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Matthes Elstermann

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A Subject-Oriented Analysis and New Referential Process Model for IT-Tool Support and Agile Execution of Strategic Product Planning

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by
Matthes Elstermann

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Karlsruher Institut für Technologie
Institut für Informationsmanagement im Ingenieurwesen

Executing Strategic Product Planning – A Subject-Oriented Analysis and New Referential Process Model for IT-Tool Support and Agile Execution of Strategic Product Planning

Zur Erlangung des akademischen Grades eines Doktors der Ingenieurwissenschaften von der KIT-Fakultät für Maschinenbau des Karlsruher Instituts für Technologie (KIT) genehmigte Dissertation

von Dipl. Wi.-Ing. Matthes Elstermann

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DISSERTATION

von

Dipl. Wi.-Ing. Matthes Elstermann
geboren am 29. Juli 1982 in Berlin

Tag der mündlichen Prüfung: 14. März 2019
Hauptreferentin: Prof. Dr. Dr.-Ing. Dr. h.c. J. Ovtcharova
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Abstract

The origin of this research was the failed attempt or rather the impossibility of creating a working and effective information system to support the processes of Strategic Product Planning, based on existing process descriptions for that domain. This dissertation explores the origins of the according problems. As is discovered, the problems do not originate in error containing models or simple programming failures. Rather, as is explored, the origin of the encountered problems lies in fundamental principles of the employed description concepts for processes. It is examined why those 'classical' description concepts, in theory, may be usable to model the complex circumstances of Strategic Product Planning, yet, as can be seen in the originally referenced models, do reach certain, not-directly evident, limits rather quickly when actually employed. As an alternative to classical approaches, the paradigm of Subject-Orientation is analyzed and applied to existing models in order to create a comparative study. As a result and on that basis, a new, formal and thereby digitally executable, subject-oriented, referential process model for Strategic Product Planning is developed and examined. According to the derived requirements, this new model is a superior foundation for companies or organizations to develop and implement the execution of according strategic product planning processes.

Kurzfassung (German)

Der Ursprung dieser Forschungsarbeit lag in einem gescheiterten Versuch bzw. dem Unvermögen auf Basis von bestehenden Beschreibungen für Abläufe der Strategischen Produktplanung ein funktionierendes und effektives Informationssystem zur Ausführung und Unterstützung dieser Prozesse zu entwickeln. In dieser Dissertation werden die Ursprünge für diese Probleme erforscht. Wie gezeigt wird, liegen Hindernisse dabei nicht direkt in fehlerhaften Darstellungen oder Unvermögen bei der Programmierung. Vielmehr liegt die Problematik ursächlich in den grundsätzlichen Prinzipien der verwendeten Beschreibungslogiken für Abläufe bzw. Prozesse. Es wird untersucht bzw. begründet warum diese, als klassischen zu bezeichnenden, Beschreibungskonzepte, zwar theoretisch dazu verwendet werden können komplexe Umstände wie die der Strategischen Produktplanung abzubilden, jedoch, wie bei den ursprünglich verwendeten Modellen sichtbar ist, sehr schnell an Grenzen stoßen, die jedoch nicht direkt erkenntlich sind. Als Alternative zu diesen klassischen Ansätzen wird das Beschreibungsparadigma der Subjekt-Orientierung analysiert und auf die bestehenden Modelle angewendet um eine Vergleichsstudie zu erstellen. Auf Basis der dabei gewonnenen Erkenntnisse, wird schließlich ein neues, formales und daher digital ausführbares, subjekt-orientiertes Referenzprozessmodell der Strategischen Produktplanung entwickelt und überprüft. Entsprechend den entwickelten Anforderungen, eignet sich dieses neue Referenzprozessmodell sehr viel besser als Grundlage um in Unternahmen oder Organisationen allgemein die Ausführung der entsprechenden strategischen Produktplanungsprozesse sowohl analog sowie digital zu konzipieren und implementieren.

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List of Abbreviations

BPM	Business Process Management
OO	Object Orientation
PASS	Parallel Activity Specification Shema – a subject-oriented process modeling language
PLM	Product Lifecycle Management
SBD	Subject-Behavior Diagram – a diagram type in PASS
S-BPM	Subject-Oriented Business Process Management or Modeling
SID	Subject Interaction Diagram – a diagram type in PASS
SO	Subject Orientation
SOV	Subject-Object-Verb: the standard grammatical structure of simple sentences in 50% of the world's natural languages
SPP	Strategic Product Planning
SVO	Subject-Verb-Object: the standard grammatical structure of simple sentences in 30% of the world's natural languages
UML	Unified Modeling Language – a collection of 14 different diagram types. Used for the conceptualization of Software. Object-oriented

Acknowledgments

It was a strange time to come to this point, but it is done. This thesis could be finished due to luck and coincidences, but also to hard work and patience. However, it also came to be due to the people around me; some good, some interesting, some rather ambiguous. Nevertheless, all of them to be mentioned because they had an impact on me and this work in the last years:

Foremost, my parents and my brother and his wife who supported me and encouraged me whenever possible.

Albert, who planted the seed for subject-oriented that is explored here.

Hagen, who set me on this path and Detlef, who led me to walk it for a bit.

Sven and Thomas, who picked me up and led me walk the path further.

The largest thanks are, naturally, to Prof. Ovtcharova and Prof. Schmidt, my supervisors and advisors for this thesis, without whom this would not be possible.

The final mention is of Desi, who I cared about the most in these past years and who was on my mind, possibly be a little bit too often.

Karlsruhe, December 2019 Matthes Elstermann

1 Introduction

"Plans are worthless, but planning is everything."
~ Dwight D. Eisenhower (1890-1969 – 34th President of the United States)

1.1 Motivation and Research Problem

Due to pressure from market demands and competition, enterprises are forced to develop and produce new, compelling products increasingly faster and more cost-effectively in order to survive. Consequently, extensive (re-) development iterations or expensive miss-developments need to be avoided. This is even truer for small and medium-sized enterprises (SME).

The disciplines of Strategic Product Planning (SPP) and the closely related Innovation Management combine activities, techniques and methods that support early stages of product development by proposing holistic long- and medium-term scouting and evaluation of ideas with cost and sustainability aspects. These aspects are considered across multiple domains that may have an impact on a given innovation or development project or may lead to changes in or discontinuation of existing products and services. However, due to the level of complexity and the enormous effort required, SMEs in particular rarely consider implementing and executing such efforts within their organization.

This research[1] originated with the goal to improve on that situation and enable easy implementation and execution of Strategic Product Planning through the following approach: the conceptualization and implementation of IT-tools that comprises all concepts of SPP are adaptable to any

[1] Originating in the ADISTRA Project funded by the German Federal Ministry for Education and Research

given situation, and thus enables and supports the Execution of Strategic Product Planning.

The initial approach was to directly adopt a formal referential process model from existing theories that ideally would be automatically executable by a workflow engine to support the respective methods. It was assumed to be a simple task since SPP and the correlated discipline Innovation Management are well-researched domains. However, it turned out that this was not the case, and developing a coherent system – able to bring together people, information, and preexisting concepts in a meaningful way – was more complicated than anticipated. A gap remained between theory and practical execution, preventing the simple creation of a coherent execution methodology for SPP and subsequently hindering the development of an active IT support. Yet this was a gap that could not directly be deduced, thus prompting this research to first identifying the origin of the problem or misunderstanding and determine why things did not fit together as intended.

Thus, the scientific contribution of this thesis can be determined with the model of Ovtcharova (Figure 1). She identifies a general bi-directional gap between the layer of operative processes[2] and the layer of high-level management concepts and their methods and corresponding process concepts. In consequence, she proposes a formal system integration layer that bridges the gap. This work will analyze why current thought structures and modeling paradigms themselves hinder that bridging effort and make automation nigh impossible. It will be shown how and what methods or techniques can be used to alleviate and overcome the problems by deriving a conclusive concept and providing a cornerstone in the effort to align, differentiate, and communicate the different goals and boundary conditions of different layers – for the domain of strategic product and product-portfolio planning and its execution.

[2] Processes that are actually being executed by people and supporting IT systems

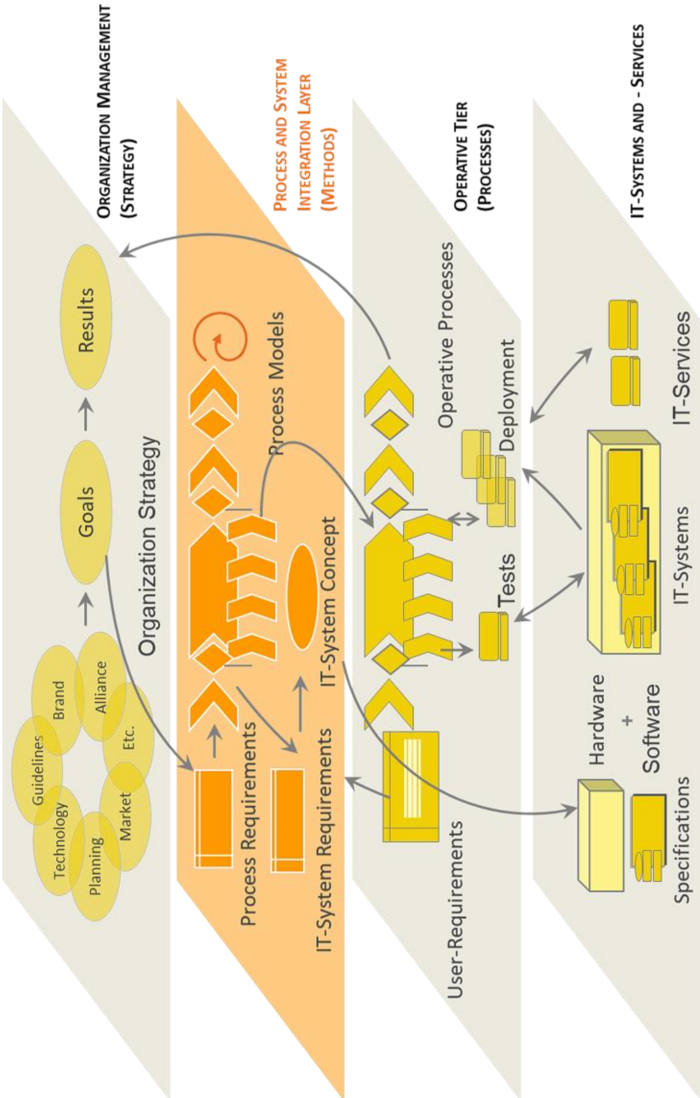


Figure 1: Proposal for a Process and System Integration Layer by J. Ovtcharova.

1.2 Research Objectives

Based on the perceived obstacles, the research goal of this thesis is twofold:

Firstly: Try to locate and precisely describe the problem(s) within the theory of Innovation Management and Strategic Product Planning – and their theoretical foundation – that hinders an easy and direct development of IT-tool support.

If so, secondly: Find a solution to the problem which translates into the derivation of a holistic description approach that enables a coherent understanding of Strategic Product Planning and its execution, and subsequently allows to derive effective IT-tool support, ideally a holistic execution within an IT-system, which so far does not exist. (ADISTRA, 2015)

To preempt some of the results and contributions of the thesis: the nature of the ultimately identified problem is subtle, especially since in real life application, SPP efforts were more or less working according to the theories (or at least the involved people used the theories to describe and explain their activities). The problem turned out to be one of information "getting lost in translation" in the gap between description/theory and practice. This gap is often not perceived in real life since deficiencies are covered by the pragmatism of intelligent people being to adapt their behavior to the necessities of a given situation when required, going beyond the bounds of a model and filling the gaps themselves to make things work[3]. In turn, this behavior makes it hard to prove a lack or to propose a possibility for improvement of the theories.

[3] Alternatively, it is simply trial and error and a question of luck.

1.3 Research Methodology

In theory, the following problem processing is simple, following the pattern depicted in Figure 2.

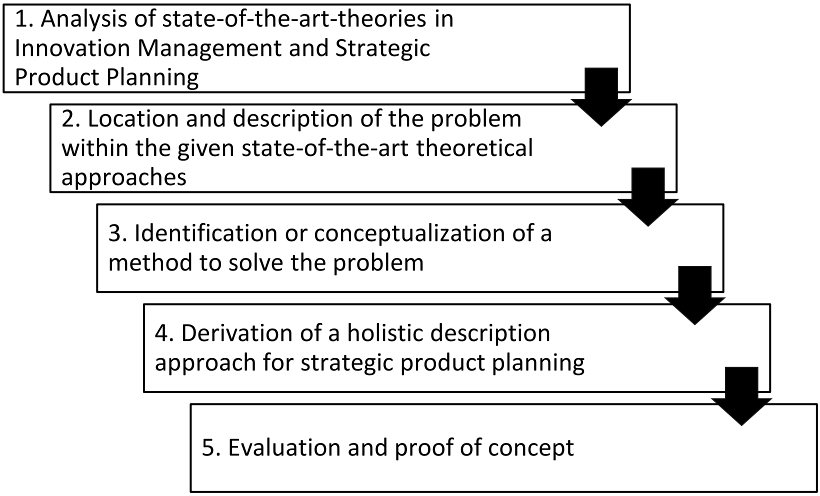


Figure 2: Simple waterfall-process-model for research methodology

The actual research pattern was more complex and is described in Figure 3.

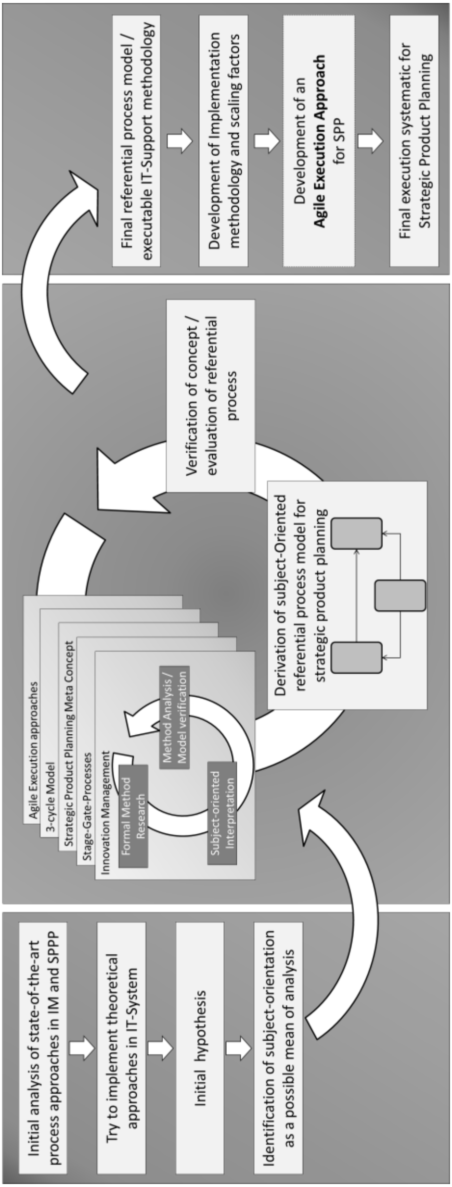


Figure 3: Iterative research methodology employed

Initially, issues with implementing and encoding said SPP process into software were not anticipated. At that time in the development, the implementation problem was ascribed to a lack of understanding rather than a conceptual problem that could be improved upon.

In a second step, an early hypothesis was formed that postulated that a problem existed, what the causes might be, and how the problem may be solved. Based upon that hypothesis, a coherent research approach had to be devised which could be used to examine the problem.

A potential tool for that task was found in the methods of subject-oriented business process management (S-BPM), a discipline of modeling and analyzing processes based on active entities rather than only on simple tasks. However, that applying the subject-oriented concept to the analysis of Strategic Product Planning would yield results, was in itself a hypothesis.

In consequence, the following research was an iterative process strewn across the most important domains with relevance to Strategic Product Planning identified before. For all relevant approaches/processes, corresponding interpretations were developed, built upon subject-orientation concepts. The derived models were then analyzed and the results verified using qualitative research methods together with domain experts and Innovation Management practitioners.

Using this method, it could be shown that the application of subject-oriented means did indeed help to identify and formally express the problem, and also that it could be applied to create a formal approach for SPP that captures more aspects and interactions with relevance for the execution of SPP than other approaches.

Subsequently and based on the understanding gained in the research process, an overall subject-oriented referential process model for SPP was derived, analyzed, and cross-verified, again using qualitative means.

This procedure was iterated several times until a state was reached that could qualify and can be presented as a final, completely formal, referential model that fulfils all requirements derived directly or indirectly from the earlier research. Due to the formal nature of subject-oriented models, the derived referential process description is per se executable. Thereby it can serve as the specification for an IT-tool supporting Strategic Product Planning, but it can also be executed directly by according workflow engines.

Finally, and based upon those results, another measure was taken: the development of a scaling methodology or implementation approach that will function as a guideline when implanting SPP into an organization or implementing a supporting IT system based upon the referential model.

1.4 Thesis Structure

Due to its cyclic nature, the actual research approach cannot be reflected in the linear structure of a written text document. In order to support the argumentation logic of the thesis and provide comprehensibility, the content is presented in the following schema:

First, it is necessary to lay down theoretical foundations in **chapter 2**, to set the focus and familiarize especially unversed readers with the central domains of this thesis, their correlations, and their vocabulary. This is done in three main sections:

Section **2.1** is concerned with Strategic Product Planning and the very similar discipline of Innovation Management as core aspects of the thesis, which are therefore introduced first.

Section **2.2** evaluates the general state-of-the-art or fundamental principles of processes, process thinking, and process execution and their evolution as the foundations for the analysis.

Finally, section **2.3** introduces the fundamental principles of the subject-oriented business process management and modeling approach (S-BPM) that will be used as an integral tool and means of analysis in the following chapters.

Chapter 3 contains the actual methodology of this work: First, in section **3.1**, a theoretical analysis of the traditional process concept and its weakness is done. The need for another approach will be derived and subsequently a similar theoretical investigation of S-BPM as that possible alternative and a comparison of both approaches will be made in section **3.2**. The derived knowledge about process description is then applied for an in-depth analysis and exploration of typical execution descriptions from the domains of Strategic Product Planning and Innovation Management in section **3.3**, in order to investigate the initial hypothesis of the thesis. Finally and based on the findings of the previous section, section **3.4** derives requirements for a possible executable process model for strategic product planning.

All the research, analysis, and conclusions culminate in the **Subject-Oriented Referential Process Model of Strategic Product Planning** that is introduced and explored in **chapter 4.** The model combines the essential elements of previous approaches and unifies them into a genuine and formal structure, thereby creating a novel and unified fundament and reference for learning and planning activities in the domain of strategic product planning and Innovation Management. Its practical applicability is validated and verified in **chapter 5.**

The thesis is concluded with a summary and outlook in **chapter 6** providing final insights as well as the limits of this research and a discussion regarding where future research should be applied in this matter.

2 Theoretical Foundations

2.1 Strategic Product Planning and Innovation Management

The core aim of this thesis is the establishment of a referential process model for strategic product planning that, due to coherent, logical structure and intuitive understandability, allows for easy introduction of the according processual elements into real-life workflows of an organization interested into adopting them.

However, what is Strategic Product Planning (SPP) and what are its relations to the quite similar domains of Innovation Management (IM) or (Strategic) Product Portfolio Planning (PPP)? This section introduces the principle concepts, the state of research, and the relevant vocabulary. Due to their overlapping nature, a comprehension canon will be established to help matching, identify, or contrast same, similar, or contradicting concepts.

2.1.1 Innovation and Innovation Management

Strategic Product Planning is closely related to the research topic of innovation and Innovation Management. In consequence, essential concepts and terms of both are introduced and explained in this section. Process models and approaches concerned with these topics are not described in this introduction. These are explored in detail in section 3.3.2.

2.1.1.1 Innovation

Definition

The term *innovation* is widely used as a keyword in economics, technology development and society in general. However, there is no single actual definition or inter-domain understanding of the term (Vahs, et al., 2013 p. 1). In general, it refers to something “new” as the roots of the word in the Latin “novus” indicate (Vahs, et al., 2013 p. 22) while the prefix “in” refers to something that has been created on purpose and not only by chance (Löhr, 2013).

The current understanding of the term innovation was heavily influenced by the works of Austrian economic researcher Joseph Schumpeter (Goffin, Herstatt, & Mitchell, 2009, p. 29). According to (Hauschildt & Salomo, 2011, p. 9), he was the first to describe that innovation is not only concerned with technology but also has an economical and organizational component. This makes innovation differ from the term invention, which describes only a technical development and thus only a sub-part of innovation or innovation processes (Vahs & Brem, 2013, p. 21). (Hauschildt & Salomo, 2011, p. 4) further describe innovation as new kinds of product or processes that noticeably differ in any way or aspect from another referential state of development. How to measure such difference or even define the referential point is not predetermined.

Significance

For profit-oriented companies, innovation, being innovative, or being able to offer innovative products and services[1] is generally considered an essential aspect necessary to sustain or improve a company’s standing within the economic system in the face of competition (Vahs & Brem, 2013, p. 8 ff) (Weiber, Kollmann, & Pohl, 2006, p. 84) (Macharzina & Wolf, 2008, p. 741).

[1] For most parts of this thesis, the terms product and service will be used in conjunction and only if explicitly mentioned the terms product or product innovation will include the concept of service – an understanding dating back at least to (Thom, 1976).

Not being innovative bares the risk of diminishing turn-overs, lower success rates, and significantly fewer market shares with new products and services (Larbig, et al., 2012) (Cooper R. G., 2010, p. 85). As an example for the consequences, (Cooper R. G., 2010) cites that 40% of the largest US companies in 1975 are not in existence anymore due to inability to adapt their product portfolio to new challenges and keep up with new developments. Acknowledgment of this fact in the industry can be deducted, e.g., from an overall investment budget of 121.3 billion € in Germany in the year 2010 alone (Vahs & Brem, 2013, p. 8).

Beyond the importance of innovation on the individual business level, it has also impact on a macroeconomic scale, being regarded as the significant factor in the economic growth of whole nations or even globally with the according impact on economic and social development. In consequence, innovation is also deemed necessary by political decision-makers and innovation supporting institutions and corresponding development schemes exist in many nations with the goal to increase and foster the chances for innovations, which in turn are expected to increase wealth, or solve other social or political challenges (Goffin, Herstatt, & Mitchell, 2009, p. 83 ff)

Innovation inducing factors

There has been much research into the causes or conditions that trigger innovation. Two theoretical mechanisms are distinguished that drive work on innovations: **Market Pull** and **Technology Push**:

Innovation is considered to be initialized by Market-Pull if it is based on consumer or market needs or requirements that have at least partially been identified by market research. A Market-Pull innovation is supposed to carry fewer risks due to it often only being an increment on existing products or services. However, they are also less likely to yield an advantage over the competition as a rivaling institution theoretical has equal access to the according information as well as the required technologies. To keep up with the markets, institutions operating their innovation efforts mainly on Market-Pull principle are required to act swiftly and develop their products under time pressure. As such, the Market-Pull mechanism is also considered to describe external innovation triggers. (Vahs & Brem, 2013, p. 242 ff) (Nag & Corley, 2003, p. 608)

In contrast, a product or service innovation initiated through the Technology-Push mechanisms is caused by the emergence of a new technology. Often this is brought forth by research and development (R&D) efforts of an institution that tries to transform an internally developed invention into a new product. The economic risk of such often rather radical innovation is higher than with incremental development since it is harder to predict success and sales rates in the market as no previous experiences exist. Also, such product or service innovations may need a certain amount of time to be established and fostering them may be a long-term investment (Brock, 1999) (Macharzina & Wolf, 2008, p. 746) (Nag & Corley, 2003).

Both mechanisms are archetypes that describe principles. In reality, a mix of both is a likely scenario to be encountered. This can happen in both directions. On the one hand, new technology is often developed in symbioses with market research efforts that guide the development to ensure that the new technology will not be completely unnecessary. On the other hand, a new product concept may be very likely to require a substantial technological/feature advantage over existing, competing concepts in order to be successful. Research has shown that such hybrid approaches may even have the highest overall success rates for innovative product development projects (Macharzina & Wolf, 2008, p. 751) (Hauschildt & Salomo, 2011, p. 4).

Market Pull and Technology-Push are both innovation-inducing mechanisms that work for individual institutions on an economic level. However, the requirements to be innovative and creating innovation may also be induced by other factors such as changes in the political system or society as a whole. New laws and standards for environmental protection, new international trade treaties, wars, or demographic changes can be named as examples of events with consequences that require innovation. (Vahs & Brem, 2013, p. 111) (Goffin, Herstatt, & Mitchell, 2009, p. 22 ff)

2.1.1.2 Innovation Management

Introduction

The previous sections established the importance of innovation for profit-oriented companies. However, being innovative comes with a high level of cost and risks, due to unpredictability and complexity of such endeavors. A failure of a development effort, due to, e.g., overspend resource budgets or a resulting unsuccessful product, may even cause the demise of a whole company or institution. Unsurprisingly in this context, a whole management discipline for innovation has been established.

In general, the term management implies planning, organizing, executing, and controlling a value creation process. In addition to managing material resources, this also includes factors such as information, usage rights, values, and social aspects. (Hauschildt & Salomo, 2011, p. 29)

This section introduces the range and the tasks of the discipline of Innovation Management.

Tasks of Innovation Management

The goal of Innovation Management is to organize and structure all activities and efforts of an institution connected to the creation of "innovations". This means creating an environment that fosters innovation and innovative thinking and provides the resources required to procure them. However, at the same time, it is necessary to minimize the risk of failure. (Vahs & Brem, Innovationsmanagement - Von der Idee zur erfolgreichen, 2013, p. 28).

At the core of the tasks of Innovation Management is the facilitating of innovative developments in the form of projects or the work of accordingly oriented groups or department within an organization. To capture and foster ideas and concepts that may be triggered by one of the mechanisms described in the previous section.

Beyond that, innovation efforts should be consistent with the strategic goals of the whole institution, corporate philosophy and mission statements. Therefore, the creation of corresponding organizational structures and implementation of a culture of innovation is another task for innovation managers. This includes formulating and communicating formal goals and monitoring their reception within the organization. (Vahs & Brem, 2013, p. 28; Stern & Jaber, 2007, p. 8) (Heismann, et al., 2012)

Another task for innovation managers is the creation of information gathering mechanisms and decision-making bodies within the managed institution, that can deliberate whether the potential of given development efforts may be worth the possible costs and risks. (Hauschildt & Salomo, 2011, pp. 41, 60; Stern & Jaber, 2007, p. 8)

In order to support and foster the tasks and manage the generated knowledge and ideas, an integral requirement for effective Innovation Management is also the creation, introduction and continuous improvement of a supporting knowledge management (Hauschildt & Salomo, 2011, p. 35) (Vahs & Brem, 2013, p. 28).

Range

Due to this broad range of tasks, the range over institutional areas of activity that should be considered by innovation managers also is rather broad. According to (Macharzina & Wolf, 2008) Innovation Management can be distinguished from the more limited concepts of Technology Management and Research & Development (R&D) Management by the range or scope that is considered by the corresponding concepts:

Technology Management is supposedly only concerned with exploring and introducing the use of new technologies as part of new product development projects. The scope of R&D Management goes further and considers the development of innovations more holistically, including the domains of fundamental research as well as embracing the whole product development process. In the concept of (Macharzina & Wolf, 2008) Innovation Management additionally spans over the domains of production and Marketing & Sales.

