Professional MBA
Automotive Industry

Guideline for implementing a standardized product development process in the automotive supplier industry

A Master's Thesis submitted for the degree of
"Master of Business Administration"

supervised by
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Vienna, 17.09.2018

Affidavit

I, **LUKAS JESACHER, BSC**, hereby declare

1. that I am the sole author of the present Master's Thesis, "GUIDELINE FOR IMPLEMENTING A STANDARDIZED PRODUCT DEVELOPMENT PROCESS IN THE AUTOMOTIVE SUPPLIER INDUSTRY", 91 pages, bound, and that I have not used any source or tool other than those referenced or any other illicit aid or tool, and
2. that I have not prior to this date submitted this Master's Thesis as an examination paper in any form in Austria or abroad.

Vienna, 17.09.2018

Signature

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List of abbreviations

APQP	Advanced Product Quality Planning
CAD	Computer-aided design
CAQ	Computer-aided quality
ISO	International Organization for Standardization
IT	information technology
JIS	just-in-sequence
JIT	just-in-time
KAM	Key Account Manager
KPI	Key Performance Indicator
MST	milestone
OEM	original equipment manufacturer
PDP	product development process
PPAP	Production Part Approval Process
QMO	quality management organization
QMS	quality management system
SLP	Safe-Launch Phase
SOP	Start of Production
VDA	Verband der Automobilindustrie

Abstract

This paper describes a guideline for series product development, with special consideration of automotive suppliers. The subject of this thesis is the field of product project management, with special emphasis on the necessary processes of product development.

A unified and coordinated product development process can have a strong influence on the success of the company. In the fast-growing automotive industry and the associated growth of automotive suppliers, it is advisable to establish a uniform product development process, also called PDP, in the company structure. This makes it easy to generate a central and value-adding process for product and process development that can be monitored using effectiveness and efficiency indicators.

The PDP delivers a fully developed and freely tested series product in accordance with the agreed requirements, which can be manufactured in the production plant without problems in accordance with a reliable manufacturing process. In order to get there, a multitude of activities are necessary, which are generally summarized in the course of this work.

1. Introduction

1.1 Motivation

The automotive industry is one of the industrial groups with the highest turnover in Europe. In the past five years alone, the number of passenger cars registered in the EU has increased by 4.5 percent. In 2017, almost 21 percent of passenger cars produced worldwide came from the European Union, see figure 1 (cf. ACEA, https://www.acea.be/statistics/tag/category/key-figures- accessed on: 04.08.2018).

EMPLOYMENT		
Manufacture of motor vehicles (EU28)	2.5 million people = 8.3% of EU employment in manufacturing	2016
Total (EU28 manufacturing, services and construction)	13.3 million people = 6.1% of total EU employment	2016
PRODUCTION		
Motor vehicles (world)	98.9 million units	2017
Motor vehicles (EU28)	19.6 million units = 20% of global motor vehicle production	2017
Passenger cars (world)	80.2 million units	2017
Passenger cars (EU28)	17.0 million units = 21% of global passenger car production	2017
REGISTRATIONS		
Motor vehicles (world)	97.9 million units	2017
Motor vehicles (EU27)	17.5 million units = 18% of global motor vehicle registrations/sales	2017
Passenger cars (world)	79.8 million units	2017
Passenger cars (EU27)	15.1 million units = 19% of global passenger car registrations/sales	2017
Petrol (EU15)	49.4%	2017
Diesel (EU15)	44.8%	2017
Electric (EU15)	1.5%	2017
VEHICLES IN USE		
Motor vehicles (EU28)	298.9 million units	2016
Passenger cars (EU28)	259.7 million units	2016
Motorisation rate (EU28)	587 units per 1,000 inhabitants	2016
Average age (EU25)	11 years	2016

Figure 1: Comparison of production statistics
Source: https://www.acea.be/statistics/tag/category/key-figures- accessed on: 04.08.2018

However, this significant growth also means a highly competitive field and constantly increasing requirements for automotive suppliers. In order to survive in the automotive industry, a company must know how to cope with these changing requirements and be able to offer a product or service in the best quality at the lowest possible price.

1.2 Definition of the research problem

The product development process is complex and forms the core business for many automotive suppliers. Cross-company and cross-departmental cooperation in series development projects is indispensable and must be well planned and coordinated. The factors time, quality and costs play a central role here. One of the tasks of a standardized PDP is to make these factors, which are in competition with each other, more controllable. The primary goal of this concept is the early detection and avoidance of potential risks in the development of series products, as well as a harmonized project process starting with customer enquiries through to series production. The project status is thus easily visible at any time and allows early reaction to any deviations.

1.3 Aim of the thesis

The product development process is in general only very roughly represented. However, the individual phases can be very complex. Due to the rapid market growth and the associated growth of the company itself, many companies are faced with the task of establishing a standardized product development. The aim of this work is to create a generalized process for automotive suppliers in which the most important controlled documents and points to be observed are presented. These include work instructions, process descriptions and the most important work tasks of the individual phases of the product development process.

Based on this Master's thesis, the following research questions will be answered:

- Which quality requirements for a standardized product development process are necessary?
- Which are the most important applicable documents within the product development process?
- What kind of improvement measures are available when implementing a PDP within a company?

2. State of the art

The automotive industry is a key industry in the European Union in terms of number of employees and turnover. Due to competitive pressure, this industry is very often the initiator of new methods in production and technologies (cf. Himpel & Kaluza 2008: 67).

The number of requirements companies have to cope on the market is constantly increasing. Globalization, new competitors such as those from Asia and technical developments play a major role here. This chapter intends to break down the existing requirements for the automotive industry.

The European passenger car market grew by 2.4% during the first three months of 2018. This corresponds to 4.8 million vehicles. In terms of vehicle registrations, values within the European Union have risen by 0.7% compared to last year. With 4.2 million cars sold this year, the EU represents 21% of the global automotive market and ranks second worldwide behind China (cf. ACEA, https://www.acea.be/statistics/article/economic-and-market-report-state-of-the-eu-auto-industry-quarter-1-2018, accessed on: 04.08.2018). From today's perspective, the development of the automotive industry must be viewed on a global level. The most important sales markets, consisting of North America, Japan and Western Europe, are saturated. Due to increased sales markets in the BRIC countries (Brazil, Russia, India, China), the complexity and number of different requirements has increased. Country-specific material and quality requirements increase the demands on automotive suppliers. At the moment there is a fast change for existing and new markets and there is great competitive pressure as well as a struggle for market shares. Tier1 and Tier2 suppliers are also feeling this pressure. For explanation, a Tier1 supplier delivers its goods directly to an automobile manufacturer (OEMs=Original Equipment Manufacturer), whereby a Tier2 supplier sells its goods to a Tier1 supplier, who reassembles the goods. Increasing complexity, cost pressure and price erosion, such as an annual reduction in the price of parts of up to 4% demanded by the OEM, are requirements that suppliers have to cope with (cf. Becker 2007: 9).

2.1 Increasing range of models

As a result of competition, the model range is increasing more and more, which confronts companies with an increased individualization of products. This has a decisive influence on the complexity within product development and consequently in the product development process. The car and commercial vehicle industry is characterized by globalized competition from heterogeneous competitors (cf. Lehmann & Grzegorski 2009: 82). Regardless of the increasing competition and the growing model range of OEMs, the increasing number of variants can be attributed to the companies themselves. Due to poor communication and immature knowledge management, new solutions are often developed without taking existing solutions into account. Of course, the development of the variety of variants cannot be traced back to the company itself. The customer himself very often forces a wide range of services with individual requirements, which are tailored to him.

Many automotive suppliers are adapting to the permanently changing market conditions and are focusing on customer orientation (cf. Lindemann et al. 2006: 7). The increasing number of variants not only presents the PDP with new interdisciplinary tasks, but also increases the scope of activities in production, development, logistics and sales. This is not only a great challenge, it can also become a high cost driver in many areas. At the beginning of industrialization during Henry Ford's time, the focus was on the production of large quantities of uniform products. For example, in Ford's production between 1915 and 1925, initially of the first automatically driven assembly line production, only black body parts were produced so that only one painting line was necessary and the black paint dried fastest. Only after the saturation of the market and increasing customer requirements, a differentiation of the offered services has come to the fore. In order to achieve a lasting competitive advantage a certain variety of variants is necessary.

This results from interaction with the customer and differentiation from competitors (cf. Völling 2009: 1). As a result, the start of series production and the product development process are becoming increasingly important, as the number of series start-ups is inevitably increasing because of a higher number of product launches. Car manufacturers and automotive suppliers are faced with the task of making their production more flexible and faster. The product development process is therefore a very good tool for faster and more reliable product development and represents a critical competitive factor for success. In addition, the service life cycle of a vehicle has been drastically shortened irrespective of the increased model variety (cf. Schuh et al. 2008: 3).

2.2 Product lifecycle

In the history of the automobile, there has been a change in the way we look at our own vehicle. The idea has changed fundamentally. Today, a car is often used as a prestige object as an expression of the of your personal lifestyle. The Volkswagen Beetle was produced for almost 65 years as an example. As a result of its life cycle, it has hardly changed at all. For a long time the Volkswagen Beetle held the record for the best-selling car with almost 21.5 million units produced. A product life cycle of this scale will hardly be repeated today. The following figure shows the production years of different models.

Figure 2: Change of the product lifecycle
Source: Own illustration

As a rule, the lifecycle of a product extends from the product idea through series production to final stocking. The contents of the product life cycle may vary depending on use and industry, including the duration. The life cycle can last from a few days to decades. The automotive industry usually spends six to ten years on the road. For comparison, 10-50 years are common in the aircraft industry, whereby cycle times of up to six months are possible in the rapidly changing software industry. The next figure shows a list of the different cycle times taking different industries into account (cf. Raubold 2011: 42).

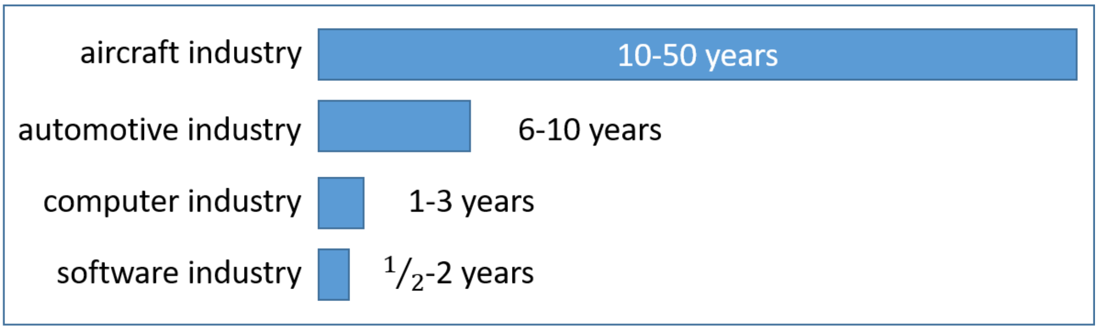


Figure 3: Product lifecycle of different industries
Source: Amended from Raubold 2011: 42

Technology competition and price wars between individual companies are continually shortening life cycles. Successor models are replacing predecessor models ever faster. This also greatly reduces the market presence and the potential profit. In the 1980s, the average product life cycle was around eleven years. Since we are now around six years, the life cycle has been almost halved (cf. Romberg & Haas 2005: 10). The shortened life cycle has a significant influence on production and development costs as well as implementation costs. In order to cover development costs, it is necessary to introduce a product at the lowest possible cost and at short notice (cf. Feldhusen & Gebhardt 2008: 2).

The next figure shows a typical product lifecycle of a motor vehicle. In the history of the automotive industry, this process has proven to be effective and can be used for a large number of vehicle models.

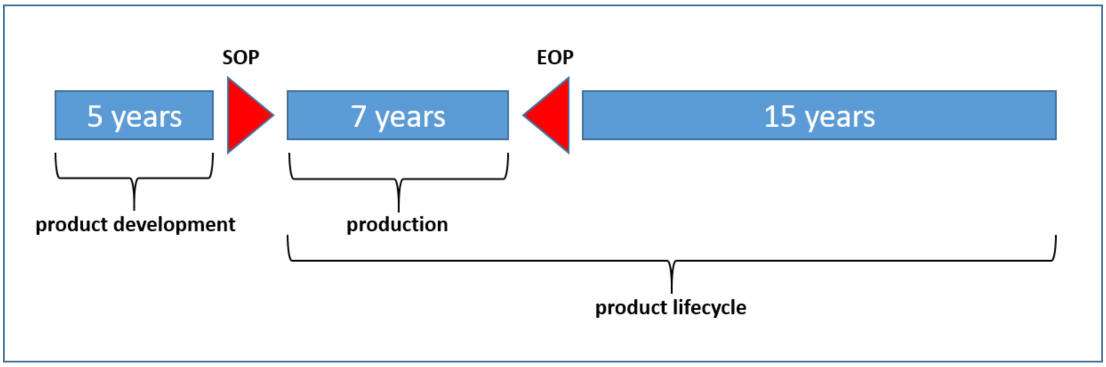


Figure 4: typical product lifecycle within the automotive industry
Source: Amended from Raubold 2011: 45

The product development phase is particularly important here. Due to the shortening lifecycle and the faster market launch of new products, product development time is constantly shortening. As a result, special attention must be paid to avoiding errors. Quality support tools are used to achieve a zero-defect strategy.

2.3 New forms of cooperation

The tactics used by car manufacturers to produce the widest possible range of vehicle models means that OEMs are forced to outsource a large proportion of their value creation to suppliers. In the past, the automotive supplier played a rather subordinate role. However, this has changed over time as the development and production of vehicle parts is increasingly outsourced. (cf. Hab & Wagner 2010: 8)

Outsourcing is a policy that has been observed by OEMs in the past. Whereas at that time only individual parts were produced by suppliers, today complete modules or systems including the necessary development performance are passed on to Tier 1 and Tier 2 suppliers. This significantly increases the proportion of value added for suppliers. The German Association of the Automotive Industry (VDA) does not yet see this development as complete, but predicts that the trend will continue. This sounds promising for automotive suppliers, but you have to take into account that the requirements increase and the competitive pressure is much more noticeable. They not only have to take over the development and the associated financial burdens, but are also liable in the event of a complaint and in the event of warranty services. The following figure shows to what extent the share of value added is changing. The share of value added shifts in favor of the automotive supplier, the share of development tends to increase as well. (cf. Ebel et. al 2004: 11)

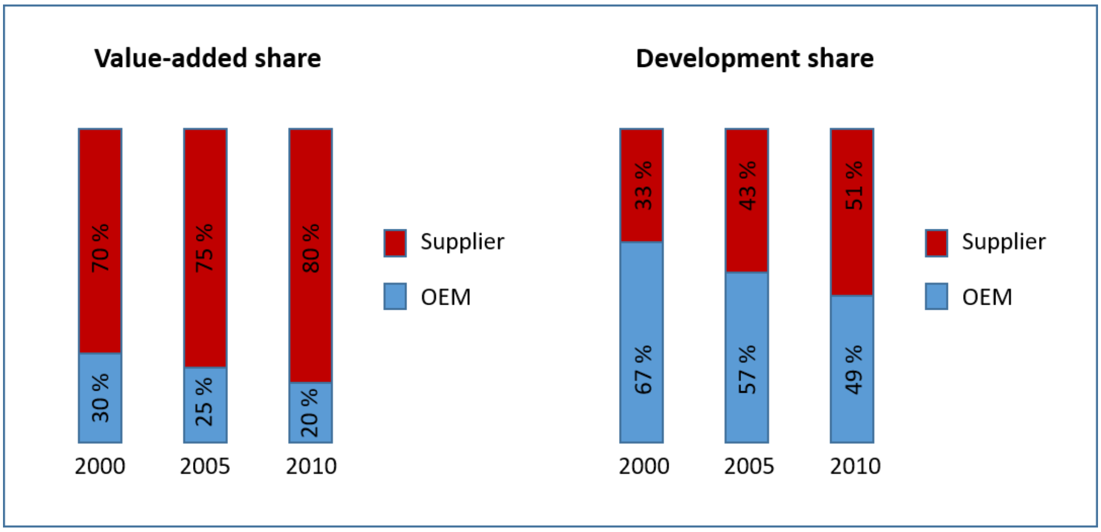


Figure 5: Transfer of the development share
Source: Amended from Ebel et. al 2004: 11

Today we very often talk about strategic partnerships between OEMs and suppliers. More coordination and coordination work is needed.

