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Feasibility Studies in the Product Development Process

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Abstract

The term "feasibility study" is often used in context of product development processes. Feasibility studies focus on five subjects: technical, economic, legal, operational and scheduling feasibility studies. The best known field is the economic one. While in economy science there is a standard-proceeding of a "feasibility study", in a technical context the term is used in different ways as shown by various research work. Thus, this paper aims to point out the relation of technical feasibility studies (TFS) and product development in context of the integrated product development model (iPeM).

The analysis of role and proceeding of feasibility study bases on three aspects: literature research and definition of terms, analyses of selected documented examples of technical feasibility studies resulting in a classification in iPeM and the matching of the classifications concerning the role of technical feasibility study in product development.

The results of research give a closer look at the various definitions and descriptions of the term. Thereby, the research focusses on the economic just as the technical feasibility. Whereas DIN69901-2 defines a standard for the evaluation of feasibility in context of project management, no consistent definition for technical feasibility studies is found. Thus, a consistent understanding of the aims of a technical feasibility study is compiled. In addition, examples of technical feasibility studies in product development processes will be analyzed regarding in which steps evaluations of technical feasibility are be done. Result of the classification of the identified activities of the examples to activities of product development and problem solving, is a graphical representation in iPeM. The third aspect is the matching of the iPeM-classifications. Using the gained understanding of "technical feasibility study" it is possible to conclude at which specific points in product development feasibility studies are done. These aspects concerning the role and aims of technical feasibility studies are underlying for further works.

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Keywords: Feasibility study; Product Development Process; Design assessment methods

1. Introduction

1.1. Motivation

The term "feasibility study" is often used in context of product development processes. There are two main examination aspects: economic feasibility and technical feasibility. While in economy science the term "feasibility study" is clearly defined, in technical sense the term is used in very different ways. The common meaning can be described as "evaluating whether an idea is realizable under certain circumstances".

Feasibility studies in economic sense are investigations which tend to determine whether a product development is profitable and viable for a company. For these economic feasibility studies (EFS), different models can be used and various methods are well known. (Ch. 2.1)

In product development processes the term "feasibility study" is also used in a technical sense, whereby different companies use it in different ways. Frequently, it is unclear, which are the pursued aims or which activities are necessary, resulting in uncertain methods. Those could support the engineer by performing feasibility studies. Often, a technical feasibility study (TFS) is similar to the process of design itself. Results can be various ideas or concepts to solve a technical problem. The related question is, whether a feasibility study differs from a product development process respectively how it is integrated in a product development process.

Regarding the above mentioned points this paper aims to analyze and to point out the contents of the term "technical feasibility study" in context of the integrated product devel-

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opment model (iPeM) [1]. Hereby, an important part is the classification into the “activities of product development” and the “activities of problem solving” (s. Ch. 3.2).

1.2. Structure

First the term “feasibility study” will be examined in context of economic and technical business. With regard to EFS, the DIN69901-2 as a standard-proceeding will be mentioned. For TFS various views will be presented and as quintessence a definition for this work will be found. (Ch. 2)

Afterwards the methodical approach will be shown. (Ch. 3) Various documented examples of product development in industrial context will be split up into the different activities. Based on that, the classification in iPeM is gained. The so generated graphical representations are matched in order to find commonalities or differences (Ch. 4), followed by the interpretation. (Ch. 5) The paper ends with a conclusion. (Ch. 6)

2. Basics – Feasibility studies

In general, feasibility studies aim to point out chances and risks of projects, which are planned or already in process. Feasibility studies focus on different factors. The acronym TELOS refers to the five areas of feasibility – Technical, Economic, Legal, Operational and Scheduling. [2]

2.1. Feasibility Studies in Economic Business

In this context the economic view is chosen because of clearly definition in context of project management and product development process. In this section a definition is given followed by a short introduction in used models and methods.

2.1.1. Definition

The economic feasibility evaluation purposes to determine whether project objectives are viable with benefit to the organization under consideration of the company boundary conditions – resources and know-how. In addition to the definition of objectives and the timeframe, the estimation of effort and all expected benefits is needed. A commonly used method is the cost-benefit –analysis. [3] [4]

Thus, the main aim is to determine the financial risk of a planned project and to prevent bad investment. [5]

2.1.2. Models and Methods

Different process models for product management including feasibility studies exist. Two common approaches are the PMBOK Guide [6] and the standard DIN69901-2 [7].