However, that description still is limited since the concept of (Macharzina & Wolf, 2008, p. 752) leaves out tasks and definitions of previous subsections. Figure 4 describes how Innovation Management should be understood if the missing considerations for a holistic Innovation Management approach are also included.

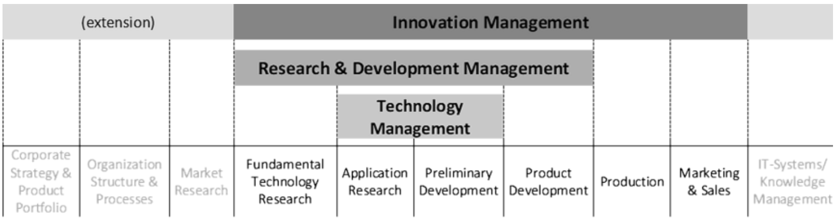


Figure 4: Range of Innovation Management over areas of different activities based on (Macharzina, et al., 2008 p. 752), (Vahs, et al., 2013 p. 28) (Hauschildt, et al., 2011 p. 41, 60) (Stern, et al., 2007 p. 8).

Four more areas of activity have been added to the model. They include Corporate Strategy & Product Portfolio Planning, managing of organization structure and business processes, Market Research Efforts for Market-Pull considerations, and IT systems, including knowledge and idea management concerns.

2.1.2 Strategic Product Planning

This section introduces the concept of Strategic Product Planning (SPP). It discusses how and in which aspects this discipline differs from Innovation Management.

Depending on the considered scope or range of Innovation Management, SPP can be considered a whole sub-discipline of Innovation Management or an area of activity orthogonally supplementing Innovation Management activities.

2.1.2.1 Strategic, Product, Portfolio, and Planning

Strategic Planning

The overall goal in any planning activity is the benefit (profit) of an organization (Bea & Haas, 2013, p. 54). In contrast to tactical or operational planning, strategic planning is considered a long-term planning approach. On a time scale and depending on the definition that implies a planning horizon beyond three to five years (HaushaltsSteuerung.de, 2015).

Figure 5 depicts the difference between the levels.

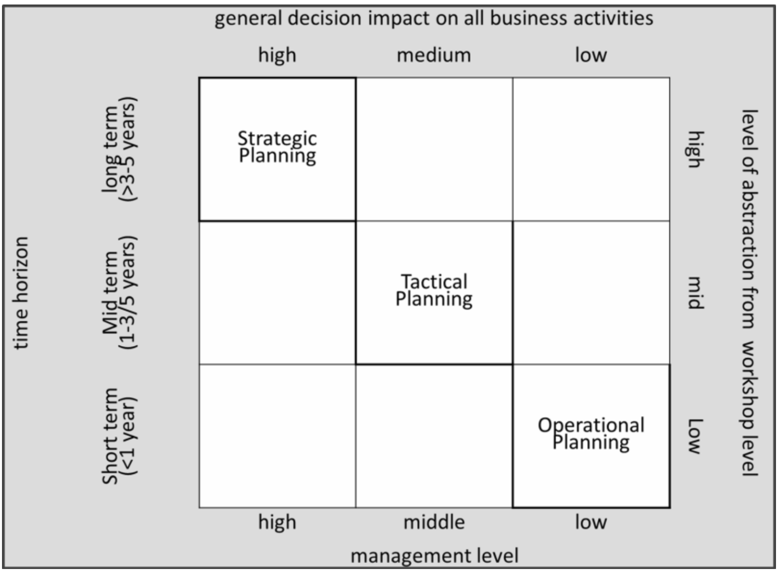


Figure 5: Overview differentiation of Strategic, Tactical and Operational planning activities (based on (Tempelmeier, 2014) and (HaushaltsSteuerung.de, 2015).

The result of strategic planning, the developed or chosen strategy, provides a perspective or vision for employees and defines the official position of a company. Made by the highest management level, it serves as a plan for future activities or as a template for an organization's behavior and has heavy influences on tactical and operational levels (Mintzberger, 1995, p. 29 ff.)[2].

Formulating and choosing a good strategy is in itself a complex and resource-consuming task that incorporates the processing of a vast and very diverse set of information about current status and the forecasting of future developments for the organization within the social, technological, and political environment it is embedded in (Bea & Haas, 2013, pp. 58, 220). Methods and technologies that describe systematic approaches to compiling and evaluating such information and derive strategies are the core of academic research on the topic of strategic planning. However, with a planning horizon of more than five years, the reliability of any forecasting and prediction of future developments can be questionable. As it is most likely that in the time span of five years, circumstances will change, plans and strategy will need to be adjusted accordingly, and most approaches incorporate the idea of iterative and continuous development and adjustment of strategies, e.g. (Bea & Haas, 2013, p. 58) (Gausemeier, Plass, & Wenzelmann, 2009, p. 26).[3]

[2] Very simply put, the strategy is a rough but long lasting plan for a company of how to make money in the future.

[3] In the face of uncertainty and ever-changing environments, it may be questionable whether the considerable efforts of a systematic strategy planning, or any planning at all, are worth the effort. The counterargument in this case would be that a plan is always better than no plan and that the actual effort taken in planning will improve the knowledge and thus the competence of managers and decision makers. To quote Dwight D. Eisenhower: "*Plans are worthless, but planning is everything*" (Eisenhower, 1957).

Product Planning

As the name indicates, the discipline of **product planning** is concerned with the planning of products. Naturally, this is most likely done by commercial companies that produce and sell these products as their main activity.

The term "product" indicates an actual physical product, but, as mentioned before, services can equally be offered to customers as products. Even more: modern-day business often requires hybrid approaches that offer a mixture of goods and accompanying services in the form of complex, so-called **Product Service Systems** (Abramovici, et al., 2005), or “product as a service” concepts (Mathieu, 2001).

It is important to note that in principle development of all these variations is considered to be in the scope of product planning activities.

In contrast to the concept of "strategic planning", product planning as a whole has no fixed time or abstraction scope. It defines the objective or domain that is planned. In this function, it can be distinguished from the planning of other tasks within an organization such as (pure) research and development (R&D), marketing, risk management, or the planning of production facilities. The differences may be fuzzy as all of these concerns are interconnected in some aspects (Kluwer, 2015).

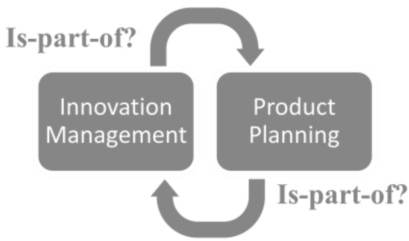


Figure 6: Argumentation Cycle: Product Planning is Part of Innovation Management is Part of Product Planning.

The same is true if a comparison of product planning and Innovation Management is considered. There is dedicated literature for both (see literature of the previous sections), marking them as individual disciplines. However, it should be evident that at least for the topic of "innovative products", they are basically the same or have large intersections. Innovation Management, in theory, focuses on innovations at any level within the organization, with products and product development being a prominent and integral example. However, it also could imply innovations in currently existing production processes or organizational structures.

Product Planning, on the other hand, focuses on the conception of successful/profitable products, which necessarily includes innovative products and the fostering of such. However, product planning is also explicitly more concerned with business aspects such as release strategies or bundling considerations that are not necessarily innovative.

So which is part of which? Both points of view are valid. Nevertheless, systematic differentiation is not necessary as long as the core essence and activities of both ideas are understood. The process descriptions of the later chapters are meant for that purpose but do not attempt to explicitly differentiate the two concepts.

Strategic Product Planning

Like any planning activity, product planning can be done on an operational, tactical, and strategic level with activities on the former two more likely being referred to as product development.

The basic idea of Strategic Product Planning is to determine what types of products or services an enterprise should offer, to sustain itself and grow, based on long-term considerations and somewhat abstract information. The decisions made will then steer and guide further product development efforts that are concerned with actual details of products and production. (Gausemeier, Ebbesmeyer, & Kallmeyer, 2001, p. 49ff), (Gausemeier, Plass, & Wenzelmann, 2009, p. 19).

Product Portfolio Management

This is true for the long-term development of single products, however:

"There are two ways to win at new products: doing projects right and doing the right projects. And that's where portfolio management—picking the right projects—comes into play". (Cooper, 2008)

If a company offers multiple products, **Strategic Product Planning** efforts should consider all development efforts for products, services, and their combination that make up an organization's product portfolio. In this case, the terms **product portfolio planning** or **strategic product portfolio management**[4] can be used in order to distinguish planning and development of individual products from efforts to manage and plan product strategies holistically and across multiple development projects (Cooper, 2008) (Edgett, et al., 2016) .

Figure 7: Classifying strategic planning concepts

Classically Strategic Product Planning could be considered a clearly defined sub-set of strategic planning (Figure 7) and the corresponding aspects concerned with pure (financial) business planning or pure marketing. This is usually the case in larger companies with strict separation of

[4] Product Portfolio Planning as a term may be enough since it automatically carries with it the connotation of the high abstraction level (multiple products at once) that is associated with strategic planning.

departmental scopes – depending on management culture. There Strategic Product Planning may be derived from formally defined business and financial strategies, with separately conceived business plans and marketing plans (Kluwer, 2015). In smaller companies though, strategic planning may be entirely product-planning-centered with business and marketing aspects holistically integrated into current and future product portfolio considerations or even singular products.

"They [portfolio and portfolio reviews] deal with issues such as achieving the right mix and balance of projects in the portfolio, project prioritization, and whether the portfolio is aligned with the company's strategy" (Cooper, 2006)

2.1.2.2 Execution Responsibilities

It can be summarized that the activities of the previous section are similar to each other insofar as they are concerned with the long-term activity planning of an organization – a task most likely present in all types of organizations, no matter the size or product and service portfolio. However, the size and organizational structure of the executing institution, as well as the domain and complexity of products, services, and variants may have a significant impact on the execution process of strategic product planning.

In smaller organizations, activities to plan, formulate and communicate long-term strategies may be very informal tasks, if done at all. All strategic planning may essentially be done ad-hoc by a group of people or even in the head of only a single person.

However, the larger an organization is, the more complicated it becomes to formulate and communicate adequate goals. In larger organizations, the planning activities will involve multiple decision makers on different management levels. Together with supporting IT-systems, they are part of a profoundly interconnected socio-technical system with different types of bureaucratic structures. In such cases, the organization and management of the execution of Strategic Product Planning is a complex process in its own right.

Likewise, where simple, non-complex products will allow even larger organizations to estimate impacts of decisions without elaborate tools, with a complex product portfolio and even more complex technology, determining the impact of a decision is much harder and may require internal or external experts.

2.1.2.3 Systematic SPP Execution

At the core of all the ideas and approaches above and regarding the management of innovation activities and product planning is the concept of orchestrating and executing those activities systematically, according to rules, doctrines, and processes – even if they are potentially bureaucratic and stiff. The alternative would be to forego all formalized (possibly restricting, and suffocating) approaches and instead trust a singular visionary owner or genius developer within the organization – or simply leave it all to chance.

Two mechanisms foster the idea that working without a systematic execution concept for SPP – or forgoing SPP altogether – could seemingly work very well:

One is *survivorship bias* (Elton, et al., 1996). It can be encountered, when innovative and successful products are invented by a before mentioned visionary that subsequently gets all attention and can claim to always have had the right idea at the right time, and it was him personally that successfully directed all efforts to this one product that no one except him always believed in. While true in hindsight, such stories are told about survivors of an economic battle for success. However, for one successful idea, there may be many other inventors and visionaries with similar ideas or ambitions, who may not have been as visionary, or did not meet the right chances, and subsequently, no stories are told about them. Under the assumption that humans are not all knowing, it is feasible to assume that the successful development in such a situation often and to a more considerable degree is up to chance. Good for the survivors, less ideal for unsuccessful people.

The second aspect that may make an organization averse to a systematic Strategic Product Planning approach is the problem of traceability over time: The results of an abstract, high-level strategic decision five years ago are not easily measurable. In cases where a strategic decision may be completely wrong (based on the given information at the time), changes on operative or tactical levels may mitigate especially bad decisions, or their failure may even be blamed on them. Meanwhile, the reverse is also true: A good strategic decision could be undone by mismanagement on other levels. The complexity and opacity of an organization's development within a five-year-span thus could appear to make long-term-planning altogether invalid.

In individual cases relying on chances and feelings, it may be a feasible concept. Disproving a "hunch", especially in cases of success, is impossible.

However, consideration of both aspects and their common focus on chance and luck should provide reason not to heedlessly discard the idea of engaging systematic approaches [5] and employ according methods, methodologies, tools, and techniques. Methods, methodologies, tools, and techniques, including the results of this thesis, developed to support Strategic Product Planning activities and their execution.

[5] Unless of course if you do feel lucky, indeed.

2.1.3 Methodologies, Methods, Techniques, and Tools

2.1.3.1 Terminology

As introduced in the previous section, the terms "method", "methodology", "technique" or "tool" will be frequently used within this thesis.

A look at the corresponding dictionary entries for all four terms shows that all of them are partially related and somewhat similar or synonymous.

Table 1: Vocabulary Definitions for Method, Methodology, Technique, and Tool from (Merriam Webster, 2017)

methodology	*1*: a body of **methods**, rules, and postulates employed by a discipline: a particular **procedure** or set of **procedures** *2*: the analysis of the principles or procedures of inquiry in a particular field
method	*1:* a procedure or process for attaining an object: as *a (1):* a systematic procedure, **technique**, or mode of inquiry employed by or proper to a particular discipline or art (2): a systematic plan followed in presenting material for instruction *b (1):* a way, technique, or process of or for doing something (2): a body of skills or techniques *2:* a discipline that deals with the principles and **techniques** of scientific inquiry *3 a:* orderly arrangement, development, or classification: plan *b:* the habitual practice of orderliness and regularity
technique	*1*: the manner in which technical details are treated (as by a writer) or basic physical movements are used (as by a dancer); *also*: ability to treat such details or use such movements *good piano technique*

	2a: a body of technical **methods** (as in a craft or in scientific research) *b:* a method of accomplishing a desired aim
tool	*1a*: a handheld device that aids in accomplishing a task *b (1)*: the cutting or shaping part in a machine or machine tool *(2)*: a machine for shaping metal: machine tool *2a*: something (such as an instrument or apparatus) used in **performing an operation** or necessary in the practice of a vocation or profession *a scholar's books are his tools b*: an element of a computer program (such as a graphics application) that activates and controls a particular function *3a*: one who is used or manipulated by another - a foolish or unlikable person

The first three terms in Table 1 are quite similar and rarely differentiated. Especially on the abstract consideration level of management sciences, it is often up to the personal writing tastes of an author whether she or he strictly distinguishes all three by some smaller detail, or uses them as synonyms, to lighten up monotonous texts – as it is the case for this work.

If differentiation is required, it may be based on the abstraction level where the according concepts are applied. *Methodologies* tend to be rather broad and abstract concepts or principles and may even represent whole domains or fields (e.g., the "survey methodology"). *Techniques* are on the other end of the spectrum and often are comprised of exact, practical, and detailed procedural descriptions. The term *method* can either be considered the middle ground between the other two or a superclass that contains them.

More often, and in accordance with the dictionary definition, methods are differentiated from tools. In the context of intellectual work, only the second dictionary definition of the term *tool* is applicable with a particular emphasis on the reference to a computer or IT system, and always with the necessity for "*the practice of a vocation or profession*".

Following the line from very abstract to very concrete or defined, *tools* would range the closest to concrete. However, even here it is only a gradient rather than a clear differentiation. In cases where the concepts and procedures of a method, methodology or technique are woven into IT tools, their usage may be impossible to distinguish from the containing software tool. E.g., in the simulation of mechanical constructions, the application of the simulation concept Finite Element Method actually refers to opening up and running a simulation program that incorporates said method rather than *being it*. Equally, the usage of a tool may become synonymous with the application of a method or is not even clearly distinguished from it.

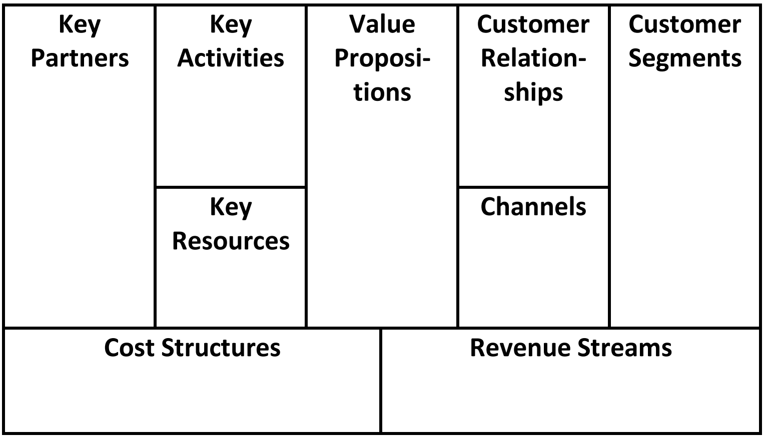


Figure 8: Typical Structure of a Business Model Canvas (Strategyzer AG, 2017)

An example would be the "Business Model Canvas" (Osterwalder, et al., 2011) – a method for conceptualizing and summarizing a new or existing business model in certain settings. The actual Business Model Canvas is a tool, a one-page structured poster, supposedly containing the most crucial information about a business model (Figure 8). The actual method is all about answering the associated questions and filling out the fields. Nevertheless, the concept (method) is primarily associated by name and visual identification and intent with the poster (tool or artifact).

The examples given showed that while technically there is a difference between methods and tools, in practice it may not always be simple or practical to make that distinction.

Moreover, most often methods and tools are mentioned together as one single category and it is left to an inclined reader to distinguish which is which. The World Health Organization does so, for example, in their collection of "Tools and Methods" on the topic of Health Impact Assessment (World Health Organisation, 2017).

In consequence, for this work, the differentiated usage of the terms will not be strictly enforced, and the term method will be considered to be sufficient to encompass all others, if not stated explicitly otherwise[6].

2.1.3.2 Execution of Methods and Tools

Except for the term methodology, which carries the notion of being applied in a general sense, all other terms carry with them a notion of being applicable or executable in instances or single occurrences. A tool a technique or a method may be used or applied at a certain time for a particular purpose. They may also be executed repetitively. Following the previous section, the boundaries between the terms are diffuse or overlapping and, in several cases, it is also said that "a method" is being applied "as a tool" (e.g. (Loo, 2002)).

A single occurrence of such an execution usually requires information and/or physical resources gathered possibly prior to the execution instance at hand. Equally, the execution of a method or tool will yield a describable result, be it a perceivable change in a condition of the real world, or be it an analog or digital document that was compiled. These infor-

[6] For emphasis reasons, it may still be the case that e.g. method and tools are mentioned together.

mation objects, then, in turn, can be used as input for the execution of further methods, in hindsight spanning a linear chain of executed methods connected by their information input/and output.

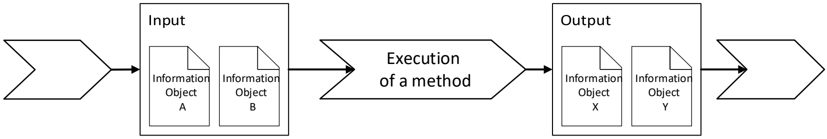


Figure 9: Conceptual execution of methods as black boxes that require information objects as inputs and outputs that connect them to the execution of other methods

This notion is comparable to – or rather conceptually identical to – the standard process concept discussed in section 2.2.1. Therefore, it is not surprising that almost all processual description approaches for SPP discussed in section 3.3 follow the path of this logic and its supposed trivialness. They, as will be shown, follow the same erroneous pattern of trying to chain multiple of such atomic descriptions together into a simple linear sequence or series.

It will be extensively discussed why that direct and tempting obvious approach is faulty, or rather why it leads to incompletes and misdirecting descriptions.

The short version is that a description of any atomic method will either be so broad that it does not contain any actual helpful detail about what to do. Alternatively, the description will be so specific that it does not cover all possible circumstances. The reason for this shortcoming is two-fold. First, the linear thinking approach – while correct in descriptive hindsight ("What have we done") – is not suitable to describe aspects of a complexly interconnected world[7]. Moreover, in a dynamic and ever-changing environment, the continuity does not lie within methods, but within the people executing them – a small but significant shift in focus.

2.1.3.3 Classification of Method Outputs – an Infeasible Approach

The spectrum of methods typically employed in SPP is rather broad and depends on available resources, knowledge, exploration focus, and education and personal tastes of the people involved within the executing organization. It ranges from generic creativity methods, such as brainstorming or brain writing, to extensive but specialized methods that serve a single specific purpose in a rather specific context, e.g., a break-even-analysis for financial investment.

As stated in the previous section, often the common description concept is to linearly chain together the execution of methods and use the output-information-objects of one method as input for the next. Using this concept to describe the overall generic processes of SPP though is infeasible. It will only work for unique situations when customized to the needs of a single organization for a particular time, but not for a generic referential process model. Next to the processual constraints discussed in later sections, other significant factors in this infeasibility are the broad range, numerous combination possibilities, and interdependencies the information content of output information objects from methods may have.

For conceptually chaining methods, this level of freedom must be restricted in order for one output to fit as perfect input for the next method. This is not impossible, but it does severely restrict the freedom of a generic process. The process description would no longer be generic and adaptable – it would rather be akin to the description of a large monolithic

[7] Each method (see also next sections) may indeed produce information objects; the produced objects have varying degree and level of complexity themselves (e.g. a one page BMC vs. an elaborate 50-page report on a created scenario). Comparison or chaining them together may only be suitable in very limited cases.

method that can be instantiated a single time precisely as stated. However, it is neither flexible nor will it easily scale, because it will require specific methods with well-defined outputs at a defined step in the process. Braking or changing a method in the flow may not yield the explicitly expected input for the next method. Thus, changing and adapting the workflow itself requires in-depth and profound direct knowledge about employed methods, as well as their substitutions. There is no abstraction mechanism that would allow differing of methods according to content-based or context-based flow. Chaining is only possible based on both aspects (content-based AND context-based) at the same time. If both do not fit precisely at the same time into the current concept, it will fail.

One factor for this is that each method in this consideration does produce information objects as output[8]. However, the produced objects have a varying degree and level of complexity themselves (e.g., a one-page BMC vs. an elaborate 50-page report on a created scenario), making the comparison or chaining them together is suitable only in limited cases, not in general.

Nevertheless, this approach has been tried and tested by us for the ADISTRA project (ADISTRA, 2015). There, a taxonomy was developed that tried to capture the core essence of each information-input/output-object in order to bring a level of variability into the method-chaining concept.

The concept was to use the generic taxonomy as a tool that would allow the abstract description of methods that in turn could be chained in a generic process model. Classified by their requirement of input/output-objects at a specific "step" or "phase" in a process, the generic method descriptions would then be matched or varied to actual methods or tool applications that might seem useful to the user at that time.

[8] Implying that someone takes care and compiles, writes down, and stores the generated information or knowledge sufficiently that there is a an actual, often digital, information object (e.g. a collection of photos from a brain storming or simply a written protocol listing all generated ideas.

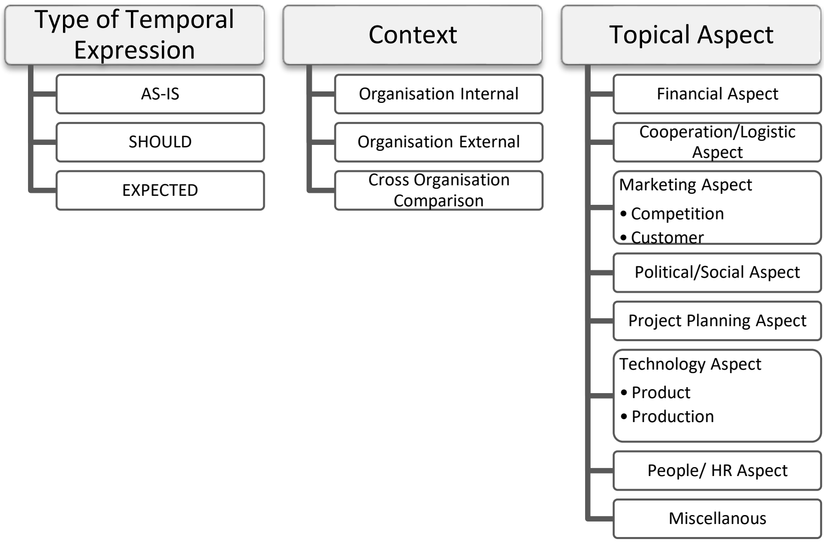


Figure 10: Classification Taxonomy for Information Objects in Strategic Product Planning developed for ADISTRA Project (ADISTRA, 2015)

While theoretically feasible, it turned out that in praxis it was impossible to describe a useful process this way. On one hand, this was due to the later discussed flow problem of co-including linear and cyclic concepts. However, more importantly, the resulting model would be hard to understand and only viable on a technical level, putting more description emphasis on the possible input or output definitions, instead of the actual task at hand without providing orientation or decision support for a possible model user. E.g., especially with generic activities in early product finding, the actual task, while complex in execution, can be summarized by a single sentence or question like: “What are the current potentials and the corresponding risks in a given scenario?” The possible information objects that could be of interest as input for this task would match pretty much all of the above categories and make any method defined to have any kind of output viable to answer the given question.

So, while being somewhat helpful for IT data management purposes, this approach did not yield the wished-for results. It led to the understanding that while, of course, certain methods will be employed as tools during SPP efforts, and of course their results will be compiled into (IT) data objects to be used “further down the line in the process”, abstracting only via inputs and outputs is not the right approach. Such a concept does not focus on important questions for users of a generic referential process model in an intuitive way. Simple questions like “for what purpose should I execute which method now?”. A description that gives answers like “because we need a certain information input for the next step” does not answer the question about the inherent purpose. It only gives a technical reason. Moreover, if that technical answer is complex (e.g., for the next step we need cross-organization-comparison information regarding the expected future development of several topics chosen prior), it might not improve adaptability, scalability, and understanding.

2.1.3.4 Exemplary Method and Tool Categories

Despite the insufficiency of the method-chaining description approach and the unpredictability of the future, SPP will always about conducting specific information generating methods in specific orders with the goal of estimating future developments and reacting accordingly.

This work does not focus on specialized methods, nor will it analyze the details of established and well-defined methods in-depth, especially when whole books can be written about some of them, like the aforementioned Business Model Canvas systematic (Osterwalder, et al., 2011). Nevertheless, it is necessary to at least briefly and non-exhaustively introduce and categorize some methods in order to clarify their meaning, position, and applicability within the bounds of this work. The following sections introduce a few selected, non-exhaustive method categories that could be part of any Strategic Product Planning effort, especially when derived from the referential process model.