3. Product development in the automotive industry

Product development is of strategic importance. The complexity of product development processes is constantly increasing and becoming increasingly difficult due to the faster introduction of successor models to the market and shorter life cycles. In particular, the start of series production, which means the start of series production, has a central role and must be planned and coordinated precisely. (cf. Himpel & Kaluza 2008: 67)

The product development process is part of the life cycle of a product. It delivers a completely developed and freely tested series product in accordance with the agreed requirements, which can be manufactured trouble-free in the production plant in accordance with a secured manufacturing process. Costs play an increasingly important role alongside quality and time. Many companies use a phase model to ensure systematic processing of the PDP. However, this representation of a sequential sequence is not entirely unproblematic, since it suggests sequential processing. But the reality is usually quite different. There are a number of correction loops and feedbacks that are not visible in the phase model. Nevertheless, the division into different phases offers the possibility to grasp and structure the complexity of the product development process in terms of content. (cf. Heindorf 2010: 11)

In series production you can talk between mass production and individual production. In general, it is common in the automotive industry to manufacture products in large series. We speak of series production when several similar products are manufactured one after the other or simultaneously. A production order comes into production, according to which a certain quantity (lot size) is produced. Companies that follow a product development process usually have a process-oriented orientation.

3.1 Process-oriented approach

Thinking in processes is an advantage during product development, as it enables a holistic view. Now the question arises what is actually understood by a process-oriented orientation.

In order to guarantee the effectiveness of a company, a multitude of complex, interlinked activities must be managed, determined and managed. This in turn generates a large number of processes. According to DIN EN ISO 9000:2005, a process is defined as "a set of interrelated activities that converts inputs into results...“ The next figure shows a simplified representation of a process.

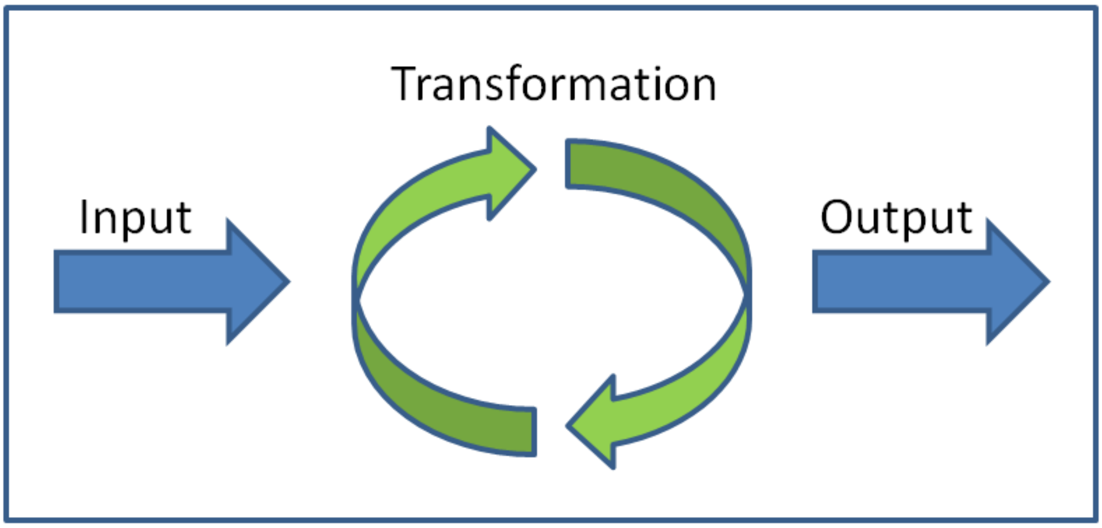


Figure 6: Simple model of a process
Source: Own illustration

In the operational environment, there is still a distinction between business processes, which consist of cross-functional links. A common process term makes no statement about the scope, content, limitation, structure, recipient and results of the process. Business processes are aimed at value-adding activities that are directly related to the fulfilment of customer requirements or agreed services. You can also say that a customer request triggers a business process.

Thus one can say that business processes have an essential decisive effect on business success. They are referred to as core processes if they contribute to customer benefits that are perceived as superior to those of the competition. (cf. Grimm 2010: 10)

Processes are very often linked, the output of a process provides the input for the following process. The application of a system of processes in an organization to produce the desired result, coupled with the recognition and interactions of these processes and their management, can be described as a process-oriented approach. One advantage of the process-oriented approach is the constant control that this approach offers through the links between the individual processes in the system of processes as well as their combination and interaction. (cf. Technical specification ISO/TS 16949 2002: XIV.)

During the product development process, many processes run across departments, which makes strong collaboration between departments important. The process-oriented orientation is intended to counteract this by pursuing the process goal instead of a departmental goal. (cf. Wagner & Beetle 2008: 3)

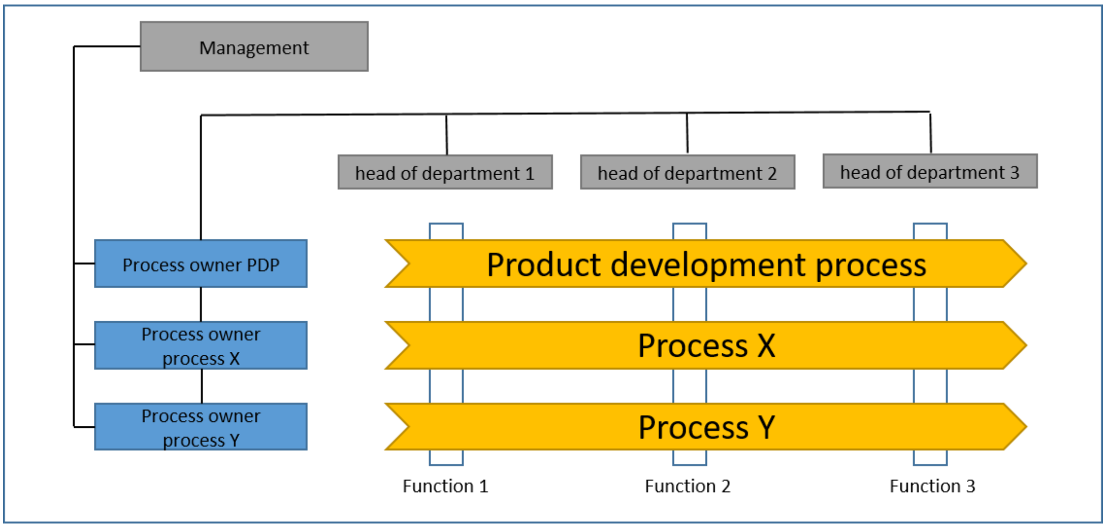


Figure 7: A process-oriented approach
Source: Amended from Wagner & Beetle 2008: 3

In most cases, a process-oriented orientation of the company has the task of continuously improving standardized processes.

3.1.1 Continuous improvement

This can be achieved according to Kaizen, which describes continuous improvement according to certain guiding principles:

- Good processes to deliver good results
- taking measures to contain and correct the root causes of problems
- Assessment of the current situation
- teamwork
- Integration of all employees

There are five central principles according to Kaizen, which are as follows (cf. Arndt 2008: 78):

1. **Standardization**

If one of the implemented suggestions for improvement is suitable for the company, it is defined as a standard and integrated into the ongoing processes. The PDCA cycle thus changes to SDCA (Standardize, Do, Check, Act). Once this process is finally completed, a further improvement will be taken up.

2. **Critical orientation**

Criticism is seen as an opportunity for continuous improvement. Therefore, every employee should be encouraged to make suggestions for improvement. The company, on the other hand, should take up these improvements constructively and try to implement them in the best possible way. This results in a continuous cycle of planning, activity, control and improvement (short: PDCA cycle: Plan, Do, Check, Act).

3. **Quality orientation**

Each company sets its own quality standard. This is finally applied to the quality requirements of activities and processes. This quality refers not only to the products, but also to the processes with which they are manufactured.

4. Customer focus

The Kaizen process focuses the company on customers and their needs and expectations. In Kaizen there are two types of customers, external and internal. External customers operate outside the company. You are not employed there or are in a different employment relationship. Internal customers in a company, on the other hand, are, for example, their own colleagues who take over the service. Each activity in the company is therefore referred to as a customer-supplier service, so the company is very customer-oriented. The company structure is such that each employee looks critically at, analyses and improves the quality of the product and his own performance perceived by the customer. Alignment with the customer is extremely important for competitive success, as the customer's requirements must be known as precisely as possible.

5. Process orientation

The process orientation ensures through continuous improvement that processes are controllable and controllable. An improved process automatically leads to improved results. Bad results can therefore be corrected by changes in the process. Process structuring must be carried out regularly in order to be able to react flexibly and quickly. The entire process is geared to the customer, so that customer satisfaction is to increase through continuous optimization. Within this process orientation, the added value increases and at the same time reduces waste and mistakes. The next figure shows the PDCA cycle as defined in a continuous improvement process.

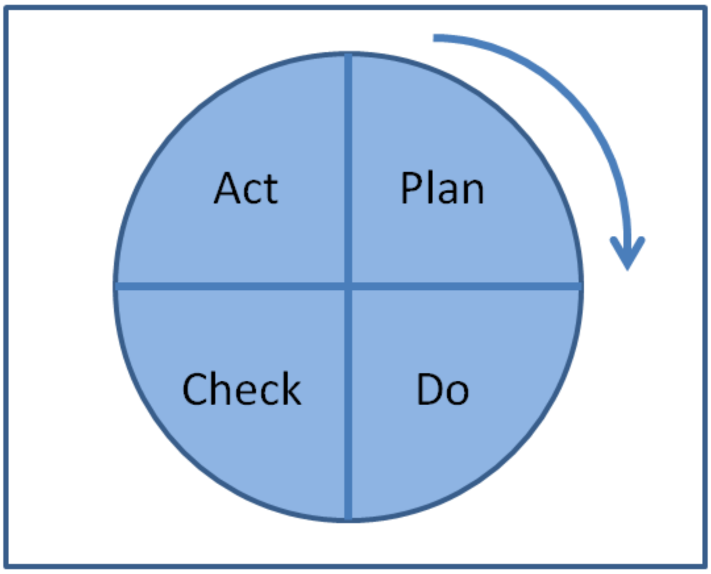


Figure 8: PDCA cycle
Source: Amended from Arndt 2008: 78

3.2 Process management

In a process-oriented structure of the company, corresponding processes, such as the processes of the PDP, must be managed. Process management has the task of analyzing and monitoring conceptual models of business processes. Furthermore, processes running in the company are identified and standardized. The continuous improvement of processes described in Section 3.1.1 is also the task of process management.

The processes of development, product development, production and disposal are of great importance as an automotive supplier. Ongoing interaction with project management is an important part of process management. In order to be able to access a common level of knowledge, the first step is to standardize the processes. The knowledge and experience gained in practice can thus flow back into a standardized process. Not only the project management has to interact with the process management, also vice versa, an agreement has to be made through continuous improvement. The aim should be to create a binding, uniform, repeatable and, most importantly, transparent basis for all processes. A certain transparency is expedient, so that a uniform understanding of the individual processes is formed (cf. Funk et al. 2010: 13).

3.3 Project management

Project management plays a central role in the development of new products. The project manager ensures that the individual tasks of the PDP are met, coordinates the core team and tracks the budget, schedule, organizational activities and primary customer contact. Due to increasing strategic challenges, the demands on project management are also increasing. The market situation is becoming increasingly acute and customers, or in our case OEMs, want products at an attractive price with the highest possible quality. It is important to have a certain balance to the line organization, as well as a certain standing of the project manager. The PDP accommodates the project manager in the course of a standardized procedure and a defined task (cf. Hab & Wagner 2010; 10).

Project management is understood as the totality of management tasks, structures, techniques and means for the initiation, definition, planning, control and completion of projects. Project management is a special performance and organizational concept that serves to apply knowledge, skills, methods and techniques of planning, management and control in order to achieve the agreed project goals. The management of a project is subject to a wide variety of influences and is typically a permanent decision-making process in which one tries to achieve the best possible result in the shortest possible time at the lowest possible cost. The execution of a project should therefore be appropriate (quantity and quality), on schedule (time) and on budget (costs) (cf. Amberg et al. 2011: 1).

The factors time, quality and costs are in a certain conflict with each other. In project management and in the economy in general, this is called a magic triangle. This always occurs when there are three different levels of requirements that fall back on the same resource. In the case of project management, the factors time, quality and costs are usually referred to. Changing one parameter has a direct influence on another parameter. As an example, an increase in quality generates an increase in costs and the time to be spent (cf. Amberg et. al 2011: 3). However, even the magical triangle is at a standstill due to the aggravating market situation in the Change. There is increasing talk of the "devil triangle". Products have to be produced on an ever-smaller budget in ever-shorter time. The time to market of a product, called "time-to-market", is constantly shortening. The following illustration graphically shows the change from the magical to the "devil triangle" (cf. Hab & Wagner 2010: 10).

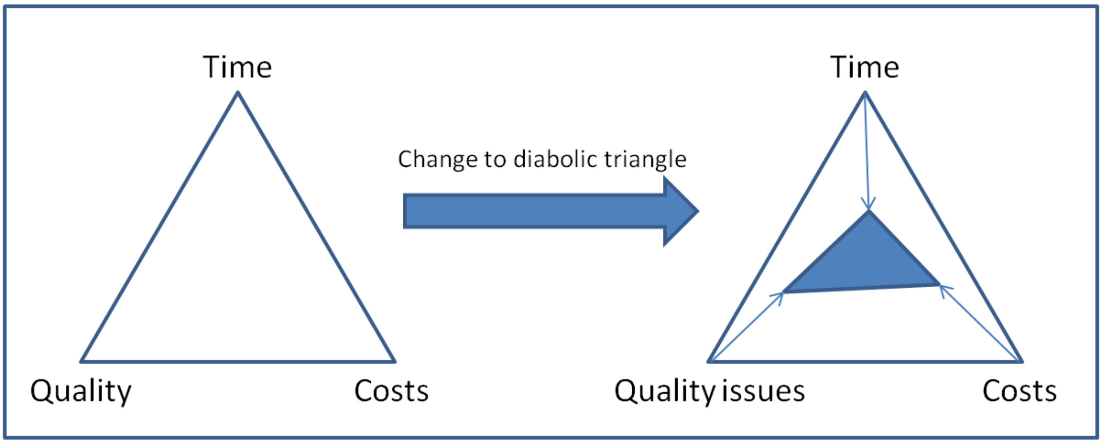


Figure 9: Change of the magical triangle
Source: Amended from Hab & Wagner 2010: 10

A project is defined by the following properties:

- Temporal, financial and personnel limitations
- Uniqueness
- Defined targets (costs, deadline, time)
- General conditions to delimit the project precisely
- Project-specific organisation

Considering these characteristics, a project is not a recurring undertaking, but once, based on the defined conditions. The project management takes over topics of control and planning under consideration of the given resources (cf. Hab & Wagner 2010: 23).

3.4 Product development process

As already mentioned above, the basis of a mature product development process is a process-oriented organization. Many companies access a phase model that divides the entire PDP into sub-processes and thus enables a simpler understanding of the tasks. If one does a literature search, one does not find a uniform phase model of the PDP nor a generally valid nomenclature of the individual phases. In the automotive industry, however, certain similarities can be observed in planning and implementation (cf. Himpel & Kaluza 2008: 67).

In order to meet market requirements, many companies have integrated a standardized PDP into their company structure. If a company repeatedly produces comparable products, it makes sense to introduce a standardized description for simplification, planning and standardization. The PDP also makes it clear that all departments are involved. Especially in the automotive industry it is often required that results can be measured by efficiency and effectiveness. This is possible via a phase model, since the project status, costs, resources and schedules can be permanently monitored and called up here. In this way, success and quality can be measured in a project.

In the automotive industry, firmly scheduled milestones very often underpin product developments. The product development process then helps to meet the given deadlines. The PDP often starts with the idea of a new project or a customer inquiry. The PDP must be able to optimally meet the challenges in the automotive industry. In addition to the topics discussed above, quality, cost and complexity play an important role in the ever-shorter product life cycles. Support through virtual development methods, modeling and simulation plays an important role and helps to significantly shorten the development time of new products (cf. Albers et al. 2008: 6).

The product development process differs from industry to industry. In the automotive industry, however, it is largely similar. The next figure shows a simplified representation of the PDP. The main phases of conceptual design, development, work preparation and production, shown here in blue, are divided into a large number of sub-processes, which are highlighted in yellow.

