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# CHAPTERS FROM THE ACADEMIC ASPECT OF PROJECT MANAGEMENT - RESEARCH AND TEACHING METHODOLOGIES
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# Chapters from the Academic Aspect of Project Management - Research and Teaching Methodologies

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# COMPLEX CHALLENGES OF PRODUCT DEVELOPMENT: A CASE STUDY

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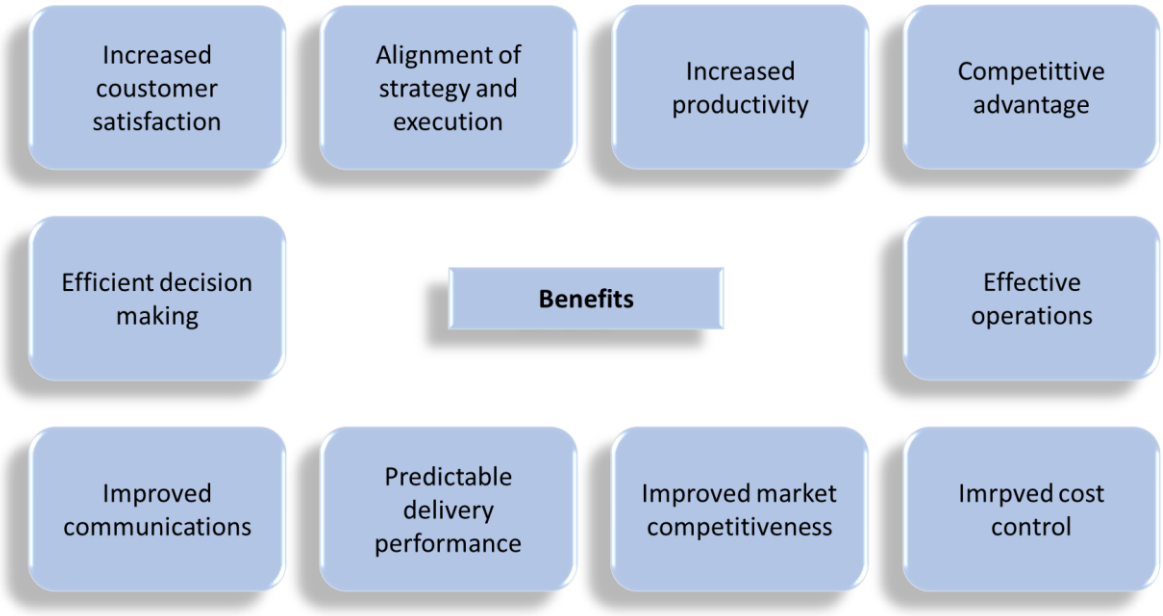
**Abstract:** Developing a new product and introducing it to the market is one of the most challenging processes of companies. Improving the competitiveness of the company through new ways of satisfying the customers requires coordinated efforts. Product development projects may have special attention in the organization. The paper shows some characteristics of a product development process in a multinational industrial environment. The research purpose is to find the critical factors to the success of product development. Engineering excellence in product development is the core component. Nonetheless, other competencies are indispensable, including an accurate understanding of the customer needs and the readiness to build up the manufacturing processes. The learned lessons point out that a long-term approach must focus on managing related information.

**Keywords:** New product development (NPD), PMBOK, project triangle, project success

# 1. Introduction

New product development may not be the only goal of a company, but it is inevitable for maintaining the market position and profitability. Innovative solutions go far beyond product development. Some of them are related to products and production, while others aim to improve organizational efficiency. The available benefits are expressively summarized in the benefits realization management by the Project Management Institute (Figure 1). McKinsey Corporation found a clear relationship between innovation activities and business success (McKinsey, 2009).

*Figure 1: Examples of benefits that organizations may realize*




*Source: Based on Project Management Institute (2018, p. 11)*

In essence, continuous product innovation is the core characteristic of the modern industrial company. Companies must continuously find new ways for creative and cost-efficient solutions to maintain their competitiveness. This effort requires the cooperation of various departments with different responsibilities and objectives. Moreover, product and production development must be harmonized. The concept of design-manufacturing integration aims to improve the efficiency of new product development (Rusinko, 1997). According to new product development, purchasing and product development departments are working together to manage the changes and to implement cost-savings in running production. There are several perspectives considered during this process to be successful.