Generic Creativity Techniques:
In most cases (see later section), the initial or nucleus part of Strategic Product Planning is always the conception or generation of (business) ideas for possible new products and services that may or may not fit with the strategic goals of a company. **However, there is no single ultimate method or tool that is guaranteed to generate the one single right idea upon request at the right time**! Often pure coincidence or a single genius person may be the actual random triggering factor. What can be done is to perform or conduct methods that increase the chance for groups of people to come up with concepts or solutions for a given problem or, before that, formulate the problem and corresponding questions to be answered.

There is a myriad of methods and concepts for that purpose with the traditional brainstorming probably the best known. Other methods are Brainwriting, TRIZ as well as others (Vahs & Brem, 2015, p. 288 ff). Many involve intensive discussions in groups of varying conceptual combination of possible involved persons (e.g., stakeholders, customers, employees, etc.). Lists or mentions of various techniques can be found in almost all literature regarding this topic from the just mentioned (Vahs & Brem, 2013), to (Gausemeier & Plass, 2014), to (Hauschildt & Salomo, 2011) – to name a few.

While not being the most reliable source and scientifically challengeable, the overview page of Wikipedia[9] is a rather quick and useful way to get insight into this domain. The following Table 2 contains a few short descriptions for a few selected methods of creativity.

[9] https://en.wikipedia.org/wiki/Creativity_techniques

Table 2: Short Descriptions of Creativity Techniques

Method Name	Method Short Description
Brainstorm-ing	A classical free-form meeting where a given topic or question is answered by a group of people, by exchanging their association, concepts or ideas regarding the overall goal of the brainstorming. Usually, a central large note device (whiteboard, pin board + paper tags, smart board, etc.) is involved too that allows tracking and (re-) grouping of voiced concepts and ideas as a means of exchange. If the condition of same time and same place is relaxed or compensated via technology, any other method of creativity could be considered merely as an elaborate, more structured and systematic version of a brainstorming that is tailored towards specific questions or designed to foster end elicit active and positive participation.
Brainwriting 6-3-5	Instead of direct conversation, Brainwriting, in particular, the method 6-3-5, is about exchange and co-creating ideas and concepts for a given question or topic in written form. With Method 6-3-5 it involves a group of six people in a Brainwriting session each initially writing down three ideas regarding the given question or topic within five minutes. Afterward, each participant will have five minutes to develop further the ideas passed on from the participant next to him until each set of original ideas has been iterated through (Rohrbach, 1969).
TRIZ	TRIZ is a generic design problem-solving methodology initially defined for engineering problems but may, with adaptions, also be applied to general business management. In a nutshell, it is a systematic approach to creative problem-solving, wherein a problem is to be generalized and then administered to a selection of 40-50 generalized problem solution principles and determine which of those may be applicable or how a solution, idea, or concept may take shapes in the regard of one of those principles (Altshuller, 1999).

Lateral Thinking	A systematic approach for problem-solving an idea generation that emphasizes diversion from a so-called standard or vertical thinking or idea generation process by prompting participants to consider somewhat random elements or concepts in the light of a given task or problem (de Bono, 1992).
Six Thinking Hats	The Six Thinking Hats approach is a group discussion concept wherein members of a group of people tasked with creating concepts or ideas take several pre-defined roles (hats) and are supposed to think according to defined requirements (de Bono, 1985).
Synectics	A problem-analyzing and problem-solving method that works on the principle forming analogies to a given matter and creating new and potentially unusually ideas or solutions on these formed analogies and then translating that analogy solution back to the original problem (Gordon, 1961).

Evaluation, Rating and Comparison Methods

Where creativity techniques, at their core, are about the generation of possibly exiting concepts or concept fragments, there are techniques for the evaluation and rating of ideas as well as projects and project progression, concepts, or the general situation of organizations.

The results of evaluation methods are usually either meant for comparison and subsequent selection processes of, e.g., individual ideas or projects or to be considered for other indirect aspects of SPP such as the evaluation or rating of, e.g., the current financial situation of an organization.

For the evaluation of ideas, projects, or similar, the goal is not to lose exciting ideas or cancel projects with potential while at the same time making sure not to waste time and resources on wild goose chases.

The simplest form of rating is the relative ordering of a given set of elements to be evaluated, according to a one-dimensional qualitative scale, e.g., “importance” or “relevance”, which may be based on opinions of the individual evaluators. More elaborate would be the rating of elements on an absolute scale (e.g., with school grades or similar numeric values).

In both cases, only concepts reaching a certain degree (e.g., at least B+ ideas, or top 30%) can be selected for further processing. Alternatively, evaluated elements not reaching a certain minimum may be eliminated from further considerations. Due to the rather obvious necessity of selection and reduction mechanism, very often creativity methods are coupled together with rating methods for further processing of the results.

SWOT Analysis
If the simple, one-dimensional ratings are not deemed sufficient, more complex methods may be employed that usually try to factor in more than one evaluation dimension.

As a generic example, the Strengths, Weaknesses, Opportunities, and Threats (SWOT) Analysis is a well-known example that requires the identification and consideration of these four categories regarding either the organization as a whole or an individual project to be evaluated. The analysis of opportunities (chances) and threads (risks) is focused on external factors whiles strengths and weaknesses are based on internal factors.

The SWOT analysis as described here is considered on a relatively small scale, where it can be used as a method within a brainstorming workshop or similar. However, following (Kotler, et al., 2010) brings forth the notion that a SWOT analysis is not merely a method to be executed, but rather the core principle or origin of all strategic (product) planning activities. Every tool applied to give management or participants an overview over a current situation may be considered a very elaborate, large scale, and complex SWOT analysis.

Growth-Share-Matrix
Another example for a two-dimensional rating or evaluation method is the growth-share matrix – aka. Boston Consulting Group (BCG) matrix – that

is being used, among other tools, for product portfolio analysis and management.

In the concept, several individual projects, products, organization units, or similar are rated according to their (estimated) relative market share and the expected market growth (potential) in a corresponding market segment (Baum, et al., 2006).

Several of thus rated elements are consequently place in a two-dimensional Grid (the matrix) for comparison, and, according to their placing, are rated as, e.g., cash cows, poor dogs, stars or question marks, allowing to decide on how to handle them in comparison further. E.g., foster cash cows, nourish stars, or get rid of poor dogs.

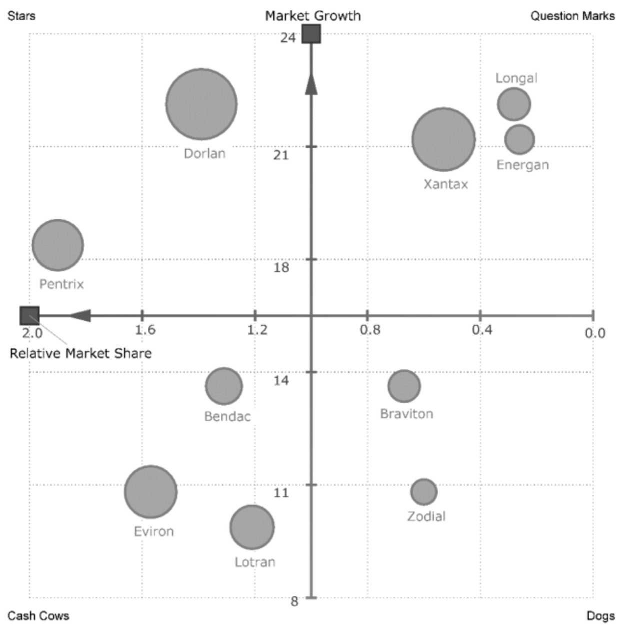


Figure 11: Example of a fictitious growth-share matrix (Wikimedia Foundation, 2018)

Beyond the two-dimension spectrum, there is an endless variety of rating concepts with predetermined, very elaborate rating schemata, that try to factor in multiple dimensions and factors, regarded as essential or relevant for one or more decision aspect or not. E.g., the Radar Chart or Star Plots.

Within all approaches, the predetermination of relevant categories is equally essential, as is their evaluation. It will have an impact on the resulting evaluation, and should not be underestimated. A choice for such an evaluation criterion in already done when, e.g., deciding to use and base decisions on the result of BCG-Matrix analysis. **Consequently, all strategic product-planning activities should always incorporate a self-evaluation concept that allows or requires the choice of methods and contained evaluation criteria**.

Financial and Economic Evaluation Methods

In almost all commercially active organizations, calculations regarding financial costs and efforts are a center staple of activities. Equally, planning and later releasing of potentially innovative products is rarely achievable without substantial financial invests. So, while somewhat of a sub-domain of Evaluation, Rating, and Comparison Methods, according proceedings involving financial aspects will be discussed individually.

In general, rating methods do not per se require quantitative input, instead incorporating qualitative information and ratings. Financial and economic evaluation methods do not have this type of freedom. They are about the accurate calculation of monetary values to rate a given concept, idea, project, or company.

In turn, this requires an accurate data basis or precise estimations. For information regarding the current (AS-IS) status of existing entities, this may well be achievable. It comes with the effort to calculate the relevant aspects, but with modern financial controlling software systems in place in almost all organizations, relevant figures are readily available and relatively precise if they regard the past or present.

However, the more future-centric the topic gets (e.g., estimations about future return of investments, etc.) the more the computed results lose their face value and become well-formulated expectations rather than definite answers. While necessary and proper indicators, they rely on estimations and predictions, that may not be given in advance or that are only achievable with great effort and spending of resources, especially time**. If that effort is taken and to what extent strategic decisions about future products are made based on the results, should always carefully be weighed by decision makers.** Otherwise, a product idea or concept that may be interesting but does not meet some imaginary economic prediction indicator will be cast out. Alternatively, efforts might be spent to make a concept or idea appear to meet some number expectations.

Nevertheless, in a market-oriented world, the methods of capital budgeting and investment calculations are necessary and, assuming a given stable, sound, and pragmatic database and reasonable assumptions, are well-established and useful tools.

Many fundamental methods of capital budgeting, investment appraisal, or costing can be found in, e.g.: (Bleis, 2016) or (Wouters, 2012) or specialized for Innovation Management (Vahs & Brem, 2015, p. 341 ff.) They come in many variations, some more complex than others, trying to mathematical factor in more types of risks and assumptions, like possible shifts in world currencies or inflation rates, etc..

Most, like the *Net Present Value* or *Equivalent Annual Cost* methods, try to estimate and calculated the value or cost of some investment over time or a lifespan or calculate the possible internal rate of return or revenue. Other consideration, like *break-even* calculations, try to assume how long an investment may return its value under the given conditions.

Alternatively, methods like *Target Costing*, meant to evaluated concepts that have progressed sufficiently to a state where cost planning can be concretized, put the financial evaluation at the core of the strategic design process itself (Cooper, et al., 1997).

Complex Business Model and Strategic Scenario Methods

The previous sections covered methods that, for the most part, serve a singular purpose and are rather direct to execute, be it the calculation of an arbitrary evaluation value or creatively coming up with concrete ideas.

As stated, these concepts will be combined and integrated into larger methods. However, it would not serve any purpose here to define an arbitrary framework that tries to group and classify all possible methods and their combinations. The simple notion that of the existence of more complex approaches and there is a spectrum between atomic singular applicable methods and complex tools shall suffice.

These more sophisticated tools are typically employed for the generation, compilation, and estimation of complex strategic scenarios. Alternatively, they may be concerned with describing and analyzing existing and new business models for products and services. They may come with their own internal, possible extensive, progression descriptions, and may cover or span larger aspect areas of Strategic Product Planning within themselves. Therefore, instead of being done on a workshop basis, possibly within 1-2h, it is more likely that their execution, including preparations and according information gathering, may take days or even months.

One of the most prominent examples is the before mentioned business model canvas approach (BMC) developed by (Osterwalder, et al., 2011). Other possibilities include Business-Model-Templates or Business Model Roadmapping (De Reuver, et al., 2013).

For general strategy building as the basis for Strategic Product Planning (Bätzel, et al., 2004) conceived the VITOSTRA-methodology, that tries to foster discursive means for developing business and product strategies.

Moreover, as a very holistic approach for understanding current and possible future constellations in general, the Scenario Technique by (Gausemeier & Plass, 2014) could be employed, that seems heavily based on the Sensitivity Analysis of (Vester, 2002), which in turn is a base method for helping participants agree on a common understanding of a complex problem domain for planning aspects.

Another rather complex tool is the Delphi-method, meant to formulate scenarios about future developments and trends based on multiple-rounds of remote expert interviews, given their opinion about a previously formulated topic or hypotheses (Häder, 2002).

Design Thinking

Rather than being a concrete method, Design Thinking is more of a general concept or approach centered around iterative development that is being done by an interdisciplinary team of people working in a “creativity-inducing environment” in order to derive creative solutions for arbitrary given problems (Fleischmann, et al., 2018).

The interpretation of what Design Thinking is ranges from a concrete set or toolbox of several methods[10], over being a method or process itself, to the more philosophical inclined understanding of Design Thinking as a methodology or mindset.

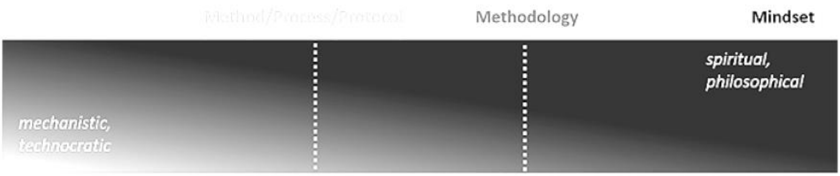


Figure 12: Implication Range of the term Design Thinking (Fleischmann, et al., 2018).

In a nutshell, it is an approach for problem-solving or the creation of innovative solutions for problems with a very strong emphasis on the exploration and understanding of a given problem or problem domain. Furthermore, it is an agile approach that is focusing on the regular generation and development of artifacts that represent the current understanding of the

[10] Many of the previously listed creativity methods could be or are being employed as part of a development effort according to the principles of Design Thinking and the according toolboxes.

problem or possible solutions and that thereby allow stakeholders to gain early and intuitive insight into the development process and possibly give feedback accordingly.

Beyond direct application in concrete and linear development efforts, Design Thinking considerations include the creation and management of innovation-friendly environments within an organization in order to foster innovative ideas (Uebernickel, et al., 2015).

However, Design Thinking has become a buzzword that, according to various authors, is not only applicable to concrete product design. It is, supposedly, applicable in any domain on any abstraction level, ranging from its origins in classical physical product design, to business process modeling and management (Luebbe, et al., 2011), to strategic design (Mootee, 2013), to business analysis (Frisendal, 2012), digitalization of processes (Fleischmann A. , Oppl, Schmidt, & Stary, 2018), the conceptualization and development of urban areas (Roggema, 2019), or solving social problems (Brown, et al., 2010), to name a few.

Nonchalant, it could be said that Design Thinking is everything and yet nothing concrete at the same time. For the execution of Strategic Product Planning the approach is neither without importance nor is it a key element for the execution itself. It rather is a possibility of how to engage in certain activities. Therefore, Design Thinking considerations stand orthogonal towards the consideration domain of this work. Every aspect of Strategic Product Planning could be executed according to Design Thinking principles depending on what is considered the problem or challenge to be solved by a development effort. On the highest level, when considering the general idea of Strategic Product Planning[11] as the problem to be

[11] Very simply put: Finding an answers to questions like: What are the strategic goals of an organization? What are good product and service ideas to foster those strategic goals? And: how to design and coordinate institutions within an organization that come up with both?

solved, even that could be considered as an effort where Design Thinking principles can be applied[12].

However, on a more practical level, Design Thinking can easily be incorporated into Strategic Product Planning in areas of activity such as Potential and Idea Exploration (see chapter 4.3.2).

Beyond that, especially in larger organizations, when not only a single team of people is involved in the creation of solutions for a singular challenge, the actual problem of SPP is the coordination and forwarding of derived solutions between different involved parties. As in any agile development approach, it becomes more of a (nontrivial) challenge of how to scale the coordination system and keep the required organizational discipline (Larman, 2009).

2.1.3.5 The Importance of Information and Information Management Methods within Strategic Product Planning

The previous sections on methods and their classification have stated that and later chapters will analyze why chaining methods according to their input and output may not be a useful abstraction concept for the description of executable referential process models. Nevertheless, the reason that is done is due to the simple fact that information objects will be needed and generated during execution of any according planning tasks, somewhat explaining why an orientation towards these information units may seem the obvious choice for description.

[12] For that regard, this thesis could be understood as a guideline or introduction into the problem domain of SPP

On an abstract level, all SPP or Innovation Management activities and methods can be understood in general as means to systematically derive *information*[13] – be they a simple brainstorming session or be they complex analysis and arguing techniques such as the Business Model Canvas (BMC) methodology, comprised with a complex workflow in themselves. In almost all cases, information will be conveyed encoded in information artifacts or information objects. Nowadays these are most often digital documents, but also letters, photo, videos. Almost all SPP workflows implicitly can be abstracted to the notion of then conveying the information contained in objects or documents and provided it to other people to note, evaluated and base further decisions on it.

Intuitively correct and therefore mentioned by many authors ((Vahs & Brem, 2015), (Nickel, 1999)) is the notion that procured information not only must be derived but also distributed to "right" persons at the right time, a task generally referred to as *Information Management*[14].

Information Management is a discipline dedicated to the tasks of collecting, storing and retrieving information for the purpose of providing it at the right time to the right people.

This includes the provision to preemptively determine the "right time", the "right people", and the structure or way of presentation for that information[15].

[13] Authors like (Tamine, 2004) distinguish the concept of information in more detail and differ between the terms *data*, *information* and *knowledge* – spanning a spectrum from primitive to complex concepts. For this work, this specialization is not necessary and therefore the term *information object* may include notions of all types, be it primitive documents or complex instruction sets comprising the knowledge and acting options of a whole development project.

[14] Depending on the definition, the term Information Management may include, be included in, or overlap with the disciplines of *Knowledge Management*, *Communication Management*, and *Document Management*. As such, it is used in this thesis.

[15] There is an inherent problem with defining according data structures in Strategic Product Planning. The future is uncertain and in constant flux, but the contents or defined structure of standard documents are not necessarily as flexible. It is therefore a challenge to find

Consequently, the methods and tools should play a crucial support role in many aspects of Innovation Management and Strategic Product Planning. It should be almost unnecessary to emphasize that, while there are some principle methodological aspects without the direct need to be executed on a computer, Information Technology is at the focus of and the principal means for Information Management. Especially with knowledge retrieval as a vital factor of this activity. However, where on short term the brain of participants may be able to compensate the abilities of an IT System, on the long-term storing, retrieving and considering large amounts of data and information requires the use of computer systems.

The literature on information management is endless, and the field is extensive. Examples would be: (Pietsch, et al., 2004), (Hildebrand, 2001), or (Matthes, 2011), with the last source covering over fifty conceptual frameworks, meant to structure, organize, and enable the automation of information management efforts within an organization.

2.1.4 Summary

For Innovation Management, the thematic focus is on initializing and fostering innovation – doing something novel/better in general. Strategic planning implies that the planning horizon is further in the future and that the abstraction level of planning is accordingly high and consequently imprecise. Product planning is concerned with the conceptualization and development of products and services. Lastly, portfolio management is concerned with the circumstance that at any given point in time, many development efforts[16] exist in parallel and that these must be coordinated and managed comparatively, due to resource limitations in an overall organizational context.

according dynamic concepts, structures, and tools, and to make them usable for supporting people without confining them within too strict boundaries.

[16] For many sources, “effort” equals “project”. However, as it will late be discussed this is not always the case.

Additionally, it has been discussed that there are many different concepts for methods or tools employed in all of these domains. Some may be employable only in a specific context while others may be so general, that they are being used within several conceptual frameworks (e.g., classic brainstorming).

All of these aspects need to be addressed and bound together in a holistic processing concept, despite the multitude of different canonical theory sets and their somewhat overlapping, often very similar, set of vocabulary. This concept should allow understanding of Strategic Product Planning as a complex socio-technical system, involving the interaction of people, technology, and information.

Such a concept has not been described satisfactorily by existing approaches – as will be analyzed in the following chapters. Therefore a better alternative will be developed.

2.2 Process Concepts

As introduced in chapter 1, the original problem of this thesis was the need to create a referential methodology and IT tool to support the execution of Strategic Product Planning.

The central hypothesis and – as will be shown – the core problem for generating such an IT-system, lies within the applied fundamental **thinking and description approaches for processes** in general.

Therefore, in this section, several standard approaches and state-of-the-art concepts about how processes are thought about, and how they are being described and argued with, are introduced.

2.2.1 Process Thinking Concepts

In order to understand the main result of this thesis, it is essential to understand the principle differences between the classical way that processes are described in order to share knowledge about related actions and events.

2.2.1.1 A Process?

In dictionary terms, the word "process" can refer to several things: "a natural phenomenon marked by gradual changes that lead toward a particular result", "a continuing natural or biological activity or function", "a series of actions or operations conducing to an end", "a continuous operation or treatment especially in manufacture", "the whole course of proceedings in a legal action", or "a prominent or projecting part of an organism or organic structure" (Merriam Webster, 2015).

This brief list already demonstrates the broad range of interpretations this simple word may have and many authors concerned with the topic of "process" have their own thoughtful and precise definition that may seem similar but often differ in some details from each other.

A look at the according Wikipedia entry (Wikipedia: Process, 2015) already shows that a single thesis could be written about that subject alone, differing between the many definitions in the different fields of science, or at least between the domains of business, manufacturing, computing, and general process science that are of more relevance here.

The following definition for the term "process" tries to capture and summaries the most common aspects as used in the domains that are covered in this thesis:

> **Definition 1**: a '**process'** is an abstract concept, representing the idea, that certain consecutive or parallel, observable events, actions of actors, or states of objects, are related in some logical-causal and/or time-dependent way. (Note: sometimes not even an action itself may be observed, but only a result of an action.)

> **Definition 2**: Thus, the concept of "**process**" gives us the ability to think and communicate about 'a process' **(process thinking**), which subsequently leads to the idea of influencing (changing, managing, designing) the process in a way that the 'result' is favorable for the influencing party. That, in turn, is the core essence of process management.

However, not all processes are manageable. The first definition holds for all kind of processes, be they governed by natural laws such as physical or chemical transformations, be they biological growth process of plants and animals, or be it processes of political or juristic nature.

However, since this thesis is ground in the domain of engineering, the processes of interest, are manageable. They are concerned with the behavior of machines and production systems, or the processes of people developing and designing products and services and the according production processes. These types of process fall into the particular class of **business processes**.

The definitions for the term business process range from rather short statements like *“Business Processes are being created from associated sequence for the purpose of value creation“* (Scheer, 1998) to longer statements of, e.g., (Staud, 2006): (translated) *“a business process consists of a connected, terminating sequence of activities necessary for the fulfillment of a business task. The tasks require certain production factors and are executed by task managers that themselves are organized in different structural units. The execution of the business process is being supported by the Information and communication system (ICS) of a company.”*

These statements do not explicitly include general administrative processes of organizations that are not geared towards value creation (e.g., public administrations or non-profit-organization). Still, they conduct processes for their “business” with action sequences aimed to foster an organization's general goal. Due to their principle similarity, these types of processes can also be considered as business processes.

This leads to the following definition for the term business process:

> **Definition 3:** a **‘business process’** is a process occurring or being executed within an organization composed of human beings and (Information) technology systems, in order to foster that organizations goal.

For the engineering domain, a particular class of business processes is that of production processes.

When the term “production process” is referring to an overall organizational goal of coordinating many different humans, machines, or even whole factories and transportation systems, it can be considered a “business process”.

However, the term “production process” may also refer to, e.g., the milling of a single block of metal on a specialized machine, or the printing of a component on with a 3D printer. This type of production process consideration is abstraction-vise very close to the actual physical level and with mostly physical constraints (e.g., used material, the power of drills, etc.). It does not fall in the category of business processes.

In-between both abstraction levels, the broad general view on production and the elemental physical level, there is not always a precise definition if a production process concept can be considered a business process or not. In reality, both considerations happen at the same time and in congruence with each other.

2.2.1.2 The Standard Process Concept

Naturally, processes, and especially those processes that can be considered business processes, are of importance for humans and a whole management research discipline exists that is concerned with them (see section 2.2.2).

However, in order to manage, handle, and design processes, humans must have the means to communicate about them. That implies describing and noting them down: the means to model them.

In turn, the foundation for that is a basic comprehension concept for thinking and describing a process. For most approaches, that is the basic Input-Task-Output model depicted in Figure 13.

Standard Concept

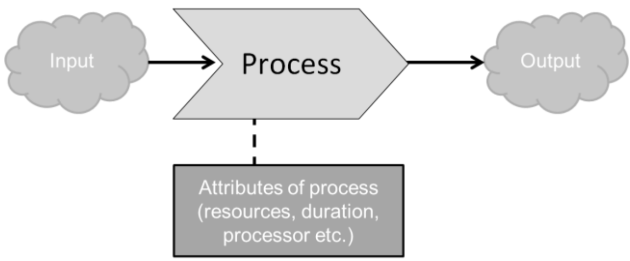


Figure 13: Standard Input-Task-Output concept of a process

With little variation that concept is proposed among others, e.g., by (Koch, 2015, p. 2), (Fischermanns, 2009), (Obermeier, et al., 2014), (Füermann, 2014, p. 1) (Schmelzer, et al., 2008).

As visualized, the base assumption in the standard process concept is that of a **task** or **activity** that has a defined **input** and results in an **output**. These inputs and outputs are often, and especially in production processes, defined to be a material object but also, as (Schmelzer, et al., 2008) note, could refer to results of services rendered for a customer. More into the direction of business processes, (Hammer, et al., 2003) for example define*: „We define a process as a collection of activities that take one or more kinds of input and create an output that is of value for the customer".* The interpretation of what that input and output really are, physical or immaterial, is left up to the reader.

Typical examples of physical input or output objects are, as mentioned, production materials and parts, e.g., a raw metal block that is milled and turned into a machined output component. Immaterial input or output objects of processes or process steps are usually information artifacts in the form of digital documents, e.g., a list of requirements noted down in an excel sheet or similar.

In variants of, e.g., the process notation "Event-Driven Process Chain" (EPC) (Scheer, 2002), the main input and output of tasks are so-called "events" that are generated and perceived. Events may trigger follow-up process steps. Information and physical objects merely support the process flow in that input-task-output description concept.

Any type of these additional information or **attributes** of process steps can be attached to the process description. As in the case of EPC, these attributes may describe physical objects or immaterial information that function as required resources for the process but are not explicitly considered as the main input and output elements. Also, further information may be attached, regarding, e.g., the planned or required processing time, or the intended processor or processing machine meant to execute a process step.

Abstraction concepts

The fundamental process concept is tied to three inherent mechanisms to compose descriptions that are more complex.

First is the straightforward concept of interpreting the output of one process as input for another, effectively **chaining processes** and thereby describing a more extensive process in which the individual tasks are considered as **process steps** within a process chain rather than individual processes.

Figure 14: Chaining process steps with input and output (linear sequence)

The second mechanism is the **sub-process concept:** It allows specifying process steps or chains as more detailed (sub) elements of a more extensive, more general process description. The relationship between a described process and its sub-process may be either that: sub-process further specify the details of their super-process. The other way around a super-process can be considered the summary its sub-process.