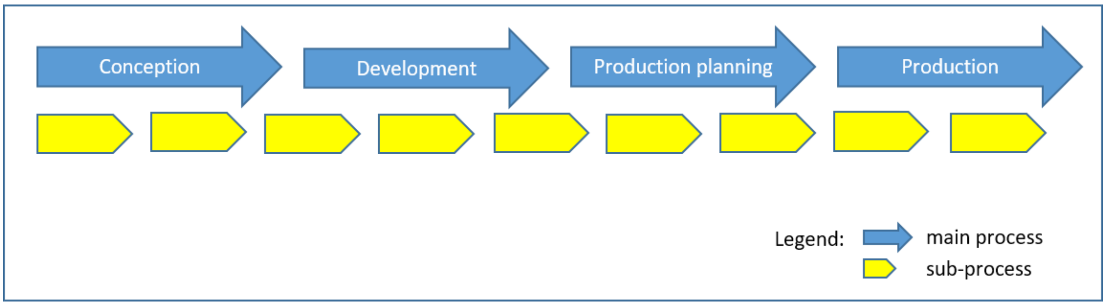


Figure 10: Product development process
Source: Own illustration

The introduction of a standardized product development process involves certain risks. Note that the main and sub processes are not processed purely formally. As a result, a lot of solution energy and a certain amount of creative freedom is lost. It is therefore particularly important that the objectives are aligned and not the approach. Every project team member involved with the PDP must be aware of the importance of the individual goals. When a standardized product development process is introduced into a company, this also means a certain cultural change. It should be noted here that there is very often a pronounced inertia among employees who work for longer periods of time. The top management should therefore communicate a clear commitment. This can only work if the PDP runs through the entire line hierarchy. To promote effectiveness, all necessary responsibilities within the project team must be clearly defined. All employees should have access to the same level of knowledge, so company-wide training for the PDP is an important measure (cf. Longmuß & Buchholz: Wissensmanagement im Prozess der Produktentstehung. http://www.business-wissen.de/organisation/loesungswege-wissensmanagement-im-prozess-derproduktentstehung/, accessed on 30.06.2018).

Usually one has defined milestones in the course of the project. In the course of time a new term has established itself to the customer, one speaks of Quality Gates. Behind the quality gate system is a refined milestone plan, which will be discussed in the next section.

3.5 Quality Gate System

Within the framework of a standardized PDP, the quality gate system can be applied, which is widely used in practice. According to estimates, 60-70% of manufacturing companies use quality gate management in addition to their PDP (cf. Peters 2010: 28). This system is frequently used in the automotive industry in particular. Things often do not go as planned in the implementation of a product development. Very often difficulties arise which are only recognized in a later phase of the product development process and then remedied under time pressure at great extra expense. Project results and customer expectations often do not agree due to unclear requirements and general conditions. Quality gates are used for the early detection of such target/actual deviations.

The early recognition should offer the project team the possibility to grant the necessary period for countermeasures. Similar to project milestones, quality gates are scheduled to a certain point in time and are often positioned so that they occur at a transition between two phases. Please note that the maturity level of the project should be exactly defined at this point in time. A maturity level describes the status with regard to process, product and project maturity (cf. Association of the Automotive Industry 2009: 13). The deadline of the Quality Gate is held with the entire project team and serves to determine the degree of maturity. At each quality gate, the respective degree of maturity is determined by querying defined measurement criteria. This also ensures the quality of the scope of supply agreed with the customer (cf. German Association of the Automotive Industry 2009: 9). This is primarily of a preventive nature. One can therefore say that in the course of the quality gate the project is subject to a status assessment. Each phase of the PDP has defined goals that are checked at the gate.

Similar to milestones, Quality Gates create comprehensive transparency of the current project status for all project participants. The transparency of the project creates the necessary information basis and facilitates decisions. What is the decisive difference to milestones? For milestones, only the time aspect of the entire project is usually recorded, but defined quality criteria must be fulfilled at the Quality Gate in order to go on with the next project phase. These quality criteria can also be combined with milestones to create a combination of the two methods. As long as the necessary criteria are not completed, the next phase cannot start. The next figure shows a PDP extended by the quality gates.

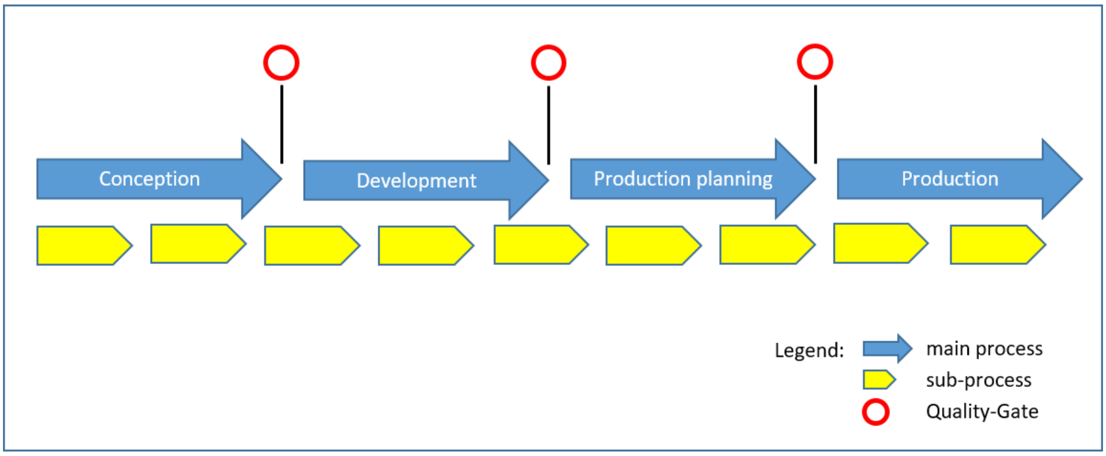


Figure 11: Product development process with Quality-Gates
Source: Own illustration

The Quality-Gate system is used to support project success.

3.6 Launch management in the automotive industry

The product development process is characterized by many critical points that are important for future project success. A particularly important point for manufacturing companies is the so-called start of series production. The start of series production starts when the product has been fully developed and shows whether the product can be manufactured under series conditions. The series conditions determine the required product quality and quantities to be produced. Project management is supported by the launch management. The increasing variety of models and variants also plays a role here. For the launch management this means a shortening of the intervals between the individual start-ups, with an increasing total number of products.

If you look in the literature for the definition of launch management, you will find different definitions:

Launch management comprises all activities and measures for controlling, planning and implementing the launch with the production systems provided for this purpose (cf. Kuhn et al. 2002: 8).

Launch management comprises the organization, planning, control and implementation of internal and cross-company material and information flows in the production start-up phase, taking into account all those involved in the PDP. The aim is to meet the set cost, quality and time requirements (cf. Risse 2002: 139).

Launch management means the coordination and monitoring of the processes necessary for the start-up in the form of implementation, control and management of the transition from project-oriented management to production management (cf. Nagel 2011: 10).

The start of series production has a time limit. It corresponds to the period between the completion of product development and the achievement of capacity. Care is taken to ensure that this capacity is not reached immediately. This only happens gradually in the course of a start-up curve, whereby one also speaks of a safe launch phase, in short SLP. In the automotive industry, the start of series production is usually divided into three different phases. The first phase describes the pre-series, in which prototypes are manufactured under conditions close to series production at least. In this phase there is very often still no approved series tool. The pre-series serves primarily to discover possible problems, check the feasibility of the defined production processes and, if necessary, train employees at the plant. The subsequent phase, also known as pilot series, describes production under complete series conditions. Only approved series tools are used here. The third and final phase begins with the start of production (SOP) and describes the production ramp-up. If the planned daily production can be produced under stable series conditions, the start of series production ends (cf. Schuh et al. 2008: 1).

Figure 12 shows the integration of the production start phases in the PDP.

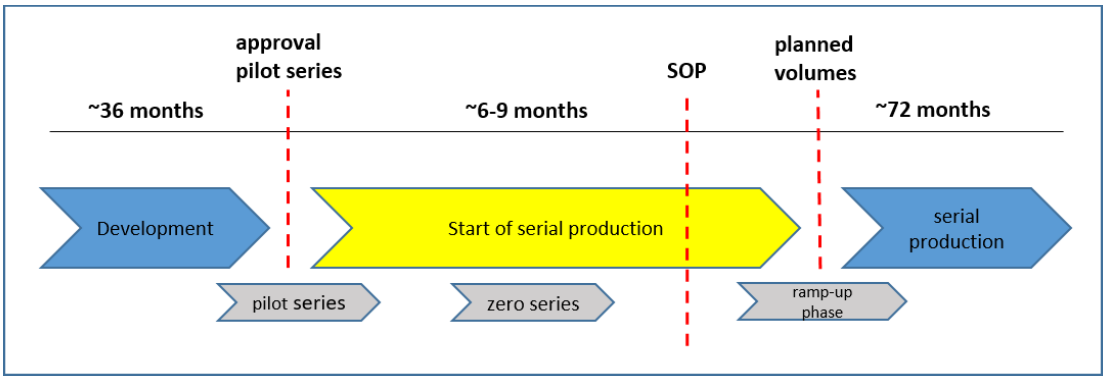


Figure 12: Start of serial production within the PDP
Source: Amended from Schuh et al. 2008: 2

The ever-increasing complexity and variety of variants is mainly noticeable in the start of series production. The large number of design objects and functional areas that have to interlock during the production start phase are largely responsible for the complexity. The goal should be to create a controllable series start-up that does not require any troubleshooting. Errors undetected in earlier phases often become apparent during the start of series production (cf. Schuh et al. 2008: 1).

Launch management has become a success factor for the company due to the increasing production and series start-ups. Problems at the start of production can have a very strong effect on the project result. If, for example, the start of sales is delayed due to launch problems, the entire calculation of a project can be impaired. Basically, the start of sales is not postponed. No automotive supplier wants to bear the blame for a delay at the OEM with the ensuing enormous additional costs. In fact, in the European automotive industry, about 60% of production launch fail to meet their economic and/or technical targets (cf. Brischwein 2011: 146). The ability to bring a product to market faster than the competition creates an effective advantage in the highly competitive market.

4. Quality requirements in the automotive industry

The term and the related topic of quality plays a central role in the automotive industry. In this context, process and product quality is of great importance. In the past, quality was considered a distinguishing feature, but today it is seen much more as a basic requirement. The list of customer requirements in the area of quality is long and varies from OEM to OEM. In the course of product development, the term quality is omnipresent.

4.1 Concept of quality

The term quality comes from the Latin "qualis" and means "how to procure" or "the nature". “Qualitas”, on the other hand, describes the "relationship to things" (cf. Koch 2011: 22). In addition to fulfilling the required functions, quality includes the requirements with regard to functional properties, safety, production and usage costs, as well as recycling and disposal (cf. Pahl et al. 2007: 661).

The concept of quality leaves a large scope for interpretation open. In manufacturing companies, the term is associated with a wide variety of objects. The focus is on a company's products and processes. In this context, we speak of product and process quality. For outsiders, a company is only perceived based on its processes and products, but the quality as a whole is also assessed. Here we speak of an organizational quality, which means the quality towards business partners, employees and owners. Quality assurance must begin as early as the design stage, otherwise it will be difficult to create a marketable product quality. Already in the earliest phase of product development it is important to address the quality issue. Quality must be produced, it cannot be tested. Ensuring quality should be part of the company culture and represents an important joint task for the entire company. The same applies to quality improvement. Quality management is often introduced in companies, especially in the automotive industry (cf. Schönsleben 2011: 902).

4.2 Quality management system

Quality management deals with the subject of quality and the target-oriented handling of quality. Comprehensive quality management is important in the automotive industry. The company management is responsible for maintaining and achieving the quality level required by the automobile manufacturer. The tasks of quality management ultimately include the qualitative fulfilment of customer requirements and the avoidance of possible faults (cf. Czaja 2009: 297). Quality Management Systems (QMS) serve the systematic implementation of quality management. In the automotive industry, important quality criteria must be properly documented and followed up. The QMS has a supporting function and helps quality management to implement relevant requirements. Quality relevant processes and procedures must be documented by means of a certifiable QMS. In order to be able to enter into a supply relationship, many OEMs require a certified QMS from the supplier. In the automotive industry, the following specifications and standards are important when introducing a QMS.

4.2.1 Important standards in the automotive environment

The requirements in the automotive industry are enormous. Demands are made on productivity, competitiveness, continuous improvement of the quality system and product quality. Suppliers must comply with strict technical specifications on quality standards, which is laid down under the designation IATF 16949:2016. Many OEMs require certification according to these quality standards to be able to enter into a business condition. Nowadays, a supplier hardly has the possibility to supply an automobile manufacturer with serial parts as long as the supplier has not established a quality management system according to the standard. Neutral certification bodies (e.g. TÜV, DEKRA) offer the possibility to have the company certified according to IATF 16949:2016. During the process it is checked whether the documents created in the company (including work instructions, quality management manual) meet the required requirements. If you do not let there is a so-called auditing. An auditor from the certification company will attend and check whether the employees know the prescribed procedures and procedures and whether they are being practiced. Independently of IATF 16949:2016, there are several independent regulations or standards by associations such as the German Association of the Automotive Industry (VDA), which also defines requirements for the structure of a QMS.

The multitude of different associations with different requirements means that a globally active automotive supplier must have a multitude of certificates. To prevent this, a globally valid standard was created with IATF 16949. It combines the content of many international quality standards, such as QS 9000 (USA), EAQF (France), AVSQ (Italy) and VDA (Germany). The standard is recognized worldwide (cf. DEKRA, Zertifizierung nach ISO/TS 16949, http://www.dekra.de/de/iso-ts-16949, accessed on 02.07.2018).

4.2.2 Technical specification IATF 16949

IATF 16949 is a generally applicable specification that was developed for the automotive environment and defines the requirements for a quality management system. In principle, the introduction of a QMS is a strategic decision, but since this standard is required by almost all automotive manufacturers, there is hardly any scope for automotive suppliers to make decisions. To be competitive in the market, an introduction is virtually unavoidable. The standard was developed by the International Automotive Task Force (IATF) in cooperation with Quality management and quality assurance. The standard has its origin in the principles of quality management defined in ISO 9000 and ISO 9004. The ISO (International Organization for Standardization) is a worldwide association of national standards institutes. The IATF 16949 is supporting for all manufacturing companies in the automotive industry. The goal is to develop a controllable QMS, since constant improvements are aimed at. The main focus here is on reducing dispersion, avoiding errors and waste in the supply chain. The standard stipulates the requirements to be met by the automotive environment within the framework of quality assurance. How exactly these requirements or the fulfilment of the requirements are managed are, however, incumbent on the company itself. No fixed procedure is specified here. In the course of an audit, however, the procedure for achieving the requirements must be submitted. However, what the standard requires is a process-oriented approach to the implementation, development and continuous improvement of the effectiveness of a quality management system. The focus is always on meeting customer requirements. The following figure shows a graphical representation of the QMS (cf. Technische Spezifikation IATF 16949 2016: 1).

