R.; Roth, G.; Smith, B.: The Dance of Change. New York: Doubleday 1999.

OTTO & WOOD 2001
Otto, K.; Wood, K.: Product Design. Techniques in Reverse Engineering and New Product Development.
New Jersey: Prentice Hall 2001

PERFORM 2003
Tang, V.; Liu, B.; Kellam, B.A.; Otto, K.N.; Seering, W.P.: Perform PD Capability Assessment Survey
Available: http://lean.mit.edu/component/docman/doc_download/681-perform-pd-capability-assessment-survey

PMI 2004
Project Management Institute: A Guide to the Project Management Body of Knowledge. Third Edition.
Newtown Square: Project Management Institute, Inc. 2004

PORTER 1980
Porter, M.E.: Competitive Strategy.
New York: Free Press 1980.

PROBERT ET AL. 2000
Probert, D.R.; Phall, R.; Farrukh, C.J.P.: Development of a Structured Approach to Assessing Technology Management Practice.
In: Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture Vol. 214, No. 4, 2000, p. 313-321

PYZDEK & KELLER 2009
Pyzdek, T.; Keller, P.: The Six Sigma Handbook. A Complete Guide for Green Belts, Black Belts, and Managers at All Levels.
New York: Mc-Graw-Hill Professional 2009

RADNOR & NOKE 2002
Radnor, Z.J; Noke, H.: Innovation Compass: A Self-audit Tool for the New Product Development Process
In: Creativity and Innovation Management, 2002, Vol. 11, No. 2, p. 122-132

REA & PARKER 2005
Rea, L.M.; Parker, R.A.: Designing and Conducting Survey Research. A Comprehensive Guide. Third Edition.
San Francisco: Jossey-Bass 2005

ROTH 1999
Roth, G.: Cracking the "Black Box" of a Learning Initiative Assessment.
In: Senge, P.; Kleiner, A.; Roberts, C.; Ross, R.; Roth, G.; Smith, B.: The Dance of Change.
New York: Doubleday 1999.

SENGE 1999
Senge, P.: The Leadership of Profound Change. Toward an Ecology of Leadership.
In: Senge, P.; Kleiner, A.; Roberts, C.; Ross, R.; Roth, G.; Smith, B.: The Dance of Change.
New York: Doubleday 1999.

SENGE ET AL. 1999
Senge, P.; Kleiner, A.; Roberts, C.; Ross, R.; Roth, G.; Smith, B.: The Dance of Change.
New York: Doubleday 1999.

SHAPIRO 1989
Shapiro, C.: The Theory of Business Strategy
In: The Rand Journal of Economics, 1989, Vol. 20, No. 1, p. 125-137

SHEWHART 1986
Shewhart, W.A.: Statistical Method from the Viewpoint of Quality Control.
New York: Dover Publications 1986

SMITH & REINERTSEN 1997
Smith, P. G.; Reinertsen, D. G.: Developing Products in Half the Time: New Rules, New Tools. Second Edition
New York: Wiley 1997

SMITH & ROSS 1999
Smith, B.; Ross, R.: From Golf to Polo. The Coaching of Leaders…and the Leading of Coaches.
In: Senge, P.; Kleiner, A.; Roberts, C.; Ross, R.; Roth, G.; Smith, B.: The Dance of Change.
New York: Doubleday 1999.

SOBEK ET AL. 1999
Sobek II, D. K.; Ward, A. C.; Liker, J. K.: Toyota's Principles of Set-Based Concurrent Engineering.
In: Sloan Management Review, 1999, Vol. 40, No. 2, p. 67-84

TANG ET AL. 2005
Tang, V.; Liu, B.; Kellam, B.A.; Otto, K.N.; Seering, W.P.: Enabling Factors in Successful Product Development.
In: International Conference on Engineering Design (ICED), 2005, August 15-18, Melbourne

TEECE ET AL. 1997
Teece, D. J.; Pisano, G.; Shuen, A.: Dynamic Capabilities and Strategic Management.
In: Strategic Management Journal, 1997, Vol. 18, No. 7, p. 509-533

TENNANT & ROBERTS 2003
Tennant, C.; Roberts, P.: The Creation and Application of a Self-Assessment Process for New Product Introduction.
In: International Journal of Project Management, 2003, Vol. 21, No. 2, p. 77-87

TURNER 1999
Turner, C.: What Are "Communities of Practices"?
In: Senge, P.; Kleiner, A.; Roberts, C.; Ross, R.; Roth, G.; Smith, B.: The Dance of Change.
New York: Doubleday 1999.

ULRICH & EPPINGER 2000
Ulrich, K T.; Eppinger S.D.: Product Design and Development. Second Edition.
Boston: Irwin/McGraw-Hill 2000

ULRICH & EPPINGER 2008
Ulrich, K.T; Eppinger S.D.: Product Design and Development. Fourth Edition.
Boston: Irwin/McGraw-Hill 2008

UTTERBACK 1994
Utterback, J.M.: Mastering the Dynamics of Innovation. How Companies Can Seize Opportunities in the Face of Technological Change.
Boston: Harvard Business School Press 1994

VAN DER WIELE ET AL. 2000
van der Wiele, T.; Brown, A.; Millen, R.; Whelan, D.: Improvement in Organizational Performance and Self-Assessment Practices by Selected American Firms.
In: Quality Management Journal, 2000, Vol. 7, No. 4, p. 8-22

VAN DE VEN ET AL. 1999
van de Ven, A.H.; Polley, D.E.; Garud, R.; Venkataraman, S.: The Innovation Journey.
New York: Oxford University Press 1999

WARD ET AL. 1995
Ward, A.; Liker, J. K.; Cristiano, J. J.; Sobek II, D. K.: The Second Toyota Paradox: How Delaying Decisions Can Make Better Cars Faster
In: Sloan Management Review, 1995, Vol. 36, No. 3, p. 43-61

WERNERFELT 1984
Wernerfelt, B.: A Resource-based View of the Firm.
In: Strategic Management Journal, 1984, Vol. 5, No. 2, p. 171-180

WINTER 2003
Winter, S.G.: Understanding Dynamic Capabilities.
In: Strategic Management Journal, 2003, Vol. 24, No. 10, p. 991-995

WOMACK ET AL. 1990
Womack, J.P.; Jones, D.T.; Roos, D: The Machine That Changed The World: Based On The Massachusetts Institute Of Technology 5-Million-Dollar 5-Year Study On The Future Of The Automobile.
New York: Macmillan 1990.

WOMACK & JONES 1996
Womack, J.P.; Jones, D.T.: Lean Thinking. Banish Waste and Create Wealth in Your Corporation. First Edition.
New York: Simon and Schuster 1996.

WRUCK 2000
Wruck, K.H.: Compensation, Incentives, and Organizational Change: Ideas and Evidence from Theory and Practice.
In: Beer, M. (Ed.); Nohria, N. (Ed.): Breaking the Code of Change.
Boston: Harvard Business School Press 2000.

YIN 2009
Yin, R.K.: Case Study Research. Design and Methods. Fourth Edition. Thousand Oaks: SAGE Publications 2009

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9 List of Terms

CE	Concurrent engineering
CI	Continuous improvement
EOL	End-of-life
EVA	Economic value added
IT	Information technology
LAI	Lean Advancement Initiative
LESAT	LAI Enterprise Self-Assessment Tool
PD	Product development
PDC	Product Development Competence
PDDC	Product Development Dynamic Capability
PDR	Product Development Result
PDP	Product development project
PDSAT	Product Development Self-Assessment Tool
TQM	Total Quality Management
TTM	Time-to-market