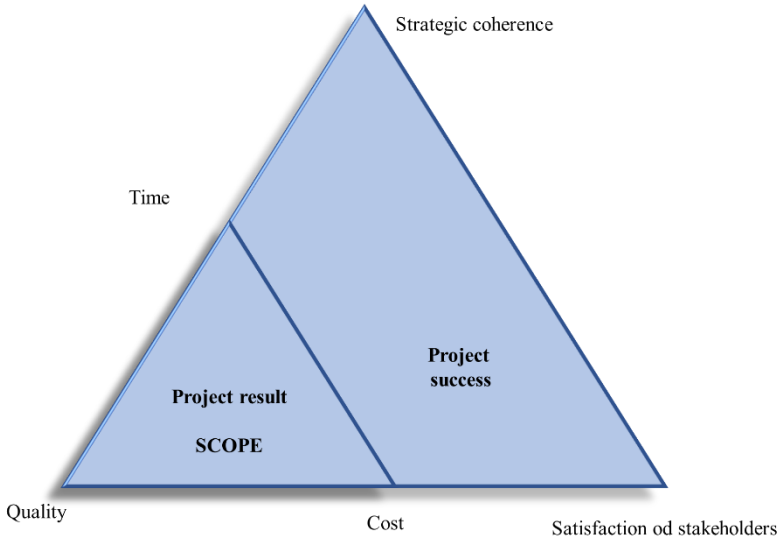
This paper presents an example of how to manage the complex challenges of new product development.

# 2. A project triangle approach of the product development process

## 2.1. Limitation of the project triangle model

The ‘magic’ triangle of time, cost, and quality is generally overweighed in product development departments (Vielhaber et al., 2010). Measurement of the performance of product development teams is regularly built up for the corners of the triangle. Although this performance can be presented with spectacular and satisfying figures in business overview dashboards, the line management cannot see a real evaluation of the innovation level of the products. The enhanced triangle (Figure 2) involves the organization level to the system of goals. Considering that organizational goals are derived from planned and expected project performance, there is a pressure on the projects to complete as proposed or with savings. It is to note that achieving the goals generated by the triangle requires a process-approach.

*Figure 2. Project triangle*




*Source: Based on Deák (2003, p. 142)*

## 2.2. Costs

The most crucial goal of companies with industrial products is to support their customers to increase their performance (Kärkkäinen et al., 2001). Cost planning of product development projects is a key factor already from the start. After accepting the design concept, a predictive cost calculation is prepared by the project manager (with or without

the involvement of designers and further interested parties). During the project acceptance meetings, the cost and payback calculations are in the focus of management. The match of costs, business case calculation, and payback with each other is an essential topic of these meetings. If accepted, the figures are built into budgeted investment plans for the timeline of projects.

A great challenge for the managers of product development projects is keeping the cost plan, and changing it during milestone meetings if necessary. However, the cost calculation in the project phase is only preliminary calculations. Most of the management teams of industrial companies want to keep this 'promised' cost plan until the end of the project.

Otherwise, in the finish of the project, when a time plan must be saved because of different difficulties during development project cost question can become irrelevant compare with possible turnover losing because of late market entry with a new product.

## 2.3. Time

To introduce a newly developed, innovative product into the market is a necessary condition for successful companies, as McKinsey proves that via researches (McKinsey, 2009). The success of a company is measured by management and investors/stock market by diverse financial data. Predicting that product will be successful on the market – according to previous market researches and tests – product development timing becomes a key factor of the product development triangle. In other words, the late in the project (not keeping the original time plan) leads to a delay in the market introduction and causes lost profit.

During the project planning phase, the project manager should focus on administrative details, including time plan and cost calculation. The task of the design engineering team is to deliver verified technical solutions shown as 'scope' in Figure 2. Finally, during project planning, the project manager should find a great balance between cost (resource use) and timing. In the right case, product strategy and profitability together possibilities from available resources by the company will define perfect or at least the best deliverable project time plan. Within a product development project, attention and influence of management to project timing are varying. This attention is quite intensive at the beginning of the project, and during the execution phase, it becomes lower. The next peak of attention comes during the verification and implementation phases (Bitzer et al., 2007).

In these phases, delays due to non-predicted issues during verification or further necessary design changes cost, especially if a timing dual must be reviewed, leads to an additional resource need.

## 2.4. Quality of deliverables

Product scope is specified first, and milestone and market research phase next. In front-loaded product development, the project scope and the customer requirements well defined and carefully researched, verified with different control groups. The main target of product design engineers is to fulfill this specification for satisfying future consumers. Parallel delivery of technical specifications and particular capability of the company must be considered, including production capabilities, available technologies, raw materials, cost-effective solutions.