The mechanism is one way to create connected complex process descriptions that can hide their more detailed sub-process when discussing aspects that are on a higher abstraction level where only the top-level general process descriptions are sufficient to support the information exchange. In such cases, too much detail may even hamper the discussion.

Excursion: Top-Down vs. Bottom-Up

The abstraction or sub-process concept is related to two principles or approaches concerned with the creation of process descriptions.

When a **top-down** principle is applied, the first thing described or defined is the general, abstract super-process at the top of the sub-process super-process hierarchy. In turn and at a later point in time the sub-process will be further detailed out but must fit logically into the concept spanned by their super-process. This is more common for process models describing new processes.

In a **bottom-up** scenario, the process description starts with the description of the most detailed steps. Afterward, it is tried to summarize multiple process-steps by one super-process. Bottom-up is more likely to be employed when trying to precisely describe what is already going on in a scenario without caring for formally specific super-process classifications.

The result may in both cases be the same, yet this is unlikely because such kind of general and always valid classification of sub-super-process relations can rarely be done right on the first try when no previous knowledge about the process structure exists. In a top-down approach, when the first classification is not ideal, this may lead to different descriptions for the lower tier process that indeed fit the super-process structure, but are not able to depict the complexity of what is to be done during execution.

Equally, in a bottom-up approach, it may be hard to find suitable summarizing descriptions that allow generalizing a given set of tasks in a way that also their super-processes can be linked consistently.

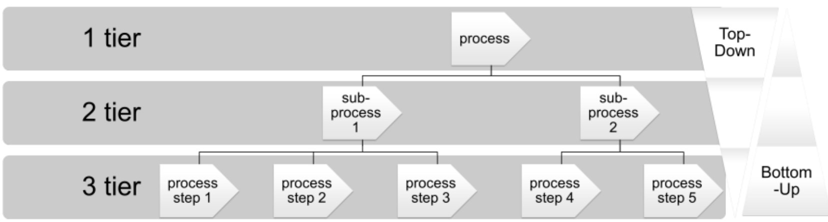


Figure 15: Top-Down vs. Bottom-up + (Sub-) Process Hierarchy Concept

The third concept is that of **multiple in- and outputs** for process steps as shown in Figure 16.

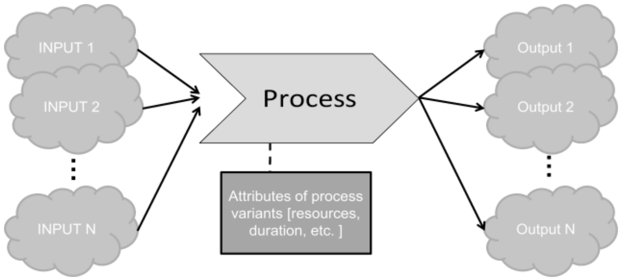


Figure 16: Multiple In- and Output – interpretation possibilities: AND, OR, or both?

Logically simple, it may describe the circumstance that multiple inputs are needed to create multiple outputs at the same time (input 1 AND input 2 AND …). This interpretation makes it harder to visualize the process in two dimensions, especially if more than two in- and outputs are considered. Linking all defined elements to other processes will not yield a sequential process description but rather a complex network with overlapping flow description when depicted graphically.

In a more abstract description, this concept may be interpreted as a specification for several alternative in- and outputs in a process step (input 1 OR input 2 OR …). This inclusion of alternatives into the description is usually done when a general process description is to be reused or referred to in several other process description in order to denote the commonalities between them and with the option to maintain and change a common description in a centralized manner. E.g., the coating of a car body may be done with either black or red color optional inputs, but due to chemical behavior the drying time for black may be shorter than with the red paint and as such the follow-up process may vary in length.

Graphical depiction of an actual process may be simpler when only one in- or output is used in a concrete case. Nevertheless, optional definitions usually lead to different behavior "within" the process, and that differing must be described either in sub-processes that in turn also need to become more complex in order to handle the variants or the variation at least must be captured in elaborate attribute descriptions.

Most process notation (see next section) have means to specify whether alternative (OR, XOR) relations are defined for a process, or if the combination of all inputs is required to define all output (AND relation). Prominently to name here is again the Event-Driven Process Chain (Scheer, 2002).

2.2.1.3 Process Notations

Thinking about processes is rarely is done without the intent to share the thoughts with other persons. To do so, process description, including their linking, sub-process relations alternative or multiple inputs, must be written down in one notation or another[17].

Following (Börger, 2012-2), *“the three major purposes of business process descriptions”, are “model design and analysis (requiring accurate conceptual models in particular for high-level development and management support)”, “model implementation, where the models play the role of the specification of software requirements and are transformed into executable models”, and the “use of models (user model for process execution, monitoring and management)”.*

However, there is a wide range of possibilities to express and describe processes.

Human Language and Written Text
The most common tool used to describe and discuss information about processes is human language in verbal communication and its non-time-

[17] Naturally, the act of creating process descriptions is in itself a complex, multi-person involving, possibly long lasting, and resource consuming activity with a variety of factors that may have an influence on the outcome or quality of the process description. However, this thesis is more concerned with the structure and concept of process models of SPP instead of their genesis process and therefore does not cover the details or complexity of this topic. For further detail about this topic, refer to the early work (Elstermann, 2010).

variant version, the written text. Supposedly understood by any member of a culture-language circle, it is the first choice to convey information to another human being, be it an explanation or instruction.

A simple subject-verb-object (SVO) sentence such as “the worker fastens the screw” is the simplest description of a process. This structure, or the even more common subject, object, verb (SOV)[18] conveys all essential information about a process or action: the actual actor, or processor, the action that is being performed, and the object that the action is being done to. Of course, more complex processes require more complex structures to express them, and most modern languages offer a wide range of concepts to specify more details or clarify aspect. Examples are conditional sentences, adverbial and relative clauses, passive constructs or differentiation in time and appeal aspects. E.g. “the copper screws, prepared by the supporter”, or “when the worker has fastened screw, and if this has been tested and verified, the new construction can be used”.

Since explanation is time-consuming and may be tedious, process descriptions may be shortened by leaving out details if they are, supposedly, common knowledge in a given context. E.g., that “the screw comes in a plastic bag and needs unpacking” is unnecessary information for workers with the actual object in front of them. Another example for the possibilities of creating descriptions that are more compact would be of passive voice to describe a process, as was the case with the “screw to be tested”.

When and which information can be left out of an explicit description and which is necessary, is up to the person creating the process description and what prior knowledge he or she expects of the recipient of the description. In a conversation between well-accustomed co-workers, abbreviations and omitted actors would be unproblematic because everyone is “on the same page” knowledge-wise. However, naturally, the more im-

[18] More than half of the world’s languages have a subject-object-verb (SOV) structure. Among them Turkish or Japanese or Latin. Roughly 30% have the subject-verb-object (SVO) structure e.g. the English or German languages (Dryer, 2017)

plicit or implicated information is conveyed in a sentence, the more difficult it becomes for an external person without extensive knowledge about the circumstances to fully understand a process description or any description at all.

> **Definition 4: Implicit Information** or **knowledge** – information that that is not explicitly given in a description (text, model, etc.). It is necessary to understand a described context but left out because it is considered "common knowledge" or "trivial to derive" by the person giving the information.

Supposedly, the big advantage of describing processes in natural language is that everybody in a particular cultural or language setting can understand it. However, natural languages are not perfect and the quality of information exchange depends on the language skill of encoder and decoder. Even when both are aware of the given context (e.g., culture or company context) communication between them is likely to be error-prone. If that level of perfect understanding is not the case, natural language description may be full of errors, ambiguities, inconsistencies, and incompleteness[19].

Errors can range from simple grammar[20], spelling, or punctuation mistakes, to wrongly used vocabulary[21], to more complex problems stemming from the existence of homonyms, synonyms, abbreviations or grammatical constructions with ambiguous and or dual meaning, to name just a few sources of problems that may lead to inaccuracies and misunderstandings in process or any description in general.

---

[19] Following the conceptual descriptions of Schulz von Thun in his "Four-sides model" (Schulz von Thun, 1981).

[20] "Simple Grammar" mistakes is a relative term, when complete grammar description of the English language in printed form may have measurements of 10 by 8.5.by 2.8 inches and is roughly 1779 pages long in a small font (Quirk, Greenbaum, Leech, & Svartvik, 1999).

[21] From personal experience the story of senior editor with Ph.D. at a large German software company can be given, who used the term "legacy system" to refer to every 3rd party software be it old or new not being aware of the implication of the vocabulary "legacy".

Freestyle graphical notations

Two-dimensional (2D) pictures and pictograms can be strong information carriers and are often used to support textual descriptions or even substitute them if an audience for information is illicit. Unsurprisingly, many process descriptions are accompanied by or consist entirely of pictures and drawings that try to give information about a sequence of actions or process in order to alleviate the drawbacks of natural language descriptions.

Figure 14 is an excellent example for a freestyle kind of drawing with typical but not necessary feature such as arrows to point the flow of things like clouds to depict entities or objects different from the tasks that are being depicted as (chevron-shaped e.g. Figure 13) blocks, denoting a flow of action from left to right.

Style and form of such graphical notations are only limited by the human imagination[22], and so is their interpretation, as it is up to the reader or the accompanying text to clarify the meaning of the symbols.

Formal and Semi-Formal Graphical Process Modeling Notations

(Elstermann, et al., 2016) discuss the problem an IT system would have when trying to conceive precise (formal) instructions from a natural language text. Even with the most sophisticated language processing technology, it is impossible to do so without any mistakes, mostly due to the ambiguities of the human language. Freestyle graphical notations are barely better.

However, instructions for IT-systems must adhere to a formalism in order to guarantee their consistency. Classically, that would be done via programming using programming languages. While in principle source code

[22] Or up to the extent of the standard shape pallet of IT-Office tools such as Microsoft PowerPoint.

is a processual instruction for a computer and therefore could be considered as process description language, the term formal process modeling language is used in a different context.

For formally defined languages (e.g., programming languages, or mathematical script) parsing and compiling[23] is a rather simple task since the rules that define valid words and valid sentences are specified in a precise, well-defined, and short[24] manner.

> **Definition 5: Semi-Formal Process Model** – a process model adhering to a modeling language specification that is given in non-mathematical, formal means (e.g., natural language). Even though adhering to a standard, a semi-formal model cannot formally be checked, due to the lack of formal mathematical foundations. It can also not be instantiated and run in a process engine.

> **Definition 6:** A **Formal Process Model** is a process description that adheres to a precise formal/mathematical language specification. Given the right IT-Tools and adequate evaluation tools, the syntax of a process model can be verified.

> **Definition 7:** A **Graphical Process Model** is a process model expressed using various graphical elements (e.g., boxes and arrows) to define human legible diagrams that represent processes. Usually, it is supposed that the graphical notation helps to describe and discuss more complex process than would be possible without a graphical notation, due to the limits of human expressiveness.

[23] The automated activity translating from a human readable textual or graphical representation into an executable machine script that is that contains the actual instructions for an IT system.

[24] For comparison with the grammar of the English language: for the Java Programming language the according specification PDF (standard Din A4 with 13.5 Point Text font) is "merely" 788 pages, including extensive explanations, examples, legal disclaimer and prefaces (Gosling, et al., 2015).

Definition 8: A **Formal Graphical Process Model** description that adheres to a precise formal/mathematical language specification and has a precise graphical notation.

There is a myriad of formal, semiformal, and graphical description languages for processes. In the next pages, a few more prominent examples are introduced and briefly discussed.

Flowcharts

One of the oldest and most commonly used versions in engineering is the **Flowchart** that has already been proposed in 1921 (Gilbreth, et al., 1921). A German Industry Standard Norm with the same focus has been proposed in 1966 (DIN 66001, 1966) with its latest increment in 1983.

Flowcharts are collections of symbols that can be used to describe the temporal flow of activities as shown in Figure 17.

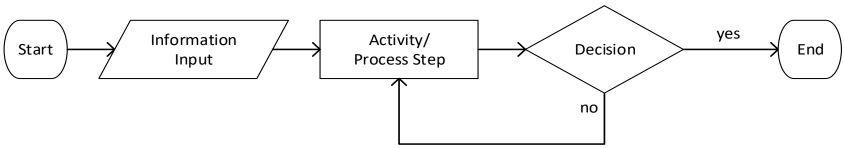


Figure 17: Simple Exemplary Flowchart (DIN 66001, 1966)

Flowcharts do not contain the inherent expressive power to formalize parallel activities and are otherwise rather informal. Due to their widespread and longtime usage, many professionals have encountered flowcharts in one form or another in their life. Often examples of freestyle notations that can be encountered are based on the flowchart symbols and semantics but rarely comply with the standard. So while pure standard-conform Flowcharts could be considered a formal approach, their lack in expressiveness and their missing formal mathematical definition, makes them semi-formal at best.

UML-Activity Diagrams

Seemingly very similar, but with a formal, Petri-Net based formalism behind them are UML-Activity Diagrams, as one of the 14 Diagram types that make up the Unified Modeling Language (UML) (Object Management Group, 2005).

While Flowcharts originally were meant to describe processes in general and every domain. UML Activity Diagrams were explicitly conceived to describe the inner workings of computer programs and to be used in context the object-oriented modeling and programming paradigm. They share the diamond shapes as decision or split (OR-XOR) split, but also contain symbols that explicitly state and AND-split for parallel execution of the workflow.

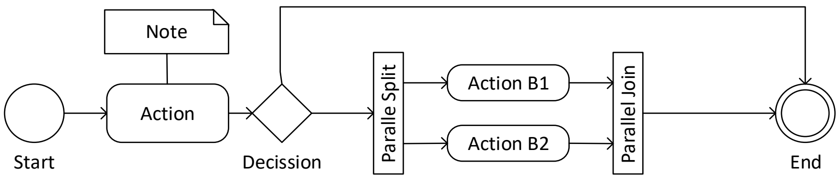


Figure 18: Exemplary UML 2.1 Activity Diagram based on the official standard (Object Management Group, 2005)

Event-Driven Process Chains

Another type of process description are the so-called Event-Driven Process Chains (EPC), as an integral part of the Architecture for Integrated Information Systems (ARIS) concept of (Scheer, 1998) & (Scheer, 2002). EPCs have found widespread use in the Industry roughly since the middle of the 1990s and are used primarily by larger companies (Morelli, 2010) (Rump, 1999).

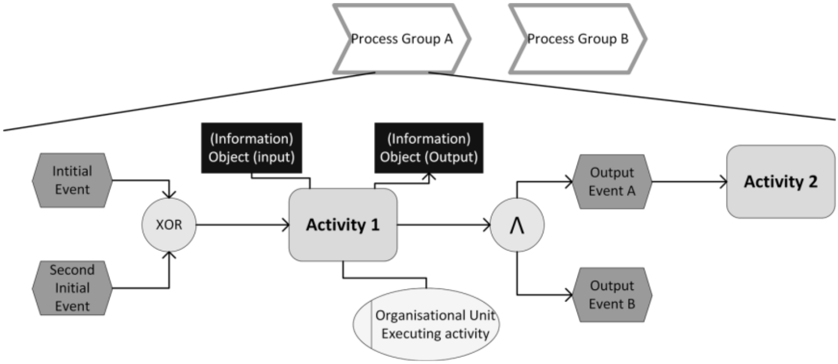


Figure 19: Example model with Event-Driven Process Chains (EPC)

As shown in (Figure 19), with EPCs the workflow is described as a sequence of activities (rectangles with round edges) that are triggered by input events (hexagon shapes) and in turn create other output events. Optional information blocks may denote the involved organizational unit (ellipses) or (information) objects that are necessary to execute the described activity (rectangles). Equally, created (information) objects may be defined as outcome or output. The actual process description, though, is never directly dependent on the objects and only the chain of activities and events is relevant for the process flow.

Next to the actual description concept, workflows can be summarized in process groups that in turn are grouped in so-called process-landscape-descriptions, containing multiple of the chevron-arrow-process hierarchy concept process-landscape descriptions can also be further summarized by other process landscape descriptions that are on a higher abstraction level.

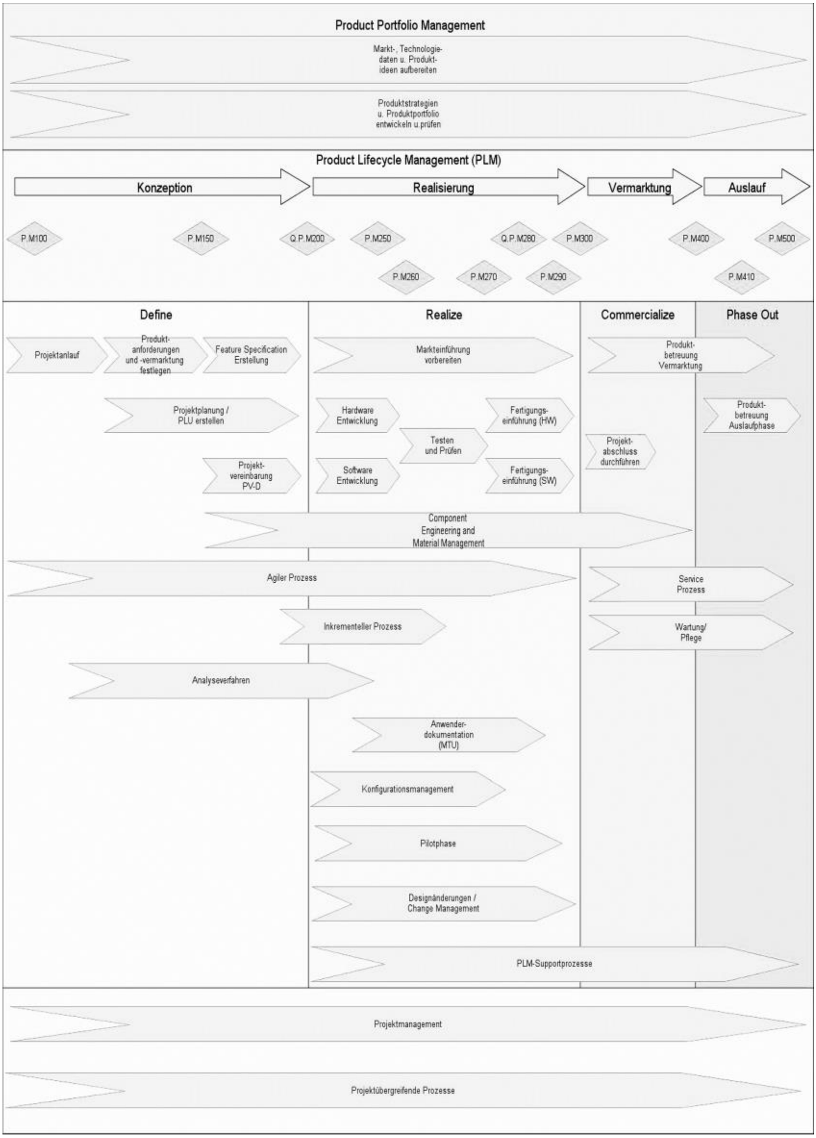


Figure 20: ARIS process landscape for (only) the product lifecycle management based development domain of single division of a larger German engineering & manufacturing company (real-life example)

Business Process Model and Notation
In recent years, starting in 2004, and the Business Process Model and Notation (BPMN) currently in version 2.0 (Object Management Group , 2011). It is a widespread process-modeling notation supported and employed by many larger IT companies, such as Oracle, IBM or Microsoft in their products[25]. Even the ARIS Express modeler of Software AG, formally a pure EPC modeling tool, can be used to describe BPMN models (Software AG, 2018) (Chinosi, et al., 2012).

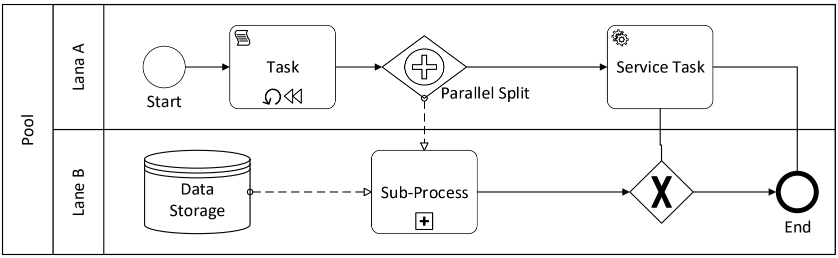


Figure 21: Example BPMN Workflow Description

BPMN is very extensive and comes with formal specifications for execution. While in theory very powerful and widely accepted and therefore with a tendency to be described as the state-of-the-art best solution, there are a few drawbacks.

Most significant is the complexity that BPMN Models may have. BPMN 1.2 already had 55 symbols of which a typical modeler uses only a fraction (20%) according to (zur Muehlen, et al., 2008), which raised the question "How much language is enough?" or "How much BPMN do you need?" Many elements are simply not used very often. Nevertheless, the BPMN 2.0 standard currently features 116 different graphical elements with individual semantics meant to be used in special circumstances.

[25] E.g. process definition for Microsoft SharePoint solutions can be done using BPMN descriptions.

Despite the number of elements and formal standardization efforts, still critics like (Börger, 2012-2) claim that the so-called standard contains "numerous ambiguities" and "under specifications" that leave "many things open especially regarding the execution". Still, BPMN is usually as a formal process modeling approach

OMEGA Notation

The last notation to be introduced is the OMEGA[26]-process modeling. It is not a formal notation in the sense that it lacks a mathematical or formal definition for model syntax or interpretation. It was conceived by (Fahrwinkel, 1995) at the University of Paderborn, Germany, with the focus on having the means to easily communicate with stakeholders and process participants about the procedures in a given organizational context.

At the core of the OMEGA notation are also the familiar chevron shaped process arrows, denoting processes or activities that take input or generate outputs in the form of objects of various concepts. There are several specialized symbols to differentiate between several types of objects explicitly. Among the object categories are material objects, paper information objects, (transient) verbal information objects, or explicit IT information objects. In addition, the storage of these objects can be denoted via symbols correlated to the different types. Activities are to be contained in box marking the organizational unit responsible for it, which is simply another form of annotation.

As with the previously introduced process notations, the principle process flow is defined by the chaining of the process steps with generated objects as input/output definitions. The flow may be split up or joined with AND, OR and XOR splits and joins.

Objects generated outside the overall process description scope should originate from entities, that may be either part of or lie outside the organization for which the process is described.

[26] (**O**bject-oriented **Me**thod for Business Process (Ger: **G**eschäftsprozess) **A**nalysis)

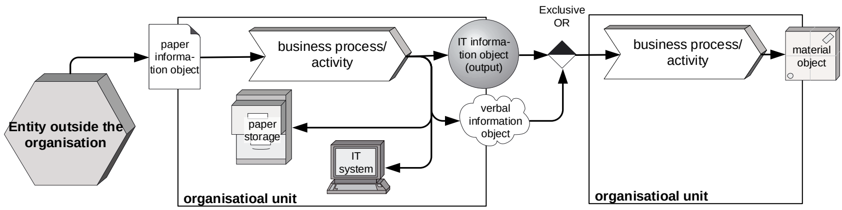


Figure 22: Example Process Model with elements from OMEGA Notation (Fahrwinkel, 1995)

The OMEGA business process notation can be used to describe processes on several abstraction levels that are aligned with a company's organizational hierarchy as depicted in Figure 23.

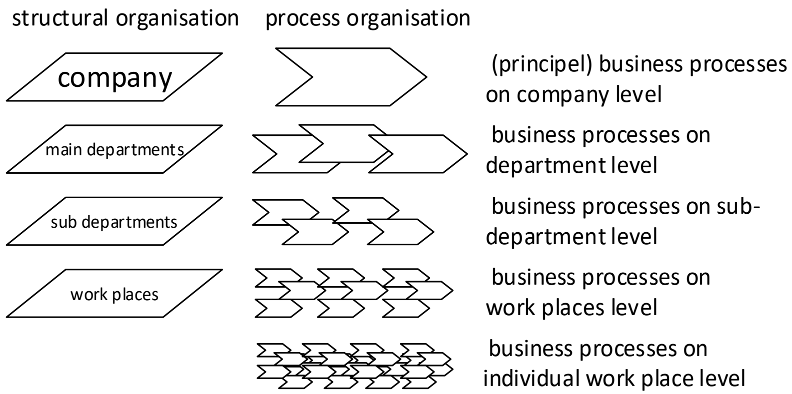


Figure 23: Defined Abstraction Levels (Fahrwinkel, 1995)

Even if not explicitly stated, the depiction given for the different abstraction levels implicates the standard sub-process hierarchy concept that contains more precise descriptions on lower abstraction levels.

Excursion: Swim Lanes and Pools
All notations introduced here (but especially BPMN, as seen in Figure 21) feature the possibility to define so-called swim lanes.

> **Definition 9:** A **Swim Lane** is a graphical partition in a two-dimensional process description that denotes that every activity or tasked modeled to be within that swim lane is bound to be executed by the same entity or responsible party.

The *pool* concept seen in Figure 21 combines several lanes, it goes beyond the swim lane concepts. However, even with a pool present, the swim lane itself is rarely more than an additional structuring concept. The constituting concept, even when swim lanes are employed, still is the flow of activities in general.

The concept itself is almost as old as the idea of flow charts in general, supposedly with descriptions as early as 1945 (Executive Office of the president bureau of the budget, 1945).

Intermediate Conclusion

Several different process notations have been introduced, but there are even more languages and notations that could be discussed. Noteworthy examples include Petri-Nets (Oberweis, 1996) or YAWL (The YAWL Foundation, 2017) (Börger, 2012-2). Furthermore, only graphical modeling languages with digital representation have been discussed. This excludes machine-code like the (Web-Service) Business Process Execution Language (WS-BPEL) (OASIS, 2007) that has a formal definition but is explicitly meant to convey information to a computer system and therefore was not considered.

In any case, all Languages have one thing in common: their modeling more or less follows the input-task-output concept. Some have swim lane concepts that allow grouping tasks and functions, but mostly only as a structuring mechanism. The general flow of activities is still procedurally oriented.

Objects are considered, at least implicitly, by all notations, may they be physical or conceptual and carrying information. However, while the notion of handling objects may lead one to consider them as object-oriented, that statement should be disputed. The introduced languages are meant for the description of processes. They do not allow more than the mere specification of an object's existence. Classical concepts of object-orientation (Meyer, 1997), most importantly, aspects like inheritance or polymorphism, do not exist formally for the objects[27] and even less for the process description itself (also see the excursion on Object-Oriented process modeling).

2.2.1.4 Referential Process Models

After analyzing means and concepts for describing processes, the question not answered completely is what the process descriptions – read: process models – will be used for.

"The principle function of business process modeling is, to standardize and depict the abstract process of interaction between humans and/or other system elements, with the overall goal to focus a user on a relevant partition of the, often rather complex, reality. The content of the resulting models are the processes as well as the involved personal and other actors, such as, e.g., departments, machines, other technical resources, exchanged material as well as information." (Gausemeier & Plass, 2014, p. 245)

In general, it can be stated that process models serve as instructions to execute the processes they describe in one way or another. These instructions require an implicit execution system to be run.