The DIN69901-2 describes the process for evaluating feasibility. This process is situated in the second phase of product management, which correlates with the PMBOK Guide. The phase model of product management structures in processes and phases (Fig. 1).

This structure has to be adapted for each single project. So different management processes are given; these can be distinguished in mandatory and optional management processes. Mandatory processes define the minimum standard. The classification of the process “evaluating feasibility” in the structure is shown in Fig. 2. This process refers to the minimum standard. Thus, the feasibility has to be evaluated for every single project.

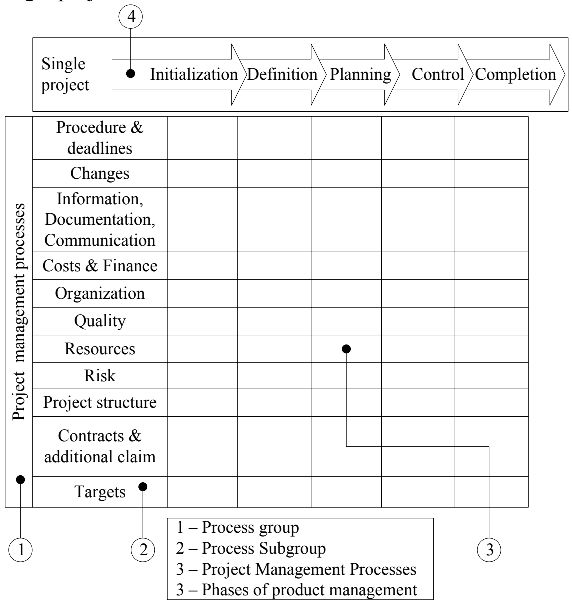

Fig. 1: Process model for project management [7]

Fig. 2: Classification of “evaluating feasibility”

For each process the aspects listed below are defined:

- Previous and following process,
- In- and Output,
- Purpose,
- Proceeding,
- Methods.

The purpose of the considerated process is to find a decision for the further proceeding in the planned project. The evaluation bases on the strengths and weaknesses as well as the estimation of risks and chances. Common methods are: SWOT analysis, utility analysis and profitability analysis. [7]

The input, which is defined as project objectives, time table, estimated expenditure and experience gained from previous projects is appraised. The evaluation aims to answer the underlying question whether the project objectives can be achieved under the specified time table and availible resources. Output is the evaluation of feasibility. [7]

Thus, the managemant process "evaluating feasibility" can be classified into the activity "project planning and controlling (s. Ch. 3.2) and is often part of early phases of product development.

2.2. Feasibility Studies in Technical Business

In technical business, contents of feasibility studies are not as well described as in economic business. Nevertheless, the following section shows some different views in the attempt to get a better understanding of the usage of "feasibility study" in technical sense. As a conclusion, the understanding of "technical feasibility study" will be defined.

2.2.1. Various Views

Literature shows that there are different usages and descriptions of "technical feasibility" and "technical feasibility study". E.g. KIVENTO says *"The term "technical feasibility" establishes that the product or service can operate in the desired manner. Technical feasibility means "achievable". This has to be proven without building the system. The proof is defining a comprehensive number of technical options that are feasible within known and demanded resources and requirements. These options should cover all technical subareas."*[8] MACKENZIE and CUSWORTH mention that *"[...] technical issues tend to predominate when assessing the development potential of a project in the process typically referred to as 'doing a feasibility study'."*[9] For most of the authors a TFS is only one part of a whole feasibility study. So OVERTON claims, technical feasibility is one part of a feasibility study amongst the proof of economical and organizational feasibility and answers if a solution can be supported with the existing technology [10]. WEISS also states, that the technical feasibility is one of many questions that have to be checked during a feasibility study [11]. After ROSENBLATT technical feasibility is one part of feasibility amongst economic, operational and schedule feasibility. He mentions that *"technical feasibility refers to the technical resources necessary for the development, purchase, installation or operation of the system."*[4]

NOORT and ADAMS describe a TFS similar to the operations during a product development process: "*In fact, a feasibility study is no single study in itself but a sequential series of interdependent technical studies with discrete objectives."*[12] These studies are "scoping studies", "prefeasibility studies", "definitive feasibility studies", "design and construction", and "operations" [12]. This view can be supported by GUBELMANN and ROMANO, they state that verifying the technical feasibility within a feasibility study bases on the technical concepts in consideration of the requirement specification. [13]

These views show that there is no consistent usage of the term "feasibility study" in technical sense. Technical feasibility is understood as one part of a feasibility study. Also, a TFS is described similar to a product development process. But there are neither approaches nor methods given for planning or doing a TFS nor results to achieve. The related question is, whether a TFS differs from a product development process respectively how it is integrated in product development process.