10 Appendix A – Additional Survey Results

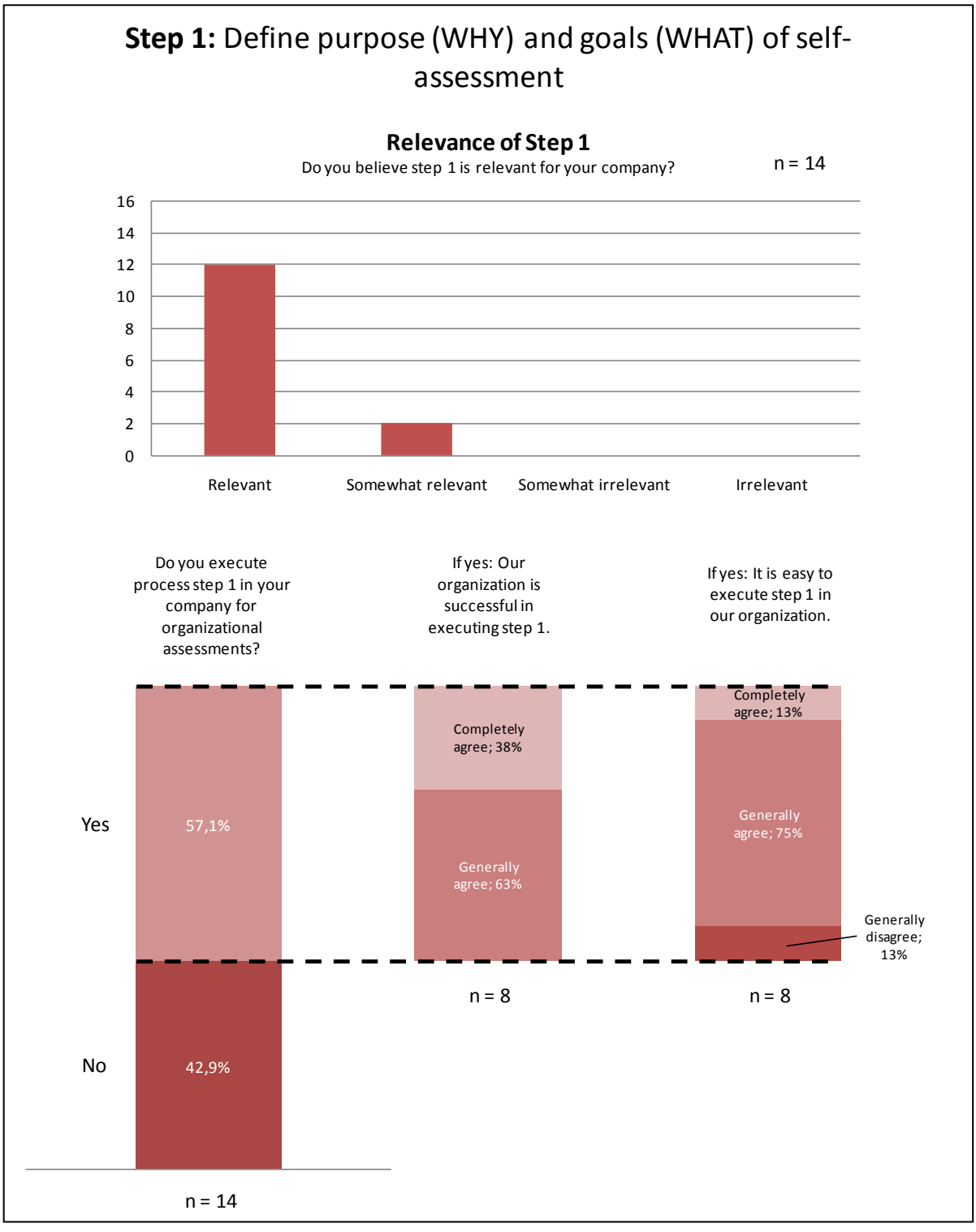

Figure 10-1: Feedback on Step 1 of the PDSAT Implementation Process

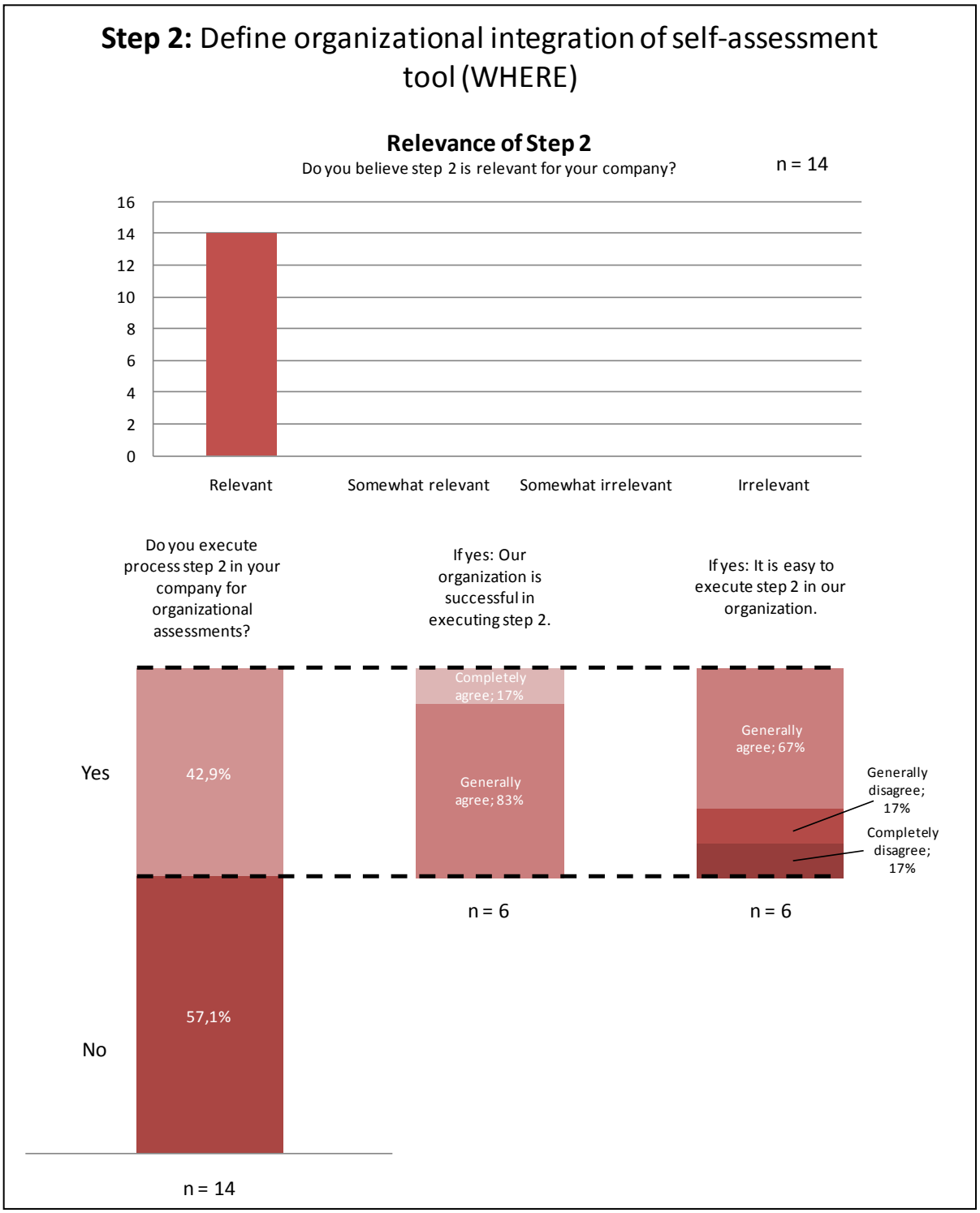

Figure 10-2: Feedback on Step 2 of the PDSAT Implementation Process

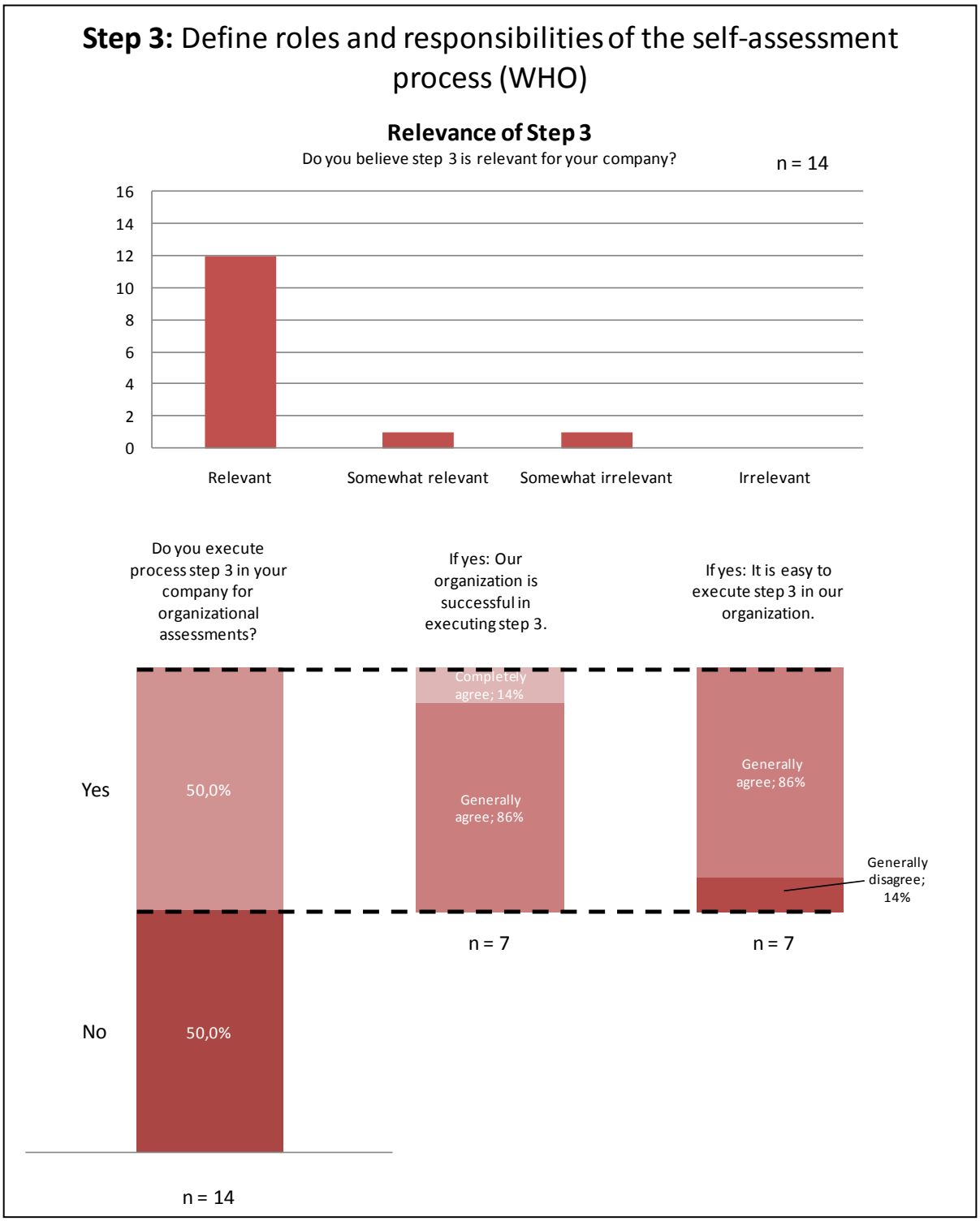

Figure 10-3: Feedback on Step 3 of the PDSAT Implementation Process

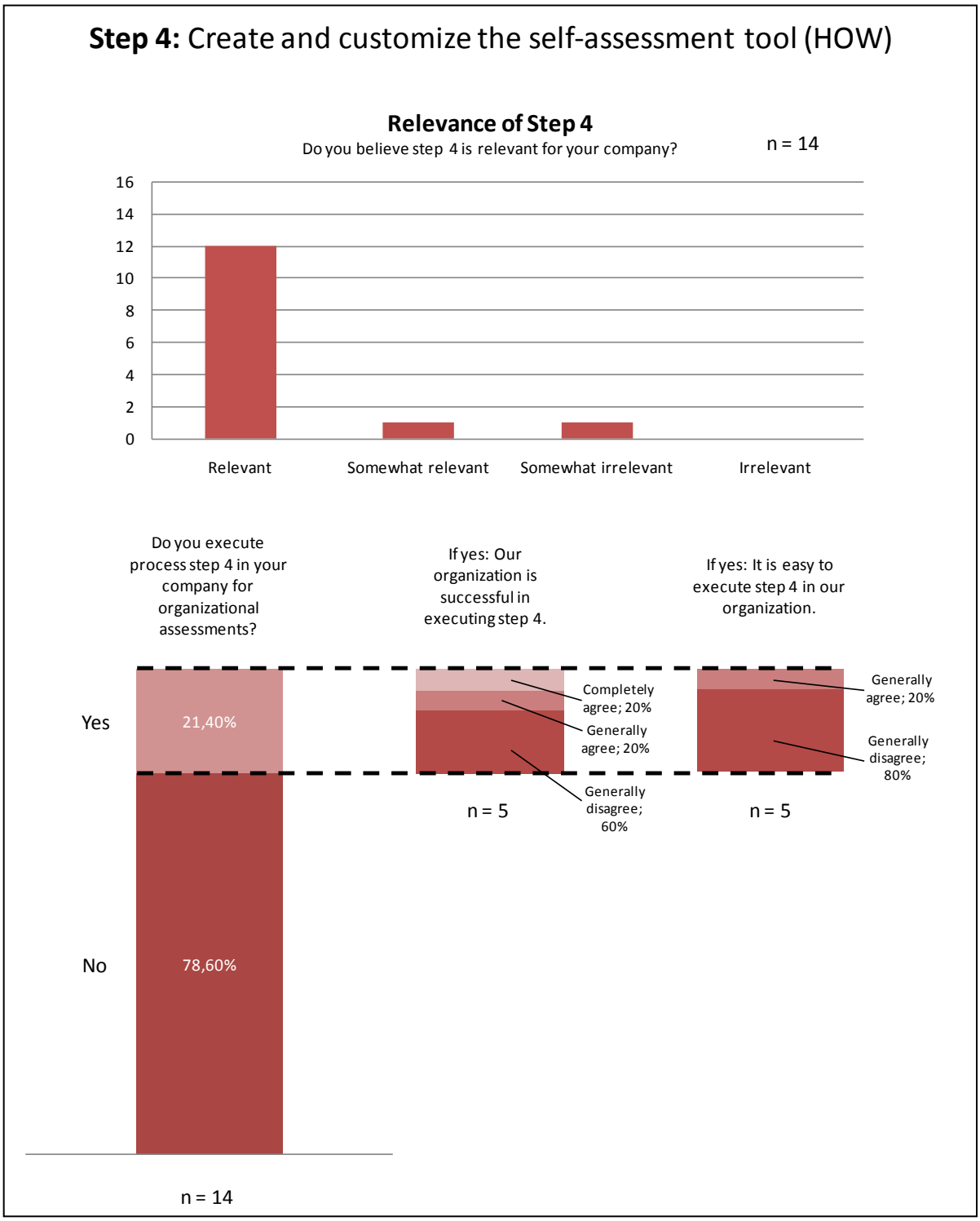

Figure 10-4: Feedback on Step 4 of the PDSAT Implementation Process

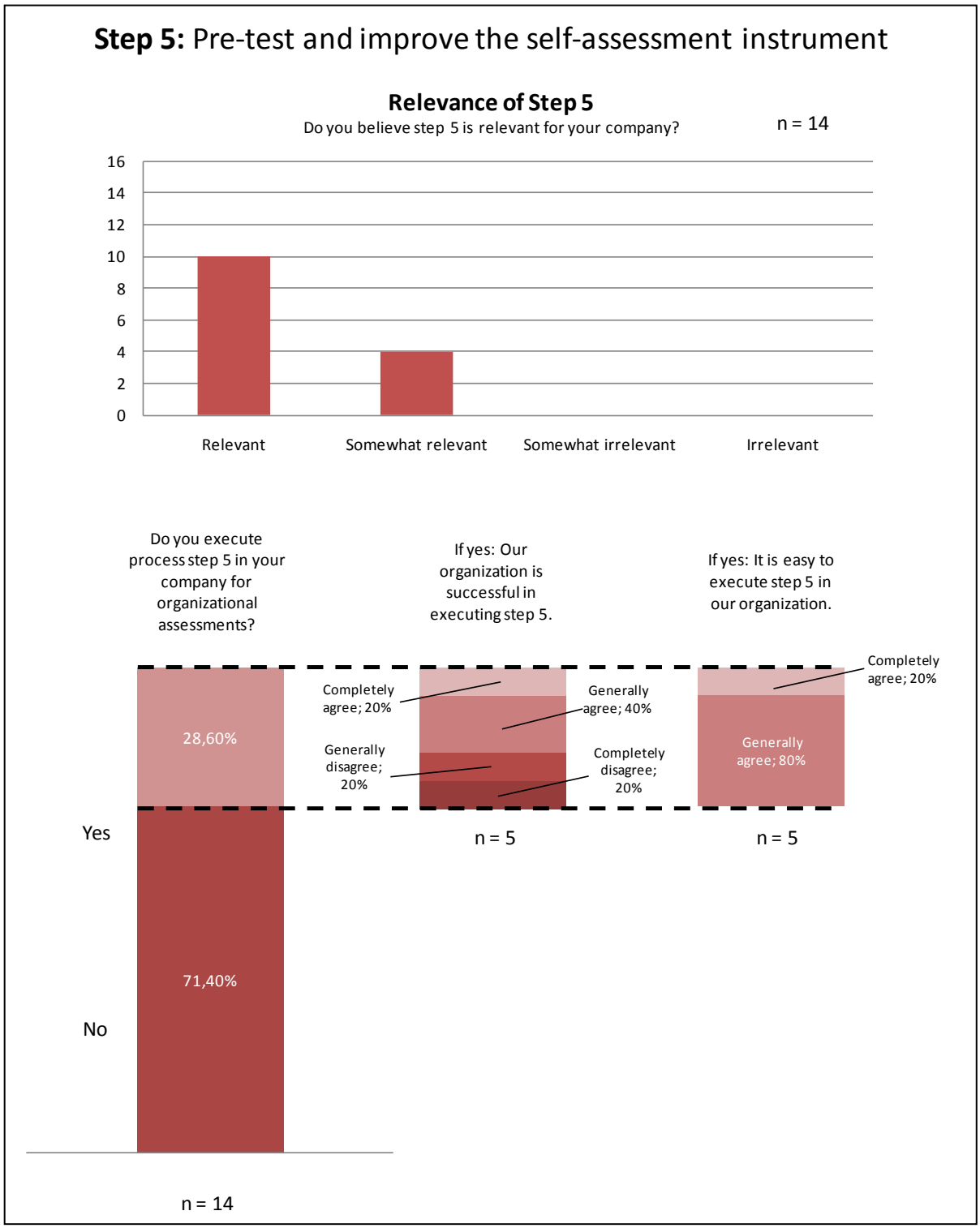

Figure 10-5: Feedback on Step 5 of the PDSAT Implementation Process

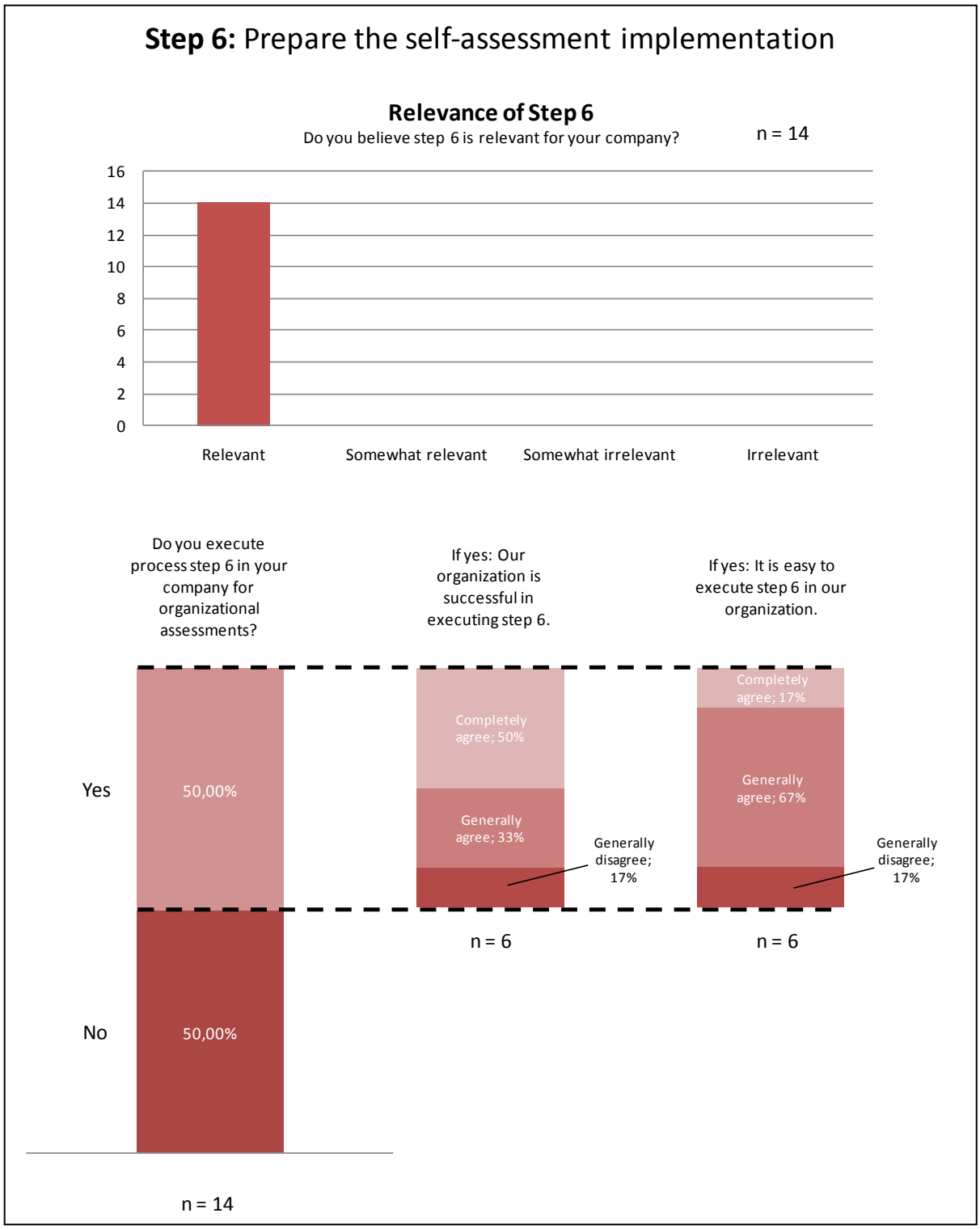

Figure 10-6: Feedback on Step 6 of the PDSAT Implementation Process

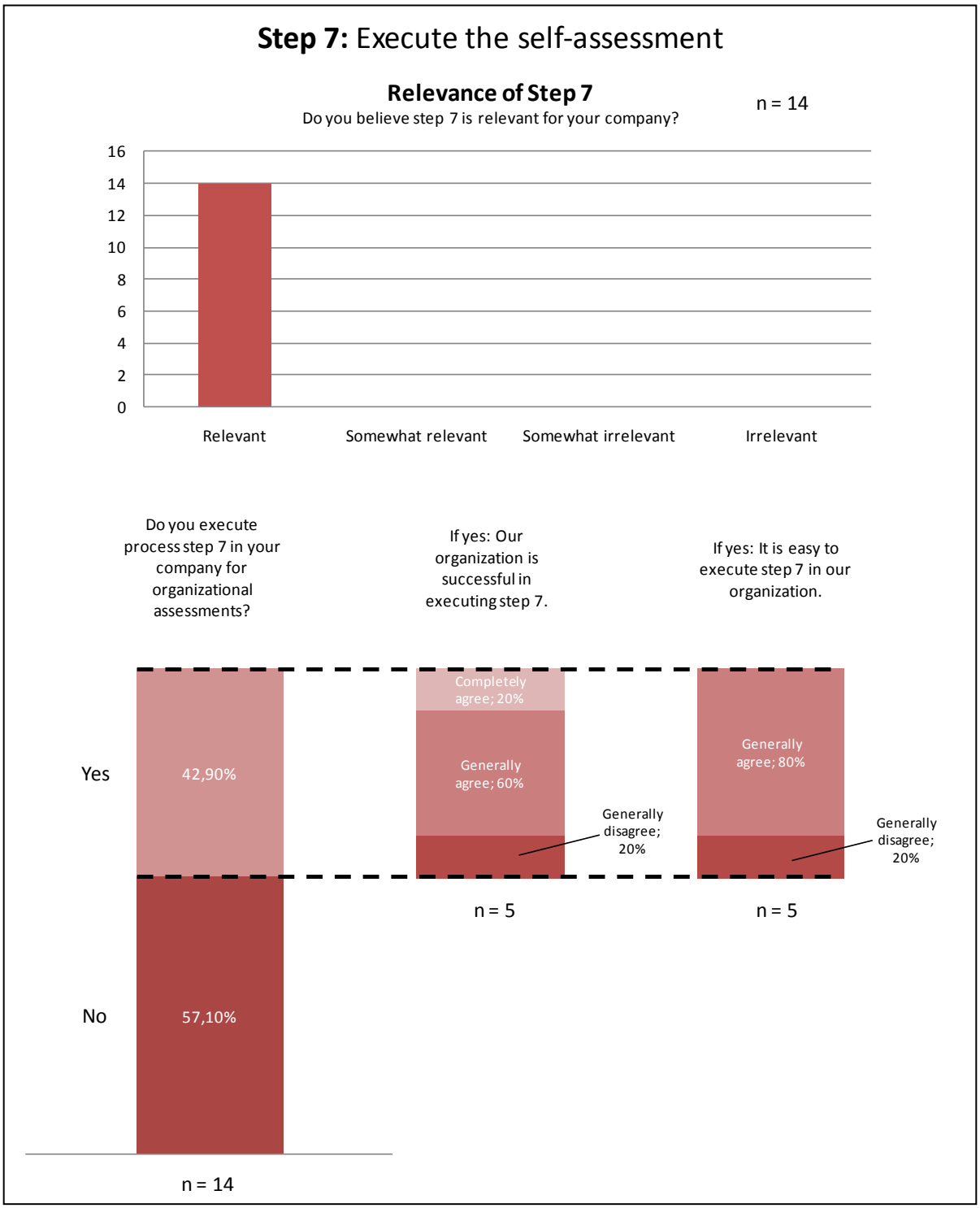

Figure 10-7: Feedback on Step 7 of the PDSAT Implementation Process

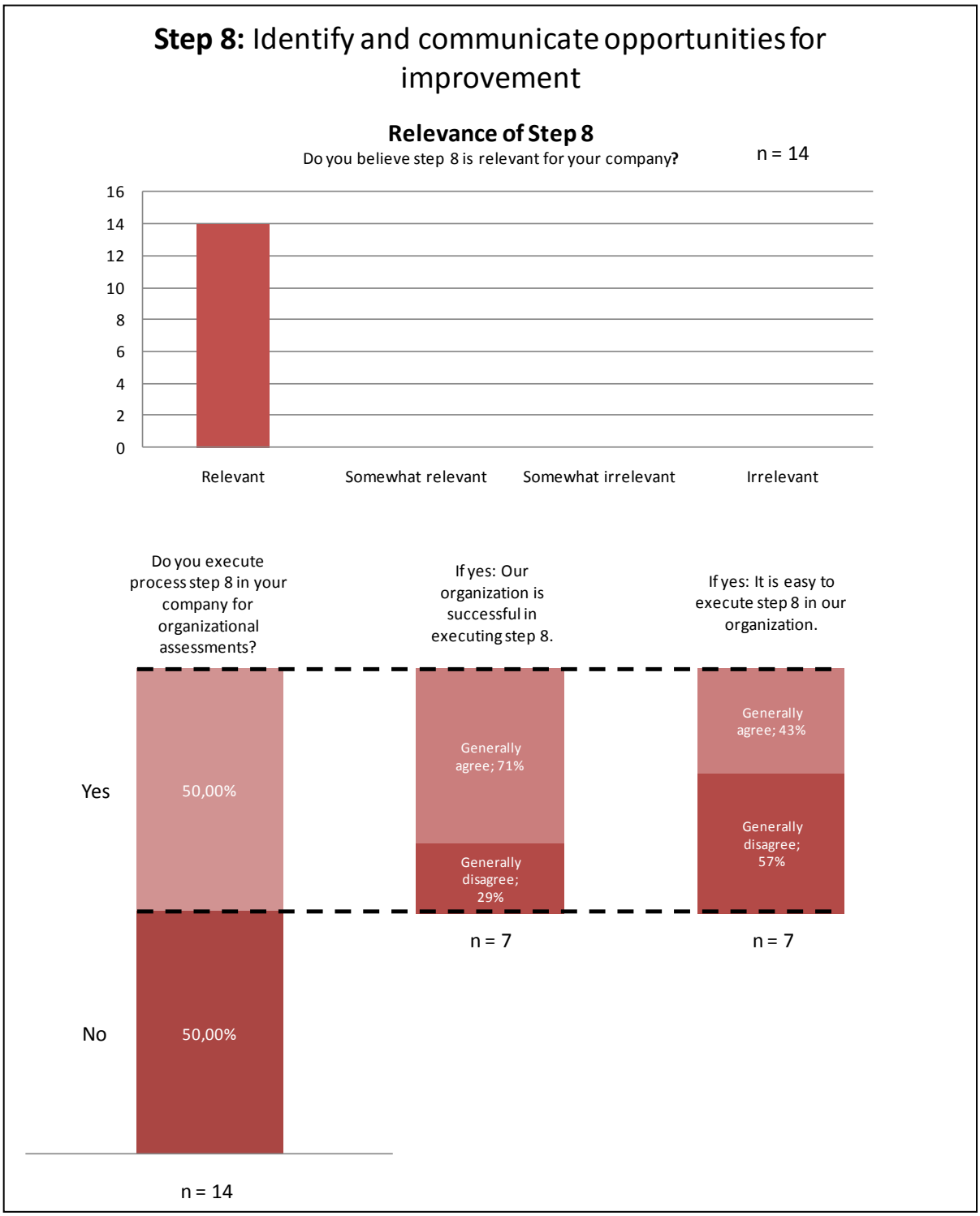

Figure 10-8: Feedback on Step 8 of the PDSAT Implementation Process

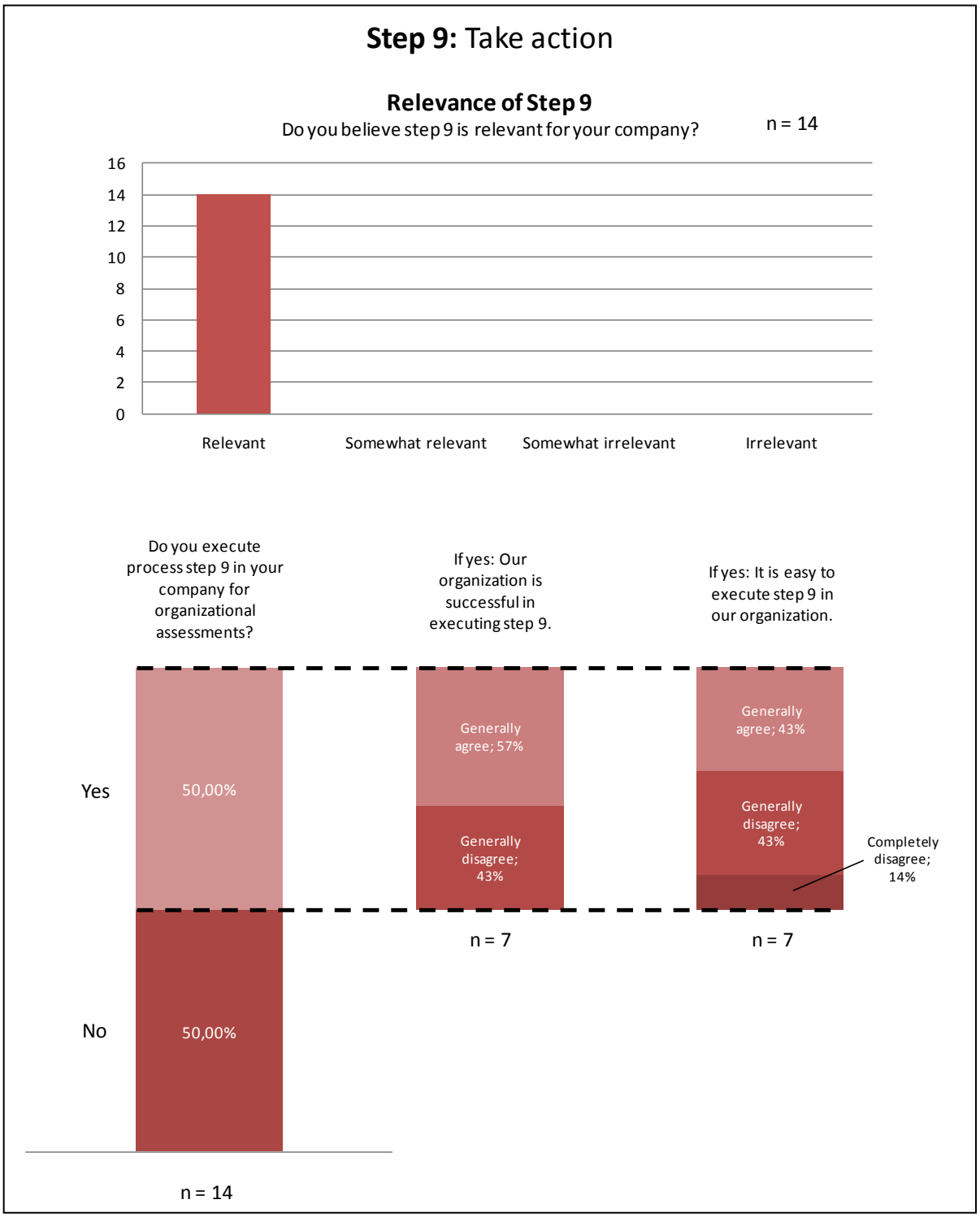

Figure 10-9: Feedback on Step 9 of the PDSAT Implementation Process

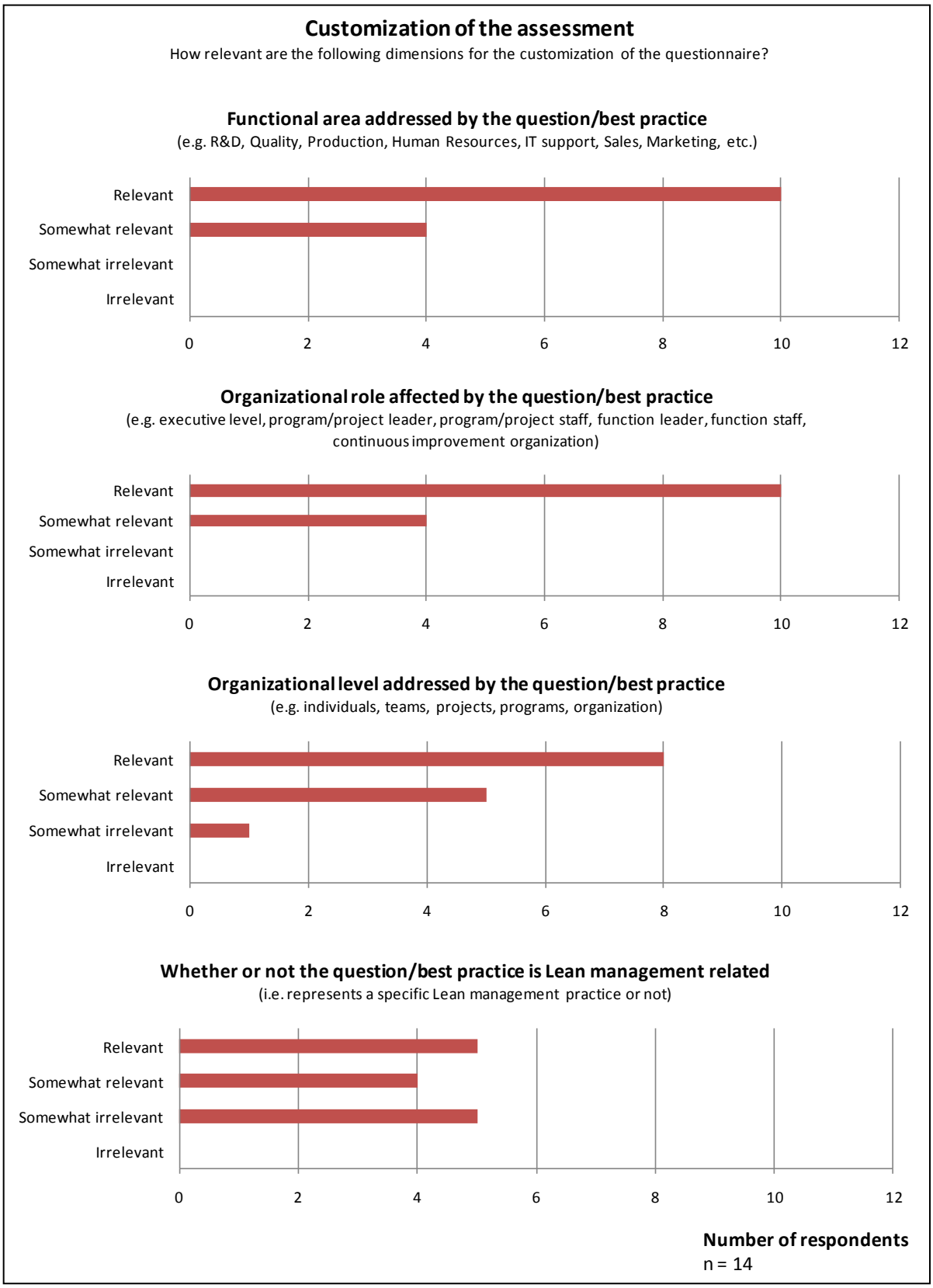

Figure 10-10: Feedback on the relevance of the customization dimensions

11 Appendix B – Interviews

Two interviews were conducted at a major American defense contractor. In the following sections, this company is referred to as Company X.

11.1 First Interview at Company X

Date: July 26th, 2010, 10.00am – 12.30pm
Attendees: three employees from Company X, one research assistant from MIT (thesis supervisor), Christoph Knoblinger
Notes:

- Customization decisions that need to be made:
    - Format of the assessment: Facilitated discussion or filling out of questionnaire? Or "hybrid", where a first version of the questionnaire is discussed, then it is filled out similar to a survey, and the results are again discussed in a group?
    - The wording of the questions might be customized to specifically reflect a targeted application, e.g. development of radar system, or execution of project X
    - When and how often are you supposed to execute the self assessment? (Suggestion: Maybe at the end of a life cycle for "lessons learned"?)
- "Requirements management" should appear somewhere on the top level (if it makes sense to split one of the groups in two) => important for Company X
- To-Do List for development of questionnaire
    - Items seem to fall into two different categories:
        - Generic assessment to what degree a certain "goal" is achieved (e.g. "how high/deep is the technical expertise in your project?" / "How well is your project coordinated?", vs
        - The prescription of certain "best practices" (e.g. "Do you have a Specialist career path?" / "Do you use a Strong Project Manager"?)
        - We might want to discern between the two to make the questionnaire a bit clearer
    - Review and integration of "Systems Engineering Leading Indicators" – Those might be relevant to define "PD Performance Measures": http://www.incose.org/ProductsPubs/pdf/SELI-Guide-Rev2-01292010-Industry.pdf
    - General description of scale: What does a "1" mean, what does a "4" mean?
- Action items:
    - Send Core Competencies and draft of dynamic capabilities and performance measures to Company X by Friday, July 30

- Make sure to include as much descriptions of the single questions as we have (Joern Hoppmann had always a bit of explanatory text that went with the different practices that he was asking about)
- Arrange a time (half day) for a workshop to develop the existing "Software Self Assessment tool" into a more generic "Engineering Self Assessment" tool (week beginning August 9th)

11.2 Second Interview at Company X

Date: August 11th, 2010, 10.00am – 14.00pm
Attendees: three employees from Company X, one change management trainer, Christoph Knoblinger
Agenda:

1. Self-assessment customization and implementation process
2. Possible use of the self-assessment tool for Company X (What can Company X use from my tool?)
3. Discussion about the framework/structure of the tool

General notes:

- Main products
  - Radar systems
  - Sensors
  - Communication equipment
  - "15 products make up 80 percent of the money"
- Main disciplines
  - Software
  - Systems engineering
  - Mechanical engineering
  - Electrical engineering
  - Life services
- Company X organization:
  - Matrix organization
  - Mary Ellen, Jayne and Kurt work "for the organization", "support the programs", "support the CMMI-project"
  - Six business units; integrated defense systems (IDS) is one of them
  - IDS consist e.g. of engineering, contracts, communication, finance, business development and strategy
- Company X business improvement strategies:
  - CMMI
    - does more the benchmarking (however, different opinions about benchmarking)
    - "benchmarking ourselves against CMMI"
    - Try to "climb to higher levels"
  - Six Sigma

        - The six sigma tools "help us to get to higher levels"
    - Typical goals at Company X
        - "Increase productivity by 10 %!"
    - Once a year Company X sends out an employee survey
        - Assessing "Company X as a whole"
        - Employee opinion survey
        - High-level

Notes on (1) Self-assessment customization and implementation process and (2) Possible use of the self-assessment tool for Company X (What can Company X use from my tool?):

- CSA software process evaluation tool
    - "for the software part of the program"
    - "is not detailed enough → only (yes/no) answers
    - Has not been used for the last 10 years
    - Needs to be updated
    - "Was not customized at all – but customization would have been a good idea"
    - Some questions did not apply to Company X
    - Was conducted within a team with a defined leader; questions were given ahead; questionnaire sent out to projects in order to fill it in; then discussed together
- "old" MIT tool:
    - One person was responsible
    - This person tried to find the answers on every questions
    - Finally filled it in
    - "a lot of bureaucracy was involved in order to use this tool"
- Current role of self-assessment at Company X
    - In order to evaluate projects (!)
    - Determine "where is the project?"
    - In order to see if people do the right things
    - In order to evaluate the "current state" and link it to a certain CMMI-level
    - In order to see if changes and new processes are maintained
    - Big challenge: controlling the sustainment of change (some changes work very well in one program but very poor on another one)
- Lean self-assessment tool (my tool)
    - First impression: "seems as if it is on a higher level than the CSA-tool"
    - Assumption and experience: "if executives fill out the self-assessment tool they will perhaps assess themselves better than they really are"
    - Tool probably does not fit to Six Sigma, which "is more cycle 3

(change implementation process)"

- Discussion about the three implementation cycles
    - Cycle 1 – organizational transformation process
        - "high level process"
        - Everybody agrees that it can be used on organization level as well as on project level
    - Cycle 2 – self-assessment execution process
        - Step 1 – Define Purpose:
            - "WHY" and "WHAT" – "What do we get out of it"
            - "We never looked for opportunities….we always looked for what is wrong with our processes."
            - Purpose for Company X:
              1. Business diagnosis (assessing current state)