A human organization can be considered as such a system, where the process models are, as mentioned, used as means in the communication between people, hopefully, by providing a better understanding for experienced organization members, and guideline for new members who will perform and execute tasks described in the model.

[27] The UML-activity diagrams are somewhat an exemption to that, due to them being part of the larger UML context that has multiple means to express and define classes, objects and all possible forms of relations that are fundamental in OO. Activity Diagrams themselves though are not object-oriented.

Process models can be created either for specific organizations and situation, or they can be created to give a general overview of a knowledge domain of expertise such a Strategic Product Planning. Such models can be called referential process models.

> **Definition 10**: **Referential Process Model** for a non-specific target audience with the goal to give a general understanding of the tasks and workflows of its domain. Its goal is to allow organizations to refer to the model and derive their specific versions tailored to their needs and requirements.

When a referential process model is supposed to be only read by humans, it may be done in any, seemingly feasible way, as long as the potential readers can decipher the statements and meanings and can organize themselves to execute the process they derive from the referential model. .However, also a technical system, be it mechanical machines or computer system can be considered, an execution system for processes described in models. In that case, execution of process models becomes another question.

2.2.1.5 Automatic Execution of Process Models

Often nowadays, the system executing (especially business) processes is a mix of humans, machines, objects, and the information exchanged between them: a so-called socio-technical system as will be the case for the system that will execute Strategic Product Planning based on the referential process model conceived in this thesis. While the human members of socio-technical systems can cope with a wide range of modeled process execution instructions, the technical components cannot.

Direct and Indirect Execution

When only, informal or semi-formal process descriptions are available, a human being as intermediary must take the process model and translate it during the creation of the technical system. E.g., a programmer must take the textual or graphical representation and create source code for a software system that contains the essence of the initially described process and can support the human participants using the software to support the execution of the process. This activity is a typical form of standard requirement analysis. However, as any informal information transformation, this is error-prone as details or aspects may be lost in translation[28].

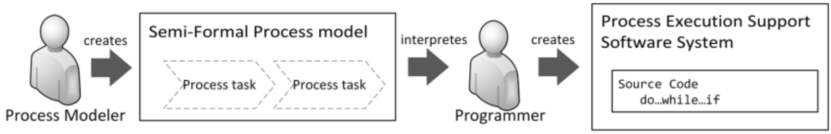


Figure 24: Indirect Execution of Process Models in a Software System (error-prone)

> **Definition 11: Indirect Execution** model means that a software system that is supposed to support the execution of the process is being programmed according to the specifications of the model, as interpreted by its human creator.

For computer-based systems there is another option: the direct execution of process models – if the models are available in a formal, machine-readable format, and the process execution control system has a program or software component that can load and interpret the model: a workflow engine.

As (Karagiannis, et al., 2008) put it: *"One possible application of business process models is to use them for the configuration of workflow engines that in turn control or support the (semi-)automated execution of business processes. In order to be useful, such workflow engines have to be able to determine which option in the context of decisions has to be taken."*

[28] That was the case at the origin for this research, as described in the introduction.

Definition 12: A **Workflow Engine** is a computer program or system that is able to load formal, digital process models that adhere to a certain language description and use the models to guide and control the described process based on the given descriptions.

Definition 13: Direct Execution of a formal process model means that a formal process model is being loaded into and interpreted by a workflow engine that (semi)-automatically generates instructions and requests in order to control or support the execution of the modeled process

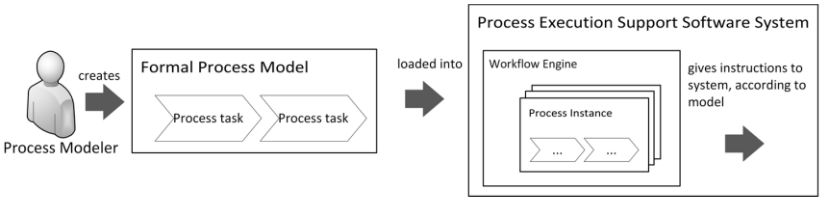


Figure 25: Direct execution of process models – execution via workflow engine

Process → Model→ Instance

Introducing the notion of model execution via a workflow engine requires distinguishing between the model and the data connected to its execution. A process model itself not the *"concrete realization or realization/execution of a (business) process"* as, e.g. (Rump, 1999) or (Staud, 2006, p. 9) put it.

The actual execution of a process the first is referred to a "process instance", a single incarnation of the process that is based on an according process model. This terminology also enables to differ between different "runs" of a process, namely different instances. E.g., in a company there may be several projects being executed at the same time, but each of these "instances" is based or run according to the same process description that specifies the duties and liberties a project officer may have or not in a given context. Each running project can be considered an instance of that single project process model. While in real life the term "instance" is rather rarely used, it is of much more importance in the IT context.

Definition 14: A **process instance** (or process model instance) is one of possibly many concrete realizations of or execution runs through a single process model, created by a workflow engine that executes the process model.

2.2.2 Process Related Concepts and Thoughts

The following sections cover terms related to process and process models used within this thesis. The terms will be discussed to clarify their meaning or correlation within the thesis and to avoid confusion for readers that may have encountered them in other slightly different contexts.

2.2.2.1 Process Types

Since the term '*process'* is often and widely used, it has developed several similar meanings in an industrial context. If not clearly distinguished, these may confuse readers. In consequence, for most parts of this text, it will be avoided to use the term *process* stand-alone. Instead, an attached description noun will be used to identifying the current concept explicitly.

The following three examples describe where and why this explicitness is necessary.

Development Process
In an organizational context with product development activities, the term "process" may refer to two different, but related concepts. They are easy to be distinguished if their complete definitions are given:

On is the "*development process"* of products or services, referring to the activities and tasks done by an organization to generate new concepts and plans for goods and services. The other is the "*production process"* necessary to produce physical goods or the "*provision process"* for services to be offered. The second is usually a result or outcome of the first, and thus they are easily distinguishable when stated with their full denomination. The term "*process development*" may refer, in principle, to both concepts, yet it seems to be more often refer to the development of the production process.

Additionally, in this context it may be noted, that there are possible differences in the scope that the term *production process* may implicate that are not comprehensible from the term itself but must be deducted from the context of its usage. The interpretation spectrum range includes a very holistic view on a complex logistic supply network that needs to be coordinated in order to just-in-time deliver right product elements to different assembly stations within the same factory building or even spread across various geographic locations. On the other end of the spectrum are processes executed by, e.g., an individual computer controlled (CNC) milling machine to produce a single type of physical good. Considerations about that kind of *production process* include the physical structure of materials or the thermodynamic behavior of tools and workpieces. It should be obvious, that those considerations are fundamentally different from considerations about the former type of production processes. For this thesis, the more general interpretation and its scope are more relevant.

Process Industry vs. Service Industry

The term 'process' is also a prominent part of the descriptor "*process industry*" – or more precisely the "*manufacturing process industry*"[29]. The term "*process industry*" though is neither a reference to consulting agencies specialized in supporting companies with their *business processes*, nor is the term a synonym for the non-producing *service sector* or *service industry* of an economy, that creates value by executing service processes instead of producing goods.

Instead, *"Process industry"* is a self-description term for a field of industrial engineering that is concerned with the design and construction of machines for the handling of chemical *production processes*. It is a domain where products are not moved in lots or individual units, but in pipelines

[29] The term "*process industry*" in itself seems to be more prevalent in German Language and according culture area. Internationally the term does not seem to be as prevalent, even though it is the direct translation of the German term "*Prozessindustrie*".

or tanks and a continuous flow in the right quantities or at the right temperatures must be guaranteed for a continuous running production process. See, e.g. (Fachverband Anlagenbau: Energie, Umwelt, Prozessindustrie, 2017) (Fraunhofer IPA, 2017)

Business Process vs. Workflow

While the former two examples were about the dual usage of the term *process* for several concepts, this section is about an often-encountered arbitrary differing between two types of process descriptions*: Business Process* and *Workflow*.

Simply put, *workflow* is a term referring to a particular subset of processes in a working environment that involves activities and tasks related to the production of goods and services. With that definition, workflows may be understood as the sub-processes of a business process if an according hierarchical sup-super-model is applied. However, there is no clear 100% coherent definition for up to which level of abstraction a process description may be referred to as a workflow or what is required to qualify as a business process description. There only is a kind of soft, gradient distinction between the two concepts. Here, the spectrum ranges on the workflow side from very simple and linear process descriptions for rather atomic tasks that will be performed by single processors. Therefore, they often can be described precisely using formal modeling notation. On the other end on the business process side of the spectrum are complex, nonlinear, highly abstract organizational processes that are not easy to describe formally precise, especially, as will be seen, using a classical approach to process description. However, that is only a rule of thumb.

The primary purpose in this distinction is, supposedly, the necessity to differ between formally and precisely specified models and more generalized higher-level process models, without devaluating the later as "informal" and "imprecise" because of a free-form process description that may leave many aspects up to the interpreter of the description due to lack of specification.

As a proof for this considering it can be noted, that most formal languages used for workflow description like BPMN or EPCs refer to themselves as "*process modeling notations*" and not as "*workflow*" notations.

2.2.2.2 Business Process Management

In the context of literature on processes, often the keyword BPM is mentioned. It is referring to the management discipline of "Business Process Management", with whole books and many research papers written about it, e.g. (Weske, 2007) (van der Aalst, 2013).

Business Process Management (BPM) is a broad field and, following (Schmidt, 2009), has at least two aspect-dimensions to it: First as an economic management philosophy with consideration of factors like costs, time, or amounts of resources regarding the design and execution of processes. Secondly, BPM encompasses a technical aspect that is concerned with technologies, tools, and methods, to document and automate business processes or workflows – A task nowadays also referred to as digitalization as, e.g. (Lederer, et al., 2017) state.

In both cases, the modeling of processes is a crucial factor, for gaining a common understanding of current (AS-IS) processes or the planning of future process or process improvements. A common understanding either between the involved human beings or in order to map the processes directly or indirectly to an executing IT system.

2.2.3 Summary

Section 2.2 introduced and explained vocabulary typically used to describe processes, their management and their handling by people and machines. It was shown that a lot of vocabulary might be ambiguous or depending on the context. Even so, this section has provided working definitions for the terms that are going to be used within this thesis. Furthermore, the reader has gained a basic understanding of the traditional thinking and description approaches for processes in general. An in-depth analysis of these concepts as well as their consequences will be done later in section 3.1 as part of the methodology of this research. Before that, however, section 2.3 shall introduce the theoretical foundations and state of the art concept of another, different way of thinking about processes.

2.3 Subject-Orientation and Subject-Oriented Business Process Modeling

In the previous section, several process description concepts were introduced and discussed. Later in chapter 3, their drawbacks or weaknesses will be analyzed in more detail, yet the need for an alternative appears evident already or weaknesses and alternatives are necessary. One possible alternative researched and the one selected to further work with is the process-modeling paradigm of Subject-Orientation, conceived initially by (Fleischmann, 1994) and elaborated in (Fleischmann, 2011). The theoretical foundations and terminology of this state-of-the-art process modeling methodology are discussed here. The necessity and usefulness of its application will be derived and shown later in chapter 3.

2.3.1 Introduction

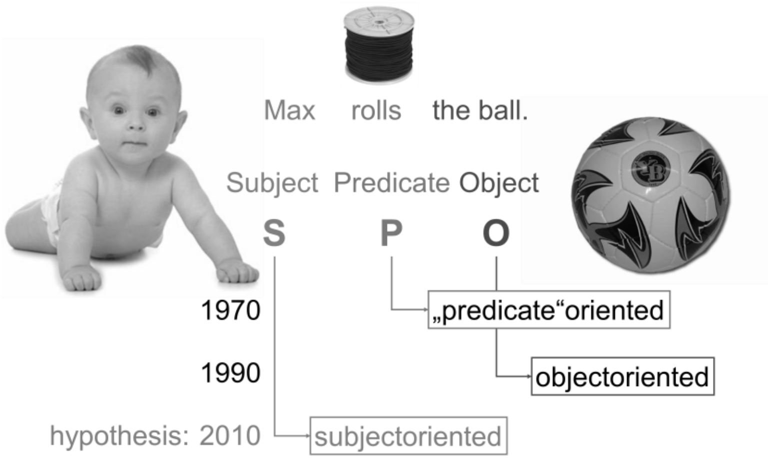


Figure 26: The principle of conveying information using human (English) language compared to description paradigms typical found in programming (from (Buchwald, 2009))

At the core of the Subject-Orientated Process Modeling Paradigm is the recognition that when humans convey information using natural language, the basic information units (sentences) require the structural, grammatical elements of *subject*, *object* and *predicates*/*verbs* (compare Human Language and Written Text in section 2.2.1 about process notations). Following (Buchwald, 2009), Figure 26 depicts how different modeling paradigms match to these elements.

However, that the subject of an activity is of importance to a process description is a not new insight. The ability to express the existence of active entities is immanent in various modeling concepts. Yet, as an in-depth analysis of (Schmidt, et al., 2009) in Figure 27 shows, with the exception of natural languages and the later introduced Parallel Activity Specification Shema (PASS), many of major process modeling approaches do not really embrace the notion and therefore lack expressiveness.

2.3.1.1 A Definition

Even if they are not embracing it completely, other approaches do cover the notion of subject, leading to the question of what Subject-Orientation is supposed to be and to the necessity to propose a definition for the paradigm itself, derived from the earlier cited sources:

> **Definition 15: Subject-Orientation** – a modeling or description paradigm for processes that is derived from the structure of natural languages. It requires the explicit and continuous consideration of active entities within the bounds of a process as the conceptual center of description. Active entities (subjects) and passive elements (objects) must always be distinguished and activities or task can only be described in the context of a subject. The interaction between subjects is of particular importance and must explicitly be described as exchange of information that cannot be omitted.

Considered Modeling Language	Development Paradigm	Consideration of Subject	Predicate/Verb	Object
Natural Languages	n.a.	●	●	●
Flow Charts	Function-oriented	○	●	○
Event driven Process Chains (EPC)	Function-oriented	○	●	○
Extended EPCs	Function-oriented	◔	●	◔
Entity Relationship Model (ERM)	Data-Oriented	○	○	●
Unified Modeling Language (UML)	Object-oriented	◔	●	●
Calculus of Communicating Systems (CSS)	Subject-oriented	●	◔	○
Business Process Modell and Notation (BPMN)	Function-oriented	◔	●	◔
Parallel Activity Specification Schema (PASS)	Subject-oriented	●	●	●

Figure 27: Explicit consideration of the language elements of subject, object, and predicates in various process modeling concepts (translated from (Schmidt, et al., 2009))

Where standard modeling approaches may also cover these elements, they are not oriented towards it. They do not require the explicit definition of a subject and a strict notational differentiation between subjects and objects. However, for true Subject-Orientation, subjects must be the initial and central element of a modeling activity, not an optional, secondary information.

It is this simple concept that sets Subject-Orientation apart from other process description approaches. This, however, profoundly challenges the perspective, perception and thinking about processes and process design. It is the primary factor that even fosters the possibility to translate process description from human language into a formal executable process model and reverse (Elstermann, et al., 2016).

2.3.1.2 S-BPM

In the context of Subject-Orientation, another keyword or acronym is often cited: S-BPM - Subject-Oriented Business Process Management.

> **Definition 16**: **Subject-Oriented Business Process Management** (S-BPM) – A process management discipline that is oriented towards and heavily incorporates the Subject-Orientated modeling paradigm for the purpose of restructuring and automation of business processes with a strong emphasis on involving all active stakeholders and participants for that task.

Therefore, while Subject-Orientation and the concept of S-BPM are closely related, they are not necessarily the same.

2.3.1.3 Subject-Based Modeling

Only if S-BPM is interpreted as Subject-Oriented Business Process *Modeling* instead of *Management*, the term may be understood as equivalent.

Describing processes in a subject-oriented manner requires specialized modeling languages. By employing the swim lane concept, it is possible to model processes similarly to a subject-orientation. However, as stated, most languages do not embrace the subject-oriented paradigm. As such, according models are at best described as *subject-based* instead of being fully *subject-oriented*.

Definition 17: Subject-Based Modeling – A definition for process models that follow the broad principles of subject-orientation, but without embracing a modeling notation that enforces the paradigm and therefore lacks the possibility of automation tool support and requires strict paradigm adherence by a modeler without the according tool support.

2.3.2 PASS

Currently, only the **Parallel Activity Specification Schema (PASS)**, conceived by Fleischman as an integral part of S-BPM can be considered a fully subject-oriented process-modeling notation (Fleischmann, 1994) (Fleischmann, 2011).

Definition 18: Parallel Activity Specification Schema (PASS) – a formal and graphical subject-oriented process modeling and description language consisting of two separate but interlinked diagram types called Subject Interaction Diagram (SID) and Subject Behavior Diagram (SBD). Due to the relatively widespread usage of the key term and PASS being the only dedicated subject-oriented process-modeling notation, PASS process models are often but mistakenly referred to as S-BPM diagrams.

In the following section, the modeling elements of standard PASS are defined as they are used for this thesis and as they have been included in a self-developed modeling tool for PASS based on Microsoft Visio and as incorporated into general exchange standard model on ontology basis developed in parallel with this thesis (Elstermann, 2017).

Beyond that, there are possibilities for extending PASS for more elaborated process modeling means, such as (Elstermann, et al., 2014). While being powerful abstraction concepts, those are not necessary for this thesis and will be subject in further research.

In principle, a PASS process model consists of one Subject-Interaction Diagram (SID) and several Subject-Behavior-Diagrams (SBD).

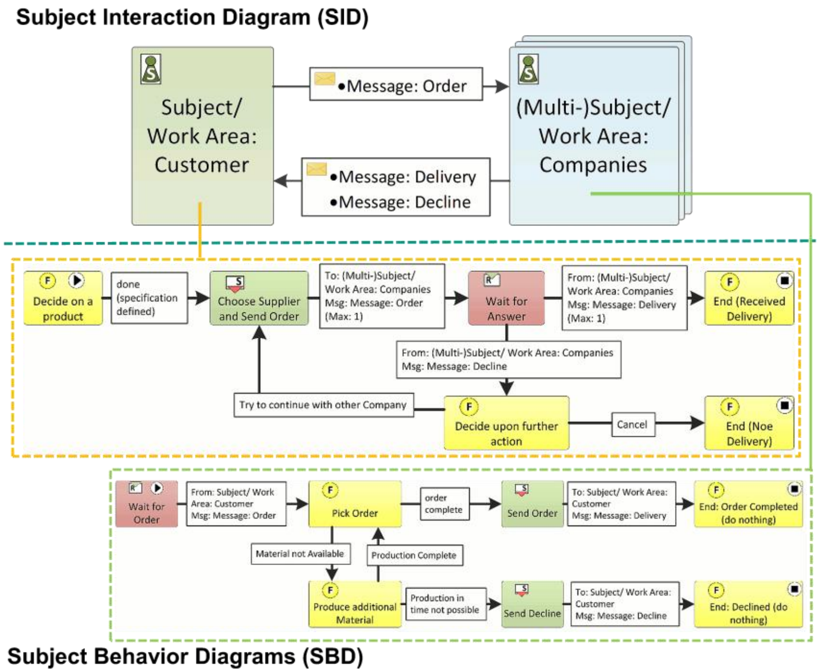


Figure 28: Example Process modeled in PASS with Subject Interaction Diagram (SID) and individual Subject Behavior Diagrams (SBD)[30]

2.3.2.1 Subject Interaction Diagram

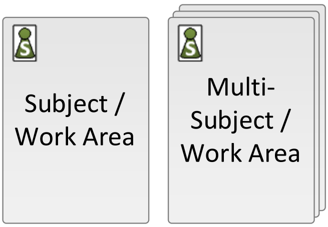
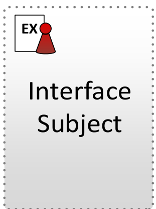
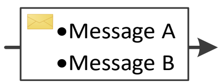
In accordance with the subject-oriented principle, any process model must first include a description of the involved active units or roles – the subjects – and the (information) objects or messages they may exchange. This type of definition is done in the Subject Interaction Diagram (SID).

> **Definition 19: Subject Interaction Diagram (SID)** – An initial definition diagram of the modeling language PASS. The SID defines the principal

[30] This figure as well as all other subject-oriented process models, including the referential model in this work, are being described using the general concepts of PASS in a graphical notation style. They were modeled with a self-developed S-BPM plug-in for Microsoft Office Visio as part of this thesis.

subjects and exchanged messages that may occur within in the modeled process.

Table 3: Principle Elements of Subject Interaction Diagrams

	(fully specified) **Subjects** define the active units or roles within a process. Each Subject possesses an individual Subject Behavior Diagram (SBD) denoting its workflow within a process. **Multi-Subject**s are subjects that may be instantiated multiple times within a process, implying that there may be several actors executing copies of the same behavior.
	**Interface Subjects** are subjects without specified behavior descriptions (black box). Behaviors may not be described if they are either unknown if they are not of importance to the model, e.g., if they are too simplistic or modeling would require more effort than the benefit it would bring. Alternatively, the behavior may be described in a separate model. In that case, the subject functions as the interface to the other model.
	**Message Exchanges** and **Messages** conveyed via a message exchange define the capabilities of one subject to send (information) objects to a receiving subject.

Except for the option to mark subjects that start without being triggered by other subjects, **an SID does not contain any temporal or causal information** about when or in what order the messages are being exchanged. It simply shows what kind of communication will occur in a given process. The following table contains an overview of all model elements used in the SID.

2.3.2.2 Subject Behavior Diagram

In PASS, the actual tasks or activities of a process and their temporal and or causal (work)flow are described in several individual **Subject Behavior Diagrams (SBD)** that exist for each fully specified subject appearing in the SID.

> **Definition 20: Subject Behavior Diagram (SBD)** – The second diagram type of the modeling language PASS. A single SBD describes the actions, interactions, and their temporal and causal flow of an individual subject defined in the corresponding Subject Interaction Diagram.

The blocks in SBDs are called **states**. A subject always is said to *be in* exactly one state at a time. Being "*in a state"* implies that the activity associated with the corresponding state is being executed. The arrows connecting the states are called **transitions** and show the possible follow-up states of a state. The transitions may be traveled if and only if the exit condition denoted on the transition is fulfilled during the execution of a state's activity.

There are two principal categories of states: action and interaction: **Function States** (yellow) denote that a subject is performing an activity, task or function that does not require input from other subjects. Function states are usually left via **Function Transitions** that denote the outcome of the state. The default exit condition is the simple notion that the activity or function of a state "has been finished" or is "done". They may also be called Do-States.

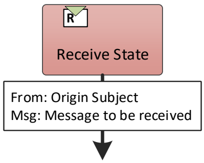
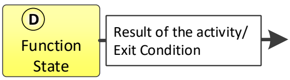
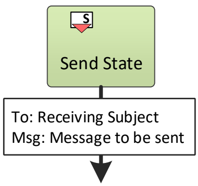
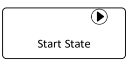
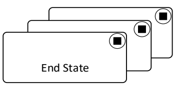
Send States (green) and **Receive States** (red) denote the interaction with other subjects. They are exited via corresponding **Send** and **Receive Transitions** that again denote the condition that must be fulfilled in order to leave the states. For Receive Transitions that is the active reception of a message from a defined sender. For Send Transitions, the exit condition is the completed transmission of the denoted message to the indicated recipient.

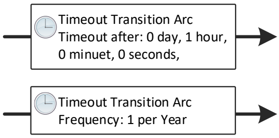
One and only one state in a Subject Behavior Diagram may be denoted as the Start or **Initial State** (). Any state type is eligible to become the initial state in an SBD. Equally, a state may be denoted to be an **End** or **Final State** (), but a Subject Behavior Diagram may have more than one Final State. This does not include Send States since there is no semantical meaning to stop in the middle of sending information to someone. Consequently, only Functions States and Receives States are defined to be End States. A process is considered finished when every subject is in or has reached a state denoted as End State. Nevertheless, it is important that in PASS an End State may be left again, either because of a subject's own decisions in case the end state is a Function State or when a message reactivates the subject if the final state is a receive state.

In addition, it is possible to model that waiting in a Receive State or the execution of Function States may be interrupted. This is expressed with a *User Cancel Transition,* implying an arbitrary user decision to overrule the default receive or function conditions. The other option are time-based events expressed with *Time Transitions*. *Time Transitions* come in two variants and denote either that a specific waiting duration has been expired after a state has been entered (Timer), or that a reoccurring frequency-based period has lapsed again (Reminder). Both types can be considered or are akin to the reception of messages from a non-explicit reminder or calendar subject.

Table 4 contains an overview of all elements to be encountered in an SBD.

Table 4: Overview Model Elements of Subject Behavior Diagrams

	**Receive State / Receive Transition:** These states describe that further progression in the behavior process requires input from another subject in the form of the messages. This is denoted on one of the ioutgoing receive transitions. Receive states usually imply waiting for input. Upon reception of the required input message, the flow of behavioral task may continue.
	**Function State/Function Transition:** Denote that a subject is doing a task or activity independently. Function transitions denote possible (conditional) outcomes of the state necessary to exit that state.
	**Send State + Send Transition:** A send state denotes the send of objects and/or information to another subject. It will be considered finished if the messages denoted on the subsequent send transition has been sent to the according recipient. In contrast, to receive and function states send states should only have a single outgoing send transition.
 	**Start and End States:** Each state in a subject may be denoted to be the single start state of a behavior. Similarly, a state can be denoted as one of multiple end states, which is limited to receive or function states.

<table>
<tr>
<td>
</td>
<td>Time Transitions denote that a state will be left due to time-based event akin to the reception of a message from a (non-explicit) timer or calendar subject. There are two general types of time-based events: transitions that trigger upon the expiration of a specific duration after the previous state has been entered (Timer) and reoccurring timeouts that are triggered regularly with a specific frequency (Reminder)</td>
</tr>
<tr>
<td>
</td>
<td>User Cancel Transitions may be used to describe that (usually Receives) States may also be left upon the arbitrary decision of a user without reception or sending of the appropriate messages.</td>
</tr>
</table>

2.3.3 Execution Concept of PASS

Next to being subject-oriented, the process modeling language PASS is a formal language and closely tied to a corresponding execution concept described by (Fleischmann, 1994) with an Abstract State Machine specification by (Börger, 2012-1). Those specifications define how Subject Behavior Diagrams may be interpreted upon execution by a workflow engine.

2.3.3.1 Subject Instances and finished process

A PASS workflow engine or interpreter will create **instances** for each subject individually as sub-elements of a process instance. In turn, this implies that there may be **optional subjects** in a model that are not instantiated. On the other hand, there may be multiple instances of the same behavior if a subject was declared a *Multi-Subject*.

In contrast to a classical process description approach such as Petri-Nets, there is no directly defined overall end state for the whole model. Instead, the execution of a process instance of a PASS model is considered finished when each instantiated subject is in an end-state. As long as not all subjects have reached such a state, the overall process instance is still active. Subject instances already in an end state may be reactivated if a model defines such an option to leave an end state again.