Product quality strictly belongs to product specification, but it is a different topic. Several years ago, high-level quality (according to consumer requirements) led to a remarkable advantage in the market and supported the companies to improve their market share, turnover, and profit. Nowadays, market situations with a large number of competitors raise different challenges. A high level of quality is just a ‘must’ but not enough. There is no way to make any concession of quality during the execution of the project. The only way to change timing or cost if any fine-tuning is necessary even lightening of quality level can be a more natural way to deliver product development projects.

# 3. Process approach to new product development

## 3.1. Design-manufacturing integration

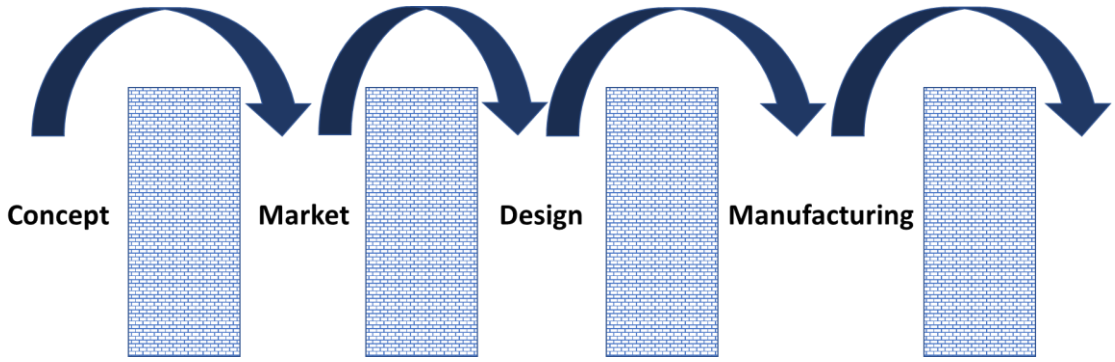
There are three main phases of introducing a new product (Rusinko, 1997):

- product design,
- process design,
- prototype and manufacturing start-up.

Of course, process design requires an accurate definition of the product details, but process capability and estimated production costs may have a backlash to the design characteristics. Finally, the start-up phase of manufacturing can show the bottlenecks of the system that leads to corrections or need for re-design: communication and a systematic approach to development help to avoid unfavorable impacts. Organizational and process boundaries may have been overcome.

The traditional (also called 'over the wall') approach to product development (Figure 3) is at a complete lack of team working and understanding of other departments' problems, which can result in late, over-expensive, and poor quality products (Owens, 2004).

*Figure 3. Typical 'over-the-wall' engineering approach*

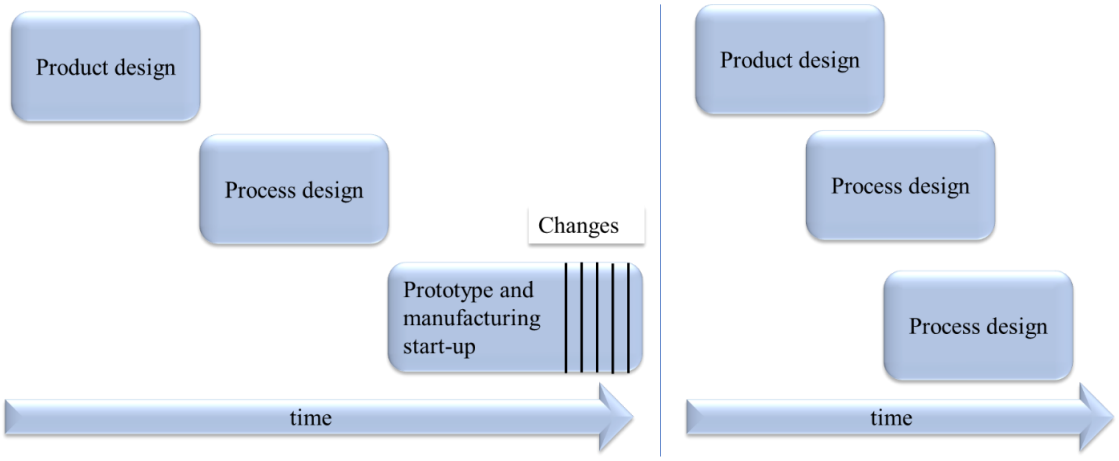



*Source: Owens (2004:314)*

Design-manufacturing integration must speed up the processes by managing parallelization (Figure 4). If it succeeds, shorter throughput time and a lower cost level are available. Nevertheless, this shortening needs a new approach in project management due to new risks awakening from starting downstream processes. Risk management requires an integrated approach (see Fekete, 2015a; 2015b). A detailed analysis of the risk is out of the scope of the paper, but it is to note that the issues highlighted in the case study chapter can be considered as risk factors.