              2. Identifying improvement → to better perform, to meet engineering goals
              3. Supporting a control plan for change sustainment
        - Step 2 – Define Organizational Integration of the SA-tool:
            - "WHO"
            - Company X will annually execute the SA-tool (the budget is annually planned; money comes in January; planning begins in fall)
            - Maybe split this step (separately integration and definition of roles (e.g. facilitator))
        - Step 3 – Create and Customize SA-tool:
            - "HOW"
            - "customize it for engineering levels, e.g. by disciplines"
            - "just pick certain relevant set of questions"
            - "some questions are perhaps not applicable to Company X → because the either do not apply at all or because certain people cannot answer them"
            - Company X may feel certain that there are some questions in areas where there are no issues ("We do not have issues in this area") → then just delete the question
            - "target certain questions to certain functions/roles/groups"
            - Standard set of questions: to all people involved
            - Customized set of questions: to experts in certain areas
            - "better filling questionnaire in individually…keep people separate"

- Link to purpose of the tool:
    - For finding improvements: come together in a group
    - For assessing current state: better answer individually
- Problems with answering the questions in a group
    - "some people talk more than others do"
    - "some people are influenced"
    - "it depends on the programs…some people have multiple hats"
- Facilitator:
    - "use a kind of moderator who ask questions and collects answers"
    - "can be anyone from the highest staff to project staff"
    - "Selecting facilitator depends on the scope of the self-assessment" → What is the level? (unit of analysis)…projects, whole PD organization,…
    - At Company X: usually someone familiar with CMMI who has been on appraisals
    - Could be Kurt or Mary Ellen
    - A set of important questions which have to be addressed for the customization process should be included in the Excel-based self-assessment survey → "forces" people to think about these questions (especially questions in cycle 2)
    - Providing extra-cells in Excel-self-assessment tool in order to make the customization process easier
        - Levels: organization, project, etc.
        - Levels: executives, project leaders, etc.
    - Conclusion: Customization process is a bigger step than expected; there are few people within the organization who have expertise on the whole set of questions; customization involves perhaps a couple of people from different functions; a separate meeting for the customization of the tool would make sense
    - Weighting
        - Questions
        - Answers (yes/no;

excellent/good/fair/poor)
        - Step 4 – Pretest and Improve the Self-assessment tool
            - "Peer review"
        - Step 5 – Preparation for Self-assessment Execution
            - "getting people involved"
    - Cycle 3 – change implementation process
        - "brainstorming processes are more part of cycle 3"

Notes on (3) Discussion about the framework/structure of the tool

- Core PD Competencies:
    - Maybe rename; just remove the "core" → confusion (because "core competency" is a widely used word in strategic management)
    - Is very similar to GP (generic practice) in CMMI
    - "huge number of questions"
    - CC 1 – "Definition of product attributes and their values" for example does not suit to Company X which is a defense contractor and does not sell consumer products
    - CC 28 – "Development process" would be always 4 for Company X (highest score)
- Linking structure of Lean SA tool to CMMI would be very important for Company X (Mary Ellen tried to do that)

Notes for myself (for thesis):

- Define words like organization, implementation, enterprise, benchmarking in the thesis separately → no common understanding of this vocabulary
- Add a abbreviations list - for example PD, SA, etc.
- Lean SA-tool does focus on PD but on a high level; would fit very well in the "engineering division of Company X"

Next steps:

- Most of the group is on holiday until beginning of September
- Mary Ellen, Kurt and Jayne will think about how the tool could be used for their annual assessments in September
- Full integration of Lean SA-tool will be difficult to accomplish within the next 3 months
- Internal funding is needed in order to send out the tool to employees (people won't do it in their free time)
- Beginning of September (about 10th): sending updated PD Dynamic Capabilities set

12 Appendix C – PD Competencies

Customer Focus Competence

PDC 1	1.1.1									
	Customer relationships									
Competence Level Description:	Customers have no contact with the design or development teams.	Customers have little contact with the design or development teams.		Customers are visited occasionally, particularly in the up-front activities.		Customers are consulted regularly throughout the development cycle about the product and lifecycle requirements (service, updates, availability, etc.), but do not have a voice in the design decision-making.		Users and customers are co-developers throughout the PD cycle and critics during field operations. They review development specs, field manuals, and key functional strategies. They are readily consulted on unexpected problems.	
Competence Level:	**Level 1 (poor)**	**Level 2 (fair)**		**Level 3 (good)**		**Level 4 (very good)**		**Level 5 (excellent)**	
	Functional area:	Product Design Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
	Organizational role:	Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
	Level of analysis:	Individuals	Teams	Projects Programs	Organization				
	Specific Lean Management Practice:	Specific Lean	Not specific Lean						

Figure 12-1: PD Competence No.1 – Customer relationships

PDC 2	1.1.2									
	Customer satisfaction data									
Competence Level Description:	Customer satisfaction data is not collected.	Customer satisfaction data is anecdotal or generic making it difficult to react and improve customer satisfaction. A large effort is needed to improve the accuracy and completeness of the data in order to make it useful.		Customer feedback, warranty and repair data is made available by the sales and service staff. System promotes extended enterprise communications with customers.		Customer feedback, warranty and repair data is made available in reports, documented and structured. System promotes customer extended enterprise teamwork to make the project succeed.		Web site exists for customer feedback. Warranty and repair data is also online and easily available for use by product development teams and functional groups. Customers and partners readily provide proprietary data for their mutual benefit.	
Competence Level:	**Level 1 (poor)**	**Level 2 (fair)**		**Level 3 (good)**		**Level 4 (very good)**		**Level 5 (excellent)**	
	Functional area:	Product Design Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
	Organizational role:	Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
	Level of analysis:	Individuals	Teams	Projects Programs	Organization				
	Specific Lean Management Practice:	Specific Lean	Not specific Lean						