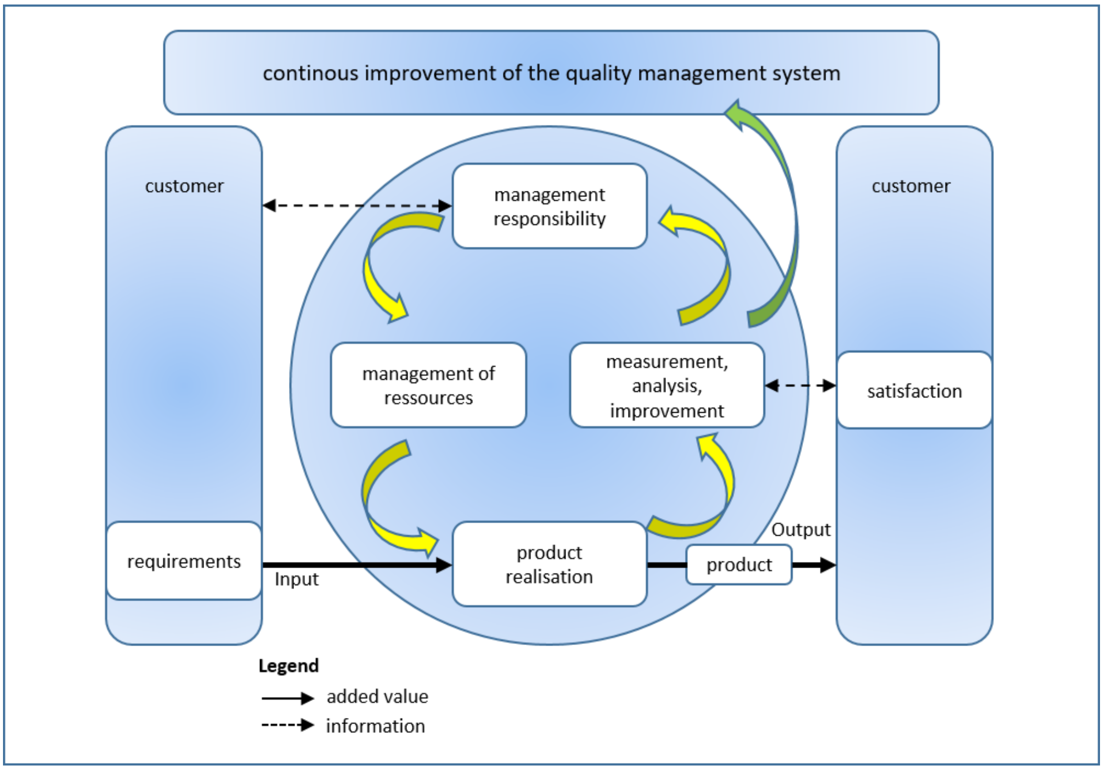


Figure 13: Model of a process-oriented quality management system
Source: Amended from Technische Spezifikation ISO/TS 16949 2002: S. XVI

The successful certification according to IATF 16949 is intended to strengthen high-quality cooperation and the OEM's trust in their own company.

4.2.3 German Association of the Automotive Industry

The "Verband der Automobilindustrie", VDA for short, is an association of German automobile manufacturers and automotive suppliers. The aim of the association is to safeguard their interests at national and international level. Its members include automobile manufacturers, suppliers and manufacturers of bodies, trailers and buses. The association specifies its own certification standard, VDA 6.3, which can also be used to set up a QMS.

4.3 Preventive quality assurance

Foresighted quality assurance is very important for automotive suppliers and is supported by the standards described above as part of the quality management system. The acceptance of the customer decides on success or failure. Accordingly, a product must meet the required requirements in terms of quality, price and deadline. Preventive measures are necessary to guarantee quality assurance. The product requirements are defined at an early stage of the product development process in cooperation with the customer. Solutions are then developed according to the requirements. If there is a deviation from the required services and agreements in the early phase, an error occurs in the implementation. Mistakes are usually only discovered at a much later stage. In the worst case, the defect will only be discovered after the market launch, which could result in a customer complaint and possibly a recall action.

It should be noted that the later an error is discovered, the more expensive it becomes for the company to correct this error. Troubleshooting through production interruptions can quickly become very expensive for the supplier and, in the worst case, ruin it. The time span between the discovery of the error and its correction can amount to several months up to years. If an error occurs after the alleged maturity for series production, this means, apart from the probably high financial losses, a loss of image vis-à-vis the customer. Early fault detection is therefore particularly important. As a rule of thumb, the cost of troubleshooting increases exponentially with the time of discovery. Various methods aim at error detection and error avoidance in the course of quality assurance. One of these is APQP (Advanced Product Quality Planning), especially in the automotive industry. (cf. Westkämper 2006: 131)

The next figure shows that most defects are made at an early stage of the product life cycle. However, the correction of the errors usually takes place at a much later point in time.

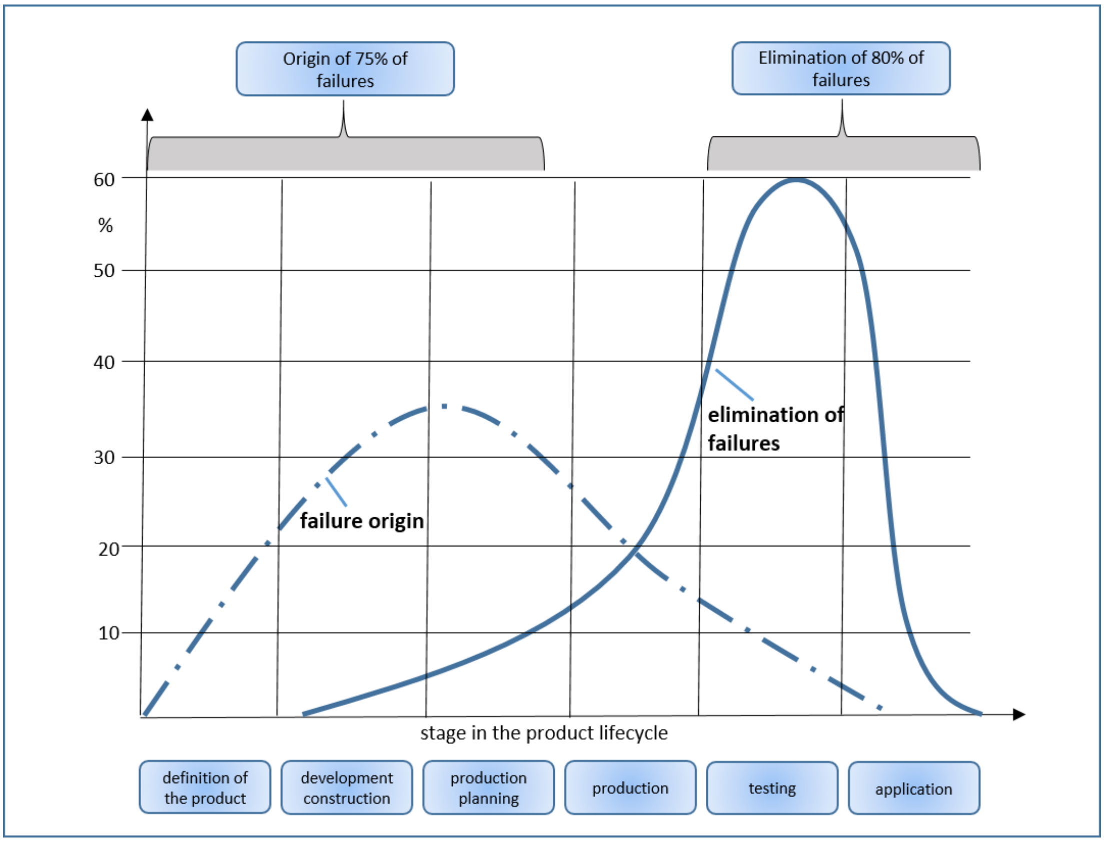


Figure 14: Detection and elimination of failures within the product lifecycle
Source: Amended from Westkämper 2006: 131

4.3.1 Advanced Product Quality Planning

Advanced Product Quality Planning is a project management tool that helps with product and quality planning. The detection and avoidance of all types of faults are of paramount importance here. The APQP process covers all phases of product development. APQP controls, monitors and documents every single phase of the PDP. The necessary steps are defined and initiated to ensure that the desired customer requirements are met. With the APQP, information is distributed among all project team members, the development projects are structured and all defined project steps are tracked using checklists. The APQP should result in complete transparency of project resources and project status. The idea behind this is that the expected quality is not only checked at the end, but is implemented right from the beginning. Thus it is a matter here of the implementation of foresighted quality planning (cf. TQI Innovation Center 2011: 17).

Entering into supply relationships between automobile manufacturers and suppliers always carries certain risks for the automobile manufacturer. It is important that all approved suppliers are able to meet their signed delivery agreements. Most OEMs produce just-in-time (JIT) or just-in-sequence (JIS). If the supplier now has difficulties, such as time delays, the worst-case scenario could be a production stoppage. To minimize risks in the supply chain, OEMs require compliance with APQP guidelines. Originally, three American car manufacturers (Chrysler, Ford and General Motors) developed Advanced Product Quality Planning. For this purpose, a separate standard, the QS-9000, was established at that time. There are different quality techniques to ensure the quality. These are the following (cf. TQI Innovation Center 2011: 17):

- Fault Tree Analysis (FTA)
- Design of Experiments (DoE)
- Cause-and Effect Diagram (Ishikawa)
- Failure Mode and Effects Analysis (FMEA)
- Quality Function Deployment (QFD)
- Poka Yoke
- Statistical Process Control
- Production Part Approval Process (PPAP)

4.3.2 Production Part Approval Process

The Production Part Approval Process (PPAP) describes a release procedure for production parts. The PPAP consists of 18 different standard documents. The customer requires the documents from the supplier to ensure that the supplier has implemented all the customer's requirements in compliant and reliable processes and products. These test procedures are necessary to obtain a corresponding release from the OEM at product level. The trigger for a PPAP is the obligation to prove new or modified products to the customer. Sampling means checking the scope of delivery for the criteria requested by the customer. All parts that are subjected to sampling must be removed from series production. Within the sampling procedure there is in most cases a coordination meeting between OEM and supplier, in which the scope of the sampling is determined. Other names for PPAP include initial sampling, sampling procedures or initial sample test reports. The lowest presentation level is the cover page, where you can see a summary of the most important information. (cf. TQI Innovation Center 2011: 108)

5. A standardized development process for automotive suppliers

The product development process is complex and forms the core business for many automotive suppliers. Cross-company and cross-departmental cooperation in series development projects is indispensable and must be well planned and coordinated. The factors time, quality and costs play a central role here. One of the tasks of a standardized PDP is to make these factors, which are in competition with each other, more controllable. The primary goal of this concept is also the early detection and avoidance of potential risks in the development of series products, as well as a harmonized project process starting with customer enquiries through to series production. The project status is thus easily visible at any time and allows early reaction to any deviations. The PDP delivers a fully developed and freely tested series product in accordance with the agreed requirements, which can be manufactured in the production plant without problems in accordance with a reliable manufacturing process.

The product development process is generally only very roughly represented. However, the individual phases can be very complex. Due to the rapid market growth and the associated growth of the company itself, many companies are faced with the task of establishing standardized product development. The aim of this standardized work is to create a generalized process for automotive suppliers in which the most important controlled documents and points to be observed are presented. These include work instructions, process descriptions and the most important work tasks of the individual phases of the product development process.

5.1 General description of the standardized PDP

In the literature, the product development process for series products is usually only described in very rough terms, without a more detailed breakdown of the necessary work steps and necessary documents. The division into the most important process steps provides information about the necessary development steps, but is too imprecise according to the actual complexity behind it. Car manufacturers who decide to integrate a PDP into their company only get a very inaccurate picture of the necessary workload. The following figure shows a highly simplified process picture, which is often depicted in the literature.

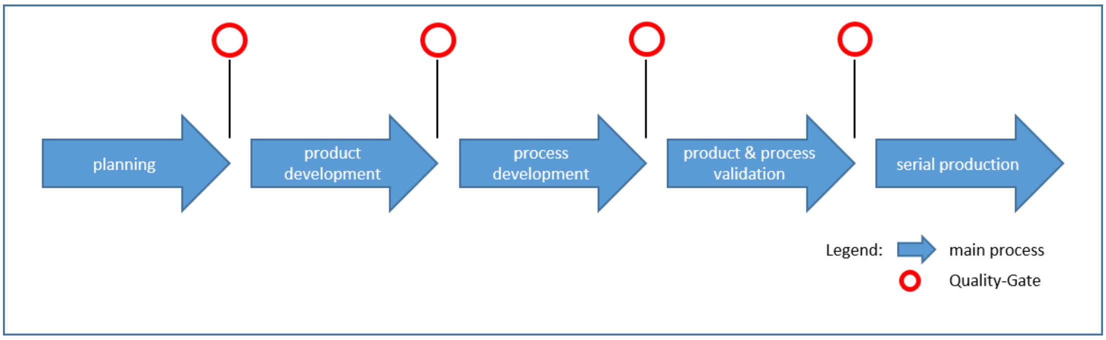


Figure 15: A simple model of the PDP
Source: Own illustration

The main processes are divided into sub-processes in which the individual tasks are processed. The PDP presented here is much more complex and serves as a template for implementation in a process-oriented organization of an automotive supplier. The quality gate system is integrated into the milestone plan. The number of main processes doubles from the five phases shown above to ten phases. In developing the product development process, care was taken to ensure that it is subject to the requirements of VDA 6.3 or an APQP.

The following figure shows the main processes of the developed product development process with the necessary milestones for quality assurance.

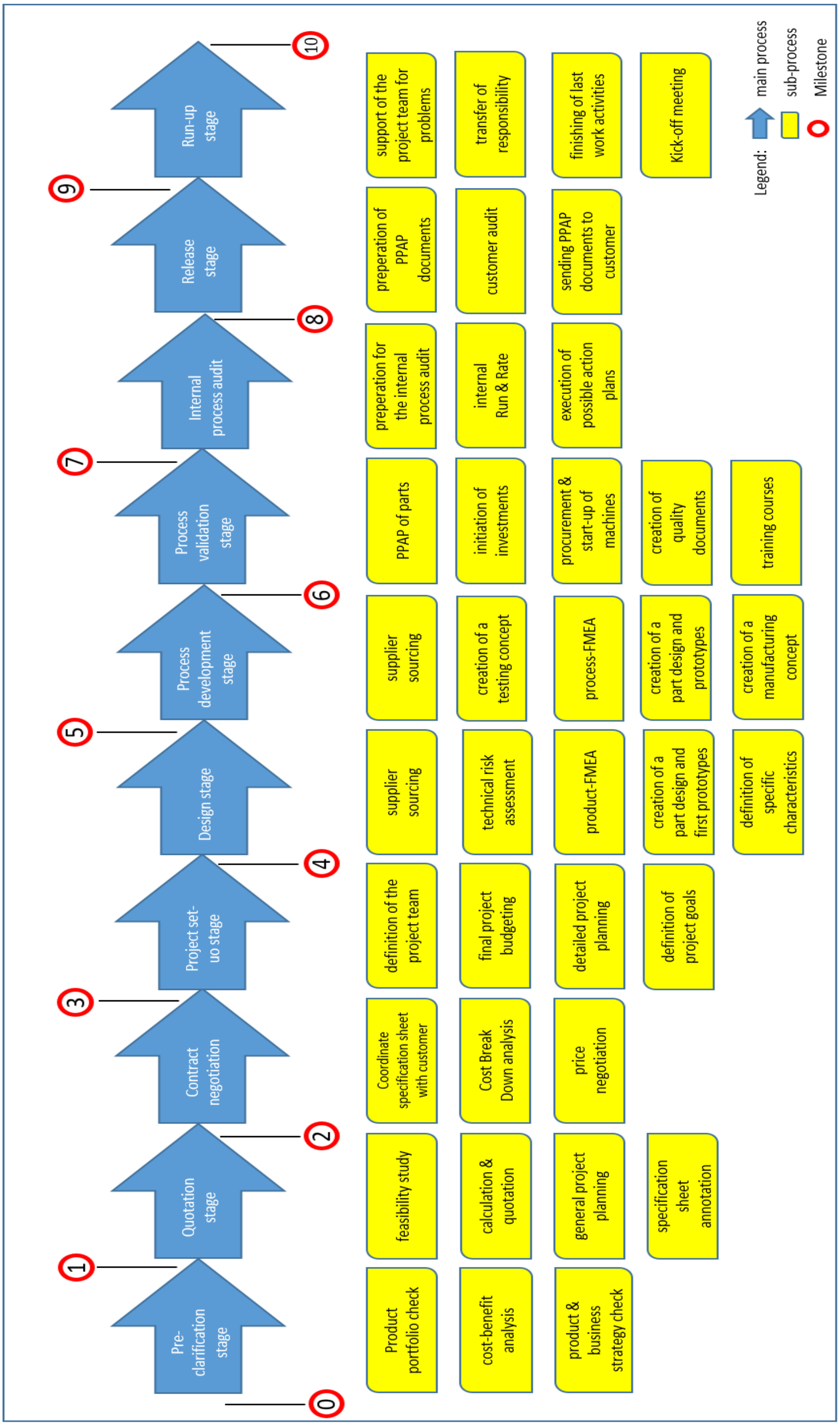


Figure 16: A more complex model of the PDP
Source: Own illustration

Since the milestones take over the function of the quality gate, the project status with the fulfillment of the respective work packages is queried during each milestone. There are separate milestone reports in which the degree of completion of the task, possible notes and follow-up actions are recorded. The next step only follows once the tasks resulting from the work packages, which are recorded in the milestone plan, have been completed. As a result of quality assurance, the product development process must have key process figures to which the success of the project is adhered. This is a requirement of IATF 16949, which can be met via the milestone plans. The effectiveness and efficiency of the process is measured.