While the predecessors are not validated, and elemental changes of the products may become indispensable. Pons (2008) describes the applicability of the project management processes, adjusting to the product development tasks.

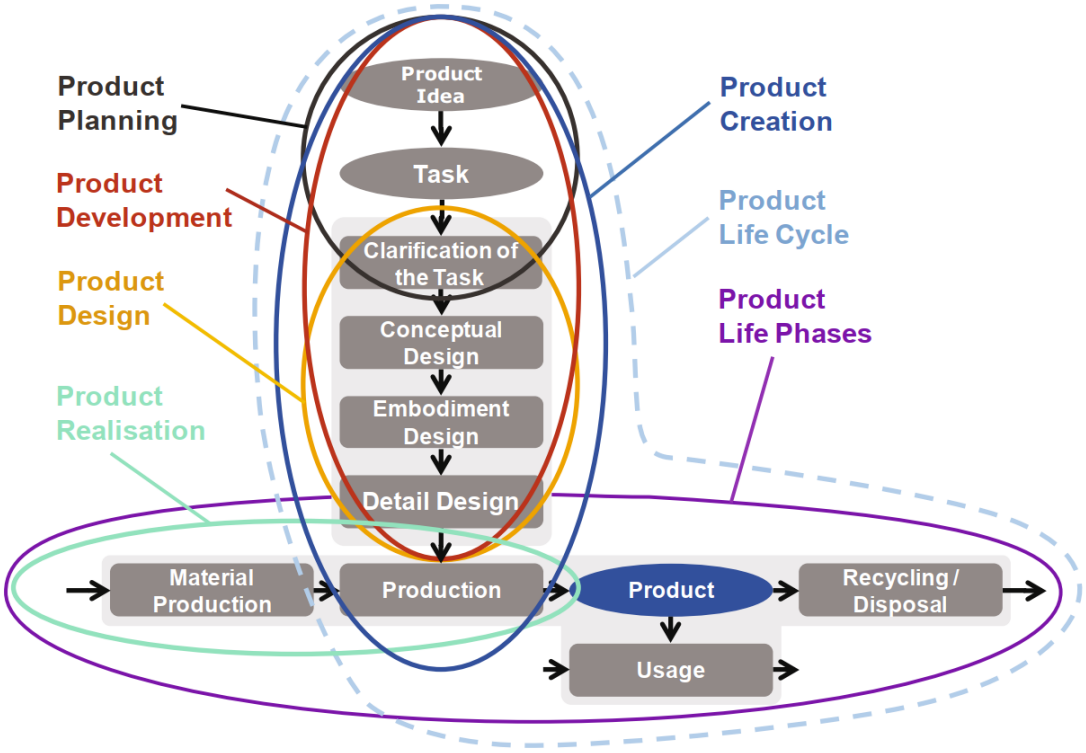
*Figure 4. Design-manufacturing integration*




*Source: Based on Pons (2008)*

The risk is moderate if the product that had predecessors than a brand new one. There are different types of innovation defined in the engineering literature, including design/innovation, particularly research vs. radical design vs. new product development (NPD) vs. incremental design improvements (Hubka, 1987; Pons, 2008). Birkhofer (2011) gives a multilevel, process-oriented overview of the tasks (Figure 5).

*Figure 5. Different areas of design work with system boundaries*




*Source: Birkhofer (2011:7)*

In the mirror of the categorization in Figure 5, the moderate risks mentioned are related to projects that are questionable as new product developments. However, improved products may open new functions or new market opportunities as well as new technological challenges, so there is no shape borderline between the categories of the innovation. As a result, a mixed project management style and toolset must be applied based on the judgment of the company.

## 3.2. Value creation in new product development

Based on the concept of dual value creation (Chikán, 2003), profit (short-term), and satisfying customer need (long-term) describe together the primary goal of a company. Sustainable profit is only feasible if customer satisfaction is assured. Moreover, meeting the expectations of other stakeholders are available through these. Due to the changing needs of customer needs, the renewal of the products and the processes are inevitable. In this term, projects are the frames of the changes, including also organizational development projects.