Figure 12-2: PD Competence No.2 – Customer satisfaction data

Product Concept and Design Competence

PDC 3	1.2.1	Product architecture							
Competence Level Description:	A standardized process for defining the product architecture is not performed at any time.	Consideration is limited to the single product.		There is a product architecture that considers future upgrades and derivative products.		Architectural integrity is enforced in product design and system validation. Architecture reinforces brand identity.		Architecture is a strategy issue determined by senior executives. Architecture addresses all key functions of the firm.	
Competence Level:	Level 1 (poor)	Level 2 (fair)		Level 3 (good)		Level 4 (very good)		Level 5 (excellent)	
Functional area:		Product Design Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
Organizational role:		Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
Level of analysis:		Individuals	Teams	Projects Programs	Organization				
Specific Lean Management Practice:		Specific Lean	Not specific Lean						

Figure 12-3: PD Competence No.3 – Product architecture

PDC 4	1.2.2	Linkage to corporate objectives							
Competence Level Description:	Project's/Program's/Product's benefits are not mapped onto quantifiable business goals and objectives.	Most of the project's/program's/product's benefits are vaguely mapped onto quantifiable business objectives and goals. Many inconsistencies remain with no plans for their resolution and are left to personal interpretation.		Many of the project's/program's/products benefits can be mapped onto quantifiable business goals and objectives. Remaining inconsistencies are known but avoided and deferred for later resolution (no comeback dates are defined).		Project's/Program's/Product's benefits are explicitly mapped onto key quantifiable business goals and objectives. Mission and goal inconsistencies are known and delegated with due dates for resolution.		All project/program/product benefits are explicitly and comprehensively mapped onto key quantifiable business goals, objectives, and business initiatives. Few and only trivial mission and goal inconsistencies remain open.	
Competence Level:	Level 1 (poor)	Level 2 (fair)		Level 3 (good)		Level 4 (very good)		Level 5 (excellent)	
Functional area:		Product Design Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
Organizational role:		Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
Level of analysis:		Individuals	Teams	Projects Programs	Organization				
Specific Lean Management Practice:		Specific Lean	Not specific Lean						

Figure 12-4: PD Competence No.4 – Linkage to corporate objectives

PDC 5	1.2.3	Product's functional content							
Competence Level Description:	The definition process of the product's functional content is based on extensions of existing products and customer complaints.	Process of defining the product's functional content is largely driven by extensions of existing products and customer complaints.		Process of defining the product's functional content is largely derived from extensions of current products and product family consistency. Known customer base and competitors shape the product's functional content.		Process of defining the product's functional content is driven by market segment needs, strategic positioning, architecture, and input from benchmarks. Use of repeatable methods is made to prioritize and determine value to customers and of the firm.		Markets new to the firm and to the industry shape product's functional content. Architectural advantages are leveraged. Functional content sets new level of competitive advantage.	
Competence Level:	**Level 1 (poor)**	**Level 2 (fair)**		**Level 3 (good)**		**Level 4 (very good)**		**Level 5 (excellent)**	
	Functional area:	Product Design Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
	Organizational role:	Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
	Level of analysis:	Individuals	Teams	Projects Programs	Organization				
	Specific Lean Management Practice:	Specific Lean	Not specific Lean						

Figure 12-5: PD Competence No.5 – Product's functional content

PDC 6	1.2.4	Definition of product attributes and their values							
Competence Level Description:	The product definition and planning process does not follow any standardized approach.	Product definition process is dominated by current products, engineering doability, and costs.		Product definition process considers current products' strengths and weaknesses relative to its competitors' products.		Product definition process is based on consumer preference methods, such as conjoint studies, to select product attributes and their values.		Product definition process considers consumer preferences and EVA in their use environment. Specifications are validated with lead users and suppliers. Cost-benefit analysis is performed by using quantified value propositions and models.	
Competence Level:	**Level 1 (poor)**	**Level 2 (fair)**		**Level 3 (good)**		**Level 4 (very good)**		**Level 5 (excellent)**	
	Functional area:	Product Design Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
	Organizational role:	Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
	Level of analysis:	Individuals	Teams	Projects Programs	Organization				
	Specific Lean Management Practice:	Specific Lean	Not specific Lean						

Figure 12-6: PD Competence No.6 – Definition of product attributes and their values

PDC 7	1.2.5	Concept development							
Competence Level Description:	There are no standardized supporting processes for concept development in place at all.	Only very simple methods (e.g. brainstorming sessions) are in use for supporting the concept development process. Participation in concept development is limited to a very small group.		Participation in concept development is limited to a small group. Concepts are extensions of existing products. Bold ideas are not adequately considered. Concepts are shown to customers after the fact.		Concept development is unconstrained and uses generation tools and methods with broad participation from key functions (i.e. manufacturing, quality assurance, purchasing). Options are explored with lead users and partners. Industrial design is a key consideration.		Brilliant people with proven track records are given unconstrained freedom to create concepts. Concept space is large and "down-selection-systematic". Concept development relies on broad internal and external participation.	
Competence Level:	Level 1 (poor)	Level 2 (fair)		Level 3 (good)		Level 4 (very good)		Level 5 (excellent)	
	Functional area:	Product Design Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
	Organizational role:	Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
	Level of analysis:	Individuals	Teams	Projects Programs	Organization				
	Specific Lean Management Practice:	Specific Lean	Not specific Lean						

Figure 12-7: PD Competence No.7 – Concept development

PDC 8	1.2.6	Set based concurrent engineering							
Competence Level Description:	There is "no time" for considering alternative solutions for a product module. Concepts for a product module are frequently revised during all stages of development.	Only few alternative solutions for a product module are considered in the concept development stage. Early found solution ideas are quickly assessed. The most promising solution idea is selected at an early stage in the concept development. A quick selection process is preferred over a detailed objectively grounded assessment. Concepts for a product module are usually revised after they have been selected.		A variety of possible solutions for a product module are considered in the concept development process. Decisions for a particular solution are based upon all the data available at the time of the decision. Concepts for a product module are sometimes revised after they have been selected.		Different possible solutions for a product module are considered early in the process. Alternative solutions for a product module are designed simulaneously until a particular solution has to be selected. Most decisions are based on objective data. If data is not available decisions can be delayed once. Once concepts have been selected for product modules they are rarely revised afterwards.		A large number of possible solutions for a product module is considered early in the process. A large number of alternative solutions for a product module is designed simultaneously. Decisions in favor of a particular solution are delayed until objective data is available. Once concepts have been selected for product modules they are not revised any more.	
Competence Level:	Level 1 (poor)	Level 2 (fair)		Level 3 (good)		Level 4 (very good)		Level 5 (excellent)	
	Functional area:	Product Design Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	AdministrationI T Support
	Organizational role:	Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
	Level of analysis:	Individuals	Teams	Projects Programs	Organization				
	Specific Lean Management Practice:	Specific Lean	Not specific Lean						

Figure 12-8: PD Competence No.8 – Set-based concurrent engineering

PDC 9	1.2.7	Product variety management							
Competence Level Description:	Product variety management is not in place.	Product variety management (reuse of parts, product platforms, modules, use of commodities) is not explicitly addressed in the product development system. Some of these ideas are used implicitly, though.		Catalogued parts are used within a product, but there are no clear rules. Product parts among different modules, products and product families are reused, but there are no clear rules either. Some components are modular and have standardized interfaces. Some products are built on the same platforms.		There are clear goals for the use of off-the-shelf components within a product and for the reuse of product parts among different modules, products and product families. Most components are modular and have standardized interfaces. There are common product platforms encompassing several product lines.		There is a common understanding among all the staff responsible for product development for the use of off-the-shelf components within a product and for the reuse of product parts among different modules, products and product families. Almost all components are modular and have standardized interfaces. All the products produced by the company are based on the platform idea.	
Competence Level:	**Level 1 (poor)**	**Level 2 (fair)**		**Level 3 (good)**		**Level 4 (very good)**		**Level 5 (excellent)**	
	Functional area:	Product Design Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
	Organizational role:	Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
	Level of analysis:	Individuals	Teams	Projects Programs	Organization				
	Specific Lean Management Practice:	Specific Lean	Not specific Lean						

Figure 12-9: PD Competence No.9 – Product variety management

PDC 10	1.2.8	Re-use of physical and design assets							
Competence Level Description:	Re-use is not addressed at all.	Re-use is not actively addressed.		The goal of re-use is driven by cost only. Engineering managers are given targets for the re-use of electrical and mechanical design, software, packaging, purchased parts, test programs and test equipment.		The product architecture enables reuse that optimizes cost. From this a re-use target is established for electrical and mechanical design, software, packaging, purchased parts, test programs and test equipment.		Product families are established on architectures. Re-use also includes subsystems and their ability to interoperate. This analysis is used to target and maximize the reuse of systems, software, test programs, and hardware assets.	
Competence Level:	**Level 1 (poor)**	**Level 2 (fair)**		**Level 3 (good)**		**Level 4 (very good)**		**Level 5 (excellent)**	
	Functional area:	Product Design Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
	Organizational role:	Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
	Level of analysis:	Individuals	Teams	Projects Program	Organization				
	Specific Lean Management Practice:	Specific Lean	Not specific Lean						

Figure 12-10: PD Competence No.10 – Re-use of physical and design assets

PDC 11	1.2.9	Make-buy decisions							
Competence Level Description:	Make-buy decision are ad-hoc considerations without considering the strategic implication to the firm.	Mostly dominated by tactical and ad-hoc considerations, without considering strategic implications to the firm.		Process is led by product planning and principally determined by engineering and cost reasons.		There is a cross-functional team to ensure PD, manufacturing, and finance are considered. Customers and partners are informed. Scalable parameters are identified which provide a range of applications for the technology.		Considered a strategic decision. Deliberated with senior executives to consider architecture, IP, manufacturing, finance, strategic and competitive implications to the product. Full critical parameter model developed, including scalable and sensitive parameters.	
Competence Level:	Level 1 (poor)	Level 2 (fair)		Level 3 (good)		Level 4 (very good)		Level 5 (excellent)	
	Functional area:	Product Design Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
	Organizational role:	Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
	Level of analysis:	Individuals	Teams	Projects Programs	Organization				
	Specific Lean Management Practice:	Specific Lean	Not specific Lean						

Figure 12-11: PD Competence No.11 – Make-buy decisions

Product Validation Competence

PDC 12	1.3.1	Prototypes							
Competence Level Description:	Alpha and beta prototypes both work in a controlled environment after a couple of iterations.	Subsystems are developed and integrated into the product. Alpha prototypes work in a controlled environment. Beta prototypes are developed using parts from real tooling, and the prototypes work as expected in a controlled environment.		Subsystems are developed and debugged. Manufacturing suppliers are consulted and standard tolerances used. Alpha prototypes work as expected. Beta prototypes are developed using parts from real tooling and system integrated from short runs, and the prototypes work as expected. Key tolerances are assigned. Design consults with production, service, and sales on their development efforts.		For alpha prototypes architecturally consistent and robust subsystems for system integration are developed. Explicit key dimensions are used. Prototypes work in wide range of conditions. Beta protoypes use critical parameters management and robustness for key dimensions and tolerances. Test customers use short runs using real tooling. Prototypes work. Manuals, sales and service plans proceed concurrently.		Alpha prototypes are fully functional under a range of conditions. Lead users have alpha units. All learned product features and customer operation changes by doing. Critical parameters are validated using the alpha prototype. For beta, lead customers, given short run prototypes, work at the development site to test performance and usability. Design, service, production and sales all use the beta to validate their plans.	
Competence Level:	Level 1 (poor)	Level 2 (fair)		Level 3 (good)		Level 4 (very good)		Level 5 (excellent)	
	Functional area:	Product Design Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
	Organizational role:	Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
	Level of analysis:	Individuals	Teams	Projects Programs	Organization				
	Specific Lean Management Practice:	Specific Lean	Not specific Lean						

Figure 12-12: PD Competence No.12 – Prototypes

PDC 13	1.3.2	Rapid prototyping, simulation and testing							
Competence Level Description:	Designs are validated by using physical prototypes at a very mature design stage. Simulation and testing methods are practically not used.	Basically, designs are validated by using simulations and tests at a mature design stage. Detailed physical protoypes are built at the end of the product development process. Product design and product validation act sequentially.		Closer interaction between product design and product design validation begins usually towards the end of the product design process. Standardized and well-established tools like computer-aided modeling, simulation and physical models are used for design validation.		Designs are quickly modeled and usually validated at an already early stage in product development as well as at later stages. Simulation, testing, rapid prototyping and physical models are used for validation. There is a close interaction between product design and product design validation.		Designs are tested and simulated throughout the product development process. Physical models and prototypes are built very fast and are already used in early stages of product development. Designer can react with changes within one day. There is a very close interaction between prototype specialists, production engineers, designers and quality assurance experts throughout the product development process. Computer aided modeling, simulation, digital assembly and rapid prototyping are well established and perfectly aligned within the company. Methods of Lean Production are used in prototype build and tool manufacturing.	
Competence Level:	Level 1 (poor)	Level 2 (fair)		Level 3 (good)		Level 4 (very good)		Level 5 (excellent)	
	Functional area:	Product Design Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
	Organizational role:	Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
	Level of analysis:	Individuals	Teams	Projects	Organization				
	Specific Lean Management Practice:	Specific Lean	Not specific Lean						

Figure 12-13: PD Competence No.13 – Rapid prototyping, simulation and testing

Product Delivery Competence

PDC 14	1.4.1	Release to manufacturing ramp-up							
Competence Level Description:	Manufacturing is considered at a very late stage in the product development process. Product development and manufacturing act rather sequentially.	Manufacturing commits to the product and ramp-up plan, both of which contain many qualifications and contingencies for PD, other key functions, and suppliers.		Manufacturing commits to the product and ramp-up plan with negotiated engineering assistance during early production and relief /slack from other key functions and suppliers.		Manufacturing, development have proceeded in parallel development with suppliers for some time. There is a formalized process for evaluating design proposals regarding manufacturing and assembly compatibility. Manufacturing commits to the product without reservation and with support from other key functions. Critical parameters identified.		The release to manufacturing is a non-event; manufacturing has been developing (with suppliers) their systems for some time and is well prepared to ramp-up with credible plans. Critical parameters quantitatively related to requirements and scalable parameters are identified.	
Competence Level:	Level 1 (poor)	Level 2 (fair)		Level 3 (good)		Level 4 (very good)		Level 5 (excellent)	
	Functional area:	Product Design Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
	Organizational role:	Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
	Level of analysis:	Individuals	Teams	Projects Programs	Organization				
	Specific Lean Management Practice:	Specific Lean	Not specific Lean						

Figure 12-14: PD Competence No.14 – Release to manufacturing ramp-up

PDC 15	1.4.2	Transition to sales							
Competence Level Description:	Sales presence is completely absent during the PD cycle.	Sales organization develops sales plans when PD "releases" to sales. Readiness takes great effort. Sales presence is largely absent during PD cycle except when the product is tossed "over the wall."		Sales participates in all key review checkpoints during PD. Sales has reviewed and critiqued the product specs and prototypes during PD.		Product is validated with lead users and beta customers with sales groups as full-fledged team members. Sales is confident of the product and its ability to perform in customer environment.		Product readiness is a non-issue. Sales has been a co-developer from the concept development stage. Product issues from sales are resolved as they arise throughout development.	
Competence Level:	Level 1 (poor)	Level 2 (fair)		Level 3 (good)		Level 4 (very good)		Level 5 (excellent)	
Functional area:		Product Design Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
Organizational role:		Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
Level of analysis:		Individuals	Teams	Projects Programs	Organization				
Specific Lean Management Practice:		Specific Lean	Not specific Lean						

Figure 12-15: PD Competence No.15 – Transition to sales

PDC 16	1.4.3	Organizational readiness for sales							
Competence Level Description:	Sales issues are not considered during the product development process.	Sales commits to units, revenue, and expenses after negotiating technical support from development, pricing flexibility from finance, delivery from manufacturing and other issues from key functions.		Sales commits to units, revenue and expenses with negotiated engineering assistance during early customer usage.		Sales and development have proceeded in parallel for some time. Sales commits without reservation – conflicts were resolved during development.		Sales readiness is a non-issue. Sales persons, systems, campaigns, and service and support are all coordinated. Sales has been an integral part of development along with other key functions.	
Competence Level:	Level 1 (poor)	Level 2 (fair)		Level 3 (good)		Level 4 (very good)		Level 5 (excellent)	
Functional area:		Product Design Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
Organizational role:		Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
Level of analysis:		Individuals	Teams	Projects Programs	Organization				
Specific Lean Management Practice:		Specific Lean	Not specific Lean						

Figure 12-16: PD Competence No.16 – Organizational readiness for sales

PDC 17	1.4.4	Service and support (S&S) complexity							
Competence Level Description:	Service and support issues are not considered during the product development cycle.	PD concentrates on function and performance, not service and support, which are viewed as "downstream" responsibilities of other functional groups.		There is a formal PD process that brings in the service and support groups to ensure design addresses serviceability and support. The functions have equal clout.		A cross functional team, that includes customers, has been working on this issue early in the process. Customers review S&S specs and comment.		Service and support has been part of the beta prototype testing with lead users to refine S&S strategy and plans. This issue has strong support from the project leader.	
Competence Level:	Level 1 (poor)	Level 2 (fair)		Level 3 (good)		Level 4 (very good)		Level 5 (excellent)	
Functional area:		Product Design Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
Organizational role:		Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
Level of analysis:		Individuals	Teams	Projects Programs	Organization				
Specific Lean Management Practice:		Specific Lean	Not specific Lean						

Figure 12-17: PD Competence No.17 – Service and support (S&S) complexity

PDC 18	1.4.5	Product service processes							
Competence Level Description:	Product service processes are not considered during the product design process.	Product service processes are not a high priority for product design. The PD process concentrates on costs rather than customer satisfaction. Service is viewed as a "downstream" issue.		Engineering leads the process and brings in the service groups to ensure that the product design addresses serviceability and support issues.		There is a cross-functional team to ensure product design, manufacturing and finance address serviceability and support. Customers and partners are informed.		The PD process includes a cross-functional team that includes customers and partners to ensure product design, manufacturing, and finance address serviceability and support.	
Competence Level:	Level 1 (poor)	Level 2 (fair)		Level 3 (good)		Level 4 (very good)		Level 5 (excellent)	
	Functional area:	Product Design Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
	Organizational role:	Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
	Level of analysis:	Individuals	Teams	Projects Programs	Organization				
	Specific Lean Management Practice:	Specific Lean	Not specific Lean						