2.3.3.2 Message Inbox

Another fundamental assumption for the execution of PASS is that every subject instance in a process possesses a so-called **Message-Inbox** that will store and buffer all messages[31]. By default, this message inbox is unlimited. As such, every communication is assumed to occur asynchronously. Messages may be sent and received, but their processing is not guaranteed as a receiving subject must explicitly extract a new message from its inbox during the execution of a receive transition.

2.3.3.3 Subject Carriers

The subjects and their behaviors in a model are mere descriptions of how tasks should be executed and what options for progression at a particular step exist. During execution, the actual choice of how-to-proceed or which-message-to-read is up to the execution system and the according *Subject Carrier*.

> **Definition 21: Subject Carrier** – A subject carrier is the arbitrary entity or processor responsible for decisions regarding an individual subject during the execution of a PASS process model. The subject carrier may be a human being exerting its will via the GUI of the workflow system. Alternatively, the subject carrier may be an automated processing system acting upon an algorithm or executing instructions autonomously and reporting the results back into the process engine to advance the execution of the instance. The same subject carrier may be responsible for the execution of several subject instances even within the same process instance (Figure 29). Equally, it may be possible for several

[31] In advanced PASS process models, limitation may be set for messages in the inbox, restricting e.g. maximum numbers of messages or setting handling strategies for excess messages if such a maximum is potentially reached.

changing subject carriers to be responsible for the execution of a single subject instance[32] (Figure 30).

Subject Carriers are therefore interchangeable and the whole mechanism allows for a level of flexibility beyond the PASS process model itself.

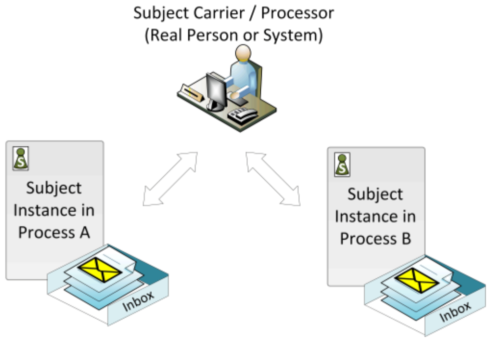


Figure 29: Concept Depiction: processor or subject carrier may take upon the execution of several subjects in possibly different processes

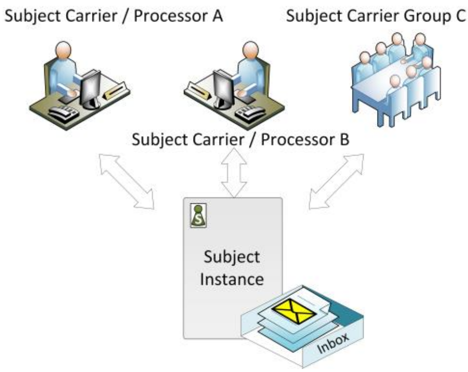


Figure 30: Concept Depiction: Multiple, possibly changing, subject carrier/processors may be responsible for the execution of a single subject

[32] The rules for changes and their execution depend on the according execution engine.

2.3.4 Summary

This section introduced the modeling methodology of Subject-Oriented Business Process Management (S-BPM), its primary modeling language, the Parallel Activity Specification Schema (PASS), and the execution concepts tied to them. These concepts are essential to understanding the modeling choices and reasoning behind the analysis in chapter 3 and the provided the basis for the subject-oriented, executable process model of Strategic Product Planning in chapter 4 that is the core result of this research.

2.4 Conclusion of Chapter 2

The second chapter of this thesis introduced and analyzed the theoretical background of this thesis, as it is currently state-of-the-art.

Due to the nature of this research and the deductions and argumentations made later on, it was necessary to include the fundamentals of two rather different research domains.

The first domain included the general concepts of Strategic Product Planning and Innovation Management. Excluded from those, for now, were approaches to describe processes in that field. The analysis of these process description approaches is an integral part of the methodology in the following chapter, where the flaws of these description approaches will be shown.

Additionally, to set up the basis for reasoning in the coming chapter, it was necessary to explain the foundations of classical description and thinking approaches regarding processes and process management. This especially means the input-task-output concept that seems to be inherent in all classical process descriptions.

Finally, the fundamental principles of the subject-orientated (business) process modeling approach and the according process modeling language PASS have been presented in a separate section to emphasize the fundamental difference between Subject-Orientation and standard approaches – a difference that not only allows analyzation of problems and description gaps, but also helps to create an actual executable referential process model for Strategic Product Planning.

3 Methodology

The previous chapter covered the theoretical foundations for Strategic Product Planning, classical Process Thinking concepts, and the modeling paradigm of Subject-Orientation. These will be integral to the following analysis.

The hypothesis to be examined in this chapter is that there are flaws in existing approaches to describe the processes of Strategic Product Planning (SPP). These flaws hinder the creation of entirely formal yet sufficiently complex process models and thus prevent a simple, non-contradicting adoption into an executable process[1]. The further hypothesis is, that those flaws are not necessarily built into the individual process description (bad modeling), but rather stem from the general limitations of the classical description approach.

Chapter 3, therefore, analyses the general weaknesses of classical process thinking and modeling approaches in section 3.1.

The alternative subject-oriented principle is undergoing the same treatment in section 3.2.

Both aspects are necessary as preparation to understand how the classical concepts affect or limit existing SPP process descriptions in section 3.3, via a comparison of the given process description with accordingly derived subject-oriented- models.

[1] Based upon the finding, that as far as known, there has only been one attempt to for that at all and that with limited effectiveness (See section 3.3.4).

3.1 Analysis of Classic Process Thinking and Modeling Approaches

Using any of the means described in sections 2.2 to model, analyze, discuss, and (re-) design processes is always better than not doing so at all. However, the classical input-task-output model, while established, simple, and widely used, is not perfect and has some limitations that will be analyzed theoretically in the following section.

3.1.1 Where the Input-Task-Output Model Works Well

As stated, the input-task-output model is well established, especially in engineering domains. Supposedly, this is the case because it works well in the domain of production and production processes for physical products, where rarely descriptive means are necessary that require more expressiveness or multiple extensive abstraction concepts.

There are a few factors for that circumstance: A production process in, e.g., a factory, can be naturally structured hierarchically (factory → production lines → individual machines). The single sub-process abstraction mechanism works well to cover all aspects. Further, in a production process, almost all inputs and outputs are on the same level of abstraction – namely none at all: they are all within the physical domain. In addition, they are strict sub-sets that fit well with each other, making the need to break the simple and well-mannered tree structure of the according process description very unlikely. Furthermore, it is the laws-of-nature that provide the context or frame, that govern such a process; a well understood, and (at least partly) widely known, accepted, and agreed on, set of rules that make understanding the relationship between an input and output simple. To give an example: A block of cast aluminum can be machined in a machining process task, and material can be deducted (block → machined block + scraps), but the block cannot magically turn into golden shower knob and a few silver feathers. Also, it is logical that the same block will not undergo the same identically machining task three times.

All of this does help to foster an intuitive understanding of the according linear and hierarchically process models and avoid misunderstandings for recipients. The successful application of the input-task-output concept may be one of the more important reasons for trying to apply it to process descriptions outside the production domain and on much higher abstraction levels. It is being taught to young engineers from the beginning of their studies as can be seen in elementary teaching material such as (Jacoby, 2015) or (Walter, 2012) and most of the analyzed approaches for Strategic Product Planning in section 3.3 are using simple input-output-logic.

Considered individually, nothing is wrong with such approaches and simple models that describe individual aspects. The problems come when the need arises to combine several simple individual process descriptions into larger, more complex models that are still required to be logically and syntactically correct, as well as comprehensible.

3.1.2 A Comparison with Programming

To have an indicator for the limits of the classic input-task-output process description approach, an analogy or comparison with another formal description domain can be made.

Programming a computer is nothing but describing a computation process as instructions for a computer or processor (algorithm). Consequently, the input-task-output description approach is equivalent to the concept of describing computer programs with the means of (only) so-called procedures or methods. The according programming paradigm that has no expression means beyond methods or procedures is called procedural programming.

```
public static int combine(int a, int b){
    int result= a + b;
    return result;
}
```

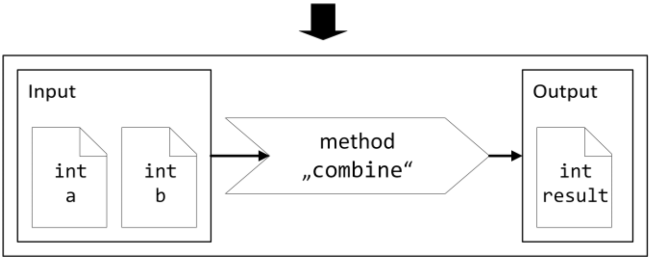


Figure 31: A method/procedure in the JAVA programming language and its representation as an input-task-output process

Within the field of computer programming, the description paradigm of procedural programming was the predominant concept to formulate instructions for computers for a long time. It is the central element of programming languages such as C, PASCAL, or (partly) BASIC (see among others (Buchwald, et al., 2012)). These languages are already **Turing complete** (Herken, 1995), implying that it is theoretically possible to describe any computation process with them! This is important because even though every problem is describable this way, another programming or description paradigm is nowadays predominant with the most widely used programming languages today supporting it: Object-Orientation (Parbel, 2017).

> **Definition 22: Turing Completeness** - A formal language or description concept (a system of data-manipulation rules) said to be Turing Complete can be used to express any computation problem to be executed on a theoretical Turing machine. (based upon (Turing, 1937)/ (Herken, 1995))

As will be discussed in the later excursion in section 3.1.7, object orientation is not the ultimate description standard. However, its adoption, from a scientific concept born in the 1960s, to the most widely known programming paradigm (Buchwald, 2009) (Meyer, 1997), allows to make one observation or statement: the procedural input-task-output description concept was not sufficient for the needs and requirements of ever increasing complex programs and operating systems (Buchwald, 2009). Especially the challenge to coordinate the development of more and more parallel and concurrent activities with the complexity of graphical user interfaces and the need for multi-tasking increased the renunciation rate from the classical description approach.

While theoretically adept, it was simply not sufficient practical for the task. In programming, next to the complexity of the programs/process descriptions themselves, another problem quickly arises: the organization of the development itself, and thus the need to understand and integrate process/programming descriptions created by a growing group of heterogeneous people caring for different aspects into one single coherent and working processing system. To give an example: while the original Microsoft Windows NT was developed by a team of about 200 people at the end of the 1980s, the development team behind Windows 7 had around 3000 people contributing processual description for a single product (Melanchthon, 2009). Next to an according organizational structure and development culture, this required description means suitable for that cause: namely C, C++, or C# of which only C is non-object oriented.

Now the questions to be raised here is: why is the input-task-output description concept that is not suitable anymore for “simple” programming, still being used to describe even more complex socio-technical systems?

While no absolute answer can be given, the made comparison strongly indicates that a (business) process, involving already complex programs, as well as human interaction, can only theoretical be expressed using simple means. The input-task-output description logic is not enough for the requirements of modern business processes, especially if the resulting description is supposed to be generated and understood by several heterogeneous recipients such as different developing humans or computer systems for automation purposes.

While the comparison is a strong indicator, the next sections give some in-depth hypothesis about two fundamental reasons for the limits of the classical approach.

3.1.3 Complex Circumstances to Describe

One principle problem with the input-task-output model arises when more-complex processes need to be modeled. This is the case, e.g., when more than one input or output needs to be described. The free-form depiction of such multiple in- and outputs in Figure 32 leaves it open whether these multiple inputs are connected as additional inputs and outputs (AND), whether they are optional (OR), or absolute alternatives (X-OR).

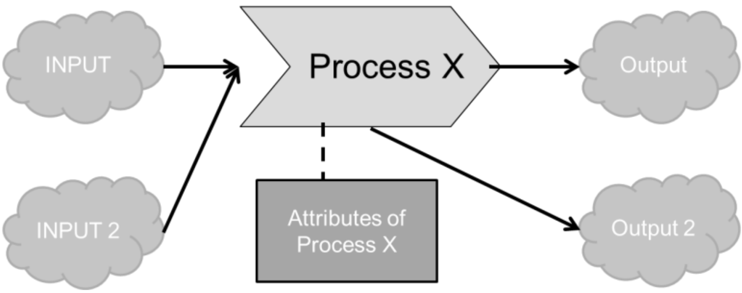


Figure 32: Describing Multiple (AND) or Optional (OR) Inputs and Outputs

That this is not unlikely can be seen in Figure 33 that shows an original description taken from an actual Siemens–ARIS-Platform process model in EPC notation. It shows the single process task of “Mechanical Design” with all the attached information and possible data inputs and outputs. To keep it readable the authors did not show a flow from this task to possible follow-up tasks nor do they show its predecessor. Instead, they described inputs outputs of multiple different types or aspects (such as different document types, involved people, or system, indicating a definite difference between actual temporal and causality or results from this tasks.

In addition, it is not precisely clear if all of these inputs are necessary or will always be given (AND) or if some of these are optional (OR) or may exclude each other (XOR). Yet all of these are important and typically exist in process descriptions concepts. However, they make process modeling much more complicated.

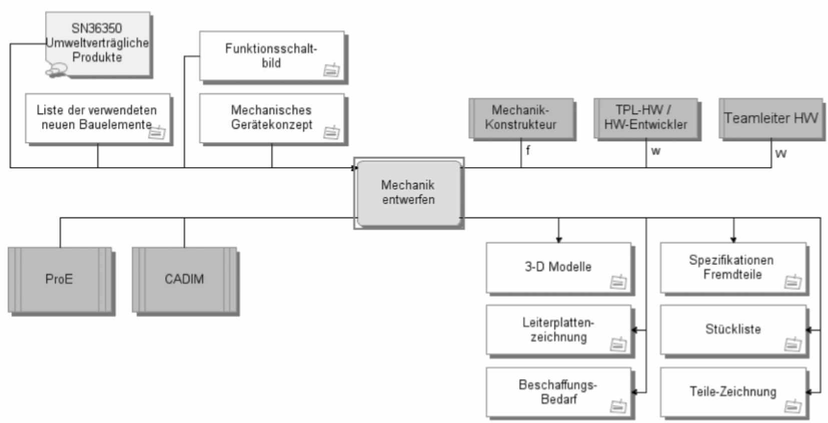


Figure 33: Overladen single process task with a multitude of inputs and outputs.
(Real life example taken from Siemens ARIS-process modeling suit - German original)

It is hard to fathom which of the three multi-input-variants (AND, OR, XOR) leads to more complex description problems.

With OR and XOR, optional aspects can be modeled, allowing for re-usage of that description in different contexts. E.g., the description of possible variants in a generic manner, so that some aspects may be omitted upon the construction of an actual process model from several preexisting description blocks. As long as only one option is required, the final depiction may be reduced to a single and straightforward linear flow showing only one path through a possible variant rich process. However, if the alternatives and options need to be addressed and thus shown in the process model, the resulting depiction will automatically become harder to comprehend.

For AND-inputs and outputs that is always the case and may not even be omitted for simplicity reasons due to two or more inputs being necessary.

Nevertheless, with two in- and outputs, be they additional (AND) or optional (OR), it will become increasingly challenging to depict them on a two-dimensional graph in a correct manner. With input and output numbers larger than two, depiction, especially on a two-dimensional plane will get even more complex. Figure 34 sketches a graphical depiction of such a complex process with multiple consecutive tasks and many interconnections that are not easily hidden in sub-processes. The result is a so-called *process tapestry*, a network graph that is not readily comprehensible or navigable even though it is faithful to the business process it is representing. The usefulness of process-tapestries is at least debatable. While any effort to understand and describe a process is always better than not doing it at all, it is only useful as an activity for the creators of the model. Personal experience from the author as well as general arguments on the legibility of such complex depictions, while not being a scientific proof, indicate that people not involved in the creation process of such models have a hard time to understand complex elements. However, using any two-dimensional graphical process description approach with only the sub-process abstraction mechanism that cannot be correctly applied for situations with multiple in- and outputs, will automatically lead to such large tapestries.

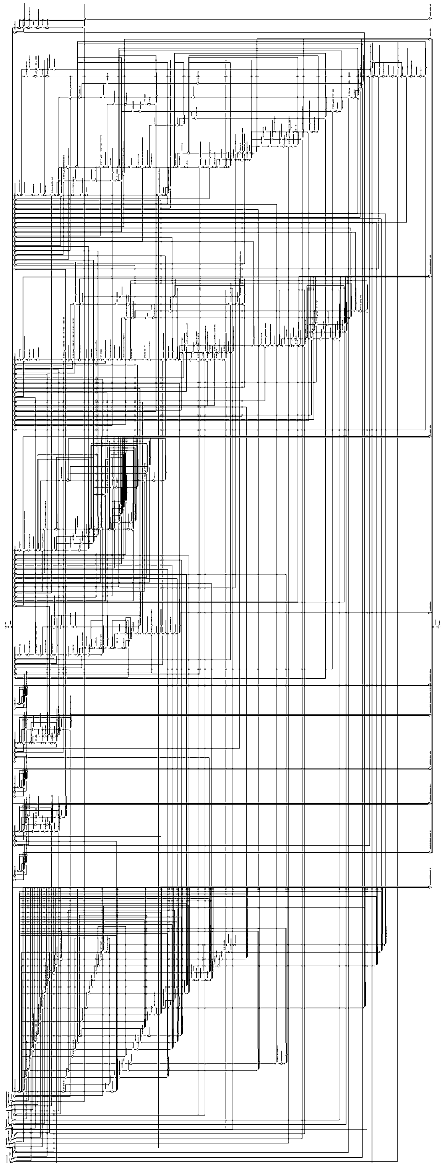
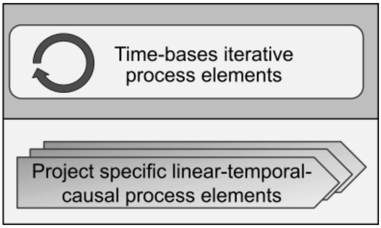


Figure 34: Graphical sketch of a complex process using classical process description logic leading to a process tapestry (equivalent to spaghetti code)

3.1.4 Linearity vs. Iteration



Multiple in- and outputs of tasks are one challenge when describing complex processes. Another aspect that is not easy to grasp stems from repetitive tasks. As previously stated, the input-task-output chaining description approach is very well suited for linear processes that have a definite start and a singular finish. However, especially in larger commercial organizations, some processes do not fit that schema. Instead of an event based start or defined finish, they run repetitively with a specific frequency. There are many examples for such processes that run iteratively, e.g., every year an annual financial statement needs to be made, every three months a quarterly statement needs to be released, or every two weeks the project team will meet up and discuss progress. These types of process are executed at the same time as other, linear processes, e.g., project management tasks. Often, iterative processes encase or frame more linear describable processes. It is not impossible to use the linear logic to describe cyclic activities. However tracking multiple cycled process description with different iteration frequencies within the same, coherent process model increases a models complexity.

In consequence, as will be seen with the examples in section 3.3, the different process descriptions are either strictly separated, or cycles are simply ignored and not deemed necessary to be described, in order not to complicate a simple, linear or causal description. However, not including these aspects will automatically hinder the execution of a process, as information about, e.g., iteration frequencies is integral for such a purpose. If not included in a process model, the according information must be kept in other forms, e.g., as additional information written into the source code of an execution system.

3.1.5 Consequences and their Examples

The previous sections argued and showed where the classical input-task-output description approach has its principal limitations. To show further indicators for their existence, this section shows examples of how the stated drawbacks are being coped with and what their consequences may be.

3.1.5.1 Limiting Modeling Capabilities

One way to avoid the description problems stemming from multiple inputs and outputs is to restrict the expression capabilities of the modeling system. This is partially done, e.g., within the Siemens Team Center[2] workflow modeling tool. There, any flow of task must always be between one single start and one single end element, guaranteeing that any modeled process will have the perfect hierarchical structure as depicted earlier in Figure 15, no matter how many sub- and sub-sub-processes are modeled. Cycles or alternative paths within these are allowed, but only within a linear start-to-finish logic. That simplifies any resulting model structure and the expressive means.

3.1.5.2 Limiting the Point of View – Showing Linear Cycles

The limited workflow approach works suitable for the low-level technical functions of Team Center. However, Siemens themselves use ARIS and EPCs internally for their higher-level abstract business processes.

Figure 20 on page 65 depicts a real-life example of the process landscape at Siemens for their Product Lifecycle Management projects for a single product.

[2] Siemens Team Center is Product Data and Product Lifecycle Management (PDM and PLM) software system meant to support and structure the execution of engineering processes. It has a build in proprietary process or workflow modeling environment useful for the automation of organizational processes within team center.

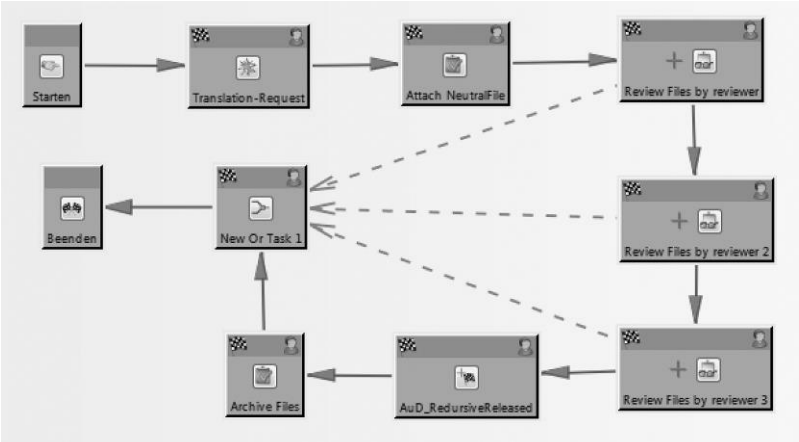


Figure 35: Real-Life Example of a workflow model taken from Siemens Team center[3]

By default, it has a defined start and end[4]. It carries many useful and correct definitions, and only a closer analysis reveals inconsistencies. Technically the

Product Life Cycle Management (PLM) process is at the core: A clear, linear, milestone-based concept that runs from start to finish[5]. Other process tasks that are part of this PLM-process or run along this process are depicted using chevron shaped arrows, indicating their linear nature. This works well to detail out the steps and sub-tasks in areas like "Define" and "Realize".

3 The non-complex workflow is meant as an instruction for team center and limited by its depiction. Grammatically the description of tasks is not consistent and somewhat irritating. E.g. "Review Files by Reviewer" may imply that a "Review **of** Files **is done** by a Reviewer" or, interpreted as instruction for the Team Center software itself "let Files be reviewed by a reviewer". Within the limited expressiveness, the meaning is relative certain and same in both cases. With more complex task that do not run in the fixed context of Team Center, it is details like this that, especially when occurring multiple times, that may easily confuse and hinder understanding.

4 Note the irony within the word Lifecycle that rather is a process with start and end, and does not restart on its own.

5 The grey arrows and the yellow diamond-shaped elements in Figure 20.

However, in the same diagram, following seemingly the same logic, there are processes that are not part of the PLM flow. They are outside the bonds and on a higher abstraction level. These are the large green chevron arrows spanning the whole width of the diagram of Figure 20 at the top and bottom. They describe aspects like general Product Strategy Conception, Product and Project Portfolio Management, and general multi-project spanning activities. Formally, these are not expressible in this manner. Rather what is shown in this context of a single product genesis and managing project, are “shadows”[6] of activities surrounding and framing it, but not their whole extent. Because they are important, their existence is depicted, but their nature, their complexity, and their non-linear cyclic nature cannot be shown – a perfect example for the problems of linearity vs. cycles described in section 3.1.4.

3.1.5.3 Bending or Misusing Model Semantics

Figure 20 does not only show an example of how it is attempted to represent cyclic activities within a linear concept. It also shows how it is tried to fit in elements that should not be depicted at all in that manner and do not fit the model logic and semantics. The general process landscape depiction of Figure 20, supposedly, shows different sub-processes elements that may run in parallel (AND). E.g., during realization phase hardware and software development run in parallel as depicted. However, not all elements fit that concept. Most notably the “Agile Process”, spanning the definition and realization phases. It is a variation of “*how”*[7] the other depicted tasks and activities may be organized, rather defining another “*what”* to be done. In the same way, the “Incremental Process” is a placeholder, most likely introduced to depict that these concepts are considered within this process-modeling framework, but via misusing the sub-

[6] The term Shadows following Socrates’ cave allegory wherein the real nature of the real world is not perceived by denizens of a cave as they only get to see mere two-dimensional shadows cast by the external sunlight.

[7] Based on the statements by the people actually living the depicted process. Also, the term *agile* obviously is only a definition of “how” and not “what” like other elements in Figure 20.

process mechanism. Furthermore, agile or iterative approaches and milestones concept do not mix very well on a conceptual level and therefore are alternatives to each other, instead of being parallel running activities as depicted.

3.1.5.4 Confusing People with Tasks

The limited expressive capabilities and the conceptual thinking boundaries of the input-task-output model may also have an impact on the quality of human resource management and interactions. An example of that was encountered during the analysis of a process description for German car manufacturer Daimler AG. There was a task called "cross-division function" (Querschnittsfunktion) – a function concerned with coordination and conveying of information between different divisions in a matrix organized structure. The human being responsible for that task was, likely for the lack of according terminology, also simply referred to as the "cross-division function" – a practical decision to match the descriptions in the organization's process handbooks[8] with reality, but in essence leading to an employee that is referred to only by an objectifying, dehumanizing, and somewhat derogative term. This anecdotal example is only an indicator that may seem harmless but demonstrates how a description concept may have a potentially negative impact on effective interactions within an organization. That naturally is only the case, if it is assumed that objectifying and de-humanizing people and considering them merely faceless tools through wording and management, is something negative that should be avoided.

3.1.5.5 Too Much or Too Little Detail in the Model

Finally, yet importantly and already implicated, if no foul compromises are made during modeling as described before, two possible consequences may arise.

[8] The non-disclosable handbooks of Daimler could be surveyed for this thesis. They followed the input-output and milestone concept in a classic approach in a very linear fashion.

The resulting process models may be correct but are not detailed enough for a given purpose such as an in-depth functional analysis.

Alternatively, the model is, in theory, detailed enough, but at the same time too detailed and even structuring elements such as swimlanes are not suitable to keep a model from being overwhelmingly complex as sketched out in Figure 34. This problem is, e.g., described by (Fleischmann A. , Oppl, Schmidt, & Stary, 2018, p. 234) that also note the limits of swimlane based, classical process diagrams to show transparently the interactions between individuals for processes having as little as 5 or more interacting elements.