Cleland's statement (1984:38) is still valid today: internal projects usually indicate that a change in the operating policies is forthcoming.

A project is a temporary endeavor undertaken to create a unique product, service, or result (Project Management Institute, 2017). It drives changes in the company. The PMBOK standard emphasizes that projects enable business value creation that refers to the benefit that the results of a specific project provide to its stakeholders (Project Management Institute, 2017). Based on the dual value creation concept and the project characteristics, a project should create a new result that allows the company to create value. In other words, the project is the source of the future value creation of the company. Since the projects temporarily use the resources of the company, adaptation to the company requirements is enhanced. Performance indicators, budgets, and administrative norms frame the project activities. However, these are measurable; the approach is short-term. The dual character of value creation can be presented in this approach by Laursen (2017) that may have conclusions on the product development process. Value creation may be divided into two separate processes:

- the first process is the generation of the output, which is subject to an assessment of the user value,
- the value capture process subsequently follows the firs process, where the stakeholders capture the value (appropriation, realization).

The complexity of value creation must be mirrored in all phases and processes of the project. Supervision of the company incorporates the financial and customer viewpoint, while the realization is the responsibility of the project management. The issues presented in the next session shows a case study of how to coordinate the diverse interests and to improve both customer satisfaction and profitability. Good practices behind the decisions are based on the experience of the company in product development and the ability to using the lessons learned.

# 4. Case study

## 4.1. The new product

This study shows some issues of an industrial product development process as an example. Due to business reasons, the product and market details should remain hidden. The product of the case study is a special valve that makes regulation, control, and operation function in automation assemblies of heavy-duty equipment, whose predecessor has been in the business for years. The product (more precisely two versions within a product family) is combined with electrical and mechanical components converting the electric controller signal to mechanical signals. Two versions of the product are designed with different voltage and power levels. In both cases, speed is highly essential since it influences the working speed of the total system. The product operates on a medium scale of input mechanical driving input; however, it can operate and control the higher limit value of mechanical input. I.e., that the product can work on lower-level input that is not the same as the input level in the executing system. The validation and verification tests were performed in the test laboratory of the company.

However, the new product performs a similar function; moreover, it is interchangeable with the old version, it can be considered as a new product in most aspects since the main parts use new technology.

## 4.2. Market situation

Usually, a company produces for the domestic market in the standard product lifecycle in the ramp-up phase first. After sufficient marketing and manufacturing knowledge is built up, the international market introduction is targeted (Wortmann et al., 1997). Because the predecessor product was available in Europe at the beginning of developing a product, the product family has shown the potential to improve, based on former functions and customer feedback. Therefore, a commitment to improving them further, as well as to create new products is taken. The results are the new Version 1 and Version 2 products.

The new product shows improvement in several features (e.g., reliability, operation speed) contrary to its predecessor. Therefore, the expansion of the market segment is expected by the company both in local and foreign areas, even where former products were not in a competitive position.

## 4.3. Project objectives and conditions

The goal of the company is to serve the customers with the required quality and innovative solutions created with the optimal extent of energy investment. Besides, the goal is to set an example with the quality of the work on the domestic and national market with the intention to help the Hungarian industry and economy.

There are three objectives declared by the company:

- solve delivery disturbances;
- cost-saving;
- reduce dependence from external conditions.

According to the customer's expectations, the key factors of increasing their satisfaction were defined as:

- operating (switching) time;
- environmental efficiency (for example anodizing instead of painting);
- energy efficiency;
- stable operation;
- usage of less packaging (replacing supplier import);
- design for assembly/automation.

The most critical market advantage of the product compared to similar products is the short working time, operation speed.

## 4.4. Product design

In both product versions, the manufacturing is performed in the Hungarian factory, and no external supplier is needed anymore. As a result, the manufacturing cost of the products got significantly lower as well as the material flow got more straightforward than before:

- Version 1 of the product, the material of the house is black surface treatment metal. Internal parts are also made from light metals, which guarantees the resistance and the long lifetime of the parts against corrosion and the extreme temperature intervals.
- The house of Version 2 of the product is made of glass-fiber reinforced plastic, and parts are made of light metals.

The lifetime of products is measured in actuating cycles. The guaranteed value is several million cycles for both versions.

Based on the results of the stress tests, a triple safety factor is applied in both cases, which means that for a short period, they can bare three times the maximal operating load. As a result of the Version 1 valve development, on maximum operating load, it grants a more stable and more reliable function than before. The usage of the product is relevant because it is used as a control actuator in the high flow-rate systems in heavy industry. A high level of usage comes from the ship and train industry.