Figure 12-18: PD Competence No.18 – Product service processes

Project and Portfolio Management

PDC 19	1.5.1	Schedule planning and control							
Competence Level Description:	There are no standardized tools (Gantt charts, PERT, CPM, etc.) in use for schedule planning and control of projects.	Delays ranging from small to 100% are common. Used tools do not really guarantee meeting the time schedule.		Monthly review meetings are held to monitor delays and take action. Key dependencies are informed of status of delays.		Weekly review meetings are held to monitor delays and take action. Meetings and actions are coordinated with key functional dependencies. Project planning and control process usually utilizes standardized tools.		There are daily updates to the project plan. Project slips are measured versus commitment at project funding time - not just versus most recent revised schedule. Standardized tools are used for the project planning and control process.	
Competence Level:	Level 1 (poor)	Level 2 (fair)		Level 3 (good)		Level 4 (very good)		Level 5 (excellent)	
	Functional area:	Product Design Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
	Organizational role:	Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
	Level of analysis:	Individuals	Teams	Projects Programs	Organization				
	Specific Lean Management Practice:	Specific Lean	Not specific Lean						

Figure 12-19: PD Competence No.19 – Schedule planning and control

PDC 20	1.5.2	Time to market (TTM)							
Competence Level Description:	Time to market is not measured nor controlled.	TTM is not controlled versus product specs. Product goes to market when development is complete.		TTM is controlled by inflating schedules with large buffers. When buffers are exhausted, forced overtime and additional people are placed on the project.		PD project/system has the flexibility to cut functions to meet delivery and/or schedule. Knowledge of market and competition enables the minimization of market impact.		TTM is addressed by concurrent development and co-development with customers and partners.	
Competence Level:	Level 1 (poor)	Level 2 (fair)		Level 3 (good)		Level 4 (very good)		Level 5 (excellent)	
	Functional area:	Product Design Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
	Organizational role:	Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
	Level of analysis:	Individuals	Teams	Projects Program	Organization				
	Specific Lean Management Practice:	Specific Lean	Not specific Lean						

Figure 12-20: PD Competence No.20 – Time to market (TTM)

PDC 21	1.5.3	PD project financial goals							
Competence Level Description:	Financial goals of PD projects are set by finance only.	Meeting the project's financial goals is led by finance with participation of PD and other key functions. PD role is passive other than meeting budget and product cost.		Finance has the lead to ensure project meets financial goals. PD's financial metrics are budget and product cost. PD can comment, but has limited power on sales, distribution, and service expense strategies and tactics that influence financial goals.		PD is part of a formal multi-functional group that addresses financial issues. PD's responsibilities are budget and product cost. PD is also in a group that addresses sales, distribution, and service expense strategies and tactics.		Financial goals are determined through options-assessment and flexible planning during the development cycle.	
Competence Level:	Level 1 (poor)	Level 2 (fair)		Level 3 (good)		Level 4 (very good)		Level 5 (excellent)	
	Functional area:	Product Design Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
	Organizational role:	Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
	Level of analysis:	Individuals	Teams	Projects Programs	Organization				
	Specific Lean Management Practice:	Specific Lean	Not specific Lean						

Figure 12-21: PD Competence No.21 – PD project financial goals

PDC 22	1.5.4	Portfolio of product opportunities							
Competence Level Description:	The managment of the product portfolio is not actively addressed.	Current offerings and customers dominate the organization's view of opportunities. Portfolio planning is ad-hoc and informally led by a single function. Consistent methods and business processes are sparse.		A collection of product families exists. They are rationalized qualitatively, by organizational structure and product managers. There is financial planning and roll up, but no real portfolio optimization.		A collection of product families exists. Finance and product managers plan and manage revenue and profit. Optimization is accomplished through simple scenarios and a handful of alternative cases.		Portfolio decisions drive new product development. Portfolio planning is linked to market, business, and functional strategies. Its methods are quantitative and qualitative engaging senior executives and PD managers.	
Competence Level:	Level 1 (poor)	Level 2 (fair)		Level 3 (good)		Level 4 (very good)		Level 5 (excellent)	
	Functional area:	Product Design Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
	Organizational role:	Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
	Level of analysis:	Individuals	Teams	Projects Programs	Organization				
	Specific Lean Management Practice:	Specific Lean	Not specific Lean						

Figure 12-22: PD Competence No.22 – Portfolio of product opportunities

PDC 23	1.5.5	End-of-life strategy (EOL)							
Competence Level Description:	There is no EOL strategy process. Surprises from competitors drive product withdrawals.	EOL strategy process is not formalized but reactive. Management reacts predominantly to the deceleration of sales.		EOL strategy process is partly formalized but largely reactive. Management reacts to technology maturation, deceleration of sales and profit, and increasing competitive pressure.		EOL is opportunistic. New products are ready at early signs of technology maturation, deceleration of sales and profit, and increasing competitive pressure.		Business strategy and corporate goals set EOL strategy. EOL strategy is planned by architecture, technology, and pricing. There is no problem cannibalizing any existing product.	
Competence Level:	Level 1 (poor)	Level 2 (fair)		Level 3 (good)		Level 4 (very good)		Level 5 (excellent)	
	Functional area:	Product Design Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
	Organizational role:	Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
	Level of analysis:	Individuals	Teams	Projects Programs	Organization				
	Specific Lean Management Practice:	Specific Lean	Not specific Lean						

Figure 12-23: PD Competence No.23 – End-of-life strategy (EOL)

PDC 24	1.5.6	Risk management analysis							
Competence Level Description:	Risk management analysis is not considered in the product development process.	Uncertainties and risks are barely considered. Uncertainty and risk mitigation is not part of the PD process and neither is robustness.		Few uncertainties and risks are characterized and most of them remain vague. Some plans exist to address the risks. Robustness is not part of the PD process.		Many uncertainties and risks are characterized. Based on this, plans are formed to ensure robustness.		Key uncertainties and risks are characterized. Sensitivity analysis is done to identify key sources of risk. Based on this, plans are formed to ensure robustness.	
Competence Level:	Level 1 (poor)	Level 2 (fair)		Level 3 (good)		Level 4 (very good)		Level 5 (excellent)	
	Functional area:	Product Design Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
	Organizational role:	Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
	Level of analysis:	Individuals	Teams	Projects Programs	Organization				
	Specific Lean Management Practice:	Specific Lean	Not specific Lean						

Figure 12-24: PD Competence No.24 – Risk management analysis

Execution Competence

PDC 25	1.6.1	Project leader's responsibilities and power							
Competence Level Description:	Project leader has many "responsibilities" but very little "power" compared to functional managers.	Executive micromanagement is visible. Project leader must frequently request approval for simple decisions.		There is visible executive support for projects when requested. Some senior executives buy-in, but their visibility is not strong.		There is visible and frequent executive support for projects initiated by the executives. Senior executives buy-in and actively work to form high-majority consensus.		Project leader has final say on all project tradeoffs. Project leader defines the product concept and advocates the customer value. Project leader leads the product development project from concept to market. Project leader chooses the technology and makes major component choices. Project leader sets the project timeframe and controls the adherence to it. Senior executives do not and cannot easily subvert or slow down the project. Executives communicate forcefully their trust and confidence in the project leader.	
Competence Level:	Level 1 (poor)	Level 2 (fair)		Level 3 (good)		Level 4 (very good)		Level 5 (excellent)	
	Functional area:	Product Design Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
	Organizational role:	Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
	Level of analysis:	Individuals	Teams	Projects Programs	Organization				
	Specific Lean Management Practice:	Specific Lean	Not specific Lean						

Figure 12-25: PD Competence No.25 – Project leader's responsibilities and power

PDC 26	1.6.2	Project leader's experience							
Competence Level Description:	Project leader needs help and rework very frequently.	Project leader's experience is limited to narrow product issues, and is weak in other areas. Needs help often.		Project leader is experienced in many of the technical issues, but requires some direction on business, financial and customer issues. Needs help occasionally.		Project leader manages technical, business, financial and customer issues. Does not need help.		Project leader has track record of delivering complex technical projects, business, financial, and customer issues. His advice is frequently sought after.	
Competence Level:	Level 1 (poor)	Level 2 (fair)		Level 3 (good)		Level 4 (very good)		Level 5 (excellent)	
	Functional area:	Product Design Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
	Organizational role	Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
	Level of analysis:	Individuals	Teams	Projects Programs	Organization				
	Specific Lean Management Practice:	Specific Lean	Not specific Lean						

Figure 12-26: PD Competence No.26 – Project leader's experience

PDC 27	1.6.3	Concurrent development							
Competence Level Description:	Product development is organized sequentially with separate functions.	Product development is organized rather sequentially. Functional silos are connected by specs and formal meetings.		PD uses a functional orientation with informal and personal cross functional relationships to work out dependencies and concurrencies.		Formal cross functional groups organize tasks for maximum concurrency.		Strong cross functional teams are led by experienced project leader. Leader is supported by motivated and skilled functional participation.	
Competence Level:	Level 1 (poor)	Level 2 (fair)		Level 3 (good)		Level 4 (very good)		Level 5 (excellent)	
	Functional area:	Product Design Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
	Organizational role:	Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
	Level of analysis:	Individuals	Teams	Projects Programs	Organization				
	Specific Lean Management Practice:	Specific Lean	Not specific Lean						

Figure 12-27: PD Competence No.27 – Concurrent development

PDC 28	1.6.4	Internal task coordination							
Competence Level Description:	Information handoffs between different functions occur in a completely unstructured way. As a result, a high number of negative surprises occur at al levels of the company.	More time is spent in meetings than with product development. There are many surprises at all levels of the organization.		Specs between silos are used for task coordination. Personal initiative and informal relationships help close many gaps but cannot prevent surprises.		Formal specs and formal cross functional meetings are used to discuss dependencies, timing, and content of task coordination.		Information handoffs include detailed walkthroughs of specs, functions and dependencies. Results are reflected in extended task mapping documents.	
Competence Level:	Level 1 (poor)	Level 2 (fair)		Level 3 (good)		Level 4 (very good)		Level 5 (excellent)	
	Functional area:	Product Design Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
	Organizational role:	Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
	Level of analysis:	Individuals	Teams	Projects Programs	Organization				
	Specific Lean Management Practice:	Specific Lean	Not specific Lean						

Figure 12-28: PD Competence No.28 – Internal task coordination

PDC 29	1.6.5	Workload leveling							
Competence Level Description:	The idea of workload leveling is not applied for product development.	The idea of workload level is known but the execution fails. Different projects are not aligned regarding resource allocation. Resources are rarely flexibly adapted in advance. Project leader is not fully aware of the capacity utilization for his project. Development activities are rarely scheduled and prioritized.		Product development resources (financial, technical, human) are planned and scheduled, but mostly independently for different projects. Most critical resources are flexibly adapted in case of occuring bottlenecks. Actual and planned capacity utilization are compared occasionally. Development activities are basically scheduled and prioritized.		Product development resources (financial, technical, human) are planned and scheduled on a cross-project basis. Most resources are flexibly adapted in case of occuring bottlenecks. Actual and planned capacity utilization is compared frequently. Most development activities are scheduled and prioritized.		Product development resources (financial, technical, human) are planned on a cross-project basis. Different projects are classified, staggered and launched in constant intervals. Cumulated demand in resources is very well levelled throughout the project's time frame. All resources are flexibly adapted in case of occuring bottlenecks. Project leader is constantly aware of the gap between actual and planned capacity utilization. All development activities are scheduled, synchronized and prioritized.	
Competence Level:	Level 1 (poor)	Level 2 (fair)		Level 3 (good)		Level 4 (very good)		Level 5 (excellent)	
	Functional area:	Product Design Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
	Organizational role:	Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
	Level of analysis:	Individuals	Teams	Projects Programs	Organization				
	Specific Lean Management Practice:	Specific Lean	Not specific Lean						

Figure 12-29: PD Competence No.29 – Workload leveling

PDC 30	1.6.6	Development process							
Competence Level Description:	Basically, projects do not follow a standardized process.	Projects follows a standardized process.		A standard process with no changes is used. Go/no-go decisions are made at each phase gate. Decisions are passed that should not be passed.		Well defined go/no-go criteria exist at each phase gate. Measured planvariances, are assessed their overall effects, and specified contingency plans to reduce risk.		Standard process is redesigned for the current project by the project champion and core team who have proven competence and a successful track record.	
Competence Level:	Level 1 (poor)	Level 2 (fair)		Level 3 (good)		Level 4 (very good)		Level 5 (excellent)	
	Functional area:	Product Design Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
	Organizational role	Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
	Level of analysis:	Individuals	Teams	Projects Programs	Organization				
	Specific Lean Management Practice:	Specific Lean	Not specific Lean						

Figure 12-30: PD Competence No.30 – Development process

PDC 31	1.6.7	Supplier integration (ties between PD and suppliers)							
Competence Level Description:	The relationship between PD and the suppliers is problematic, partly because they do not trust each other.	Ties between PD and suppliers are formal, colored by a zero-sum "we/they" attitude. Mutual trust is minimal.		Ties are formal with informal personal ties. There is sufficient mutual trust and confidence that development proceeds unimpeded.		Both formal and informal ties exist. Suppliers are integrated in the concept definition phase (e.g. review development specs and key functional strategies). They are consulted on problems. Mutual trust and respect is strong.		A small number of high-capability suppliers are used for critical parts, i.e. suppliers are co-developers throughout the PD cycle. They define some of the development specs and key functional strategies. They are assigned to solve tough problems. Supplier loyalty is firm. Suppliers are mentored to improve their performance.	
Competence Level:	Level 1 (poor)	Level 2 (fair)		Level 3 (good)		Level 4 (very good)		Level 5 (excellent)	
	Functional area:	Product Design Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
	Organizational role:	Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
	Level of analysis:	Individuals	Teams	Projects Programs	Organization				
	Specific Lean Management Practice:	Specific Lean	Not specific Lean						

Figure 12-31: PD Competence No.31 – Supplier Integration (ties between PD and suppliers)

PD Staff Competence

PDC 32	1.7.1	PD staff competence							
Competence Level Description:	Staff is weak in most areas and needs help very frequently.	Staff understands limited to narrow product issues, but is weak in other areas. Often needs help and reworks tasks.		Staff is capable of solving problems in their domain. Needs help occasionally.		Core staff has experience from previous projects, is equipped with advanced degrees, and is able to provide and guide others. Staff does not need help.		Core staff has demonstrated capability in many breakthrough concepts. Has 10 years experience and is equipped with advanced degrees from top institutions. Staff's advice is frequently sought.	
Competence Level:	Level 1 (poor)	Level 2 (fair)		Level 3 (good)		Level 4 (very good)		Level 5 (excellent)	
	Functional area:	Product Design Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
	Organizational role:	Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
	Level of analysis:	Individuals	Teams	Projects Programs	Organization				
	Specific Lean Management Practice:	Specific Lean	Not specific Lean						

Figure 12-32: PD Competence No.32 – PD staff competence

PDC 33	1.7.2	Multi-disciplinary staffing							
Competence Level Description:	Multi-disciplinary staffing of project teams in considered secondary.	Although the project leader tries to get members from non-engineering disciplines, teams consist mostly of engineers only.		For every team of a few dozen engineers, there is one marketing person, one industrial designer, and a few production engineers involved.		For every two dozen engineers, there are two marketing persons, two industrial designers, two systems engineers, and eight test engineers.		The team is fully loaded with non-engineers for disciplines needed as determined.	
Competence Level:	Level 1 (poor)	Level 2 (fair)		Level 3 (good)		Level 4 (very good)		Level 5 (excellent)	
	Functional area:	Product Design Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
	Organizational role:	Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
	Level of analysis:	Individuals	Teams	Projects Programs	Organization				
	Specific Lean Management Practice:	Specific Lean	Not specific Lean						

Figure 12-33: PD Competence No.33 – Multi-disciplinary staffing

PDC 34	1.7.3	Specialist career path							
Competence Level Description:	There is no specialist career path for engineers in product development. All career paths are built in a way that with promotions technical focus gets increasingly substituted by general management and administrative tasks.	Most career paths are built in a way that with promotions technical focus gets increasingly substituted by general management and administrative tasks.		There are no clear promotion guidelines but a number of PD employees is promoted based on functional experience and knowledge. Specialists usually do not spend a long period of time in the same functional division, though.		There is a designated career path for technical specialists in their functional areas which promotes the development of technical expertise. Promotion is mostly based on functional experience and knowledge. Performance of individuals is evaluated and discussed in feedback meetings every now and then.		There is a well-defined and accepted advancement path for technical specialists in product development and all over the organization. Technical expertise and knowledge is the main criterion for promotion. More experienced managers are responsible for mentoring and supporting junior engineers. Performance of individuals is regularly evaluated and discussed in feedback meetings.	
Competence Level:	Level 1 (poor)	Level 2 (fair)		Level 3 (good)		Level 4 (very good)		Level 5 (excellent)	
	Functional area:	Product Design Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
	Organizational role:	Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
	Level of analysis:	Individuals	Teams	Projects Programs	Organization				
	Specific Lean Management Practice:	Specific Lean	Not specific Lean						

Figure 12-34: PD Competence No.34 – Specialist career path

Data Management Competence

PDC 35	1.8.1	Use of project performance metrics							
Competence Level Description:	Project performance metrics are measured but barely communicated. Very few people really "use" them.	Use of project performance metrics is dominated by corrective actions and surprises. Metrics are tracked or measured, but not always consistently. People are not well informed about the project's progress. Data accuracy and completeness is lacking.		Use of project performance metrics includes proactive actions. Metrics are regularly measured and reviewed by management. People and management are kept informed of project's performance. There are efforts to improve data accuracy and completeness. Usage is isolated in functional silos.		Bias is to proactive actions, team morale and learning. Many metrics are derived from predictive models. Metrics are tracked regularly. Key customers and partners are kept informed. Operational data is readily usable and it is accurate and complete.		Bias is to proactive actions, morale, learning, and knowledge capture - in the firm, with lead users and with partners. Metrics are available online, always measured and reviewed against corporate objectives. Usage promotes cross-functional teamwork. Data can be trusted.	
Competence Level:	Level 1 (poor)	Level 2 (fair)		Level 3 (good)		Level 4 (very good)		Level 5 (excellent)	
	Functional area:	Product Design Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
	Organizational role:	Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
	Level of analysis:	Individuals	Teams	Projects Programs	Organization				
	Specific Lean Management Practice:	Specific Lean	Not specific Lean						

Figure 12-35: PD Competence No.35 – Use of project performance metrics

PDC 36	1.8.2	Productivity metrics							
Competence Level Description:	There is no standardized approach for measuring the productivity of a project.	PD system uses aggregate measures, which again are used for diagnosis of corrective and proactive improvement actions. Total project hours and errors are obtained with great difficulty.		Productivity and total project error data are collected and analyzed against historical norms. Heuristics are relied upon. There is limited use of predictive modeling.		Productivity is measured and tracked using analytical models that permit proactive action. Information is available online for management review and queries.		Productivity is measured and tracked with predictive models for proactive actions. Information is available online for management and key team members' review and queries. Information is also linked to other functional systems for a complete picture of project productivity.	
Competence Level:	Level 1 (poor)	Level 2 (fair)		Level 3 (good)		Level 4 (very good)		Level 5 (excellent)	
	Functional area:	Product Design Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
	Organizational role:	Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
	Level of analysis:	Individuals	Teams	Projects Program	Organization				
	Specific Lean Management Practice:	Specific Lean	Not specific Lean						