3.1.6 Summary and Concluding Thoughts

The following table summarizes the arguments of the previous section regarding the analysis of the input-task-output process description concept

Table 5: Summary for discussion of the classical linear input-task-output concept. It is:

• Well functional for simple linear processes • Possesses only one abstraction mechanism (sub-process) • Turing complete: functional to describe any possible process (However, not necessarily simple and easily comprehensible) • Akin to the procedural programming paradigm • Proven insufficient for (collaborative) description of complex (program) processes (→ spaghetti code) (→ rise of Object Orientation as main programming paradigm) • Especially difficult to use for processes that include different temporal scopes driving different aspects of the processes (linearity vs. iteration/cycles) • Still being used for lack of alternatives leading to possible problems with the description o Limited points of view o Bending and misusage of model semantics

In conclusion, it can be summarized that the classical and widely used input-task-output description approach has certain limits. Theoretically, as it (or, supposedly, most description languages based on it) is Turing complete, it can be used to describe any imaginable process. However, in practice, it may reach its limits when applied for non-linear complex processes that are governed by non-natural laws. Possible consequences are the application of workarounds, downright disregards of its modeling concept in process descriptions, or simply very large, complex, and incomprehensible process models. In turn, this is bound to cause misunderstandings and ambiguities in the model, and at the very least informal, non-executable process models.

The hypothesis for the cause is the approach having only a **single formal abstraction mechanism** – the sub-process concept – as a means to coherently simplify a model when needed. This single mechanism may be sufficient for simple processes, where input and output are physical objects, e.g., production material and parts. However, this is not necessarily the case for processes that are more complex and consider multiple different types of inputs and outputs – processes that do not only have the laws of nature as their conceptual boundary for the transformation of input into output, as is the case for any process abiding by human-made rules. For these, a description model must also contain all information required to understand the inherent logic and boundary conditions governing such a process, as no or only partial knowledge about the execution context of the process can be assumed. For Strategic Product Planning this is most likely the case. Nevertheless, all process models examined in section 3.3 in principle adhere to the concept and, supposedly, suffer from it in their expression capabilities[9].

The Subject-Oriented process-modeling paradigm is a possible alternative. However, it is not an all-problem-solving silver bullet and needs to be carefully considered (Section 3.2).

[9] All identified limits or problems are present at least to some degree in the analyzed models.

3.1.7 Excursion: Object-Oriented Process Modeling?

Before analyzing the alternative process description approach that is subject-orientation, this section analyzes the conceptual missing element between subject-orientation and the classical description concept.

The question raised here is: If there is Subject-Orientation, and if the classical approaches are akin to procedural or verb-oriented programming, does something like object-oriented process modeling exist? And if yes what would "object-oriented process modeling" supposed to be at all? The answer is "it does not really exist". However, this excursion will examine the idea a little more in-depth.

Following the object-oriented modeling paradigm in (Meyer, 1997), object-orientation (OO) is in principle about the description objects and what actions or methods can be done upon them. The descriptions of object are called classes. Objects that adhere to a class specifications or are build according to them are said to be instances of that class.

Applying this modeling principle of object-orientation to process description would, in natural language terms, mean that descriptions are done entirely **using the passive tense** and for each distinct object individually. E.g. "the document is being reviewed", "the car body is being painted", or "the metal block is being drilled into". The process description would need to end when an object is destroyed, transformed into another object, or several different objects are being combined into one. Actions can be done in a complex sequence or choreography, but never in parallel since the individual object cannot be simply be described to be used or controlled by two processors[10] at the same time, at least as long the description is supposed to be very generic and does not make assumption about the execution environment.

[10] In programming "processor" of course refers to the CPU of a system. In general, though, it may refer to any active entity that could execute the actions defined for an object. E.g. an automated milling machine that can execute a certain milling action upon an object.

A description like *“the worker takes two objects and welds them together to get a third object”* is, strictly speaking, not object-oriented because the actions described do lie outside or at the borders of the lifecycle of individual objects. However, such a description is simple and valid when it comes to the interaction of multiple objects that are not necessarily sub-elements of each other[11]. So, deviating from that concept may be useful or rather necessary, but also be a breach from the paradigm. At such transition points, termination or transformation activities are gaps that cannot be filled in a purely passive and individual object-oriented description. Object-Oriented, it can only be stated “that something will happen to an object” and “how it may happen”, but not “when, in coordination with other objects”. This required information contains implicit or explicit assumptions, requirements, instructions or definitions about the execution environment that handles the objects. This information cannot be inherent to an object.

Furthermore, describing that two objects are being processed at the same time (→ parallel processing/execution) is, at least in principle, not possible because that would require knowledge about another individual object or the surrounding execution environment. Parallel processing requires information about coordination mechanisms. Actions of thread execution not directly described for the object, but implicitly assumed to be in place and always valid. This is the case, e.g., for the object-oriented JAVA programming language (Gosling, et al., 2015) and the implemented multi-thread parallel programming mechanisms there. Comparing general process descriptions to programming as has been done before, programmers with experience in parallel programming usually follow a design principle where individual thread classes and their coordination

[11] When clear sub-components or sub-objects relations (as in “is-a-part-of”) do exist, their individual passive processes can be considered similar to the super-component as sub-processes. This is also the typical work-around to handle to problem in systems programming: define a main object and structure everything hierarchical under it, even if a situation is not really tree structured.

during runtime is conceptually strictly separated from developing passive, data-containing objects, even though both a formally programmed as classes.

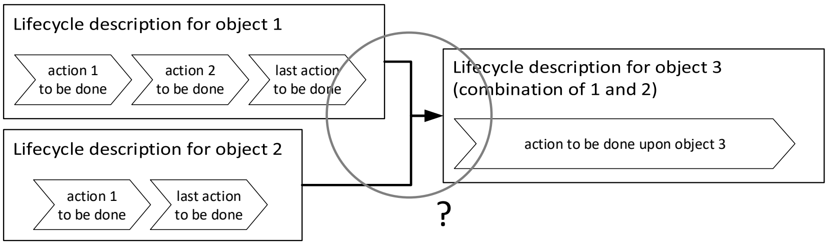


Figure 36: Object-oriented process modeling concept (sketch). Processes are described in the passive tense for different object individually. The context of transitions, termination, and object transformations is unspecific. Expectations/Assumptions about processing execution system are necessary.

The theoretical advantage gained through object-oriented modeling lies within the ability to set separate objects or their defining classes in relation to each other and formalize rules upon those relationships. Each relationship-type may form its own sub-super hierarchy and an according object may be part of several of these. Simply speaking: the object allows using more abstraction mechanisms at the same time than it is the case with pure procedural descriptions.

There are two noteworthy examples of these relationships that also have their own UML notation in UML class diagrams (Object Management Group, 2005). The first is the "*aggregation*[12]" that allows defining that an object *is part of* another object. Considered for individual process description, this abstraction mechanism for objects is what comes closest to the sub-process concept for standard process description, if the object as a whole is a complete sub-object of its super object. In that case, the whole

[12] And its somewhat related yet slightly different companion "composition".

process defined to-be-done upon the sub-object can be summarized as a process step in the super object.

The second abstraction mechanism is the well-known principle of inheritance (Meyer, 1997 p. 1197). It allows defining an "*is-a*" relationship between two classes, denoting that object instances of an inheriting (sub) class gain all the abilities and features defined in a more abstract super-class. If needed, it is possible to redefine (override) the specifications given in a super-class. What is described and inherited are two things: First, attributes – defining what data or features they have. And secondly, methods – singular actions that can be done upon the object. While methods can be supplemented with additional attributes, this concept does not envision changes in complex process descriptions defining sequences. As far as known, there do not exist definitions to inherit execution sequence restrictions or process descriptions[13]. For a method, it is a take-it-or-leave-it concept. If a given passive process description would like to add additional tasks during the middle of an inherited method, it will need to rewrite the complete method, voiding the main reason for using inheritance: saving the time by avoiding multiple.

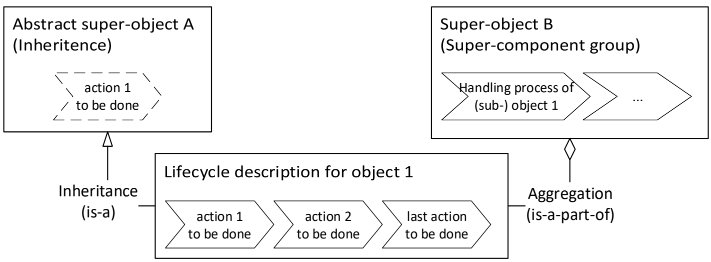


Figure 37: (Principle) two types of sub-super hierarchies/abstractions mechanisms applied at the same time in an object-oriented description.

[13] There is one self-referential exception to this in (Elstermann, et al., 2014)

Beyond the principle description problem, there are also two other drawbacks when using purely object-orient, passive descriptions in explanations in general:

Firstly, reading and understanding a description wholly written in passive is possible, but passive constructs more complex and harder to learn and understand. This, in turn, does lead to misunderstanding if a context is not clear[14].

Secondly, passive constructions allow leaving out the subject that acts upon the described object. E.g. "the ball can be rolled" vs. "the ball can be rolled by a player". The omittance may be done in order to save transmission time of information, because the subjects are not of importance, or already implicitly known in the context of the process description (e.g., in a sentence before). Simple laziness may also influence a decision towards not explicitly stating the assumptions about the execution system as well. However, leaving out this crucial information is not necessarily a good idea because not everyone may be aware of that assumption about the context, even if it may allow the creation of more compact descriptions. E.g. "the monthly salary may be raised (by 1000€)", vs. "The monthly salary may be raised by the responsible manager in concordance with the HR department".

Concluding, it can be stated that, as far as known, there is no real implementation of object-oriented process modeling, nor is there an according notation. Furthermore, there may not ever be one, as the required expressions necessary to convey information to other human beings require more elaborate constructs than a purely passive and object-oriented focus would allow. Of course, there is Object-Oriented Programming. However, while the comparison of principle description limitations can be made, this does not apply to the notion that object-oriented process modeling exists. OO-programming systems usually fill in the before mentioned gaps

[14] There is a certain irony in that statement, considering that many phrased in this thesis and in – in especially but not exclusively German – academic writing are very often written using the passive.

with pre-defined definitions and assumptions about the execution system and processors. And if they are concerned with parallel programming, even while using the concepts of classes and objects, typically a programmer's practice is to separate between the classical passive objects and the active objects or thread constructs. Active objects, though, are grammatically called "subjects" and are described quite differently than passive objects. The differences and details will be discussed in the following section.

3.2 Principle Analysis of Subject-Oriented Business Process Modeling

To overcome the stated problems of classical description approaches, other methods to model processes had to be found. As introduced in section 2.3 and in principle the only real alternative is the subject-oriented modeling paradigm and the according process modeling language, the Parallel Activity Specification Schema (PASS). They are the only paradigm and language pair that are different on more than a superficial level and offer other means, with a slightly different set of symbols. Throughout this research, the paradigm has been investigated and found to be well suited for the overall goal of an executable process model for SPP. However, in order to motivate its usage, it is necessary to analyze it and discuss the learned lessons from the application of the concept.

The findings of this section stem from observations during application and teaching of subject-oriented modeling with PASS over the course of 6 years within a multitude of smaller application studies and student projects that go far beyond the topical scope of this work. Especially, two extensive case studies were conducted as references and examples for application projects. Here however only the summary of the gained insight and resulting analysis is given.

Note that this section does not make a strict difference between using the general concept of Subject-Orientation, using Subject-Oriented process modeling, or using PASS. All are used somewhat synonymously, as PASS is currently the only subject-oriented process-modeling notation available.

3.2.1 Theoretical discussion: Pros and Cons of Subject-Orientation and PASS

3.2.1.1 The Cons

When working with Subject-Orientation as modeling paradigm and more specific with the process modeling language PASS, there are a few aspects that may seem a hindrance or tedious, especially on first glance. These aspects may cause problems or rejection of the approach for people and need to be considered, or possibly remediated by additional information when creating or using subject-oriented process models.

Interpretation Difficulties
Foremost, it must be mentioned that Subject-Orientation and its conceptual thought structures are not yet widespread or at least uncommon. While the principle concept of Subject or active entity does exist in every business process modeling approach in one form or another – e.g., swimlanes or organization units in EPC, BPMN or OMEGA – those approaches are not oriented towards the subject and do require that information to be included.

The consequence is that especially people trained in or used to classical description approaches tend to misunderstand or be confused by PASS models upon first encounter. Especially the Subject Interaction Diagrams (SID) is irritating. As any SID is still only "boxes and arrows", it is often attempted to find a temporal flow within an SID, that does not exist as any such information is separately described in the Subject Behavior Diagrams (SBD)[15].

[15] Teaching observation: people without prior formal process modeling experience seem to more easily adopt the SID/SBD structure of PASS in contrast to formally schooled process engineers that futilely try to apply the classical linear modeling structures also to Subject-Oriented models.

In addition, the strict separation of actions and interaction (send and receive), while being logic, is unusual and requires readers first to understand what the meaning of the three differently colored[16] boxes are in SBDs.

More Complexity in Smaller Models

Further interpretation difficulties may stem from an increase of perceived complexity. Especially for small processes, subject-oriented PASS diagrams will be more complex than comparable classical conceived models. Mostly for two reasons:

First, no matter the size of the process, using PASS, the model will always be split into SID and SBDs and, in consequence, have multiple model parts where classical approaches would only have a single model. Without training in PASS or an intuitive understanding where to find the according information, in general that split does not improve comprehension of a model in contrast to a comparable model that could be displayed as a single connected graph, as long as that single graph is small and simple enough to be shown on a single page or display.

Equally, the requirements to explicitly model communication and separating actions and interactions increase the number of model elements per se. While being advantageous at the same time (see next section), an increase of elements and text in any graphical model makes the model harder to grasp and comprehend simply by having more information to sort through. The following example illustrates that point: The same process is first depicted in a very compact though informal[17] process model using the Event-Driven Process Chain (EPC) notation in Figure 38.

Afterward, the same process is modeled in a PASS (Figure 39-Figure 43). It is much more detailed, truer to the actual process, formal, and executable. However, the model is much larger consisting of five different diagrams and having explicitly modeled communication, as it is required by

[16] Assuming a graphical depiction with colors and non-colorblind readers.
[17] E.g. the strict logic of event-task-event is abbreviated here

the logic of PASS. It gives much more information about who is supposed to do what and when. However, when it comes to the impression of the viewer to get a quick overview of the process and gaining the illusion of having understood everything in one glance, a compact single PowerPoint slide depiction has the advantage.

This problem may be overcome simply by showing and discussing only the SID, as it typically contains the essential information and is a valid basis for discussions on a higher abstraction level. However, that is only valid if the involved stakeholders comprehend and endorse the concept of SIDs and do not remain on a viewpoint that does not care for information or considerations outside their usual scope[18].

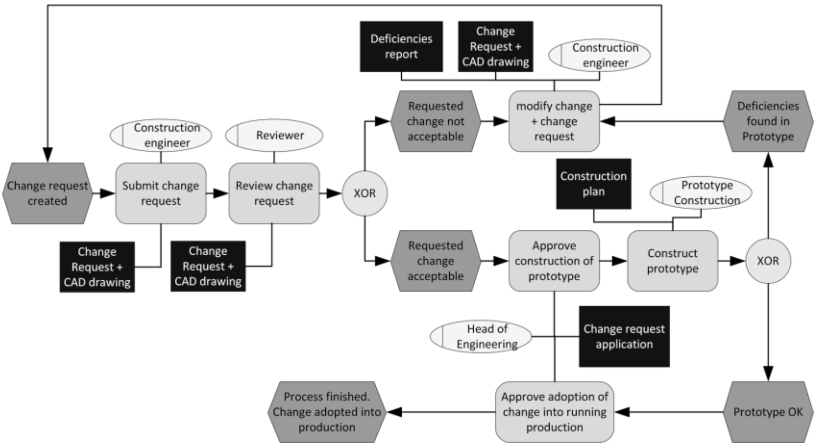


Figure 38: Example process EPC model showing a primitive engineering change request (single page but informal and not executable)

[18] This was the finding of a student study at a larger German car manufacturer where PASS was compared to classical process depictions for usage during team and management meetings. Any real discussion about usefulness or pros and contras of the approach was simply stopped by managers wanting depictions "as they always have been done", not caring for alternatives.

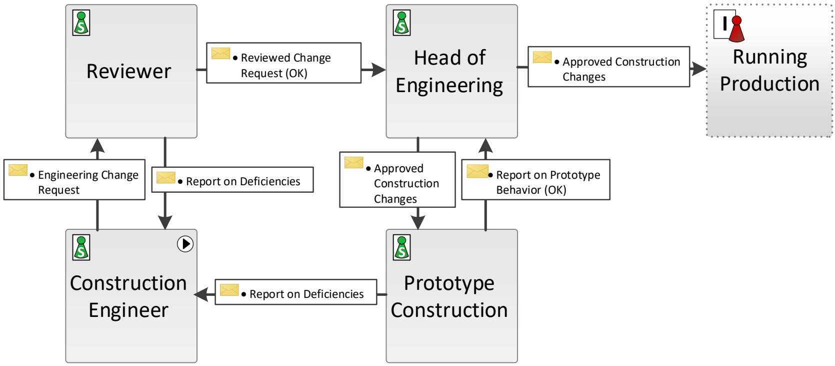


Figure 39: SID for the same process as Figure 38 (SBDs following)

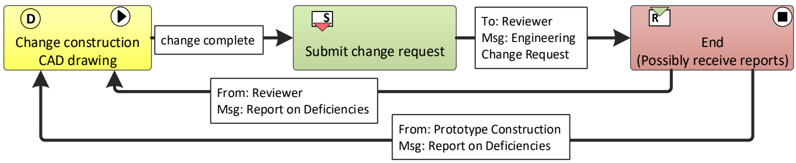


Figure 40: SBD Construction Engineer (SID in Figure 39)

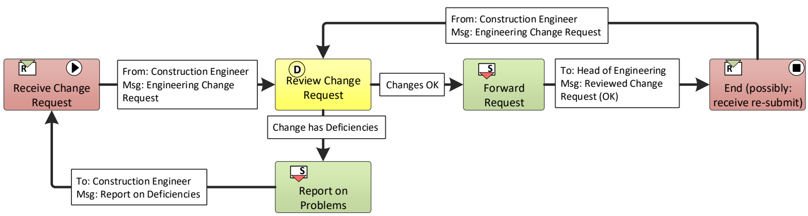


Figure 41: SBD Reviewer (SID in Figure 39)

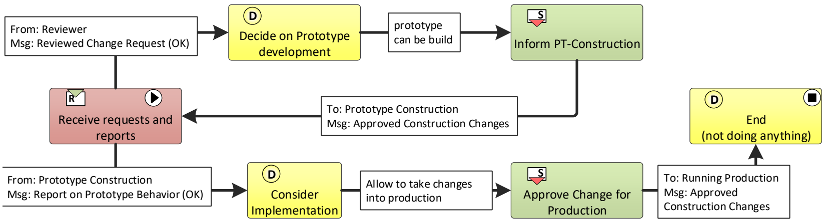


Figure 42: SBD Head of Engineering (SID in Figure 39)

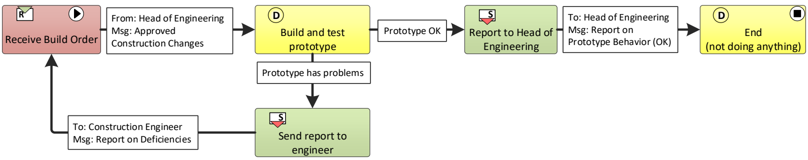


Figure 43: SBD Prototype Construction (SID in Figure 39)

Addition Effort and Consequences of Modeling Communication

The forced explicit modeling of communication does not only increase the model, but also the effort for the modeling activity itself:

As PASS is not common, usually process modelers must familiarize themselves with and get used to the subject-oriented paradigm. Especially upon first adoption, this will consume time and resources and may yield sub-par quality models if too little time is available.

Secondly, having to define a message, as well as its sending and reception, and finding a name or descriptor for that message that is agreed on by involved stakeholders and process natives is tedious. It does result in more precise and executable models, but not being able to "sweep" the communication aspect "under the carpet" during modeling and instead draw a simple line between two states may be a factor for rejection with potential practitioners.

As mentioned, the explicit modeling of communication is advantageous overall, especially for larger, more complex process models that would require the depiction of such details, no matter the modeling paradigm. However, this is not the case for small example process models that are easy to grasp anyway, easily fit on one PowerPoint slide, and are often employed as training examples and showcases for the modeling languages and their simplicity. Here, PASS may give the impression of not being worth the additional effort in contrast to simple models.

Only Bilateral Communication

An especially obvious example of the increase of effort required by PASS is caused by the fundamental modeling concept that only allows the description of bilateral communication. Models with trilateral communication or even more involved parties easily may get rather complex. E.g., an agreement process where three parties need to exchange their arguments and opinions on a disputed matter in order to reach a common agreement.

When all involved parties are explicitly modeled as individual subjects, PASS also requires to model the detailed information exchange necessary to reach the agreement, as can be seen in the SID of Figure 44. Even without the omitted SBDs, it is evident that quite a modeling effort is necessary for expressing that trilateral exchange executable on that level of detail.

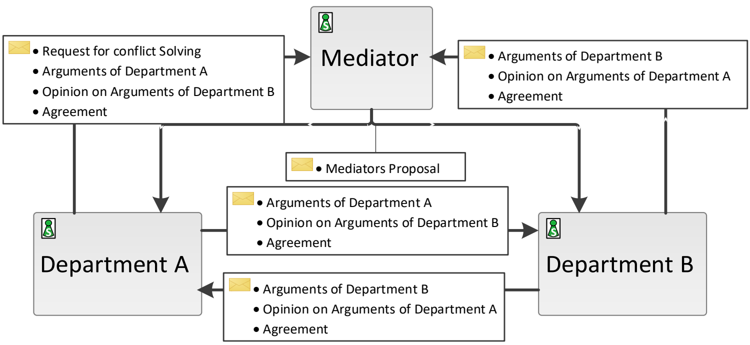


Figure 44: Example SID for trilateral agreement process with explicit modeling of options (SBDs not Shown)

Applying classical process description means, such a situation is seemingly much more straightforward to model, as shown in Figure 45 with the logic of Event-Driven Process Chains (EPC).

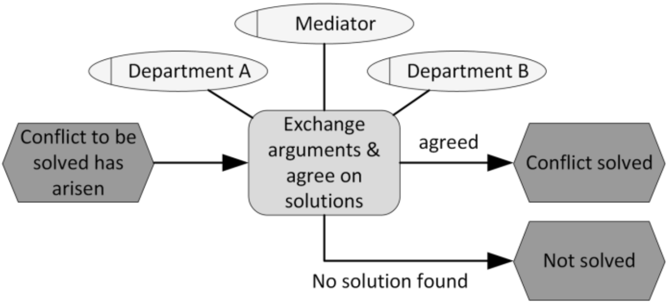


Figure 45: Example EPC for a multi-party agreement situation (non-executable)

This type of model may hide the complexity of who can do what at which time as a sub-process of the agreement task, together with all details about who is taking part. Of course, if the according sub-process would need to be detailed-out, the same complexity as the PASS diagram would arise, however.

In PASS, the same could be done in PASS if the logic of the EPC description is translated directly and no individual subjects are model as seen in Figure 46.

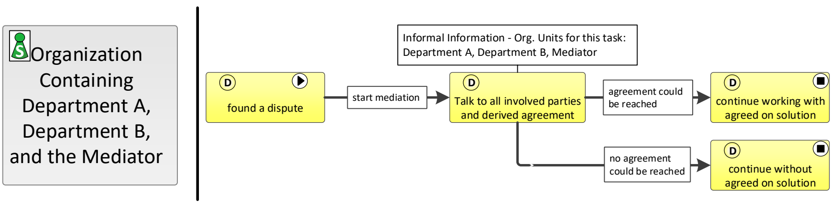


Figure 46: SID + SBD for Single Subject Process with the singular task of the Agreement Process

This model is less complex but also is not true to the concept of subject-orientation[19].

No Official Standard (Yet)
Last and least, as a minor note, it must be mentioned that, in contrast to older notations like BPMN or EPC, there is no formal description standard accepted by a global standardization organization such as the International Standard Organization (ISO) or the Object Management Group (OMG). This situation does not limit the effectiveness or logic of the paradigm or PASS, but it may foster certain reservations against the application of Subject-Orientation within established organizations trying to apply only thoroughly developed methods and technologies that can be used independently from a single tool vendor.

However, an according official standard for PASS is currently worked on and planned to be released in 2020 (Elstermann, 2017) (Elstermann, et al., 2018). Furthermore and as a second note, the actual impact of the existence of such a standard is somewhat debatable. For the Business Process Model and Notation (BPMN) the current standard has been extended multiple times and consist of 140+ different symbols (Object Management Group , 2011). BPMN Modelers typically tend to use an individual sub-set of 30 all the different symbols (zur Muehlen, et al., 2008) questioning the concept of a commonly agreed on standard here. Moreover, even while there is an official standard, it basically is not adhered to by tool vendors, making model exchange and cross-platform interoperability of standardized process models a mere hypothetical goal or vision that is only promised by the existence of an official standard, but those promises are not kept (Geiger, et al., 2018).

[19] It also is a good demonstration for the difference between classical modeling and subject-oriented modeling.

3.2.1.2 The Pros

The potential hindering factors and limitations of Subject-Orientation and PASS are more than compensated by a multitude of positive factors and aspects.

A Formal Concept and Language
First and foremost, the subject-oriented Parallel Activity Specification Schema (PASS) is a precise and formal process modeling language with a well-defined interpreter concept for workflow engines. Therefore, PASS fulfills the base requirement of being usable to create actually machine-readable and therefore executable process models. This is a significant advantage, and much in contrast to the process description means used for existing process models that are being discussed and analyzed in the next section.

Multiple-Abstraction Mechanisms and Expressiveness
Subject-Orientation is not a replacement for classical process descriptions concepts. Instead, it incorporates them in a holistic modeling canon. Therefore, the classical task/sub-task mechanisms for individual activities as well as the object-related mechanisms like inheritance or aggregation can be applied where necessary[20].

With the concept of subject, however, another and especially powerful description mechanism is available to process modelers. Subjects cannot only be used as containers to describe behaviors within a process. In the form of interfaces, subjects may serve as placeholders to refer to other process models. This can be used to either describe follow-up processes or refer to a sub-process with more details on a specific matter[21].

[20] Obviously, object-oriented abstraction concepts like inheritance (is-a) can be used for passive data-objects. In PASS this means for the description of messages or the according process relevant data (business objects) carried by them.
[21] E.g., an interface subject may represent a factory in a supply process but refer to a process model containing the active elements of a factory such stock receipt, storage or individual production facilities.

Another powerful abstraction element that is possible due to the concept of subject is the Multi-Subject mechanism. It allows to intuitively, yet formally, define the possible creation of multiple sub-processes instances within the context of one (automatic) process execution. This kind of expressiveness can formally only be matched by the advanced concept of "Colored Petri-Nets" (Jensen, et al., 2009). Colored Petri-Nets, however, are graphical-wise not nearly as intuitive to model and to comprehend as the simple declaration of a subject as a multi-subject.

Better User Matching in Execution Environments

The abstraction mechanism of subject has another practical side effect when working with actual process execution systems. For such a system, it is usually necessary to define which users have the rights to execute which process and especially which parts/steps of a process. With process models structured according to the classical description concept, that kind of assignment is usually done during modeling when each process step is individually assigned to be executable by what kind of users or more likely group of users (roles). The knowledge about these users and groups must be available during modeling and directly affects the model. When changes occur in an organizational structure that might affect the roles (e.g., new roles, combination of roles, obsolete roles, etc.) these changes will need to be addressed in the process model itself on the atomic level of the individual task that originally had been assigned a role.