Efficacy

The effectiveness of the process is measured by the degree to which the milestone has been met. The effectiveness indicator is the average of the fulfillment levels of all completed milestones.

Efficiency

The number of milestone reviews that can be released on the first submission measures the efficiency of the process. The number of immediately released milestones is compared to the total number of MST reviews held. The key figure is calculated using data from the last twelve months.

Here is a short description of the milestones selected for the PDP:

- MST0 - Customer request: a passive milestone that is not held because it is driven in externally due to a customer request.
- MST1 - Release of quotation creation: Management's decision whether to go into quotation creation
- MST2 - Offer release: Offer is released by the management (offer discussion)
- MST3 - internal release: Project order is placed and detailed project planning begins

- MST4 - Project release: operative project Kick Off - Project team starts with the realization of the product
- MST5 - Design Freeze: The product concept has such a maturity level that a concrete planning phase can be entered, change management starts. Design Freeze does not mean that the product is fully developed
- MST6 - Procurement release: Budget for production resources is released and procurements can be started
- MST7 - Release for internal audit: The project team finds the production process ready for a process audit
- MST8 - Approval for customer audit: The internal process audit has been passed and the measures have been completed to such an extent that the production processes can be presented to the customer.
- MST9 - SOP: Start of series production
- MST10 - End of project: Project completion (usually three months after SOP, depending on product ramp-up)

An example of tasks and responsibilities within the milestone plan can be seen in Appendix A.

5.1.1 Documents and templates

Project idea evaluation

At the beginning of each project there is always an evaluation of the customer inquiry or the project idea. The following figure shows an example of the document intended for this purpose. The respective head of department initiates and fills in the form.

Project idea evaluation

Date:			Project number:

Name of the project /Description:	
Reason for the project:	Commercially: Technical: Quality:
Start of Production:	

Objectives:	
Non-objectives:	

Comments:

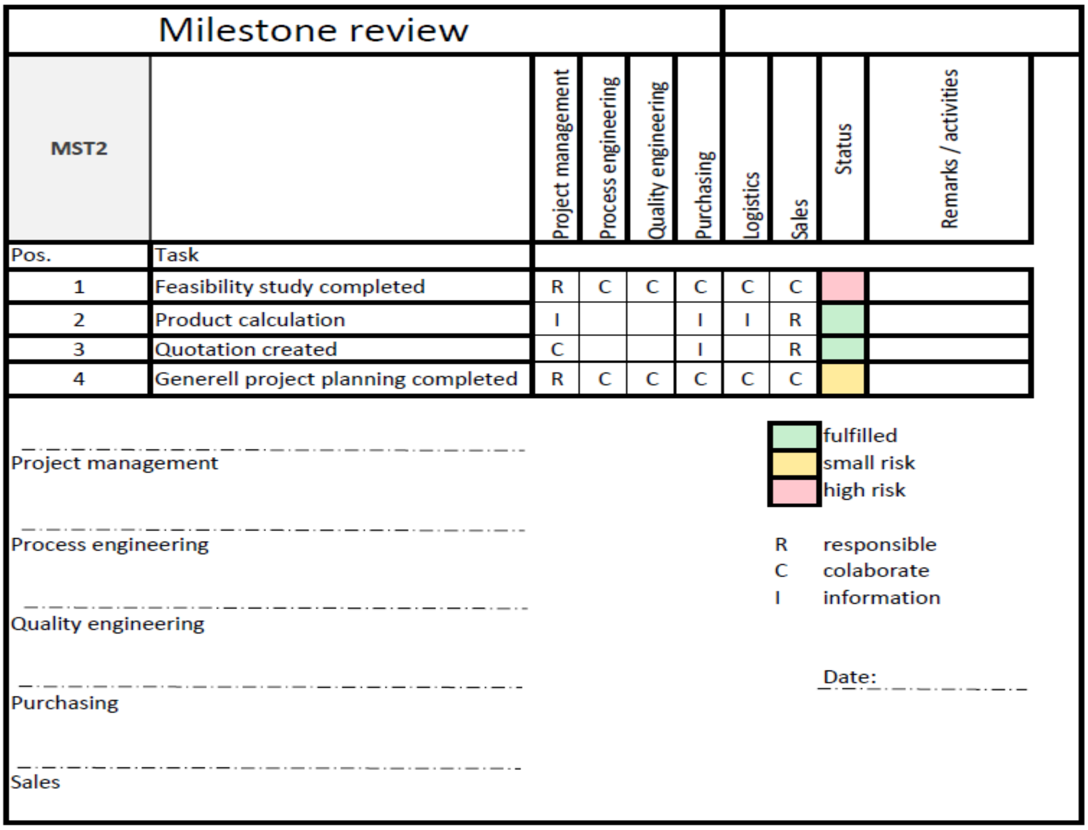
Project will be realised: YES ◯ NO ◯

Signatures: --

Figure 17: Concept of a Project idea evaluation
Source: Own illustration

Milestone plan with integrated quality gates

The milestone plan is one of the central elements for monitoring project progress. After each main phase of the PDP, the current project status is asked in the course of a review. It is recorded which work tasks have been completed and the next steps are defined. The milestone plan is indispensable for quality assurance. The requested services are listed in detail in the project manual in the individual work package descriptions and clearly assigned to the respective core team members. However, the queries are then formulated more generally and concentrate for the most part on the overall product or large topic blocks. For example, it is not the design status of individual parts that is queried, but only the creation of the entire 3D design. The degree of fulfillment can be represented by a traffic light system, where green stands for completed, yellow for partially completed and red for open. As long as at least one point is marked red, the respective milestone cannot be released.



Milestone review

MST2		Project management	Process engineering	Quality engineering	Purchasing	Logistics	Sales	Status	Remarks / activities
Pos.	Task								
1	Feasibility study completed	R	C	C	C	C	C		
2	Product calculation	I			I	I	R		
3	Quotation created	C			I		R		
4	Generell project planning completed	R	C	C	C	C	C		

Project management

Process engineering

Quality engineering

Purchasing

Sales

fulfilled
small risk
high risk

R responsible
C colaborate
I information

Date:

Figure 18: Concept of a Milestone review sheet
Source: Own illustration

Design Verification Plan and Report DVP&R

The DVP&R is a project management tool and serves to coordinate all necessary tests and trials. This not only defines the tests according to customer requirements such as salt spray, vibration and climate tests, but also tests that are carried out parallel to the design. Within the DVP&R it is also recorded whether the tests and examinations were successful and in which stage of development they were made.

Figure 19 shows a rough concept of what such a plan can look like.

Design Verification Plan & Report

Project name:
Project number:
Date:

	Task			State of Development	Test Execution	Results	
Location:	Test No.	Description:	Specification			Pass/Fail	Remarks

Figure 19: Concept of a DVP&R
Source: Own illustration

Project's organizational chart

The project organization chart shows the exact composition of the project team. Within the organization chart, there is a core team that is controlled directly by the project manager and subordinate sub teams that are controlled by the corresponding core team members. It should be noted that the core team members are responsible for certain work packages. The results of the work packages are then presented during a regular meeting with the project manager or at milestone reviews. The sub team members are responsible for the individual subareas and report to the responsible core team member. The responsibility for the proper execution of the individual work packages therefore does not lie solely with the project manager. This leads to a distribution of responsibility, a discharge of the project manager and subsequently to faster project progress. The following figure shows an example of a project team.

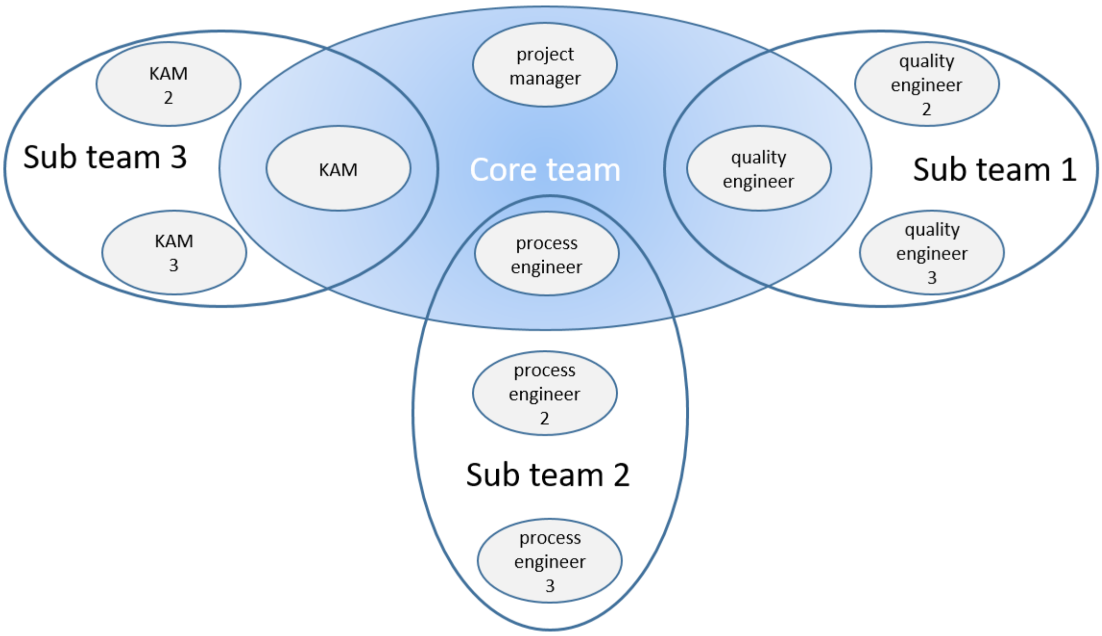


Figure 20: Possible Project's organizational chart
Source: Own illustration

Failure Mode and Effects Analysis (FMEA)

Failure Mode Impact Analysis for the design and process is one of the most important quality management methods of modern product development. This is a method for analyzing possible errors. The aim is to identify, limit and eliminate possible weak points and thus minimize risks. There are two different types of FMEAs in the automotive industry. On the one hand there is the product FMEA, which concerns the product itself, and on the other hand the process FMEA, which serves the analysis of the manufacturing process. For a close examination, all possible errors, their consequences and the responsible causes must be systematically examined. There is a special evaluation scale for the evaluation of errors. It contains three different values, which are listed as follows.

Probability of occurrence - it indicates the probability of the error occurring. The rating ranges from 1-10, where a 1 indicates that the error is almost impossible and 10 indicates that the error is certain to occur.

Meaning - this key figure indicates the extent to which this affects the process or product. A 1 means that there is no effect, whereas a 10 means a violation of regulations.

Probability of detection - it indicates the probability with which the occurring error will be detected. A 1 means that the error is inevitably detected, whereby a 10 means that the error can only be detected over time.

To make a complete risk assessment, there is the Risk Priority Number (RPN). It results from the multiplication between the probability of occurrence, significance and probability of discovery. This can result in a risk priority number between 1 and 1000. The higher the RPN number, the more unacceptable the error. In order to eliminate the potential risks and errors, appropriate remedial measures must be defined.

Potential
Failure Mode and Effects Analysis
(Design FMEA)

___System
___Subsystems
___Component
Model Year / Vehicle(s):
Core Team:

Design Responsibility:
Key Date:

FMEA Number:
Prepared by:
FMEA Date (Orig.):
(Rev.):

Item / Function	Requirements	Potential Failure Mode	Potential Effects of Failure	SEV	CLASS	Potential Causes / Mechanisms of Failure	Current Design Controls Prevention	OCC	Current Design Controls Detection	DET	RPN	Recommended Actions	Responsibility & Target Completion Date	Action Results				
														Actions Taken	SEV	OCC	DET	RPN

Figure 21: Model for a FMEA
Source: https://quality-one.com/fmea - accessed on: 04.08.2018

5.2 Understanding of roles in the PDP

To ensure efficient working it is important that the different departments are aware of their tasks. Therefore, this has been defined more precisely to avoid any ambiguity of responsibilities.

Project Manager

- Central project management for the development of new series products
- Organizational initialization of the project
- Ongoing monitoring and tracking of resources and capacities in compliance with schedule and budget
- Regular reporting to the line
- authority to give instructions to other members of the project team
- Central contact person for the customer regarding the project

Calculation and Planning

- Responsibility for project and product costing
- Continuous updating of the calculation using various KPIs and reporting to the project management team
- Final costing of project and product costing and evaluation
- Staff member for all financial matters of the PDP as cross-sectional function and contact person

Key Account Manager

- Initial contact person for the customer
- Lead in negotiations, as well as responsibility for contractual safeguarding

- Support of the PM in supporting the customer in the development project with escalations, change requests or when a double team of KAM and another team member promises added value in customer discussions.
- Specialist in legal and commercial issues relating to customer relations

Product engineering

- Responsibility of technical product development
- Central contact and responsibility for all technical questions and activities along the product development process
- Interface function and control of the Engineering Services team
- Initialization and support of internal technical reviews and consultations (FMEAs)

Engineering Services

- Support of product engineering for the realization of product development and testing of technical feasibility in trials
- Internal specialist for design up to prototype/pre-series development and test execution

Purchasing

- Responsibility in supplier selection, negotiations and procurement
- Specialist in procurement of prototype parts through to the necessary equipment and tools
- Preparation of a make or buy analysis taking into account the project parameters and strategic orientation of supplier management

Quality planning

- Contact person and direct contact person of the respective quality manager at the customer's premises
- Responsibility for all tasks All about quality in the context of the series product development process
- Definition of internal quality requirements based on the technical specifications for the product and coordination of these with the customer
- Development of testing concepts to meet the defined quality requirements for product and process testing
- Coordination and participation through the moderation and design of design and process FMEAs
- Preparation of quality relevant documentation
- Internal coordination of individual part releases from suppliers and the plant
- Central coordination of process audits and customer approvals

Supply Chain Design & Development

- Responsibility for the logistics concept
- Conception of material flow (inbound, outbound, packaging, etc.) including associated specifications and specifications and coordination with relevant suppliers and customers
- Integration of the information flows in the information systems
- Continuous further development of existing concepts, taking into account the experience gained in operations and our own function

Operations Design & Development

- Development of the manufacturing concept for new products as part of the series product development process or expansion of existing plants

- Preparation of plant specifications, acceptance of the plant at the supplier and implementation in production
- Preparation of the implementation with regard to the SOP
- Process validation and internal coordination as part of cross-process functions
- Support of production until completion of the PDP
- Continuous further development of existing concepts, taking into account the experience gained in operations and our own function

Launch Manager

- Interface to PM and coordination of activities in the plant
- Realization of the projects assigned to him in the (existing) plant structure
- Provision of capacities with regard to facilities, space, infrastructure, etc.
- Conception of the necessary work processes and subsequent specification
- Establishment of a stable production process
- Coordination of the ramp-up planning in the plant and execution of the necessary audits
- Handover of the project to the series organization

5.3 Process description of the main processes within the product development process

This section describes the individual processes of the PDP in more detail. As shown in Figure 16, the product development process is divided into ten main processes, which in turn have sub-processes.

Pre-clearification stage

This phase can be triggered by a new product development or a customer inquiry (RFQ). Both trigger the first milestone with which the preliminary clarification phase starts. This phase is used to check the customer inquiry received and, if necessary, to prepare a quotation.

The exact tasks during this phase are divided into several sub phases. The received inquiry documents should be properly prepared and checked for correctness. It must be assessed whether the customer inquiry corresponds to the product and corporate strategy. Very often, it happens that due to a non-transparent product portfolio, even a similar product are newly developed due to a customer inquiry although a complete product concept already exists. Therefore, it is important to clarify in advance whether there is a suitable technical concept. Of course, it must also be considered whether there is sufficient potential in terms of sales and return on investment, for this a cost-benefit analysis is carried out.

Once these tasks have been completed and the customer inquiry has been declared profitable, MST1 will follow and an offer will be submitted. The next figure shows the main process with the associated sub processes. These are deliberately not marked as arrows as they can be processed at least partially in parallel.