Figure 12-36: PD Competence No.36 – Productivity metrics

PDC 37	1.8.3	System of data collection, management and usage							
Competence Level Description:	PD does not have a formalized system of data collection, management and usage.	There is such a system, but for a variety of reasons, large volumes of data remain unused or ignored. Personal libraries and collection mechanisms dominate the practice.		There is such a system and it provides large volumes of data. Senior managers have budget to collect more data and develop local expertise.		Such a system exists. Senior managers budget to collect more data and develop local expertise. Members must share expertise via reports, on demand consultations, etc.		Such a system exists. Senior managers budget to collect more data and develop local expertise. System is highly integrated with learning, knowledge, and information tools and processes.	
Competence Level:	Level 1 (poor)	Level 2 (fair)		Level 3 (good)		Level 4 (very good)		Level 5 (excellent)	
	Functional area:	Product Design Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
	Organizational role:	Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
	Level of analysis:	Individuals	Teams	Projects Programs	Organization				
	Specific Lean Management Practice:	Specific Lean	Not specific Lean						

Figure 12-37: PD Competence No.37 – System of data collection, management and usage

PDC 38	1.8.4	Knowledge management system							
Competence Level Description:	Best practices and lessons learned are not captured.	Capturing and cataloguing project's knowledge assets is a low priority activity. Past project info is not easily accessible for probing questions. Project knowledge begins and ends with personal knowledge.		Capturing and cataloguing project's knowledge assets is seen as deemed necessary by the project leader for sharing within the team. Past project info not really accessible.		Standard practices include efficient means and standardized documents to naturally capture and catalogue project's knowledge assets for the team. Past project info is accessible, but hard for probing questions. Experts who can help are informally known to people.		Project's knowledge assets are systematically captured and catalogued. Standardized documents are used for capturing knowledge and lessons learned. Past project info is easily accessible for probing questions. Formal knowledge communities exist and are available to share and expand knowledge.	
Competence Level:	Level 1 (poor)	Level 2 (fair)		Level 3 (good)		Level 4 (very good)		Level 5 (excellent)	
	Functional area:	Product Design Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
	Organizational role:	Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
	Level of analysis:	Individuals	Teams	Projects Programs	Organization				
	Specific Lean Management Practice:	Specific Lean	Not specific Lean						

Figure 12-38: PD Competence No.38 – Knowledge management system

Technology Competence

PDC 39	1.9.1	Technology readiness							
Competence Level Description:	Technology readiness is not actively addressed as an issue in the company-wide product innovation process.	Technology readiness is determined by technology demonstrations under controlled environments. Executive orders influence timing of technology transfer to PD, and require large engineering resources to make ready.		Technology readiness is a joint effort between scientists and PD. Transition to PD is rocky. PD invests substantial resources to stabilize technology for transfer to PD.		Technology readiness is determined by internal simulation and application in prototype systems. Customers and partners are consulted. Readiness is a joint process between engineering, technologists, and manufacturing.		Readiness is determined by the actual application of the technology in the final form, in a stressed system and in actual customer environments. Products used are from actual short run manufacturing lines. Readiness is a joint process between engineering, technologists, and manufacturing.	
Competence Level:	Level 1 (poor)	Level 2 (fair)		Level 3 (good)		Level 4 (very good)		Level 5 (excellent)	
Functional area:		Product Design Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
Organizational role:		Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
Level of analysis:		Individuals	Teams	Projects Programs	Organization				
Specific Lean Management Practice:		Specific Lean	Not specific Lean						

Figure 12-39: PD Competence No.39 – Technology readiness

PDC 40	1.9.2	Investments in PD methods, tools and databases							
Competence Level Description:	IT and product development do not work together effectively. PD methods, tools, and databases are not widely accepted. Therefore they often are a "source" of problems.	PD methods, tools, and databases are a low budget priority. They retard progress. IT infrastructure is inconsistent with the project. IT is always behind, and too many PD resources are diverted and spent on IT. PD has to develop many of the tools required.		Methods, tools, and databases are sporadically improved and created. IT infrastructure and support are adequate for the project, but some PD resources are spent on IT. All need improvement. PD has to justify to management the acquisition of key tools.		Methods, tools, and databases are continuously improved and created. IT infrastructure fits the project and works to support it; it is generally timely, with some priority conflicts. PD progress is not inhibited by tools and their support.		Methods, tools, and databases are the envy of the industry. IT infrastructure is tailored for the project. IT support is dedicated to the projects, and not vice versa. Domain experts are identified and assigned to support PD.	
Competence Level:	Level 1 (poor)	Level 2 (fair)		Level 3 (good)		Level 4 (very good)		Level 5 (excellent)	
Functional area:		Product Design Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
Organizational role:		Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
Level of analysis:		Individuals	Teams	Projects Programs	Organization				
Specific Lean Management Practice:		Specific Lean	Not specific Lean						

Figure 12-40: PD Competence No.40 – Investments in PD methods, tools and databases

PDC 41	1.9.3	Technology forecasting							
Competence Level Description:	Product development does not consider formal technlogy forecasting.	Product development system is a technology follower - new technology is adopted only when it is widely adopted in the market. PD system uses familiar and mature technology and reuses known manufacturing processes.		Technology forecasting is based on capabilities of the organization and knowledge of the state-of-the-art. Capabilities determine adoption and competitive pressures trigger make/buy decisions.		Technology and manufacturing roadmaps with a competitive lead are defined. Work is done with customers to understand technologies. New product pipeline planning considers this when scheduling development activity.		PD uses preemptive roadmaps in technology and manufacturing. Technology is validated in lead user application environments. New product pipeline planning highly considers this when scheduling development activity.	
Competence Level:	Level 1 (poor)	Level 2 (fair)		Level 3 (good)		Level 4 (very good)		Level 5 (excellent)	
	Functional area:	Product Design Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
	Organizational role:	Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
	Level of analysis:	Individuals	Teams	Projects Programs	Organization				
	Specific Lean Management Practice:	Specific Lean	Not specific Lean						

Figure 12-41: PD Competence No.41 – Technology forecasting

Marketing Competence:

PDC 42	1.10.1	Product positioning							
Competence Level Description:	Product positioning is a purely passive process. The main reason for a new product introduction is the replacement of a preceding product. Neither lead users nor customers are involved in the product positioning process.	Most new products are positioned in a replacement business. Specifications are determined with no direct links to customer needs.		Products are positioned as improvements for the current customer base.		Products are positioned to new markets, with strong competitors. New growth opportunities, buying behavior, and market evolution are characterized. Product definition is differentiated and competitive.		Product and its derivatives are targeted for market creation in the industry. Product is unique – there are no competitive products or precedents. All key functions and processes are realigned for the product.	
Competence Level:	Level 1 (poor)	Level 2 (fair)		Level 3 (good)		Level 4 (very good)		Level 5 (excellent)	
	Functional area:	Product Design Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
	Organizational role:	Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
	Level of analysis:	Individuals	Teams	Projects Programs	Organization				
	Specific Lean Management Practice:	Specific Lean	Not specific Lean						

Figure 12-42: PD Competence No.42 – Product positioning

PDC 43	1.10.2	Knowledge of market potential							
Competence Level Description:	Market potential is determined from historical sales data only.	Market potential is predominantly determined from historical sales data and sales of known competitors.		Market potential is determined from expected sales of product line extensions and from currently served market segments. PD uses momentum models.		Forecasts of industry and market growth, adoption curves, pricing and revenues are considered. Focus is on key competitors' future actions. Some formal models are used.		Products are used to create a new market. Knowledge of market growth and acceleration is more important than potential size of the market.	
Competence Level:	Level 1 (poor)	Level 2 (fair)		Level 3 (good)		Level 4 (very good)		Level 5 (excellent)	
	Functional area:	Product Design Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
	Organizational role:	Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
	Level of analysis:	Individuals	Teams	Projects Programs	Organization				
	Specific Lean Management Practice:	Specific Lean	Not specific Lean						

Figure 12-43: PD Competence No.43 – Knowledge of market potential

PDC 44	1.10.3	Product pricing strategy							
Competence Level Description:	Target price is determined based on the development and production costs of the products.	Momentum pricing. Target price is determined by ensuring consistency with the current and to-be-replaced product offers.		Price to competition. Target price is determined through positioning analysis against competitor product offers.		Price to customer preferences. Use front-end consumer analysis methods, such as conjoint studies, to establish target price, consistent with the desired competitive market position of the product.		Price to customer value. EVA is used to price the product. Analysis uses lead users within their business processes. Pricing consistency with strategic intent is validated.	
Competence Level:	Level 1 (poor)	Level 2 (fair)		Level 3 (good)		Level 4 (very good)		Level 5 (excellent)	
	Functional area:	Product Design Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
	Organizational role:	Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
	Level of analysis:	Individuals	Teams	Projects Programs	Organization				
	Specific Lean Management Practice:	Specific Lean	Not specific Lean						

Figure 12-44: PD Competence No.44 – Product pricing strategy

Social Responsibility Competence

PDC 45	1.11.1	Social responsibilities							
Competence Level Description:	Product meets minimum legal requirements.	Product meets most of the legal requirements and exceeds in a few areas.		Product meets all legal requirements and exceeds in many areas.		Product meets all legal requirements and exceeds in many areas. Manufacturing meets and exceeds many regulatory standards in environmental compliance.		Product leads in meeting legal requirements and environmental compliances relative to its leading competitors. Product has proactively addressed many social responsibility issues not in statutes or regulations.	
Competence Level:	Level 1 (poor)	Level 2 (fair)		Level 3 (good)		Level 4 (very good)		Level 5 (excellent)	
	Functional area:	Product Design Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
	Organizational role:	Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
	Level of analysis:	Individuals	Teams	Projects Programs	Organization				
	Specific Lean Management Practice:	Specific Lean	Not specific Lean						

Figure 12-45: PD Competence No.45 – Social responsibilities

13 Appendix D – PD Dynamic Capabilities

Communication and diffusion channels

PDDC 1	2.1.1	Communication of vision, strategy and plans							
Capability Level Description:	Executives do not communicate their vision and strategy statements. Project leaders and project staff develop change plans that are not aligned with the company's vision and strategy.	Executives' communications are thin and sparse. Project's change plans are narrowly defined and vague. Project leader consistently needs executives' help to set direction and priorities.		Executives communicate vision, strategy and change plans, but their actions are not consistent. Project leader has to overcome these obstacles to drive the change project.		Executives actively communicate vision and strategy, reinforced frequently and supported by consistent actions. That makes the job of setting the change direction and prioritizing easy for the project leader.		CEO and senior management actively communicate the current vision and strategy. This is reinforced by visible actions, rewards and incentives. Consistent change messages arrive at all levels. People are encouraged to look at all of their daily activities through the lens of the organization's vision and strategy. Communication is effective and simple and uses examples and analogies.	
Capability Level:	Level 1 (poor)	Level 2 (fair)		Level 3 (good)		Level 4 (very good)		Level 5 (excellent)	
Functional area:		Product Design & Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
Organizational role:		Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
Level of analysis:		Individuals	Teams	Projects Programs	Organization				
"Leanness":		Specific Lean	Not specific Lean						

Figure 13-1: PD Dynamic Capability No.1 – Communication of vision, strategy and plans

PDDC 2	2.1.2	Communication and change diffusion barriers							
Capability Level Description:	Organizational, hierarchical and functional boundaries limit the movement of people and ideas considerably. A large part of employees does not share information and even hides it from other employees.	Organizational, hierarchical and functional boundaries limit the movement of people and ideas in a number of ways. Information is not available openly to a number of PD employees. Information about changes is generally undercommunicated.		The movement of people and ideas is only limited in parts of the PD organization. Information is openly shared among most parts of the PD organization but there is a number of people who do not get access to the information they need. Changes are communicated to a number of revelant people related to the topic.		The movement of people and ideas is not limited by organizational, hierarchical and functional boundaries. Information is available openly to most people in the PD organization. Changes are communicated to the most revelant people related to the topic.		The permeability of organizational, hierarchical and functional boundaries facilitates the movement of people, ideas, and the formation of communities of inquiry around systematic issues that cross boundaries. Information is available openly to everyone in the PD organization. Changes are communicated to those who are concerned as well as to those who are involved.	
Capability Level:	Level 1 (poor)	Level 2 (fair)		Level 3 (good)		Level 4 (very good)		Level 5 (excellent)	
Functional area:		Product Design & Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
Organizational role:		Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
Level of analysis:		Individuals	Teams	Projects Programs	Organization				
Specific Lean Management Practice:		Specific Lean	Not specific Lean						

Figure 13-2: PD Dynamic Capability No.2 – Communication and change diffusion barriers

PDDC 3	2.1.3	Formal change diffusion in PD (meetings)							
Capability Level Description:	There are very few meetings between PD employees. PD teams try to solve most of their problems themselves.	PD-related meetings are scheduled far into the future. There is no real agenda for the meetings. Participants consist almost always of the same people who feel forced to attend. Most meetings can be described as ineffective, time-consuming and chaotic.		Time, place, contents and participators of PD meetings are usually rigorously planned far into the future. Meetings are fairly effective but often fail to address the most important topics.		PD meetings are planned according to the current priorities. There is a planned agenda which can be adapted to current important topics. Participants usually consist of people who are necessary in order to discuss the topics. Outcomes of the meetings can be described as effective and useful.		There is a highly effective mix between fix planned meetings and flexible planned meetings for product development activities. Participants consist of people from different functional areas necessary to discuss current important topics. Meetings are very effective and focused on few important topics which are discussed intensively. Communication is open, direct, and honest. There is propensity to listen.	
Capability Level:	Level 1 (poor)	Level 2 (fair)		Level 3 (good)		Level 4 (very good)		Level 5 (excellent)	
	Functional area:	Product Design & Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
	Organizational role:	Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
	Level of analysis:	Individuals	Teams	Projects Programs	Organization				
	Specific Lean Management Practice:	Specific Lean	Not specific Lean						

Figure 13-3: PD Dynamic Capability No.3 – Formal change diffusion in PD (meetings)

PDDC 4	2.1.4	Informal change diffusion in PD							
Capability Description:	Informal networks foster spreading new ideas and innovative practices organically in and across PD projects and the whole organization. They are often called "communities of practice". "Network leaders" are participators and leaders in "communities of practice". **"Communities of practice":** have no name, no formal membership, no status; can be described as webs of relationships, created by bringing people together in ways that encourage them to get to know each other informally; are very good at filtering and prioritizing information and knowledge. **"Network Leaders":** are participators and leaders in "communities of practice". Good examples may be internal consultants, people in training or executive development departments. "Network leaders" are a natural counterpart to local line leaders. They spread new practices and change ideas. They establish connections with others. They assist the people working in the line organization.They often work behind the scenes which enables them to encourage people in a different way than executive can do that. Their lack of hierarchical authority makes them effective.							
Capability Level Description:	Informal change diffusion does not take place. Employees act in a very competive environment and keep their information for themselves.	There are a few established informal networks in place that diffuse change knowledge and information related to product development activities. Informal change diffusion usually takes place between certain individuals. The majority of PD employees is not aware of the existence and the benefits of informal networks. There are no incentives for creating such networks. Communication is dominated by stylized and formal mechanisms and lacks spontaneity.		Informal networks are used for diffusing PD-related change knowledge and information, but only within small parts of the organization. Informal networks are barely visible to the management. There are few incentives for building new "communities of practice".		Many already existing informal networks within the company are accepted and used for diffusing PD-related change knowledge and information. There are a number of incentives for building new informal networks.		There are a numerous incentives which encourage people to become "network leaders" or to form "communities of practice". PD employees do not only understand and acknowledge the importance of informal networks but also constantly try to spread the idea and importance of informal networks. There is a huge number of highly effective and different informal networks across different functional areas within the company. Communication is open, direct, and honest. There is propensity to listen.	
Capability Level:	Level 1 (poor)	Level 2 (fair)		Level 3 (good)		Level 4 (very good)		Level 5 (excellent)	
	Functional area:	Product Design & Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
	Organizational role:	Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
	Level of analysis:	Individuals	Teams	Projects Programs	Organization				
	Specific Lean Management Practice:	Specific Lean	Not specific Lean						

Figure 13-4: PD Dynamic Capability No.4 – Informal change diffusion in PD

Vision, strategy and plans

PDDC 5	2.2.1	Establishing a vision							
Capability Level Description:	The company does not have an official vision statement.	The company has an official vision statement. It has been created by the CEO a long time ago and does not really fit to the PD organization. Vision has little effect in motivating and directing people of the PD organization.		The vision statement is created top-down and in a systematic way but is updated rarely. Vision is understood at all levels of the PD organization and "part" of most of the operations. Vision is aligned with the organizational structure.		The company has a vision statement which suits very well to its current profile. It meets almost all the requirements for an effective vision. The statement is created in a systematic way and continuously improved and adapted. Key employees and most other employees buy into. Most of the external stakeholders (customers, suppliers) buy into. Vision is perfectly aligned with the organizational structure.		The company has a vision statement which can be described as clear, imaginable, desirable, feasible, sensible, focused, flexible, communicable and ambitious. The vision takes advantage of fundamental trends and has moral power. Vision is created in a systematic way and is continuously improved and adapted. Everyone from key executives to first-level employees buys into, also investors, customers, suppliers. Everything from the structure of the organization to the leadership style, management methods, and action plans is designed to support the vision.	
Capability Level:	Level 1 (poor)	Level 2 (fair)		Level 3 (good)		Level 4 (very good)		Level 5 (excellent)	
	Functional area:	Product Design & Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
	Organizational role:	Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
	Level of analysis:	Individuals	Teams	Projects Programs	Organization				
	Specific Lean Management Practice:	Specific Lean	Not specific Lean						

Figure 13-5: PD Dynamic Capability No.5 – Establishing a vision

PDDC 6	2.2.2	Establishing a strategy							
Capability Level Description:	Company relies more on short-term plans and budgets than on a real strategy.	The guiding team creates the company's strategy, but it is not really aligned with the company's vision, ongoing plans and current budgets.		The guiding team creates the company's strategy which is sufficiently aligned with the company's vision, ongoing plans and current budgets.		A variety of different functional groups are included into the company's strategy definition process which is based on a formal strategic planning method. Strategy is perfectly aligned with the organization's vision.		All relevant different functional groups work collaboratively to achieve the company's strategic objectives, they include also young employees, people at the organization's geographic periphery and newcomers. A variety of different strategic planning methods (e.g. scenario thinking) are used. Assumptions behind the current strategy are continually exposed and tested. Both vision and strategy are mutually reinforcing each other.	
Capability Level:	Level 1 (poor)	Level 2 (fair)		Level 3 (good)		Level 4 (very good)		Level 5 (excellent)	
	Functional area:	Product Design & Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
	Organizational role:	Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
	Level of analysis:	Individuals	Teams	Projects Programs	Organization				
	Specific Lean Management Practice:	Specific Lean	Not specific Lean						