## 4.5. Verification of the product

During the design of the construction and the functional structure of the product, consumer interest was a primary aspect. The product has a wide range of consumers, i.e., the usage has various locations, temperature ranges, and functioning mediums. The product has to stand against climate impacts and disturbing factors, including high temperature, low temperature, vibration, salt-saturated medium.

From a design point, these outer impacts during the functioning of the product must be considered. Product Version1 and Version 2 also have a lower function range of -50°C, and the higher function range is +85°C. In the case when products work on this low or high temperature, the importance of the testing phase cannot be neglected. In order to guarantee to the customers that the product is ready to operate between the extreme temperature ranges, there is an officially developed and investigated testing laboratory in service, where testing engineers are working to create a product with better quality. Even satisfying special non-series needs, they are testing the semi-finished products, in a simulated, close to a real-life environment. Therefore, eliminating the errors occurring during function and raising safety. It is to confirm that different tests with one test plan template and one test record sheet example. The record sheet displays the function speed of the working system, using a product developed.

# 5. Lessons learned

## 5.1. General conclusions

The new product family aims new market opportunities while maintaining the satisfaction of the old customers. An improved feature of the product is offered to the customers at a lower cost, which is a clear win-win situation. The key to success is technical innovation in product design and material use, but enjoying the benefits of the new product would not be enjoyable if managerial efforts were failed. Market analysis pointed out that product versions must be developed for different loads, budget constraints motivated the parallelization of product parts and development tasks, etc. The success may serve as a model of future product development actions.

After all, the company must develop the system and practice of project management. The evaluation of the project highlighted some issues that require standardization within the company for supporting further development projects:

- systematic management of development data,
- change management.

## 5.2. Database of product design lessons

At every product development case, a mandatory session is to analyze the design of similar products to see design solutions. This requirement is also managed by the ISO 9001. In practice, both the own products and competitors are regularly checked by the designer. All companies are focusing on building up design lesions or best practice databases to provide available design information from the past for new product development projects and especially for design engineers.

A database is available to designers, but they frequently find it challenging using:

- it is difficult to search in;
- it is not always clear what was original design issue and the environment;
- the designers are not interested in performing research in the database;
- the author of information in the database is not available for discussion anymore.

These points establish an uncertain usage of the lessons from previous design works to avoid similar design-related failures in the future. As a result, a slower response to the challenges may be expected.

IT systems for product development are inevitable for successful, efficient delivery of projects. From project management tools, during Product Lifecycle Management (PLM) systems until design lesson databases. Via analysis of projects, some bottlenecks were popping up.

Virtualization is becoming more important and popular in project management (Blaskovics, 2018). Since it allows cost-savings and faster communication at the same time, the return on the investments in this field can be quick. It can be the next step, but the IT background is just the springboard. Rethinking the responsibilities and communication practices is a more complex challenge.

## 5.3. Developing change management

A comprehensive change management system is essential to provide enough information for production about technical changes in the product. This tool can be combined with PLM (Product Lifecycle Management) system and MRP (Material Requirements Planning) systems on a professional level. Change management mandatory to use by sustaining engineering after product introduction into production when any undocumented changes can cause difficulties in operation systems and/or quality issues. Between milestones of production start and ramp-up phase before design ownership handover by sustaining engineering necessity of engineering change management is questionable. Product development project members (product designers) are not entirely familiar with the engineering change management system because, in regular work, they do not have to use. Otherwise, products are already in mass production Bill of Materials; technical documents are released as mandatory to documentation.

According to the virtualization and the development of IT background, change management must include the change of management style both in general and during the IT-related projects (Aranyossy et al., 2018).

# 6. Summary

Critical points awake in the progress when the importance of these three elements is in focus but parallel, there are rooms for changes at all three elements. In the right case, product strategy and profitability together will define perfect or at least the best deliverable project time plan considering available resources by the company Introduced Product development study has shown that new products took over the position of the predecessor. In several aspects like producibility, economy, energy efficiency, and environmentally friendly solution can overdeliver original product to fulfill the requirement of company management. Customers will be satisfied with stable working in a hard environment in a heavy industry area parallel high speed and quick reaction time. Especially nice achievement to execute this design work with the focus for manufacturing. The development project is a success story according to the required specification, quality, business case, or timing. At the same time, it pointed out the further challenges to the company that goes beyond engineering issues. Renewing the approach to project management, especially to managing information and teamwork is the key to sustainable success.

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