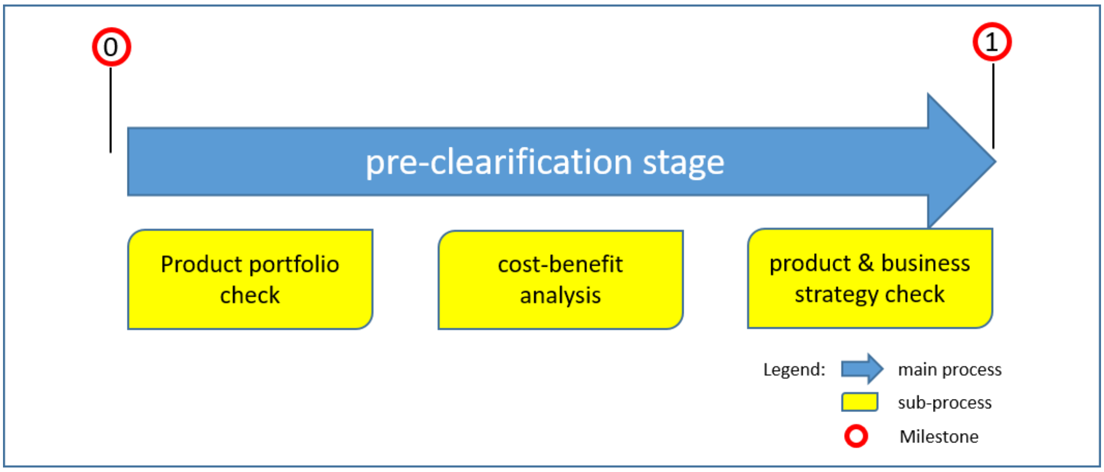


Figure 22: Stage 1 of the new PDP
Source: Own illustration

Quotation stage

This phase is triggered by the completion of the previous phase and starts with MST1.

This involves the preparation of a binding series offer based on the RFQs received and checked. In order, for an adequate offer to the customer is possible different points must be considered. The focus is on feasibility assessments, contract commentaries and the actual creation of product and production concepts. A solid data basis for a product calculation must be created in order to derive a formal offer with minimal risk.

The desired customer requirements, which are listed in the customer inquiry, must be checked and evaluated from a technical and commercial point of view. In order to achieve efficient advance quality planning, a feasibility assessment is carried out. The economic and process-capable manufacturability is analyzed. Within this evaluation, main risks are identified and documented accordingly. In the course of a customer enquiry, a specification sheet will in most cases also be sent. The specification sheet is a compilation of all requirements that a technical product must or should fulfil. The automotive supplier does not necessarily have to accept all points and can comment out certain requirements.

This commented out requirement specification will be discussed with the customer in the course of the offer, so that a proper requirement specification is created for both parties.

In connection with the qualitative requirements, the project must be roughly planned in this phase. This includes the planning of personnel resources, as well as the planning of machine resources. If it turns out during the rough planning that too few personnel are necessary for the production or a new purchase of a machine, this must be considered in the course of the product calculation. Now finally the offer preparation for the customer follows.

Milestone 2 follows when the quotation is released in the course of a quotation discussion. The sales department receives the order to go into the contract negotiations. The next figure shows the main process with the associated sub processes that are necessary during the phase.

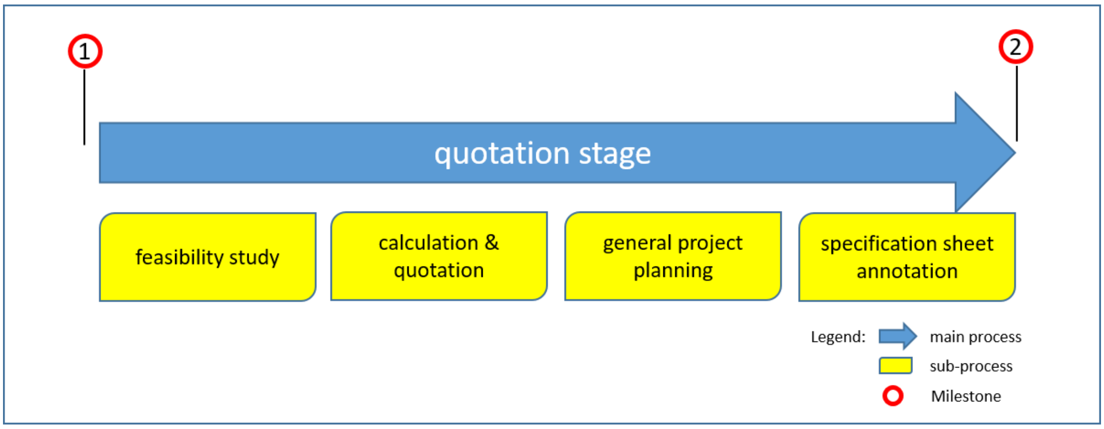


Figure 23: Stage 2 of the new PDP
Source: Own illustration

Contract negotiation

The start of this phase is defined by milestone 2, which is indicated by the quotation. Project management and key account management handle the main tasks during this phase. The aim is to protect the company's own interests and to create the best possible starting point for a project. It is not only a matter of defending prices, but also, and especially, of defining the content of the services very precisely. The more precisely the scope of services is defined, the easier it is to solve problems later on. In addition, a clearly defined range of services provides optimal conditions for professional claim management.

The tasks during this phase are strongly influenced by sales. The specifications commented out in the previous process are negotiated with the customer. As soon as the specifications are completely defined and the resulting requirements are clearly defined, the price negotiations follow. Most customers want an exact list of the price. Therefore, cost break down analyses must be carried out to check the price plausibility.

Once the contract negotiations are completed, the phase ends with MST3, the aim of which should be for the customer to make a nomination and the order probability to be very high.

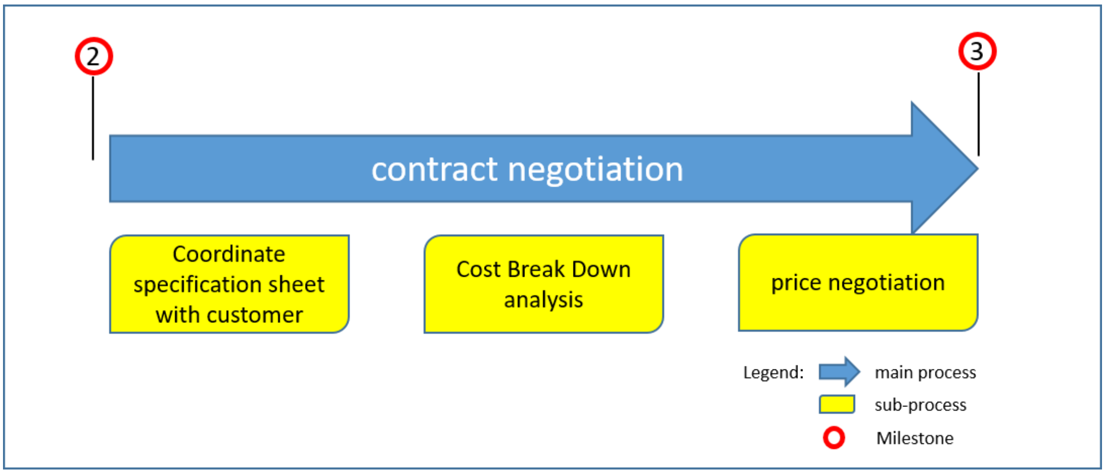


Figure 24: Stage 3 of the new PDP
Source: Own illustration

Project set-up stage

With the milestone "internal release“, the project manager receives the release to start the operative project work. Project management to prepare the project to such an extent that the future project team can be optimally oriented during the kick-off meeting project uses the set-up phase. The focus here is on the clear definition of the project context in terms of time and subject matter.

Now it is a matter of preparing the project in its entirety as precisely as possible. The project manager defines the project team and the resources required for project implementation are secured. Now the final project budgeting also takes place. In project budgeting, the costs of all resources must be recorded. These are not only personnel resources, but also machine costs, test costs and material costs. In order to train the project team in the best possible way during the project kick-off, a detailed project planning is carried out in which exact tests, environmental simulations, personnel costs and possible necessary expenses such as transport approvals are taken into account. In order to create a uniform image within the project team, the specifications are generated in which the project goals are prepared.

Many companies require a certain data classification policy. This means that certain customer data may only be readable by certain persons. Therefore, when forming a project team, it must be taken into account that project-specific data can only be called up according to the role in the project team. For this purpose, a regulation of access rights is usually introduced. If a new project is nominated internally, the project manager creates the project directory with a standard directory structure. The folder access rights are assigned by IT according to the nominated project team. By default, all project team members are granted read and write access during the project period. If the project comes to an end, the distribution of rights changes to the extent that the former project team is given read rights and the series support read and write rights.

The phase ends with a project kick-off. The project management officially familiarizes the project team with the objectives of the project and starts the operational activities.

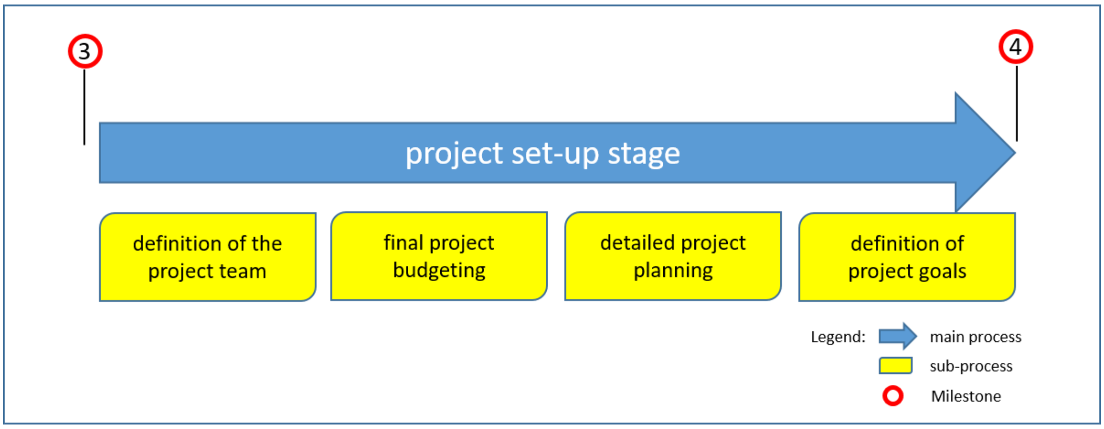


Figure 25: Stage 4 of the new PDP
Source: Own illustration

Design stage

The design phase is all about product development. This phase varies depending on the type of project. For example, a completely new development is different from using an existing concept. The essential contents are the first design creation and its validation, as well as the product coordination with the customer. All critical functions should be confirmed by tests in this phase and thus a largely secure design should be defined on which the further steps of industrialization can be carried out at low risk.

The tasks during this phase are already much more complex and time-consuming than the previous phases. First and foremost, a final product coordination with the customer should be carried out to ensure that the product ultimately meets the customer's expectations. For this a component layout and design creation are needed. Many OEMs specify the available dimensions of the component due to its possible installation space in the vehicle. Once the component layout and design creation have been completed, the design must be completed by means of a technical risk analysis and a product FMEA can be validated. This is part of the APQP process and serves preventive quality assurance. To ensure the chosen design not only within the company, first prototypes are built, which are made available to the customer. In the course of DVP&R, the first validation attempts are made to confirm the function. Most OEMs define special features for the product that must always be within a specified tolerance. These may include design dimensions, but also requirements such as coating tolerances, corrosion resistance. Once the necessary components and materials are known, supplier sourcing can start. Once the design status has been released, process engineering can begin planning the production processes.

The result of the milestone is a mature product design that the process planning activities can be started with calculable risk. An official design and an evaluated development status of the product is a prerequisite.

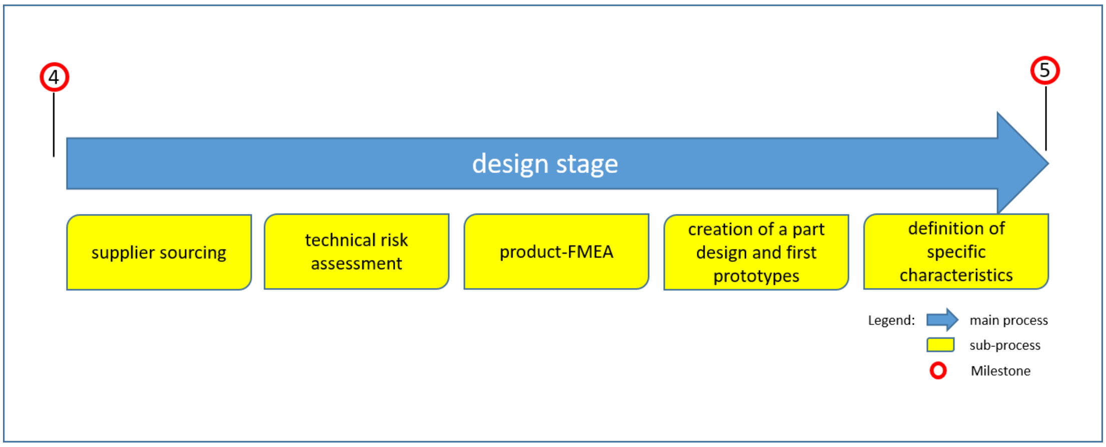


Figure 26: Stage 5 of the new PDP
Source: Own illustration

Process development stage

The process development phase starts with the planning release and a fixed design. In this phase, priority is given to process development, i.e. all necessary processes and the associated resources are detailed to such an extent that supplier sourcing can take place. This can only take place after the design phase, since the critical characteristics to be observed, the design itself and the necessary materials must be defined beforehand. In addition, all individual parts are put out to tender, resulting in a sourcing portfolio that forms the basis for the series nominations. At the end of this phase, all the conditions for placing orders are in place.

The tasks within this phase are similar to the design phase. Now, however, the entire production process is devoted to, as the product is already defined. The process phase includes all activities from the development of the required tools and equipment to the procurement of parts and the achievement of a process ready for series production. A production concept is created that contains the complete material flow. In order to be able to guarantee high-quality parts for the customer, inspection concepts are defined which must be fulfilled during ongoing production. These include, for example, a goods receipt inspection, work instructions for production and spot checks. The developed manufacturing concept with all production-relevant sub-processes is then validated via a process FMEA. This serves to prevent errors. Here too, supplier sourcing must be carried out, not for the product itself, but for the production process. All documents, such as tool specifications, article drawings and 3D data, must be made available to suppliers in order to avoid ambiguities from the outset.

The phase ends with procurement approval for process-specific applications such as machines and camera systems. The goal is to release all investment budgets required for the realization of the product.

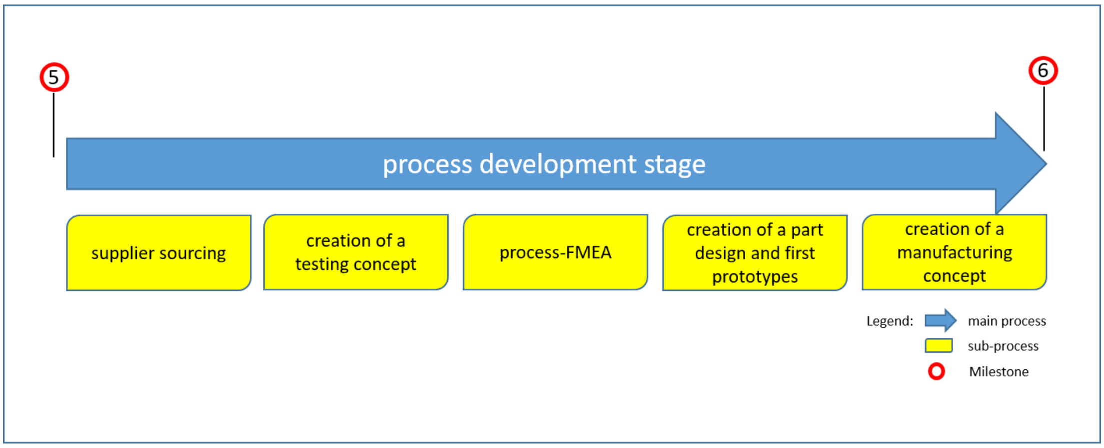


Figure 27: Stage 6 of the new PDP
Source: Own illustration

Process validation stage

The process validation phase starts with successful procurement release. All tasks necessary for the realization of a product are implemented in this phase. All equipment (system and tools) is triggered, installed and put into operation. Progress is monitored by process management, which reports to the project management and initiates the sampling after completion of the tools. The project team evaluates the first tool falling parts. The entire production process is documented and recorded in writing. All system configurations are implemented. At the end of this phase, the entire series process must be installed in the manufacturing plant and functional enough for the plant to produce afterwards. The plant personnel are trained in the production process and are able to implement it in conformity with the process.