Figure 13-6: PD Dynamic Capability No.6 – Establishing a strategy

PDDC 7	2.2.3	Short term wins							
Capability Level Description:	There is no change management coalition that collaboratively sets goals for the change effort.	Change management coalition does not focus on short-term wins. All effort is put into the realization of the "big goals".		Relevant short-term wins are achieved but change management coalition fails to communicate the results to a large number of key employees. Moreover, management does effectively leverage them for building momentum for the change effort.		Short-term wins are successfully used in order to build momentum for the overall change effort. They are related to the overall change effort and seem meaningful to the majority of key employees. Short-term wins are achieved within 6 to 18 months.		The change guiding coalition uses the right balance between short-term goals and the "grand vision"-goals. Short-term wins are perfectly aligned with the "grand vision" and clearly related to the overall change effort. They are actively created and achieved successfully and fast. Short-term wins are visible and meaningful to almost all employees, and unambiguous. People who make wins possible are visibly recognized and rewarded.	
Capability Level:	Level 1 (poor)	Level 2 (fair)		Level 3 (good)		Level 4 (very good)		Level 5 (excellent)	
	Functional area:	Product Design & Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
	Organizational role:	Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
	Level of analysis:	Individuals	Teams	Projects Programs	Organization				
	Specific Lean Management Practice:	Specific Lean	Not specific Lean						

Figure 13-7: PD Dynamic Capability No.7 – Short term wins

PDDC 8	2.3.1	Understanding and leveraging organizational culture							
Capability Level Description:	PD project tries to push change without considering the established organizational culture.	Understanding and leveraging organizational culture is not considered high priority. PD projects does not fit well to the cultural values of the firm; it is a forced-fit that impacts PD in many ways.		Firm's current PD projects and its cultural values are not completely aligned with each other. Projects have some difficulty fitting.		PD projects are aligned with the strategy and values of the firm.		Organizational culture and PD projects are mutually reinforcing. PD projects promote the culture and values of the firm and vice versa. Vision, strategy, plans and budgets are perfectly aligned with each other.	
Capability Level:	Level 1 (poor)	Level 2 (fair)		Level 3 (good)		Level 4 (very good)		Level 5 (excellent)	
	Functional area:	Product Design & Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
	Organizational role:	Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
	Level of analysis:	Individuals	Teams	Projects Programs	Organization				
	Specific Lean Management Practice:	Specific Lean	Not specific Lean						

Figure 13-8: PD Dynamic Capability No.8 – Understanding and leveraging organizational culture

PDDC 9	2.3.2	Teamwork culture							
Capability Level Description:	The teamwork culture in PD can be described as hostile and competitive.	Parochial loyalties are deeply rooted in PD teamwork culture. Group interactions are guarded with too many power games. Management intervention need to make groups work together and resolve disputes.		Intra-functional teamwork exists, but inter-functional teamwork and problem solving need management push. Conflicts remain unsolved too long and require management intervention.		Management has leveraged informal networks to promote cross functional teamwork and problem solving in PD-related areas. Conflicts are open, business-like, and readily resolved.		Self-organized cross-functional networks (formal and informal, with customers and with partners) actively promote problem solving in PD-related areas. They interact freely, and conflict resolution is fast and effective.	
Capability Level:	**Level 1 (poor)**	**Level 2 (fair)**		**Level 3 (good)**		**Level 4 (very good)**		**Level 5 (excellent)**	
	Functional area:	Product Design & Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
	Organizational role:	Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
	Level of analysis:	Individuals	Teams	Projects Programs	Organization				
	Specific Lean Management Practice:	Specific Lean	Not specific Lean						

Figure 13-9: PD Dynamic Capability No.9 – Teamwork culture

PDDC 10	2.3.3	Work environment							
Capability Description:	The right work environment plays an important role especially for creating organizational change. The work environment should provide surroundings and incentives which foster empathy, trust and personal reflection among the PD employees - all key factors for successful and sustainable organizational change.								
Capability Level Description:	Work environment is a hostile and very competitive environment. Maximizing individual work output is the main goal for a high number of employees.	Focus is on maximizing work output. PD employee well-being, satisfaction, and services are a low budget priority.		Focus is on maximizing work output, but with a concern for morale. There is enough attention to PD employee wellbeing, satisfaction, and services to avoid high turnover.		Focus is on high performance and high morale. Initiatives are in place to support PD employee well-being and satisfaction in order to sustain productivity, quality, and morale.		Recognized as an industry leader. The organization's policy addresses workplace, systems, and programs for PD employee well-being and satisfaction. Focus is also on the well being of the community.	
Capability Level:	**Level 1 (poor)**	**Level 2 (fair)**		**Level 3 (good)**		**Level 4 (very good)**		**Level 5 (excellent)**	
	Functional area:	Product Design & Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
	Organizational role:	Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
	Level of analysis:	Individuals	Teams	Projects Programs	Organization				
	Specific Lean Management Practice:	Specific Lean	Not specific Lean						

Figure 13-10: PD Dynamic Capability No.10 – Work environment

People for change

PDDC 11	2.4.1	Core change team composition							
Capability Level Description:	There are practically no "change teams" that want to create any type of organizational change.	PD employees try to implement changes with the help of already established groups.		There are people with ideas for PD-related changes, but it is hard to get together the right people who are needed in order to successfully implement these ideas.		The majority of people within the PD organization are open-minded about changes. They constantly try to form "change teams" in order to realize their change ideas. They often succeed in creating "change teams" which consist of the right people who successfully work together in order to create sustainable change. Pilot groups are used to introduce greater changes to the organization.		Single open-minded individuals with good ideas for changes can motivate and pull in the necessary people needed for PD-related change implementation. "Change teams" can be established within a short period of time. "Change teams" consist of different individuals with the appropriate skills, the relevant knowledge, the leadership capacity, the formal authority, the organizational credibility, and the connections to handle a specific kind of organizational change. Personalities in the team fit the respective organization. Pilot groups are used to introduce greater changes to the organization.	
Capability Level:	Level 1 (poor)	Level 2 (fair)		Level 3 (good)		Level 4 (very good)		Level 5 (excellent)	
	Functional area:	Product Design & Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
	Organizational role:	Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
	Level of analysis:	Individuals	Teams	Projects Programs	Organization				
	Specific Lean Management Practice:	Specific Lean	Not specific Lean						

Figure 13-11: PD Dynamic Capability No.11 – Core change team composition

PDDC 12	2.4.2	Teambuilding efforts							
Capability Level Description:	Company does not provide teambuilding events for its PD employees. PD employees are not interested in teambuilding activities either.	Teambuilding efforts are not really acknowledged by most of the PD staff within the organization. Responsible management does not support the idea of active teambuilding.		There are teambuilding incentives provided by the PD organization but these efforts seem to have no real goals behind.		Well-considered teambuilding efforts (e.g. informal blocked off-site meetings) are provided for a number of employees in product development and help to create trust and common goals between them.		Teambuilding efforts are carefully planned and customized by internal staff and/or external consultants. The purpose of teambuilding efforts is understood and appreciated throughout the PD organization. There is a common belief that teambuilding efforts are highly effective for creating trust and common goals among the staff.	
Capability Level:	Level 1 (poor)	Level 2 (fair)		Level 3 (good)		Level 4 (very good)		Level 5 (excellent)	
	Functional area:	Product Design & Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
	Organizational role:	Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
	Level of analysis:	Individuals	Teams	Projects Programs	Organization				
	Specific Lean Management Practice:	Specific Lean	Not specific Lean						

Figure 13-12: PD Dynamic Capability No.12 – Teambuilding efforts

PDDC 13	2.4.3				Roles, responsibilities and empowerment					
Capability Level Description:	Employees do not know their role. Their work can be described as carrying out tasks in order to satisfy their bosses. They are confused about the assignments from both their functional bosses and their project leader.	Roles are narrowly defined, largely at the task level. For many, it is difficult to link their work to the overall goals or the project mission. There is micromanagement, slow decision making, and false starts.		Team members understand their roles and responsibilities. They know how their work promotes goals, i.e a project's mission. There is respect for multifunctional views.		Team roles and responsibilities are determined through extensive discussions among management and employees. How to meet project goals is delegated to the project leader. Suppliers and partners review and comment.		Roles and responsibilities are determined via extensive discussions at all levels with participation from suppliers and partners. Strong power delegated to the project leader. Most have a desire to go beyond the job descriptions. All know their role and responsibilities relative to key functions.	
Capability Level:	Level 1 (poor)	Level 2 (fair)		Level 3 (good)		Level 4 (very good)		Level 5 (excellent)	
Functional area:		Product Design & Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
Organizational role:		Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
Level of analysis:		Individuals	Teams	Projects Programs	Organization				
Specific Lean Management Practice:		Specific Lean	Not specific Lean						

Figure 13-13: PD Dynamic Capability No.13 – Roles, responsibilities and empowerment

Helping, training and education

PDDC 14	2.5.1				Mentoring & coaching					
Capability Level Description:	Cultural learning process of PD employees is not supported by a mentoring or coaching program.	Mentoring or coaching relationships between mentors and mentees are not facilitated by the company but exist on an individual basis between PD employees. Mentors are usually in a higher position than their mentees and are able to give them valuable advice and help.		Company is using a formal mentoring program which is effective. However, only a limited number of employees participate in the program.		Company is using a formal mentoring program. Mentoring serves as a dual support system for both mentors and mentees. Mentors provide formal or informal support and offer to share their own network. Mentors and mentees have a professional relationship.		A highly effective company-wide mentoring program, which is accepted by employees, has been in use for years. All participating mentors and mentees take advantage of their regular interactions. Mentors are in a position of influence and coach their mentees in how to leverage the culture. They guide their mentees through pulling change processes and help them to expand their network by sharing their own network. Mentors and mentees like and respect each other.	
Capability Level:	Level 1 (poor)	Level 2 (fair)		Level 3 (good)		Level 4 (very good)		Level 5 (excellent)	
Functional area:		Product Design & Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
Organizational role:		Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
Level of analysis:		Individuals	Teams	Projects Programs	Organization				
Specific Lean Management Practice:		Specific Lean	Not specific Lean						

Figure 13-14: PD Dynamic Capability No.14 – Mentoring & coaching

PDDC 15	2.5.2								
	Attitude education								
Capability Level Description:	Organization provides no attitude training for its PD employees.	Attitude courses are offered only to key PD employees before starting their job.		Attitude courses are offered predominantly to key PD employees before starting their job as well as afterwards.		Not only skills but also attitude is trained to a high number of PD employees. Courses are offered also after starting the job. Training is aligned with the organization's vision and cultural values.		Organization attaches importance on attitude education among its PD staff. Senior executive leaders participate in teaching the culture of the company. Employees at all levels regardless their experience attend regular courses and can openly ask for help. Attitude training facilitates employees to understand the organization's vision and cultural values.	
Capability Level:	**Level 1 (poor)**	**Level 2 (fair)**		**Level 3 (good)**		**Level 4 (very good)**		**Level 5 (excellent)**	
	Functional area:	Product Design & Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
	Organizational role:	Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
	Level of analysis:	Individuals	Teams	Projects Programs	Organization				
	Specific Lean Management Practice:	Specific Lean	Not specific Lean						

Figure 13-15: PD Dynamic Capability No.15 – Attitude education

PDDC 16	2.5.3								
	Technical training								
Capability Level Description:	Training is limited to on-the-job learning.	Delivery pressures limit scope and extent of training. Training and education are constantly limited by other budget priorities. Technical effectiveness and proficiency measurements are subjective.		Technical training activities are planned and ensured for employees who really need it. Technical effectiveness and proficiency measurements are subjective, though.		Senior executives, functional managers and project champion are committed. Training is fully funded and effectiveness is measured objectively. Product delivery pressures rarely circumvent training plans.		The company's culture values technical proficiency. Training is fully funded, is never an issue, and effectiveness is measured. Product delivery pressures do not circumvent training. Training includes partners.	
Capability Level:	**Level 1 (poor)**	**Level 2 (fair)**		**Level 3 (good)**		**Level 4 (very good)**		**Level 5 (excellent)**	
	Functional area:	Product Design & Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
	Organizational role:	Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
	Level of analysis:	Individuals	Teams	Projects Programs	Organization				
	Specific Lean Management Practice:	Specific Lean	Not specific Lean						

Figure 13-16: PD Dynamic Capability No.16 – Technical training

Human resources for product development

PDDC 17	2.6.1	PD rewarding & promotion							
Capability Level Description:	There is no formal system for rewarding PD employees. There is no clear promotion regulation for PD employees.	Current rewarding & promotion system is conservative and risk averse and lacks a coherent structure and seems a mystery to a majority of the PD employees. Rewarding and promotion system is solely an affair of the human resources department. Compensation system promotes individuals instead of teams.		There is a good rewarding & promotion system for product development in place. Details of the design, implementation and administration should be improved, though. Alignment with current change processes and with the organizational structure and culture is considered but not paid enough attention. PD employees are informed about the rewarding & promotion system every now and then but there are a number of people remaining who do not really understand it.		Organization uses an effective and well-structured rewarding & promotion system in product development. Most PD employees understand how the rewarding & promotion system is functioning. There are continuous efforts to align the current PD rewarding & promotion system with business strategy, organizational structure, organizational culture and ongoing change efforts. Both extrinsic and intrinsic rewards are used.		PD rewarding & promotion system can be described as individualistic, flexible, well-designed, tied to strong performance and highly motivating. All relevant PD employees are frequently informed about changes in the system and understand how it is functioning. The PD rewarding & promotion system is perfectly aligned with business strategy, organizational structure and organizational culture. Changes to the system are implemented at the right time (as early as possible) in the change process. They are constantly monitored and adapted in order to guarantee compatibility with achieved new practices and alignment to current change efforts. PD organization uses both extrinsic (e.g. pay) and instrinsic rewards (e.g. job design) that are congruent and consistent.	
Capability Level:	Level 1 (poor)	Level 2 (fair)		Level 3 (good)		Level 4 (very good)		Level 5 (excellent)	
	Functional area:	Product Design & Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
	Organizational role:	Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
	Level of analysis:	Individuals	Teams	Projects Programs	Organization				
	Specific Lean Management Practice:	Specific Lean	Not specific Lean						

Figure 13-17: PD Dynamic Capability No.17 – PD rewarding & promotion

PDDC 18	2.6.2	PD recruiting & hiring							
Capability Level Description:	Having technical skills and experience are the only criteria for recruiting and hiring new PD employees.	The main selection criteria for recruiting and hiring new PD employees are profound technical skills and experience of the applicants.		Human resources department acts pretty independently from other functions. Selection criteria for recruiting and hiring involve technical skills and for key PD employees also behavioral skills.		Selection criteria for new PD employees involve both technical and behavioral skills. Behavioral interviews are part of the recruiting and hiring process. Recruiting and hiring system is aligned with the change vision and change strategy of the company.		Recruiting and hiring system is perfectly aligned with the change vision and change strategy of the company. Human resources department is constantly updated about ongoing change efforts and adjusts its selection criteria continuously. PD employees are selected not only based on their technical skills and experience. Heavy emphasis is put on behavioral interviews which are held in order to ensure "cultural fit" of new PD employees.	
Capability Level:	Level 1 (poor)	Level 2 (fair)		Level 3 (good)		Level 4 (very good)		Level 5 (excellent)	
	Functional area:	Product Design & Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
	Organizational role:	Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
	Level of analysis:	Individuals	Teams	Projects Programs	Organization				
	Specific Lean Management Practice:	Specific Lean	Not specific Lean						

Figure 13-18: PD Dynamic Capability No.18 – PD recruiting & hiring

Openness for improvements

PDDC 19	2.7.1	Raising and maintaining urgency level for change							
Capability Level Description:	High complacency on change within the PD organization. PD employees are opposed to changes and feel comfortable with the current situation.	Too much complacency on change within the PD organization. There is little motivation for change among the PD employees. Leaders and managers seem to push through their ideas.		Complacency is present in some PD-related functional areas. Guiding change coalition understands the role of urgency for change. There are efforts for raising the urgency level for change but they often come to late or seem not adequate.		The guiding coalition for change is constantly looking for cheap and easy ways to reduce the already low level of complacency on change. Moreover, they continually try to motivate relevant PD employees for the change effort. There is a growing group of believers.		There is no complacency on change. The guiding coalition for change is constantly trying to understand why people in PD resist or welcome change and to reduce complacency, fear and anger that prevent change from starting. All change efforts are started with raising a feeling of urgency among relevant PD people. All relevant PD employees feel motivated by visually compelling, dramatic, attention grabbing, memorable presentations, reports and other evidence that they can see, touch and feel.	
Capability Level:	Level 1 (poor)	Level 2 (fair)		Level 3 (good)		Level 4 (very good)		Level 5 (excellent)	
	Functional area:	Product Design & Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
	Organizational role:	Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
	Level of analysis:	Individuals	Teams	Projects Programs	Organization				
	Specific Lean Management Practice:	Specific Lean	Not specific Lean						

Figure 13-19: PD Dynamic Capability No.19 – Raising and maintaining urgency level for change

PDDC 20	2.7.2	Motivating breakthrough ideas							
Capability Level Description:	Employees are opposed to changes and innovations. They do not support breakthrough ideas.	PDP innovations occur when management pushes them forward.		Innovations are considered and implemented when it is clear how they will benefit.		Employees are open to PDP innovations. If the benefit is unclear, respect for the project leader will still carry it forward.		Management system and culture that promote fresh ideas. Innovation is prized and rewarded, especially from sources outside their normal expertise.	
Capability Level:	Level 1 (poor)	Level 2 (fair)		Level 3 (good)		Level 4 (very good)		Level 5 (excellent)	
	Functional area:	Product Design & Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
	Organizational role:	Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
	Level of analysis:	Individuals	Teams	Projects Programs	Organization				
	Specific Lean Management Practice:	Specific Lean	Not specific Lean						

Figure 13-20: PD Dynamic Capability No.20 – Motivating breakthrough ideas

Learning

PDDC 21	2.8.1	Pursuit of organizational learning							
Capability Level Description:	Organizational learning begins and ends with personal learning.	There is an information system to capture lessons from prior projects, but it is not accepted by the PD employees.		An information system to capture lessons from prior project is used by the majority of PD employees. PD employees agree that the system could be used in a more effective way.		The PD organization takes advantage of lessons from its latest projects and pursues its key people to learn how to apply those lessons to its new project.		The PD organization has many formal and informal incentive mechanisms. Effective practices are readily adopted by the PD organization. A high percentage of employees reads journals, books and trade press.	
Capability Level:	Level 1 (poor)	Level 2 (fair)		Level 3 (good)		Level 4 (very good)		Level 5 (excellent)	
	Functional area:	Product Design & Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
	Organizational role:	Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
	Level of analysis:	Individuals	Teams	Projects Programs	Organization				
	Specific Lean Management Practice:	Specific Lean	Not specific Lean						