2.2.2. Definition

Although the approaches, methods and results of a TFS are not homogenously defined, a joint understanding of the aims of a TFS can be concluded. Based on the researched views, the aims of TFS are defined in the following way:

TFS is a fundamental examination of the ability in general to solve a technical dimension of a problem under certain boundary conditions (that are either given or subject to the study).

Analogous to the EFS, clarification of the project objectives and of the company's experience is necessary. In addition, the technical issue has to be understood in detail. The examination results in the clarification whether the technical presentation of the problem is viable in general and in a further step whether it is viable for the company.

3. Methodical proceeding

In order to answer the above named problem – the missing of a consistent understanding of the proceeding for TFS in product development process – the authors analyzed several examples of TFS. The methodical proceeding of this analysis described in the following section.

3.1. Proceeding of analysis

The analysis starts at two points: the research work concerning feasibility studies, particularly TFS, and the analyses of various TFS in product development processes, based on the done documentation.

The various views of TFS are synthetized to a consistent definition used in this work (Ch. 2.2.2). Based on the gained knowledge the examples for product development (s. Ch. 4.1) are examined. Using the founded aims of TFS it is possible to conclude at which specific points in product development feasibility studies are done. As result the relevant activities for TFS are found for each example. These activities are considered in terms of commonalities and differences. As a result of this analysis first interpretations are proposed concerning the role and proceeding of TFS in product development process.

Central part is the representation of the examples in iPeM. Thus, the opportunity for analyses under equal conditions is given and the role and steps of TFS can be characterized with the help of the activities of product development and the activities of problem solving.

3.2. Integrated product engineering model (iPeM)

Based on the system-triple "system of objectives", "operation system" and "system of objects", iPeM is a meta-model of product engineering processes that enables to represent any product development process. Thereby the operation system is a socio-technical system that contains inter alia activities within the process and their timescale. The matrix of activities is subdivided in "activities of product engineering" and "activities of problem solving". (Fig. 3)

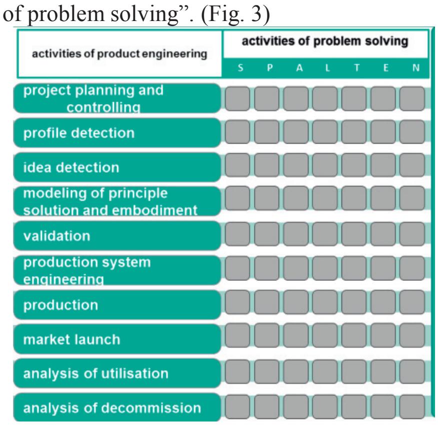

Fig. 3: matrix of activities in the integrated product engineering model - iPeM

The activities of product engineering are generic descriptions of necessary operations during different product lifecycle stages. Nevertheless, they are not describing timescales or phases during the product development process but can be performed in optional orders or in iterations [14]. The sequence of different activities can be shown in the phase-model. For a detailed description of the activities see ALBERS [1]. With the activities of problem solving the operations during the activities of product engineering can be described more detailed. Here iPeM uses the SPALTEN-activities [14]:

- S - situation analysis (gather relevant information e. g. from superior systems),
- P - problem containment (focus on the relevant problem and related information),
- A - generation of alternative solutions (e. g. with intuitive or discursive methods),
- L - selection of solutions (e. g. with methods such as efficiency analysis),
- T - analysis of consequences (investigating possible risks and opportunities),
- E - deciding and implementing (of the chosen solution),
- N - review and learning (important step to store knowledge).

In this context iPeM is used to analyze and compare different product development processes by analyzing and associating the activities in the product development processes with the activities of iPeM.

4. Analyses of product development processes and results

To examine the character and role of feasibility studies in product development, three technical feasibility studies in the context of product development processes are analyzed and represented in the iPeM. All examples had been executed in collaboration with several companies and the Institute of Product Engineering (IPEK) in Karlsruhe and address technical issues. The following sections provide a brief overview of the analyses and the results gained by matching the graphical representations.

4.1. Analyses of TFS in Product Development Processes

4.1.1. Analysis of TFS – Example A

Aim of this example is the development and analysis of a concept as basis for series development. Hereby, a new concept will be developed and be integrated in an existing product, without modifying it.