This implementation of the work tasks contained in this phase can take a very long time. Should it be necessary, all nominations for purchased parts and investments for operating resources are triggered. The supplied parts must in turn be sampled by the supplier. Most companies have their own quality department for this purpose. The necessary equipment and tools are created and put into operation during this phase. When scheduling, it is important to ensure that many resources such as tools require optimization loops. The number of optimization loops depends greatly on the complexity of the components and the execution quality of the tools. For realistic planning, three such loops are planned in order to meet the defined requirements for the component. However, this includes not only the optimizations, but also any article changes and the associated changes to the tool due to various results. Parallel to this, the first sample production is planned, whereby it must be ensured that the supply of parts is guaranteed. Many materials have several weeks to even months delivery time, therefore it is important to plan this early enough. Once the system has been commissioned, the necessary tools have been sampled and approved, production of the first serial parts can begin. Many tests such as environmental simulations should only be carried out with serial parts. In some cases, this is also required by the respective customers. Another important point is the creation and management of corresponding serial documents. Once the factory processes have been implemented and all supplier and in-house production parts have been sampled, training courses for the production team and series organization can begin. The result of the MST7 is the release for an internal audit. The serial production process in the production plant must be fully installed. Approval is given for carrying out an internal process audit at the plant.

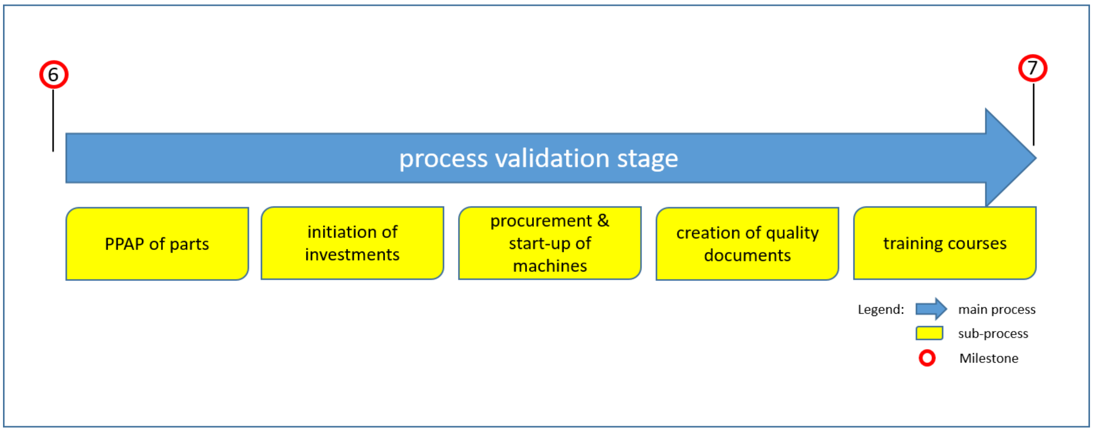


Figure 28: Stage 7 of the new PDP
Source: Own illustration

Internal process audit

This phase starts with the release for internal audit, during which the installed production process is tested for functionality and conformity. The phase also includes the complete processing of detected defects.

As the phase already says, an internal process audit is prepared and carried out. For this purpose, all participants must be trained in the product and the production process, the necessary materials must be made available and a possible production period must be defined. An internal process audit can also be called a Run & Rate. This is basically a capacitance measurement that ensures a capable production process. Formally, a Run & Rate is based on the QS9000 quality standard and derived from it the APQP. The focus of an R&R is on quantity. The corresponding quality of the individual parts was ensured by sampling. The result is a documented quantity measurement that indicates whether all required parts can be produced. Within the internal process audit, the delivery and delivery of logistics, break times, set-up times, maintenance and downtimes as well as the produced rejects are considered. Once the internal audit process is complete, any action plans are processed. Once the above-mentioned points have been completed, the next milestone follows the release for the customer audit.

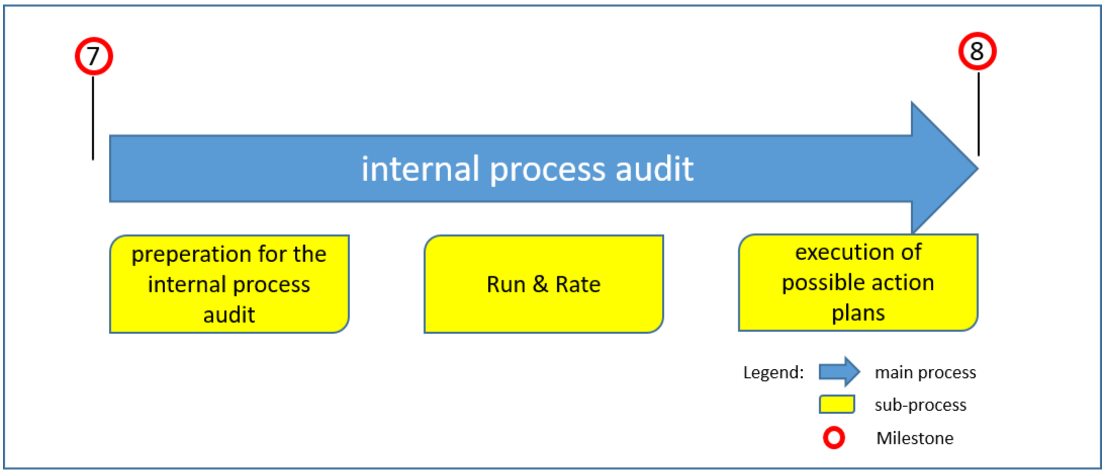


Figure 29: Stage 8 of the new PDP
Source: Own illustration

Release stage

After completion of the internal audit, release to the customer can begin. The primary goal of the phase is the initial sampling of the product and the resulting customer approval. The parts necessary for the sampling are taken from a production to be able to guarantee the production under series conditions. The PPAP documents agreed with the customer are prepared. These can be simple visual inspections, logged measurements, complete process capability verification or various material tests. The scope of sampling is incumbent on the customer. Furthermore, a customer audit is carried out, which runs in the same way as the internal audit of the previous process a. Once all necessary documents have been prepared and the customer audit has been completed, customer approval is obtained. The phase ends with MST 9, the "Start of Production", SOP for short. It marks the start of series production.

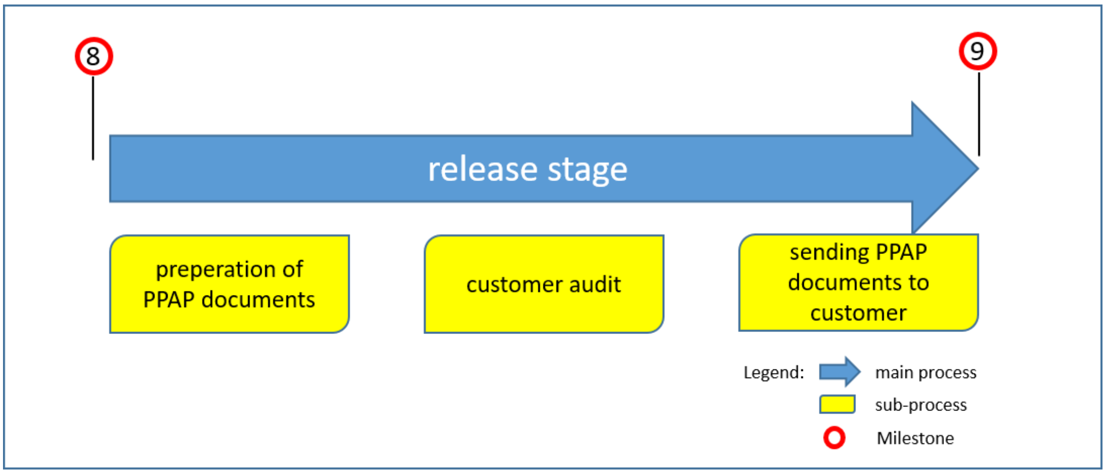


Figure 30: Stage 9 of the new PDP
Source: Own illustration

Run-up stage

This phase is characterized by the fact that all final work is carried out in the project and that risks associated with the production ramp-up are specifically monitored. The focus is also on transferring responsibility from the project organization to the series organization. The resulting support requirements are still covered by the project.

The final work is completed and in the event of technical problems in production, the project team still provides support services. The project is now closed, i.e. the project team dissolves after a kick-off meeting and no more costs can be posted to the corresponding cost center. The access rights assignment to the project folder changes in the course of the data usage guidelines. The project organization receives read rights and the series organization read and write rights. This also ends the final transfer of responsibility.

The phase and consequently the product development process ends with the completion of all project activities and the complete transfer of production responsibility to the series organization. The project team is relieved and the project is considered completed.

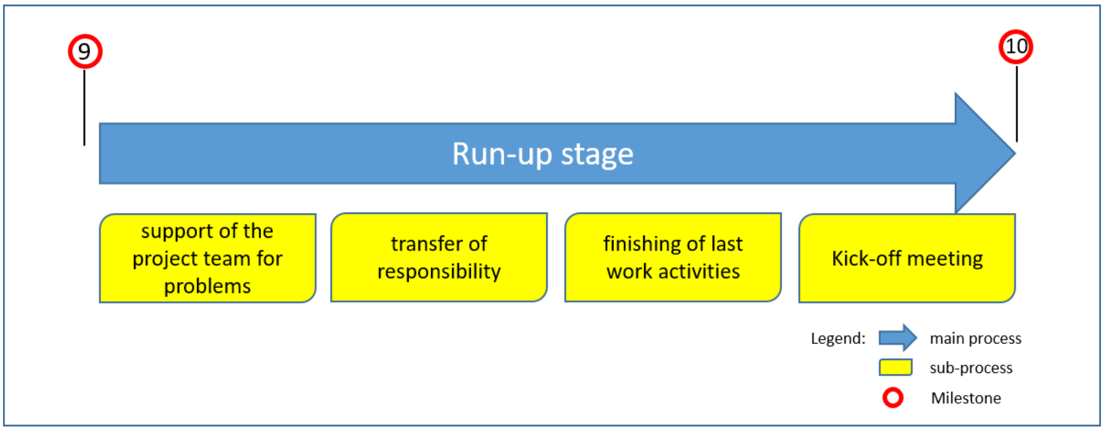


Figure 31: Stage 10 of the new PDP
Source: Own illustration

6. Benchmarking

The concept of a more detailed and standardized product development process described above must be evaluated in terms of content. It is interesting to compare the developed process with existing processes of other companies in the automotive industry. To answer this question, the chapter examines product project management. Since companies only reveal their knowledge to a limited extent, this is only very superficially possible. The companies Daimler Trucks, the automotive supplier ZF TRW Automotive Holding Corporation and Volkswagen AG are considered here to achieve a comparison.

6.1 Daimler Trucks

Daimler AG is the largest manufacturer of commercial vehicles. The variety of variants, competitive challenges and complexity are identified as the main problems when considering product development. The focus at Daimler AG is strongly on launch management. To meet these challenges, Daimler Trucks uses a standardized CV-DS (Commercial Vehicle Development System) reference process for the development of new products. This is a gateway concept that is used to check the maturity level. Daimler's CV-DS describes the standardized development of a commercial vehicle across all functional areas with the help of milestones, the so-called Quality Gates (QG), from the start of the resulting product project to its market launch. It defines a common planning basis for all commercial vehicles worldwide and simultaneously supports control and the necessary reporting (cf. Lehmann & Grzegorski 2009: 81). The product development process is divided into three main phases (product identification and definition, product development, production launch and the associated QG 10 to QG 0 quality gates. The goal is to achieve a production ramp-up after a short time. Various audits are carried out for this purpose. In the first audit, a production test is carried out to ensure process capability. The focus here is on manufacturability under series conditions. Within the second audit, the product quality is assured and the third audit serves to safeguard the process cycle time. Each of the three audits takes place across departments, involving production, development, logistics, quality management and supplier management.

The roles of the PDP are clearly defined by a quality role matrix. The tasks of the individual roles are defined in standard processes. The reporting system is also standardized to ensure transparent presentation. Communication takes place via a web-based CV-DS IT tool. The current maturity level can be called up within the tool (cf. Lehmann & Grzegorski 2009: 81).

6.2 ZF TRW Automotive Holding Corporation

The company is an automotive supplier and one of the ten largest companies in the automotive supplier industry. All divisions follow a standardized product development process. This maturity model defines the structure, responsibilities and sequence from the project idea to the start of series production. The process is called GDPIM (Global Development & Product Introduction Management) and is divided into two sub-processes (development process and application process). TRW also speaks of so-called gates in the designation of milestones. The development process is divided into Gate A to Gate D, the application process into Gate 1 to Gate 8, and the product development process is completed at the end of Gate 8. At each gate, the project progress is checked, like a milestone review, whereby standardized checklists serve as a basis. This serves the early detection of possible errors.

ZF TRW has integrated a multi-stage escalation process into its company. Every month a report is prepared, summarized for the management and discussed at a regular meeting. This ensures that any problems that arise are identified and, if necessary, solved by a higher decision-making level. A project team accompanies the projects. Each member of the project team performs a different function and has a precisely defined area of responsibility. The project manager appoints each member of the project team, prepares a project plan and monitors the progress of the project. Depending on importance and effort, projects are divided into three different categories. According to the project category, the project manager must meet a certain requirement profile, which is defined by minimum requirements. Each member of the project team is responsible for a specific work package (cf. Tom & Uske 2008: 65). ZF TRW Automotive distinguishes three different project categories, which are as follows:

1. Category 1: High importance and effort for the company combined with high entrepreneurial risk with regard to investments, impact on business development as well as development and production processes.

2. Category 2: Average impact on business processes.

3. Category 3: Regional start-up projects for existing products/manufacturing technology as well as product improvements during the current series (cf. Tom & Uske 2008: 77).

The project manager must be qualified according to the project category. The classification of the project has an influence on the involvement of the management involved.

6.3 Volkswagen AG

Volkswagen AG is one of the largest automobile manufacturers in Europe. The product development process must also meet minimum standards, which are reviewed during milestones. In principle, Volkswagen divides the PDP into three different phases. This includes the development phase, a release phase and an implementation phase. Launch management also plays a special role at Volkswagen. In order to detect errors early on, the project status is regularly presented to the management.

A committee is composed of managers from the departments of project purchasing, quality, production, procurement, development and sales. This committee decides on project development during the start-up management. The members of the committee have continuous responsibility for the project. This special form of organization has proven to be successful, as the committee has sufficient powers to make project decisions quickly. The start of series development is marked by the design decision and is usually frightened for more than two years. Volkswagen AG relies heavily on the front-loading concept for product development. The concept says that targeted development activities are carried out in the early phases of PDP. The exchange of information takes place in regular meetings. The necessary transparency during the project is ensured by an IT structure. Milestones are discussed and approved in regular meetings.

6.4 Summary

The product development process is represented in many companies in the automotive environment, although there are differences in design and organization. Daimler Trucks, ZF TRW Automotive and Volkswagen AG have designed their processes similar to the product development process presented in the work. These companies also have a standardized procedure with defined milestones.

All major automobile manufacturers and suppliers have a consistent PDP and see this as a basic prerequisite for a supply relationship. Due to their high complexity, automobile manufacturers rely on a streamlined organization.

7. Possible improvements to be able to process the PDP within the company

The use of a standardized product development process is an important step for a company. It is customary to consistently overgrow the maturity level of the project. Technical literature confirms that this is a common practice. The concept of a PDP must be consistently implemented. For this purpose, generally valid improvement potentials can be established that support the implementation. This chapter discusses possible measures that could lead to a strong improvement in the handling of product projects.

Project role and complexity assessment

In order to carry out projects successfully, a project organization must be defined in advance. A line organization is designed, for example, for the fulfillment of specialist tasks and not for the processing and fulfillment of various projects. This results in the need for a project organization that is specifically designed for the duration of the project. The prerequisites for this are professional competence, adequate decision-making authority, clear project agreements, sufficient resources and a good corporate culture. It is recommended to define fixed project roles that each project must have. Thus, every role in the project is known and a concrete flow of information remains. The roles in the project team are chosen in such a way that all required competencies are represented. To ensure that all parties involved are aware of the PDP and the associated costs, appropriate training must be carried out. With regard to the most important factors of time, quality and costs, there are three project roles that must be present in every project. The project manager is responsible for the project and is generally responsible for maintaining deadlines. A controller monitors the costs incurred in relation to the possible sales potential. In order to be able to cover the third factor, quality, a quality representative should be available in every project. The points of the milestone plan to be fulfilled should therefore also be clearly defined and assigned to the corresponding roles. Each project team member automatically knows who is responsible for which task point. The project manager plays a particularly important role within the project business, must have a comprehensive competence, and is rather regarded as a generalist (cf. Hab & Wagner 2010: 41).