Figure 13-21: PD Dynamic Capability No.21 – Pursuit of organizational learning

PDDC 22	2.8.2	Cross-project knowledge transfer							
Capability Level Description:	Product development projects are considered independent and unrelated. There is no knowledge transfer between different projects.	Knowledge transfer between different projects is not facilitated. Knowledge transfer happens through informal communication channels but not in a systematic way.		A variety of best practices and lessons learned from different projects are documented, but not in a systematic and logical way. Documented knowledge is unsteadily updated. A number of employees frequently use the knowledge database but there is also a high number of people within the organization who have never heard about it.		There are methods and devices to collect information on successful procedures, tools and designs across projects. Best practices and lessons learned from previous projects are reviewed. Documented knowledge is updated every now and then. The collected knowledge is simplified and generalized every now and then. All employees have access to the centralized knowledge database and sometimes use it.		A high number of methods and devices is effectively used in order to collect information on successful procedures, tools and designs across projects. Best practices and lessons learned from previous projects are reviewed. Documented knowledge is continuously updated by the engineers. The collected knowledge is frequently simplified, reorganized and generalized. All employees have access to the centralized knowledge databases and regularly use it.	
Capability Level:	Level 1 (poor)	Level 2 (fair)		Level 3 (good)		Level 4 (very good)		Level 5 (excellent)	
	Functional area:	Product Design & Systems Eng.	R&D (Techn. Dev.)	Finance & Accounting	Production & Quality	Sales & Marketing	Human Resources	Customer Services	Administration IT Support
	Organizational role:	Executive level	Project leader	Function leader	Project staff	Function staff	CI organization		
	Level of analysis:	Individuals	Teams	Projects Programs	Organization				
	Specific Lean Management Practice:	Specific Lean	Not specific Lean						

Figure 13-22: PD Dynamic Capability No.22 – Cross-project knowledge transfer

14 Appendix E – PD Project Results

Project Financial and Market Results

PDR 1	3.1.1		Project IRR and NPV		
Result Description:	Project does not meet IRR and NPV financial metrics by far.	Project does not meet IRR and NPV financial metrics even after many retargeting decisions and many other accounting and financial adjustments.	Project meets IRR and NPV financial metrics after some accounting and financial adjustments.	Project meets IRR and NPV metrics as committed during project funding.	Project exceeds IRR and NPV metrics committed during project funding.
Result Level:	**Level 1 (poor)**	**Level 2 (fair)**	**Level 3 (good)**	**Level 4 (very good)**	**Level 5 (excellent)**

Figure 14-1: PD Project Result No.1 – Project IRR and NPV

PDR 2	3.1.2		Product volumes		
Result Description:	Product volumes are far below forecast established during funding stage.	Product volumes are below forecast established during funding stage.	Product volumes are on track with forecast established during funding stage.	Product volumes exceed forecast established during funding stage.	Product volumes far exceed forecast established during funding stage.
Result Level:	**Level 1 (poor)**	**Level 2 (fair)**	**Level 3 (good)**	**Level 4 (very good)**	**Level 5 (excellent)**

Figure 14-2: PD Project Result No.2 – Product volumes

PDR 3	3.1.3		Product revenues		
Result Description:	Product revenues are far below forecast established during funding stage.	Product revenues are below forecast established during funding stage.	Product revenues are on track with forecast established during funding stage.	Product revenues exceed forecast established during funding stage.	Product revenues far exceed forecast established during funding stage.
Result Level:	**Level 1 (poor)**	**Level 2 (fair)**	**Level 3 (good)**	**Level 4 (very good)**	**Level 5 (excellent)**

Figure 14-3: PD Project Result No.3 – Product revenues

PDR 4	3.1.4		Product costs		
Result Description:	Product costs do not meet the plan established during funding by far.	Product costs do not meet the plan established during funding, and its negative impact is visible in the product's financial performance.	Product costs are on track with the plan established during funding.	Product costs meet all, and even exceed some performance targets established during funding.	Product costs' performance far exceeds the plan established during funding and the positive impact is visible in the product's financial position.
Result Level:	**Level 1 (poor)**	**Level 2 (fair)**	**Level 3 (good)**	**Level 4 (very good)**	**Level 5 (excellent)**

Figure 14-4: PD Project Result No.4 – Product costs

PDR 5	3.1.5		Product SG&A		
Result Description:	Product's SG&A does not meet the plan established during funding by far.	Product's SG&A does not meet the plan established during funding. Negative impact is visible in the product's financial performance.	Product's SG&A is on track with the plan established during funding.	Product's SG&A meets all, and even exceeds some performance targets established during funding.	Product's SG&A performance far exceeds the plan established during funding and the positive impact is visible in the product's financial position.
Result Level:	**Level 1 (poor)**	**Level 2 (fair)**	**Level 3 (good)**	**Level 4 (very good)**	**Level 5 (excellent)**

Figure 14-5: PD Project Result No.5 – Product SG&A

PDR 6	3.1.6	Product's market share in revenue			
Result Description:	Product's revenue market share trends show that market share is strongly decreasing in key targeted segments.	Product's revenue market share trends show that market share is decreasing in key targeted segments.	Product's revenue market share trends show that market share is uneven in target markets specified during funding stage of base plan, but adequate in aggregate.	Product's revenue market share trends show that market share is increasing in many key segments established during funding stage, and increasing in aggregate versus base plan.	Product's revenue market share trends show that product has established a new market segment. Its share is growing dramatically.
Result Level:	**Level 1 (poor)**	**Level 2 (fair)**	**Level 3 (good)**	**Level 4 (very good)**	**Level 5 (excellent)**

Figure 14-6: PD Project Result No.6 – Product's market share in revenue

Project Customer Satisfaction and Loyalty Results

PDR 7	3.2.1	Customer loyalty			
Result Description:	Customers are displacing the product with competitor's products.	Customers start to displace the product with competitor's products at an increasing rate. They are not recommending the product to others.	Customers will consider competitive products for repurchase. They recommend the product with some qualifiers.	Customer's repurchase rate is exceeding forecast. They recommend the product when asked.	Customer's repurchase-rate is exceeding expectations by a wide margin. Without prompting, they are visibly endorsing the product in important forums.
Result Level:	**Level 1 (poor)**	**Level 2 (fair)**	**Level 3 (good)**	**Level 4 (very good)**	**Level 5 (excellent)**

Figure 14-7: PD Project Result No.7 – Customer loyalty

PDR 8	3.2.2	Satisfaction with price for value			
Result Description:	Customers consider the product to be extremely overpriced for the value they are deriving from its use.	Customers consider the product to be overpriced for the value they are deriving from its use.	Customers consider the product price to be fair considering the value they are deriving from its use.	Customers consider the product price to be attractive due to the value they are deriving from its use.	Customers consider the product price to be an extraordinary value due to the unique benefits they are deriving from its use.
Result Level:	**Level 1 (poor)**	**Level 2 (fair)**	**Level 3 (good)**	**Level 4 (very good)**	**Level 5 (excellent)**

Figure 14-8: PD Project Result No.8 – Satisfaction with price for value

PDR 9	3.2.3	Satisfaction with product function and performance			
Result Description:	Customers consider the product's function and performance to be very disappointing.	Customers consider the product's function and performance to be rather disappointing.	Customers consider the product's function and performance to be acceptable and to have met their expectations.	Customers consider the product's function and performance to have exceeded their expectations.	Customers consider the product's function and performance to have created unprecedented and extraordinary competitive advantages.
Result Level:	**Level 1 (poor)**	**Level 2 (fair)**	**Level 3 (good)**	**Level 4 (very good)**	**Level 5 (excellent)**

Figure 14-9: PD Project Result No.9 – Satisfaction with product function and performance

PDR 10	3.2.4	Satisfaction with service and support			
Result Description:	Customers consider the product service and support to be very disappointing.	Customers consider the product service and support to be rather disappointing.	Customers consider the product service and support to be acceptable. Overall, their expectations have been adequately met.	Customers consider the product service and support to have exceeded their expectations.	Customers consider the product service and support to be surprisingly competent and efficient considering the unprecedented functions and applications of the product.
Result Level:	**Level 1 (poor)**	**Level 2 (fair)**	**Level 3 (good)**	**Level 4 (very good)**	**Level 5 (excellent)**

Figure 14-10: PD Project Result No.10 – Satisfaction with service and support

Organizational Effectiveness Results

PDR 11	3.3.1		Strategic intent		
Results Description:	Product does not help the strategic and competitive position of the firm at all.	Product provides little support to help the strategic and competitive position of the firm.	Product maintains the strategic and competitive position of the firm.	Product improves the strategic and competitive position of the firm.	Product redefines the strategic and competitive position of the firm.
Result Level:	**Level 1 (poor)**	**Level 2 (fair)**	**Level 3 (good)**	**Level 4 (very good)**	**Level 5 (excellent)**

Figure 14-11: PD Project Result No.11 – Strategic intent

PDR 12	3.3.2		Development time and slip rate		
Result Description:	Project slippes considerably from original schedule committed during funding. Huge management intervention, descoping, and additional resources are required.	Project slippes from original schedule committed during funding. Management intervention, descoping, and additional resources are required.	Project misses milestones committed during funding by small and acceptable margins. Needs some management intervention and incremental resources to maintain scope and schedule margins.	The project is completed on time and meets every schedule milestone defined during funding. No management intervention is required.	Project beats the every schedule milestone.
Result Level:	**Level 1 (poor)**	**Level 2 (fair)**	**Level 3 (good)**	**Level 4 (very good)**	**Level 5 (excellent)**

Figure 14-12: PD Project Result No.12 – Development time and slip rate

PDR 13	3.3.3		Development budget and schedule		
Result Description:	Project slippes considerably from original schedule and overruns budget by far. Huge management intervention, descoping, and additional resources are required to keep revised schedule on time.	Project slippes from original schedule and overruns budget. Management intervention, descoping, and additional resources are required to keep revised schedule on time.	Project misses milestones and budget by small yet acceptable margins committed during funding. Some management intervention and incremental resources to maintain scope and schedule margins are needed.	The project is completed on budget, on time, meeting every milestone, and without any slips. No management intervention is required.	The project beats the budget and every schedule milestone.
Result Level:	**Level 1 (poor)**	**Level 2 (fair)**	**Level 3 (good)**	**Level 4 (very good)**	**Level 5 (excellent)**

Figure 14-13: PD Project Result No.13 – Development budget and schedule

PDR 14	3.3.4		Partner satisfaction and loyalty		
	Key partners discontinue their business relationships. Company has difficulty in recruiting new ones.	Partners are unsatisfied and not loyal.	All things considered, partners are satisfied and loyal.	Partners' satisfaction and loyalty exceed targets. Partners recommend the firm. Company has no difficulty in finding new candidates.	Partner's are excited and enthusiastically recommend the firm. New candidates compete to become business partners.
Result Level:	**Level 1 (poor)**	**Level 2 (fair)**	**Level 3 (good)**	**Level 4 (very good)**	**Level 5 (excellent)**

Figure 14-14: PD Project Result No.14 – Partner satisfaction and loyalty

PDR 15	3.3.5		Project team morale		
Result Description:	The project team morale is very low. Staff and management turnover and absenteeism are extremely high. Staff and management recruiting is very difficult.	The project team morale is low. Staff and management turnover and absenteeism are high. Staff and management recruiting is difficult.	The project team morale is acceptable with some exceptions. Staff and management turnover is acceptable.	The project team morale is high and surveys support this fact. Staff and management turnover is low. Recruiting is easy.	The project team morale and excitement are high and surveys support this fact. Staff and management fight to join the project.
Result Level:	**Level 1 (poor)**	**Level 2 (fair)**	**Level 3 (good)**	**Level 4 (very good)**	**Level 5 (excellent)**

Figure 14-15: PD Project Result No.15 – Project team morale

PDR 16	3.3.6		Productivity		
Result Description:	Project team's productivity misses its objectives by far. Productivity deficits visibly affect the financial measures or the schedule in a very negative way.	Project team's productivity does not meet its objectives. Productivity deficits visibly affect the financial measures or the schedule negatively.	Project team's productivity indicators meet their targets within adequate margins. Productivity deficits' impact on financial measures and the schedule is within adequate margins.	Project team's productivity indicators meet and exceed most of their targets. Productivity results in incremental improvements in financial measures and the schedule.	Project team's productivity indicators exceed all key targets. They do so sufficiently to have a positive and visible impact on financial measures and schedule.
Result Level:	**Level 1 (poor)**	**Level 2 (fair)**	**Level 3 (good)**	**Level 4 (very good)**	**Level 5 (excellent)**

Figure 14-16: PD Project Result No.16 – Productivity

PDR 17	3.3.7		Contribution to knowledge assets		
Result Description:	PD has no knowledge assets in the archives.	PD has project documents in the archives.	PD does a lessons learned.	Lessons learned are actioned. Process is changed and information improved. PD now prevents a failure from occurring.	Lessons, actions, process, and information improvements now transform organizational processes and information in fundamental ways.
Result Level:	**Level 1 (poor)**	**Level 2 (fair)**	**Level 3 (good)**	**Level 4 (very good)**	**Level 5 (excellent)**

Figure 14-17: PD Project Result No.17 – Contribution to knowledge assets

Product Results

PDR 18	3.4.1		Functions and performance versus specifications		
Result Description:	Product misses key specifications committed after beta prototype by far. A huge number of renegotiations are required to continue development. These negotiations are impacting financial performance and customer/partner satisfaction and loyalty in a very negative way.	Product misses key specifications committed after beta prototype. A number of renegotiations are required to continue development. These negotiations are impacting financial performance and customer/partner satisfaction and loyalty negatively.	Product meets specifications committed after beta prototype. Minor renegotiations are required to adjust specifications to continue development.	Product exceeds specifications. Product is competitive. No negotiations are required to adjust specifications to continue development.	Product's specifications are setting industry de facto standards. Product is widely imitated. Positive impact is visible in financial performance and customer and partner propensity to recommend the product.
Result Level:	**Level 1 (poor)**	**Level 2 (fair)**	**Level 3 (good)**	**Level 4 (very good)**	**Level 5 (excellent)**

Figure 14-18: PD Project Result No.18 – Functions and performance versus specifications

PDR 19	3.4.2		Industry awards		
Result Description:	No industry awards for this product.	No industry awards for this product. Mentioned in the trade press, but not visible in analyst's and consultant's reports.	Very few industry awards for this product. Mentioned in the trade press, but barely visible in analyst's and consultant's reports.	Few industry awards, but many visible and favorable industry reports for the product.	Prestigious industry awards for the product. Me-too imitators appearing.
Result Level:	**Level 1 (poor)**	**Level 2 (fair)**	**Level 3 (good)**	**Level 4 (very good)**	**Level 5 (excellent)**

Figure 14-19: PD Project Result No.19 – Industry awards

PDR 20	3.4.3	Core technology newness			
Result Description:	PD technology focus is on cost reduction only.	PD technology focus is on cost reduction, product repositioning and/or update.	Technology is new to the firm. Competitor already offers technology in the market.	Core technology exists and is implemented in completely different types of products. New to the market.	Technology is entirely new, has never appeared in any type of product sold in the market. The technology is fresh out of the research lab and is causing competitive disruption.
Result Level:	**Level 1 (poor)**	**Level 2 (fair)**	**Level 3 (good)**	**Level 4 (very good)**	**Level 5 (excellent)**

Figure 14-20: PD Project Result No.20 – Core technology newness

PDR 21	3.4.4	Platforming extent			
Result Description:	Project considers only the single product.	Project partly considers accommodating future derivatives and/or updates.	Project considers accommodating future derivatives and/or updates. There is a planned architecture.	Project develops multiple variants and uses full platform development for a product line. The architecture is developed along product variants.	Project develops multiple variants and accommodates future technologies requiring architectural changes.
Result Level:	**Level 1 (poor)**	**Level 2 (fair)**	**Level 3 (good)**	**Level 4 (very good)**	**Level 5 (excellent)**

Figure 14-21: PD Project Result No.21 – Platforming extent

PDR 22	3.4.5	Manufacturing complexity			
Result Description:	Manufacturing processes are neither changed nor improved.	Negligible changes are made to the manufacturing processes. There are small adjustments in vendors, tools, and parts, but they are fundamentally very familiar and have been used before.	Minimal new parts, vendors, custom parts, tools, materials, and small process changes are introduced to manufacturing. New skills training is localized and for small groups.	New parts, vendors, custom parts, major tools, materials, and redesigned processes are introduced to manufacturing. Specialized skills development and training are required.	A large number of new parts, new vendors, new custom parts, major retooling, new materials, and new and redesigned processes are introduced to manufacturing. A large range of skills training and education are required.
Result Level:	**Level 1 (poor)**	**Level 2 (fair)**	**Level 3 (good)**	**Level 4 (very good)**	**Level 5 (excellent)**

Figure 14-22: PD Project Result No.22 – Manufacturing complexity

PDR 23	3.4.6	Sales and service complexity			
Result Description:	Sales and service approach is unchanged. Product sales are predominantly based on cost reductions.	Sales and service approach is largely unchanged. Product sales are mostly based on cost reductions, update, or similar repositioning to slow down customer defections.	Sales and service approach is tuned and adjusted in order to maintain customer base against competitors.	Sales and service approach is redefined to showcase product's function, performance, and technology in order to expand existing market share.	Product's unique value proposition and functionality requires new sales and service processes to expand market share and occupy new market segments.
Result Level:	**Level 1 (poor)**	**Level 2 (fair)**	**Level 3 (good)**	**Level 4 (very good)**	**Level 5 (excellent)**

Figure 14-23: PD Project Result No.23 – Sales and service complexity

Project Benchmarking

PDR 24	3.5.1		Benchmarks		
Result Description:	Benchmarking is not applied in PD. Therefore, PD does not know how good a product is performing versus its key competitors.	Benchmarks are only occasionally done. Results show that the product is underperforming versus its key competitors in many key measures.	Benchmarks show that the product is about equal to its key competitors in key measures.	Leading product development organizations benchmark their products against yours. Product is used as a model of best of breed.	Industry, standards groups, and PD groups seek to study your product, PD practices and organizational issues to develop PD norms and defacto standards.
Result Level:	**Level 1 (poor)**	**Level 2 (fair)**	**Level 3 (good)**	**Level 4 (very good)**	**Level 5 (excellent)**

Figure 14-24: PD Project Result No.24 – Benchmarks

15 Appendix F – Folder Structure of the Enclosed DVD-ROM

- Figures
- Industry Focus Group Survey
- Literature
- PDSAT Integration
- PDSAT Questionnaire
- Presentation