As first step of the study, the product including the environment and application of the product is analyzed. In addition, a trivial solution -the easiest solution- is considered to identify challenges, whereby the trivial solution is not feasible. The so conducted requirements specify the system to be created.

In a further step the system is decomposed into component-level subsystems. The solutions space is defined by analyzing the subsystems.

Through identification of interfaces, the interaction between the subsystems can be predicted. Thus, the prediction of impact for each subsystem is possible in case of changing product parameters. Further requirements are received.

After that, the detection of alternative solutions for the subsystems is performed, followed by an assembly synthesis and its examination. As result of this examination the assemblies are split up into solutions fitting into the defined installation space and the non-fitting ones. The development ends with the assessment of the viable solution, the selection of one solution and the modeling of embodiment including dimensioning. Fig. 4 shows the graphical representation of this process in the activity-matrix of iPeM.

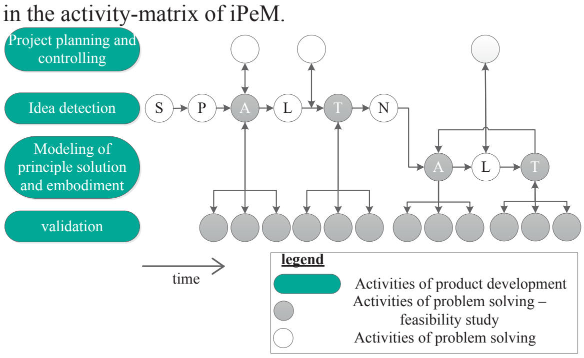

Fig. 4: graphical representation of example A in matrix of activities in IPeM

In the presented example, the technical feasibility is evaluated between the gaining and the selection of ideas; at this point consequences of the alternative solutions are examined. Also during the concretion of the system, e.g. determining the position of the components, technical feasibility is validated. Both examinations are accompanied by steps of validation in different detail. The described activities correspond to the activities of problem solving in "idea detection", "modelling of principle solution and embodiment" and "validation" represented in Fig. 4.

4.1.2. Analysis of Product Development Processes – Example B

In this example, the aim is the development of several concepts for a clutch. The concepts should be examined in terms of feasibility under extreme boundary conditions such as deep temperatures, low numbers of actuation. Inputs are description of the system and of the boundary conditions.

First step is the analysis and compilation of all relevant requirements to establish the basis for the evaluation of the concepts. The available space in the main system and the intersections between the main system and the concepts to develop gets represented in a 3D-CAD-model. Based on the compiled requirements, several ideas are derived. Ideas that obviously not fulfill the requirements are discarded immediately. All ideas that seem to fulfill the requirements are followed up to concepts. For each concept, rough calculations are made to estimate the safety. Critical points are identified and checked by calculations. In the next step the function and the dimensions are examined. In the next step rough 3D-CAD-models are created. By these models first estimations of possible physical layouts of the whole powertrain are made. To evaluate the viability of the concepts their design is further concretized. Based on this, the advantages and disadvantages of each concept are assessed and the costs are estimated. A comparison of the concepts leads to a recommendation. Fig. 5 shows the graphical representation of this process in the activity-matrix of iPeM.

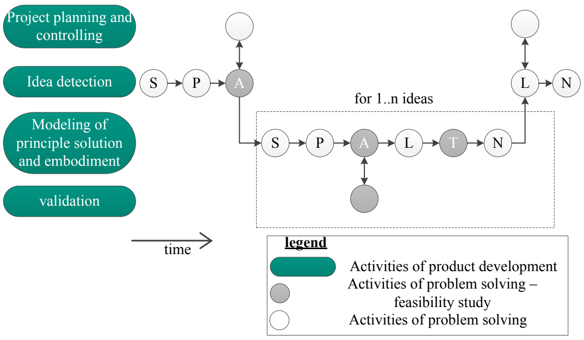

Fig. 5: graphical representation of example B in matrix of activities in iPeM

In example B the technical feasibility is considered by doing rough calculations and estimations regarding possible layouts of the different alternatives. During design concretion of the ideas further examinations are done to indicate possible risks and chances of the alternatives. Analogous to example A (Ch. 4.1.1) that is accompanied by steps of validation on different levels. Summarizing, the technical feasibility is examined in the activities of iPeM shown in Fig. 5.