Therefore, it makes sense to categorize projects according to their project complexity and select a suitable project manager accordingly. A classification can be made according to certain complexity criteria. The next figure shows how such a classification matrix can look like.

ABC complexity evaluation		
Criteria	**Factors**	**Evaluation ABC**
Component-related	Innovation	
	Form	
	Innovative nature	
Production-related	Complexity	
	Production plant	
	Warehouse handling	
Project management related	Professional competence	
	Social competence	
	Organisational competence	

A	**High complexity**
B	**Middle complexity**
C	**Low complexity**

Figure 32: Template for an ABC complexity evaluation
Source: Amended from Verband der Automobilindustrie 2009: 12

For each project classification, a requirements profile can be created for the project manager to ensure that the selected project manager meets the criteria for supervising the project. Within the framework of training courses, project managers can be specially trained for projects that are more complex.

Uniform documents in the product development process

The PDP contains a large number of documents that are processed during the process. This includes documents such as packaging concepts, product simulations or feasibility analyses. Standardized documents further promote uniform transparency.

Workshop for continuous improvement

In order to continuously improve the concept of the product development process, the project manager receives suggestions for improvement from the process users. The PM collects the proposals and after an evaluation they are integrated into the standard on an annual basis. To integrate these suggestions for improvement, there is an annual workshop on the subject of continuous improvement. Problems can be specifically discussed and gained experiences can be exchanged. Another goal of the workshop is to develop concrete solutions. The creative potential of process users can be used more specifically here than in everyday business life. The composition of the workshop group is decisive. All participants must either be directly affected by the improving topic or be able to make an expert contribution to the improvement. Therefore, it is important to select people who are involved with the PDP on a daily basis.

Project Management Homepage

The topic of product development is not only relevant for people who work directly with it. The entire group of companies should have a uniform image of the PDP. A project management homepage is a useful tool for centralizing information for the entire company. It can be accessed via the intranet. The homepage should be easy to find, easy to use and interactive. All relevant information, as well as changes in the course of continuous improvement, could be communicated to all employees. However, the possibilities of use are even more extensive. The implementation of the company suggestion system could be presented on the homepage. Employees often complain about specifications that are difficult to implement. Others, on the other hand, who may not be directly confronted with product development, have suggestions for improvement that they want to communicate to the management. Continuous improvement can only be achieved by involving employees in the improvement process. Another point that can be mapped via a project management homepage is access to a knowledge database. A knowledge database is constantly evolving. It can be used, for example, for archiving the individual workshops.

Project reporting and escalation

Project reporting is an important part of the product development process for monitoring ongoing project progress. The current status of the project is reported here for the corresponding milestones. To achieve the milestones, the project manager holds ongoing meetings to monitor progress and reports problems to the management before the actual milestone meeting. The project manager is responsible for meeting the defined deadlines. In the case of costs and quality, the corresponding controllers and quality managers should also have an escalation obligation. In order to involve top management in the course of the project, many companies differentiate the degree of involvement in project reporting. Depending on the type of project, a specific committee is selected to be reported to. It is therefore possible that projects that have a direct influence on the success of the company are presented to the Corporate Group Management. This can be done taking into account the measured turnover, strategic importance or the complexity level mentioned above. This ensures that all projects receive the necessary attention from top management (cf. Neckel 2004: 252).

Project management office

Project management plays a very important role in the PDP and can be decisive for the success of a project. In order to promote this within the organization, a so-called project management office can be set up. This can serve to further improve the success, benefit and efficiency of projects. The requirements placed on a project manager are constantly increasing. A project manager is usually responsible for several projects that are constantly increasing in complexity. This results in a shortage of resources. A project management office can be very helpful by supporting project teams and project managers on an ongoing basis.

The tasks could be very varied, for example by taking over administrative activities. It can also serve as a central point of contact for all questions on project management. On the one hand, integration into the organization can mean an improvement in the company-wide handling of projects, and on the other hand it helps to standardize projects. The administration of the project management homepage and the knowledge database mentioned above can also be taken over by the project management office. Another typical area of responsibility is the ongoing provision of training courses for project managers. The project management office should not interfere in the operational business, but should merely assume a support function.

Quality Management Organization

Process-oriented quality management with a corresponding quality management organization (QMO) can be an essential success factor in the implementation of projects. A QMO has the task that the quality management functions correctly and that the PDP is implemented correctly. Through a clearly defined QMO with fixed responsibilities and role models, a multitude of advantages can be achieved. Basically, every employee is involved in a process-oriented quality management system, but certain roles are required. Here is an example of possible roles:

- Senior management representative
- Quality manager
- Quality representive
- Process owner
- Process team

A corresponding quality management organization can look as shown in figure 33.

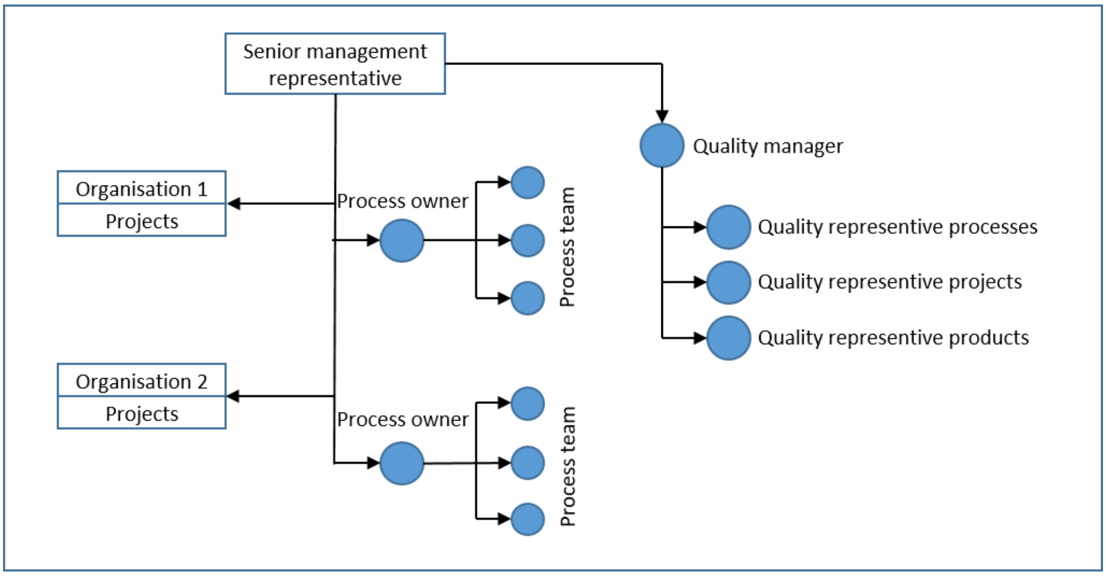


Figure 33: A possible quality management organization
Source: Amended from Wagner & Käfer 2008: 13

First, the persons responsible for the process are determined. They take care of process design, process approval and proper implementation. They are also responsible to the company's management and accountable if necessary. The process manager also measures the goals, conducts training and develops ideas for improvement. He is responsible for ensuring that all employees involved in the process are informed. Each process must be assigned to a person. It is not allowed that a process has no allocation, otherwise its objectives will not be pursued. Depending on the process, a process team can support the process owner. The members of the process team should be involved in the assigned process on a daily basis. Thus, the team member can check the practical suitability and find any errors or improvements in a timely manner. For example, a project manager can perform this function.

A senior management representative appoints the quality manager. The senior management representative has the task of establishing quality management in the entire organization. The quality manager supports him and ensures that all quality management documents are up to date as well as ongoing communication with all employees. The quality representive supports the quality manager in his tasks
(cf. Wagner & Käfer 2008: 13).

8. Conclusion

The main goal of this master thesis was the development of a standardized product development process and the underlying product project management. In this chapter a summary of the work is reviewed. Subsequently, a critical assessment of the overall result is made with regard to the desired objectives.

In today's competitive environment of the commercial vehicle and automotive industries, high flexibility, low costs and high quality are more in demand than ever. In order to be able to guarantee these requirements and thus remain competitive, the product development process plays a decisive role. It distinguishes successful companies from those that are difficult, to keep on the market. The global market is undergoing rapid change, which continues to be characterized by a battle for market share. As a result of competition, companies have continued to expand their product ranges in order to penetrate the last market niche. At the same time, product life cycles have become ever shorter. The product development process is rarely described in literature in all its complexity. Implementing the PDP can be difficult for companies and involves a lot of work.

The dividing of the process development process into ten sub processes makes sense, because it means a less workload per process. The PDP is very complex, which means the dividing makes it easier to track the progress within the milestone reports. There is a wide range of quality requirements in the automotive industry. The concept of a standardized product development process aims at continuous improvement and meets the most important quality standards of the automotive industry, which are the IATF 16949 and VDA 6.3 in Europe. This is ensured through the integration of milestones and mandatory reporting. Important quality criteria must be properly documented and followed up. There is also a recommendation for continuous improvement through workshops. Furthermore, the work provides an overview of applicable documents such as an FMEA, a DVP&R and a milestone plan and report. These documents are needed to fulfill the work tasks within the product development process. This facilitates an integration of a PDP into the company. Improvement measures were defined to ensure an optimal implementation of the product development process. These, easy to implement improvements like a project management homepage or workshops for continuous improvements are helping to integrate a PDP with his full potential. A comparison with other companies has shown that the PDP developed is somewhat more complex in its main phases, yet pursues the same goals.

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Appendix A

Tasks and responsibilities within the Milestone plan

Explanation of the used abbreviations within the milestone plan:

- R-Responsible
- A-Approval
- C-Contribution
- I-Inform

MST1 - Release of quotation creation: Management's decision whether to go into quotation creation

Task	Management	Project Management	Costing and Planning	Key Account Management	Product Engineering	Engineering Services	Purchasing	Quality	SC Design & Development	O Design & Development	Operations
Pre-Nomination of a project manager	R	I		C							
Rough estimation about efforts for creating a quotation		R	C	C	C	C	C	C	C	C	C
Check potential for turnover and profit margin			C	R							
Check strategy				R	C						
Technical requirements roughly checked and technical concept available		I		C	R						

Table 1: Tasks and responsibilities within Milestone 1

MST2 - Offer release: the management releases an Offer

Task	Management	Project Management	Costing and Planning	Key Account Management	Product Engineering	Engineering Services	Purchasing	Quality	SC Design & Development	O Design & Development	Operations
Feasibility study completed		R		C	C		C	C	C	C	C
Specifications and other requirements fully commented		R		C	C		C	C	C	C	C
Initial quality concept defined		I	I	I	I		I	R		C	C
Rough project planning available including human resource planning		R	C	C	C	C	C	C	C	C	C
Product calculation		I	R	I							
Pricing			C	R							
Quotation created	A	C	C	R	I	I	I	I	I	I	I

Table 2: Tasks and responsibilities within Milestone 2

MST3 - internal release: Project order is placed and detailed project planning begins

Task	Management	Project Management	Costing and Planning	Key Account Management	Product Engineering	Engineering Services	Purchasing	Quality	SC Design & Development	O Design & Development	Operations
Adjustment of contract & requirements annotation with customer		R		C	C			C	C		
Nomination available and confirmed	I	C		R							
Project probability defined in projectportfolio	I	R		C							
Project order created	R	C		I							

Table 3: Tasks and responsibilities within Milestone 3

MST4 - Project release: operative project Kick Off - Project team starts with the realization of the product

Task	Management	Project Management	Costing and Planning	Key Account Management	Product Engineering	Engineering Services	Purchasing	Quality	SC Design & Development	O Design & Development	Operations
Presentation of project data file (key parameters for the project)		R		I	I	I	I	I	I	I	I
Official nomination of project team		R		C	C	C	C	C	C	C	C
Presentation overall project timing		R		I	I	I	I	I	I	I	I
Presentation of development plan (DVP&R)		C		I	R	I	I	I	I	I	I
Presentation of main work packages (PSP)		R		I	I	I	I	I	I	I	I
Presentation of project budget	I	R	I	I	I	I	I	I	I	I	I
Presentation of actual status of requirements annotation		R		I	I	I	I	I	I	I	I

Table 4: Tasks and responsibilities within Milestone 4

MST5 - Design Freeze: The product concept has such a maturity level that a concrete planning phase can be entered, change management starts

Task	Management	Project Management	Costing and Planning	Key Account Management	Product Engineering	Engineering Services	Purchasing	Quality	SC Design & Development	O Design & Development	Operations
D-FMEA started and critical characteristics identified					R	C		C		C	
Design to Cost Analysis		I	I			R	C			C	
Make or Buy Analysis			C		C		R		C	C	C
Rough SCM concept							I		R	I	I
P-FMEA started					C	C		C	C	R	
Perform potential analysis at suppliers							C	R			
Release of product development status		I			R						
External release of product development status by customer		R			C			C			
Design Review		C			R		C	C	C	C	

Table 5: Tasks and responsibilities within Milestone 5

MST6 - Procurement release: Budget for production resources is released and procurements can be started

Task	Management	Project Management	Costing and Planning	Key Account Management	Product Engineering	Engineering Services	Purchasing	Quality	SC Design & Development	O Design & Development	Operations
Planning of prototype numbers at plant		C			C				R		I
D-FMEA & P-FMEA updated		I			R	C		C	C	C	C
Quality concept for all sub- and main processes					I			R		C	C
Proposed suppliers released from Quality							C	R			
Supply chain concept planned									R	C	C
Detailed concept for plant processes		I							C	C	R
Product caclulation updated		C	R	I			C				
Binding customer nomination available		I		R							

Table 6: Tasks and responsibilities within Milestone 6

MST7 - Release for internal audit: The project team finds the production process ready for a process audit

Task	Management	Project Management	Costing and Planning	Key Account Management	Product Engineering	Engineering Services	Purchasing	Quality	SC Design & Development	O Design & Development	Operations
Adjustment of PPAP requirements with customer		I						R			
Planning of pre-serial production resources		R		C	C				I	I	C
Design validation with pre serial parts finished		I			R	C					
Technical product release and final design freeze		I			R	C	I	I	I	I	I
Start of product training at plant		I			C						R
Supply parts inital sampled					C		I	R	I		I
Installation and startup of assembly line		I			I		I	C		R	C
Validation of test equipment (MSA)								R		C	C
Training of technical staff at plant										R	C

Training of production staff at plant										C	R
Takeover of disposition responsibility by plant							C				R
Ramp up planning at plant		I							I		R
Serial Q-documentation		I						R		C	C
Internal sampling for single parts performed and all parts are released		I						I			R
Internal PPAP released		I			C			A			R

Table 7: Tasks and responsibilities within Milestone 7

<u>MST8 - Approval for customer audit: The internal process audit has been passed and the measures have been completed to such an extent that the production processes can be presented to the customer</u>

Task	Management	Project Management	Costing and Planning	Key Account Management	Product Engineering	Engineering Services	Purchasing	Quality	SC Design & Development	O Design & Development	Operations
Preparation of process audit		I						I	I	I	R
Internal process audit performed		I						R	I	I	C
Action plan closed by Project Management		R									
Internal audit released	A	C	I	I	I	I	I	R	I	I	C
Deviation Approval from customer for 0-Series production available		R						C	I		I

Table 8: Tasks and responsibilities within Milestone 8

MST9 - SOP: Start of series production

Task	Management	Project Management	Costing and Planning	Key Account Management	Product Engineering	Engineering Services	Purchasing	Quality	SC Design & Development	O Design & Development	Operations
Product Validation (PV) completed		I			R	C		I			
PPAP submitted to customer		I			C			R	C		I
Preparation of customer process audit		C		I				C			R
Perform customer process audit		I		I				C		I	R
PPAP approval available		I		I				R	I		I
Handover of production responsibility to operations		R						I	I	I	C
Support in case of technical production troubles		I								R	C

Table 9: Tasks and responsibilities within Milestone 9

MST10 - End of project: Project completion

Task	Management	Project Management	Costing and Planning	Key Account Management	Product Engineering	Engineering Services	Purchasing	Quality	SC Design & Development	O Design & Development	Operations
Final cost analysis	I	R		I							
Review customer audit and safe launch plan		C			C			C	C	C	R
Review P-FMEA		I			C	C		c	C	R	C
Final handover of production tools to operations										R	C
Final handover of technical product responsibility to operations					R						C
Final handover of quality responsibility to operations								R			C
Exit from Safe Launch Plan		I						R			C
Disorganisation of project team		R	C	C	C	C	C	C	C	C	C

Table 10: Tasks and responsibilities within Milestone 10