4.1.3. Analysis of Product Development Processes – Example C

Aim of this example is the development of a modular test head for a test bench. Important are easy exchangeability of the components and similarity of the test head to the original system.

Based on the state of the art, analyses of the test bench, the environment and of rival products lead to a calculation basis and requirements. The main function of the test head is split up into sub-functions. In a creative process, ideas for the sub-functions are gained. The technical feasibility of every idea is directly examined; criteria are among others operational reliability, needed space, weight, dimensions, material stress. The compiled advantages and disadvantages are documented. Furthermore, a 3D-CAD-model of every idea is created. For the selection of sub-solutions to follow up, a utility analysis is performed. Finally the chosen sub-solutions are combined to an overall-solution. This overall-solution is modeled in 3D-CAD and notes on assembling are defined.

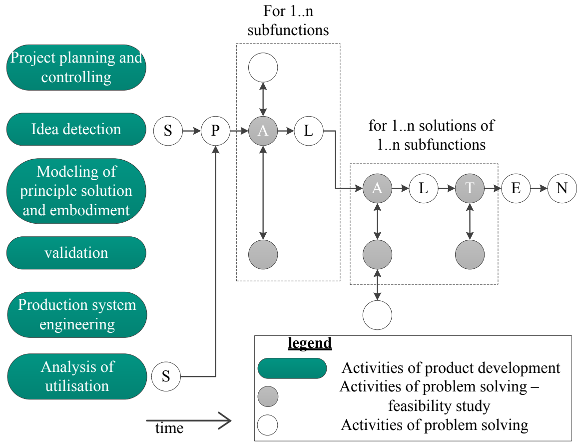

Fig. 6: graphical representation of example C in the matrix of activities in iPeM

Example C evaluates the technical feasibility of every sub-solution directly after gaining different ideas. Within the further concretion of the ideas, different calculations are made to identify risks and chances. Those steps can be classified to the activities of product engineering "idea detection" and "modeling of principle solution and embodiment", also combined witch several steps of validation in various levels. In Fig. 6 the steps of TFS in the present example are marked.

4.2. Results of the analyses

In the three analyzed examples, the activities of feasibility studies mainly correspond with the activities "idea detection", "modeling of principle solution and embodiment" and "validation". The evaluations of the feasibility are based on the development of technical concepts. The differentiation of development of concepts and evaluation of technical feasibility is challenging. Both are iterative and mandatorily depend on each other.

Under consideration of the various views of technical feasibility in Chapter 2.2.1, an assignment of single steps to the examination of technical feasibility is possible. It shows that a TFS is a multistage process corresponding with the activities of product development "idea detection" and "modeling of principle solution and embodiment" in iteration with various levels of the activity "validation" in early phases of product development.

Every examination of technical feasibility is preceded by a comprehensive analysis of the task, the system and the systems' environment. This analysis leads to requirements and boundary conditions. Analogous to the economic feasibility study (Ch. 2.1) the technical feasibility is assessed in context of the given circumstances as requirements and boundary conditions. To compare the characteristics of technical ideas with the requirements and boundary conditions different investigations such as rough calculations and investigations of the space available are done. Even though the technical system is concretized by these investigations a feasibility study leads not to a manufacturing-ready product but to a principally realizable concept.

5. Interpretation

Summarizing the previous sections three main aspects are concluded.

Based on detection that examination of technical feasibility is mostly located in "idea detection" and "modeling of principle and embodiment" without a relation to activities concerning the production or project planning, two aspects of TFS are concluded:

1. The task of technical feasibility examination means to evaluate whether a technical issue is solvable and the solution is viable under given objectives and boundary conditions without regards to economic factors.
2. The examination of technical feasibility is part of the early phases of product development process.
3. Technical feasibility studies take place before the economic feasibility study.

The interpretations are obtained with a high-level view of the product development process. For a more differentiated view it is necessary to go further in detail.

6. Summary

In literature several -sometimes contradictory- definitions are given, resulting from the analysis of the role and the proceeding of TFS in product development process. Thus, the authors tried to identify common activities for TFS through the classification in iPeM.

Based on the matching of the representations of TFS in iPeM following classification can be given: The TFS concerns usually the activities: "idea detection" and "modeling of principle and embodiment". In addition, the activities of the SPALTEN-process are important with main focus on "detection of alternative solutions" und "analysis of consequences". The compiled aspects of TFS are presented which have to be verified or falsified in further works.

At this time no statement concerning the used methods and tools can be given. Therefore further analyses will be needed.

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