With subject-oriented models, such changes need to be addressed as well. However, with the subject as the matching element, it is not the atomic task elements that need to be matched, but only the subjects of which there are fewer in a process. Also, the matching may be done outside of the modeling context separated from the actual process description. Furthermore, it is less likely that the details a subject's SBD need to be known by the person doing the re-matching. This should increase the chances to save matching time and avoid mistakes due to a lack of knowledge that would otherwise be required for a flawless assignment. See also the later section 5.4.2.

Linear and Cyclic Descriptions within one Model.
The seemingly trivial aspect of subject is what enables the possibility to have linear/ending (start-finish-logic) concepts together with iterative/circulative descriptions formally correct within the same coherent model. As far as known, PASS is the only process modeling language that can do that. An aspect simple and short to describe, but very powerful and not to be underestimated.

Powerful yet Compact
While being very powerful expression-wise, at the same time PASS is a very simple language. It consists of merely five core symbols (subject[22], message, do, send, & receive) accompanied by the according connectors (message connector + do-, send- & receive transition). The only other two symbols necessary to understand are the User-Cancel and Time-Transition. Both could be compensated or replaced by constructs using only the five core concepts.

Interestingly, these elements, together with the two diagram types of SIDs and SBDs, cover all process description aspects that are the common understanding for BPMN. There, as (zur Muehlen, et al., 2008) discovered, the most widely used symbols that are used to describe processes are normal flows (simple arrows), tasks, end event, start event, data-based XOR Gateway and especially the pool/swim Lane concept.

Furthermore, a non-publicized study conducted as Bachelor Thesis at the Institute for Applied Informatics and formal Descriptions (AIFB) at the KIT (Tölle, et al., 2009) showed that all workflow patterns[23] of (van der Aalst, et al., 2003) could be expressed with PASS. Therefore, it qualifies as

[22] Not counting the mentioned variants of interface-subjects and multi-subjects as individual symbols
[23] Van der Aalst defined these patterns as a benchmark for any process description systematic. Any business process modeling systematic worth its money is supposed to be able to express all of the defined situations. Ever since their first incarnation the number of these patterns that define what should be possible, has more than doubled.

a full-fledged, powerful, and formal process modeling language with very few symbols.

Aligned with Human Information Gathering and Thinking Structures
Contradictory to expectation, the powerful expressiveness of PASS is not tied to a complex structure.

Already mentioned, the language itself consists in principle of only five symbols making understanding it rather simple.

However, and more importantly, the Subject-Oriented paradigm is closely aligned to the structure of natural languages and the fundamental concepts of information expression and information exchange between human beings.

The main factor here is not that the notion of subject or active unit does exist at all. That is the case for almost all process modeling languages. Instead, the main factor it is the fact that Subject-Orientation not only mandatorily requires the explicit modeling of subjects, but that this is also the first information to be described and to be given in the form of the SID.

This pattern corresponds to the natural structure of human languages and therefore the way humans are used to and expect to receive information, with the grammatical subject being the initial information[24].

The importance of this order for human comprehension can also be seen in the order of the "Five W-Questions". The "Five W Questions" stem from the field of journalism but are also employed in other domains such as project management or marketing. They form a fundamental and intuitive algorithm for the gaining of understanding a matter and creating a subsequent report or documentation containing all information on that matter.

[24] There are only very few examples for languages that have their standard and simplest sentence structure not beginning with the subject. Of course, in most languages more complex constructions allow to shift around the different elements. However, the simplest structure is most often that of an active sentence with SPO or SOP in 80% of the world languages.

The first question supposed to be asked and to be answered in most cases is “who”, as can be seen in Table 6. The question about who is involved is then followed by other information necessary to be given by an information source. Only in situations where this question for the subject is given by the context, another order is viable. E.g., in the case of emergency hotlines where the subject (someone who probably needs help) and the time (right now) is given by the context the question of “where?” is most important so help can start to get there and figure out what to do on the way.

Table 6: Short Online survey of Sources that considered the Five W-questions and their order (Top 10 Google hits – 14. August 2018)

Source	Order of Questions
https://en.wikipedia.org/wiki/Five_Ws	**Who, What, When, Where, Why, (How)**
https://k12.thoughtfullearning.com/minilesson/asking-and-answering-5-ws-and-h-questions	**Who, What, When, Where, Why, How**
http://blog.journalistics.com/five-ws-one-h/	**Who, What, Why, When, Where, How**
https://www.jasonmun.com/applying-the-6-ws-of-marketing-to-seo/	**Who, What, When, Why, Where, How**
https://rosettastoneweb.wordpress.com/2015/10/15/the-5-ws-of-english-who-what-where-when-why/	**Who, What, Where, When, Why**
https://its.unl.edu/bestpractices/remember-5-ws	**Who, What, Where, When, Why**
https://www.consultantsmind.com/2013/03/07/7-key-questions-who-what-why-when-where-how-how-much/	**Who, What, Where, When, Why, How, How much**
http://www.geoff-hart.com/articles/2002/fivew.htm	**Why, Who, What, Where, When**
https://kbondale.wordpress.com/2012/05/27/project-planning-starts-with-5-ws/	**What, Why, Who, When, Where**
https://www.newyorker.com/humor/daily-shouts/additions-to-the-five-journalistic-ws	**Who, What, When, Where, Why**

Due to its closeness to natural languages and the rather non-abstract structure, the only requirement for learning Subject-Oriented modeling and/or PASS is a solid competence in a natural language and a talent for giving information in a useful manner to other people. Therefore every involved person should be, able to learn it, no matter what functional role she or he plays (Fleischmann, et al., 2012).

Natural Context Separation

PASS itself does not only follow the general structure of natural languages, the subject as a model-organizing element also allows separating or splitting larger models intuitively.

This concept is called Natural Context Separation. It is closely related to the previously mentioned expressive capabilities of the Subject-Orientation paradigm and its closeness to typical human thought structures.

Either, models depicting large and complex processes will be large and monolithic, or they will need to be split up and separated into several parts that are easier to grasp individually. With conventional process models, this separation will be done arbitrarily and up to the choice of the individual modeler. It is unproblematic for linear process models that can be split at any point in the flow or where details can be hidden in cleanly structured sub-processes. However, with complex interweaved process models, containing multiple loops and interaction, splits are harder to set. E.g., when considering the process model of Figure 34 on page 103, it is evident that with multiple interactions between the different process parts it is rather complicated to form sub-models and reduce complexity.

With PASS, a split-up automatically occurs through the modeling of several subjects and separation of concerns between the SID (interaction) and SBD (description of individual activities and flow). This type of modeling splits or organizes a process model into different active units. It matches with other depictions used to organize groups of multiple human beings, e.g., organigram descriptions of larger organizations that themselves are often organized into divisions (active units) containing sub-divisions (active units), and/or departments with teams or individual people (active units).

Consequently, when processes are complex enough to require multiple models to comprehend them, PASS is providing a mechanism for such splits according to structures humans are familiar with. Therefore, natural context separation – a separation or split of models according to natural occurring contexts (the context of active units) in contrast to artificial splits at arbitrarily set borders.

Explicit Modeling of Communication - Improved Chances for Good Models

One of the aspects stated in the analysis of the drawbacks of PASS was the requirement to explicitly model interactions. This drawback, however, is at the same time a positive aspect of subject-oriented models.

On a first glance, not being able to omit communication information that is deemed as unimportant, only means more work while modeling. However, it is this communication or points of interaction that are of most importance to a process and its participants and that have a high chance of causing errors during execution. Explicitly naming messages increases the chance for better process understanding and better process models here.

First, because what may be considered relevant or irrelevant is a very subjective decision. A communication act considered "too simple" and "common knowledge" by experienced process participants may be rather crucial for new process participants or for external developers who may need to base a system development decision upon that information.

Secondly, the requirement to explicitly model and name interactions beckons asking questions that are more precise. E.g., naming a message exchange merely "message" is very likely to lead to the question "what kind of message" by a reviewer or stakeholder. In turn, this may lead to a more precise definition for said message, e.g. "request for additional credit information". This information can be added to the model and prompt other people to agree with it or more easily disagree with it as, e.g., the subject may not be allowed to get that kind of information due to data security concerns. Also being required to think about appropriate descriptors (names) for messages is helpful for self-reflection upon one's own work within a process.

Thirdly, the communication concept increases the chances for uncovering inconsistencies in terminology early on during process modeling activities. E.g., consider a situation in an organization where a department A sends a form or message called "request" to a department B. Yet department B refers to those messages as "orders" in their descriptions as it fits their understanding. In PASS, this situation will easily be identified and it can be clarified whether the explicitly stated "orders" and "requests" are indeed the same message or two different aspects. However, if the different message names only appear in additional textual descriptions that are not cross-referenced, people working with that process model may face problems due to misunderstandings and time-consuming confusion. E.g., new employees working in the process may spend quite some time searching for the "orders" if they only get "requests". Another example for problematic consequences would be system engineers and programmers that may consider "requests" and "orders" as two different data items that need to be implemented into a process execution system, possibly costing multiple hours of unnecessary development work before found to be the same. Alternatively and worse, if not found and causing confusion and misunderstandings later on when a system goes live.

Lastly, it is the consistency and formality of the message-concept and corresponding send and receive activities that enable the automatic execution of PASS.

Facilitating Easy Process Exploration

While PASS fosters well-structured, detailed, and easy to comprehend process models, its principle structure also is practical for the task of model creation itself – modeling with PASS naturally supports process-exploration:

When process-modeling activities start, no matter the purpose of the model nor the employed modeling language, modelers usually do not have a complete understanding of the process that is to be modeled. The according knowledge must first be either developed, learned, or discovered.

When an entirely new process is to be designed, development is done through several planning meetings using the gradually growing and changing process model as the basis for development tracking and discussions. Here, except for the roughest sketches that would fit in their entirety on a single page, individual people can plan and match the activities of several different subjects.

However, the creation of entirely new processes from scratch is rarely the case. More often, it is an existing process with given boundary conditions and limitations, that needs to be described and documented (AS-IS) in order to make improvements upon it. This activity can be called "process exploration" and usually implies interviewing the involved process natives to gain the necessary understanding. Process exploration, however, is a time-consuming task. Knowledge can only be transferred linearly via speech[25] and communication is, by nature, error-prone. Answers may not contain all necessary information or may be misunderstood – under the assumption that the "right" questions were even asked to get the "necessary"[26] information.

Therefore, ideally, the information is gained by having all involved process participants in one location at the same time in order to describe their respective part of the process, to clarifying questions, and to complement and discuss the description of the other participants. The same would

[25] If the process natives do not model and describe their process themselves - which is possible but rarely the case.

[26] The general problem is, of course, that initially in an process exploration endeavor, it is rarely known what the "right" question are with or what clearly separates "necessary" from "unnecessary" information

need to be done after the resulting process model has been created in order to allow all involved persons to verify the correctness or adequateness of the process model. However, such a situation is highly unlikely, as process participants will have their own scheduling constraints. The chances for all involved person to be available at the same time at the same location are slim in most cases. It almost naturally is the case that interviews with stakeholders will be done individually, at different times and locations, and not necessarily in the temporal order that the actual interview partners are active in a process. While not all interview partners might be matched perfectly to specific subjects[27], in most cases, PASS enables a process modeler to model the given narratives individually as SBDs directly. The individual SBDs and their corresponding SIDs can afterward easily be matched to one another by comparing the communication interfaces of the individual subjects. A perfect match is not required initially.

Furthermore, inevitable changes due to new information or clarification can very easily be incorporated into a PASS model as they may affect only the communication between two subjects and do not require a complete remodeling of the overall process concept. The verification process for the resulting model with stakeholders afterward can also be done individually on a per-subject-base. It does not necessarily require the direct participation of all process natives at the same time.

Summarizing, the hypothesis here is that due to these possibilities of subject-oriented modeling and the structure of PASS, the resulting process description activities will be faster, therefore require fewer resources, and/or result in models that have better fidelity. However, admittedly, this aspect is hard to prove or disprove[28].

[27] Multiple-Interview partners might be responsible for an area of activity that is represented by a single subject. Alternatively, a single interview partner might be responsible or have knowledge about activities that will be split up into several subjects in the later model.

[28] An experiment set-up to test whether the hypothesis is sufficiently accurate would be more or less imaginary. It would require a sufficiently complex real-world process that is explored by different test participants that have the same level of prior knowledge (none)

As a final side note: taking the "naturalness" of PASS into account, process exploration with PASS may be considered as or executed according to the "natural Context Exploration Approach" (nCEA) (Elstermann, 2010)

Distributed Modeling

When working with PASS, not only can the interview process be split up and more easily coordinated, it can also be parallelized and executed decentralized. Multiple process modelers can create SBDs individually, in parallel, and at different locations with the fixed interaction semantic of the SID as their uniting and integrating technology (see Natural Context Separation).

Apparently, the interviewing itself can be done in parallel for non-subject-oriented modeling efforts as well. However, for classical process description approaches the possible hindrances and complications to integrate several separate models are much higher when all model parts were created by different modelers, without knowledge of the other parts, into a single consistent model and are required to fit perfectly together on an individual task and abstraction levels. With PASS, it is the loose coupling of subjects via messages that allows this integration of several SBDs to go much more smoothly. Necessary modifications may need to be done only to the communication of two Subjects at a time and not to the overall model all at once.

about the test case and who have an at least roughly comparable (how?) level of experience. The participants would model using different process modeling notations and paradigms. The goal for the test participants would be to create a sufficiently precise, potentially executable process model for the given process. For the evaluation, several parameters would need to be supervised, including the time required to talk to all people involved, the time spent on modeling, the frequency of mistakes made, how often the model had to be corrected after new information came up etc.. In the end, the resulting models would also need to be evaluated for their precision or usefulness and factored into the evaluation. Overall, this quick estimation shows the complexity of the task and the multitude of challenges to be solved in order to get resilient results. The task alone of getting enough comparable process-modeling experts is challenging, closely followed by the problem of how to construct a statistical model that can factor in all the involved variables and dimensions correctly. An according endeavor may be interesting for further re-search. Here, however the plausibility of the hypothesis must suffice.

Separation of Concerns – Eligibility for Training and Teaching

The last (but not least) favorable aspect of subject-oriented models, resulting from the previously mentioned aspects, is their ability to function very well as training and teaching material for new process participants that may be required to learn and understand their part in a process.

This, in principle, is due to the separation of concerns that is gained by having first and SID and then individual SBDs.

Possible trainees required to understand their role in a given process do not need to understand the full process model. They only need to be concerned with the, often for most parts linear, single SBD for the area of activity they will be responsible for. If necessary, they can refer to the SID in order to understand and gain more information about the context they will be working in. However the rest of the, possibly rather complex, process is well enclosed in the SBDs of other subjects or in entirely different process models that are connected via interface subjects. Either those process elements can be provided individually to be learned at a later point in time, or they may remain disclosed due to, e.g., data security clearance concerns.

Overall, PASS' separation of concerns potentially reduces the necessary initial information load on a trainee or reader, without the need to create additional process models or model excerpts for training purposes. With PASS, an individual SBD can be shown and presented without the overall model losing its formal structure or being reduced in its expressiveness and complexity.

3.2.2 Conclusion of the Analysis

The previous section provided an in-depth analysis of potential advantages and disadvantages that may or may not advocate the usage of the subject-oriented process modeling paradigm and the according modeling language PASS.ng observations, and arguments.

Table 7 and Table 8 summarize the analysis, the corresponding observations, and arguments.

Table 7: Summary of Cons when Using Subject-Oriented Process Modeling and PASS

Cons

• Uncommon modeling concept
  ○ Possible misunderstandings and confusion when attempting to interpret models as classical limited linear understanding
  ○ Especially the SID is often misunderstood
  ○ (The principle concepts do exist in all process modeling approach, but modeling is not oriented and structured towards them)
• More complexity for Small Processes Models
  ○ Split-ups in SID and SBDs are complex for inexperienced users or viewers.
• Extra effort necessary for linear processes without interactions
  ○ Forced explicit communication increases model sizes in contrast to classical approaches (yet also increases chances for good models)
• Complex to model trilateral communication
• No official technical ISO or OMG standard
  ○ (However, a standard is in the making)

Table 8: Summary of Pros for Using Subject-Oriented Process Modeling and PASS

Pros

• Formal process modeling language that is automatically executable
• Multiple abstraction mechanisms to increase modeling precision
  ○ Especially Interface-Subjects & Multi-Subjects
• Simpler mapping of tasks and users in workflow execution system
• Possibility to model linear and cyclic concept simply and formally correct within the same process model
• Powerful yet compact
  ○ Only five basic conceptual symbols
  ○ Possible to model all workflow patterns
• Aligned with human information gathering and thinking structures
  ○ Based on natural language structure

- Follows the order of five "W-questions"
  - Easy to understand
- Natural Context Separation
  - Automatic splitting of complex models into natural and comprehensible parts
  - Sub-Parts (SBDs) are not intervening with one another directly
- Explicit modeling of communication → increased chances for better process models
  - Requires to ask more detailed questions about the content of sent and received information
  - Fosters identification of inconsistencies in communication (neuralgic process parts)
  - Better comprehensibility for larger processes
- Facilitates process exploration
  - Stakeholder Information can usually be modeled individually into separate SBDs
- Allows for distributed, decentralized and parallel modeling
  - Loose coupling of subjects via messages/communication interfaces allows the parallel creation of different model parts that can be integrated with relative ease
- Ideal for training and teaching through separation of concerns
  - Individual SBD already are structured to be used as training material for new personnel going to be responsible for single areas of activity
  - Process parts relevant or for individual trainee can be shown without the need to create additional, reduced model excerpts

Not all the pros and cons are relevant for this research. Nevertheless, the positive aspects outweigh the possible negative ones. This makes the rather uncommon subject-oriented modeling paradigm and the process modeling language PASS a very viable candidate to foster a solution for the given research task.

The analysis led to the decision to test it as a tool for analyzing and comparing existing approaches to describe SPP processes as shown in the following section. This, in turn, showed that subject-orientation is an adequate means for the creation of the resulting executable referential process model for Strategic Product Planning (chapter 4).

3.3 Subject-Oriented Analysis of Existing SPP Process Descriptions

3.3.1 Introduction

In chapter 2.1 the principle concept and vocabulary of Strategic Product Planning were introduced. What has not been discussed there, are existing attempts that try to describe the process or rather processes of Strategic Product Planning (SPP). This was due to the introduction of existing SPP description approaches being an integral part of the methodology here.

Therefore, several SPP process description approaches have been chosen for a detailed examination in this section. Most likely, other process models and approaches that cover the domain of Strategic Product Planning to some degree. However, during the initial research, the chosen examples were the most prominent and well-documented approaches that could be found.

Each description approach will be individually summarized, and its core graphical process model will be carefully examined, supplemented by references of its accompanying textual descriptions. It will be shown what their core statements are and where they are imprecise or where the lack of formality hinders a possible derivation of executable process models and according applicable IT systems.

Essentially for this task is an individual interpretation of each concept that has been created using the modeling paradigm of subject-orientation (see sections 2.3 and 3.2) to compare and analyze the models.

As verification for the analysis, all models, originals and their corresponding comparisons have been subjected to an intensive review by domain experts as part of a series of research interviews. The proceeding is shown in Figure 47.

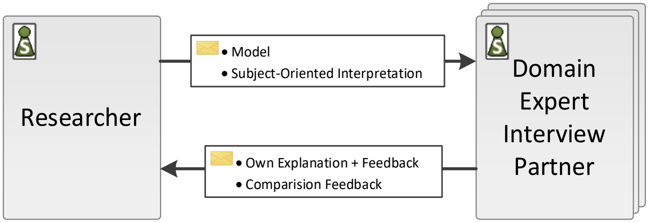


Figure 47: SID for the interview and verification process of analyzed process models and their subject-oriented interpretations

Each model was presented to the interview partner without any additional information and the task to interpret and describe the model. This activity was followed by the presentation of the according subject-oriented interpretation model together with the task to interpret them as well as compare them to the original models. Furthermore, opinions on the legibility of the subject-oriented modeling approach were inquired.

The given answers, views, and opinions have been collected and are being explicitly and implicitly used in the following analysis and arguments.

3.3.2 Innovation Phases and Innovation Stage Gates – The Standard Concept

As argued in chapter 2.1.1, SPP is a domain that shares many concepts with and cannot be easily discerned from Innovation Management. Therefore, the first process model to be discussed formally stems from the domain of Innovation Management.

The particular concept discussed here is taken from (Herstatt, et al., 2007), but similar forms or approaches can be encountered very often, e.g., in (Jacoby, 2015) who use a similar approach to describe progression for general problem solving.

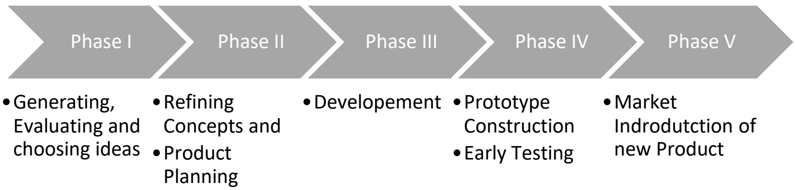


Figure 48: General concept for phases of an innovation process from (Herstatt, et al., 2007)

Based on its structure and the usage of the classical chevron arrows, it can be discerned that the process model described in Figure 48 uses the input-task-output concept. The steps or tasks are so-called phases, discrete periods of time with specific sub-tasks that are to be done in linear order to bring a new, possible innovative and therefore profitable product into the market. Graphical wise, there are no formal sub-processes defined. However, the accompanying textual descriptions do give more details about what to do "in" each phase.

When familiar with linear or procedural thinking and phase structures, this depiction seems well structured, logical, and intuitively right. Especially when considering how to execute that process in detail, certain questions arise.

When asked what the single "thing" is that goes through all phases[29] the common tendency of interview partners was to state that is was "the process" that is "in" these phases. Logical wise that is circular reasoning: These are process phases, so it is the process that is in a phase. When made aware of that fact and tasked to name something beyond the abstract term "process", interview partners found it hard to identify a singular object that phases through all stages. Most commonly, they agreed that it was "the product" or "the product innovation".

[29] Language wise, phases are periods of time. Something can be "in" a phase. E.g. electrical current (AC) is always in one phase or another. Also children can said to be in one phase of their growth or another following linearly. Therefore, there must be "some*thing*" that is "in" the phases of this process.

For the last three phases that observation does make sense. Starting with development, which is usually done as an explicitly defined project, it is easy to match phases with something tangible. In the early phases, however, this conceptual logic does not fit, because there does not exist something tangible that could be in a phase. At such an early point in time, there are only concepts or fragments of ideas. The problem here is that what an "innovation" is and how it could be captured and expressed as data. In that state, it cannot clearly be expressed in terms of a single document or artifact. As an example, the following statements should make only partially sense when considered[30]: "The (individual) product innovation is in the phase of Idea Generation". Alternatively: "The product is in the phase of product planning" – when product planning is all about defining what that product is supposed to be at all.

An indicator for this discrepancy is the existence of the Knowledge Funnel concept (among others from (Wheelwright, et al., 1992)). It describes that especially in the early "phases" there are multiple vague concepts and ideas, barely in a state where they can be discerned from one another. These concepts and ideas are being explored, developed, combined or possibly discarded until a point where they can be explored and further developed as individual projects to be finally released. The funnel concept is depicted in Figure 49.

[30] And it is not tried to use common sense and experience to overcome the inherent illogic.

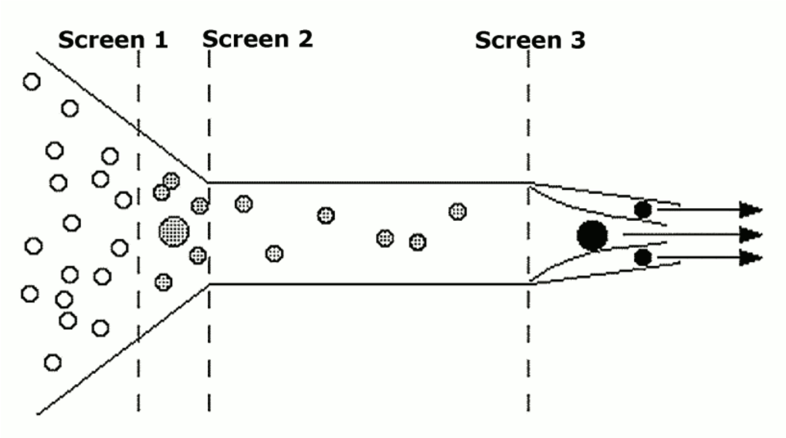


Figure 49: Innovation Funnel Concept - An explanation for "what" is going through phases (from (University of Cambridge - IfM, 2018))

Process-model-wise, the challenge here is to give instructions on how to organize a system that actually executes the necessary activities. The knowledge funnel concept, however, is an external description based on the phase concept. It is not a process description containing definitions of what to do in the when.

The problem here his two-part. First, the problem is that the phase description concept is fundamentally centered around and focused on the single individual object that goes through phases. By definition, that makes it hard to describe the comparison or combination activities that would join them (see the problem of object-oriented process thinking - section 3.1.7). Furthermore, (Weigt, 2008, p. 3), the source of the model to be analyzed in the next section, already states in a similar context the requirement or necessity to have "life phase transcending assurance and improvement of the quality of operative tasks"[31].

[31] German original: [… Bedarf an lebensphasenübergreifenden Sicherung und Erhöhung der Qualität der Bearbeitung von operativen Aufgabenstellungen...] -

The second problem inherent in the phase concept is that it is oriented backward or in hindsight. Therefore, it is not necessarily ideal to guide future efforts, especially those that are supposed to be innovative and potentially different from previous experiences. E.g., in hindsight, it is rather simple but also vain to define at what point in time some development effort or concept was in a particular phase or another. A referential process model, however, needs to instruct on how to execute and organize the according efforts and activities at a given moment. It is at least debatable how much it helps an organization to argue about which stage or phase a product or project is "in" when they do not really exist and are identifiable yet.

Humans with experience can compensate this small yet illogical description gap. However, basing a formally defined execution system does not seem ideal.

3.3.2.1 Managing the Innovation Process – Stage Gate Approach

Nevertheless, the phase-idea is the conceptual basis for many Innovation Management processes. Proof to that idea are the widely known and implemented Innovation Management concepts of (Cooper R. G., 2010).

Figure 50 shows the basic graphical description of Cooper's process model. It is easy to see that the only difference to the slightly more general phase-process descriptions of Figure 48 are the so-called "gates" or "stage gates". Cooper's model is more operation oriented and describes the idea that the retro-identifiable phase concept can and should be used to organize and manage future innovation processes. Each "innovation" or "idea" is supposed to be run through the phases (or stages). At the end of each stage, there is a gate to be passed by fulfilling the criteria defined a-priori in an according catalog for that gate. The idea of criteria is to discern whether an idea is good enough to be further developed in the next stage, whether it needs to remain in the current stage, or whether it should be discarded.

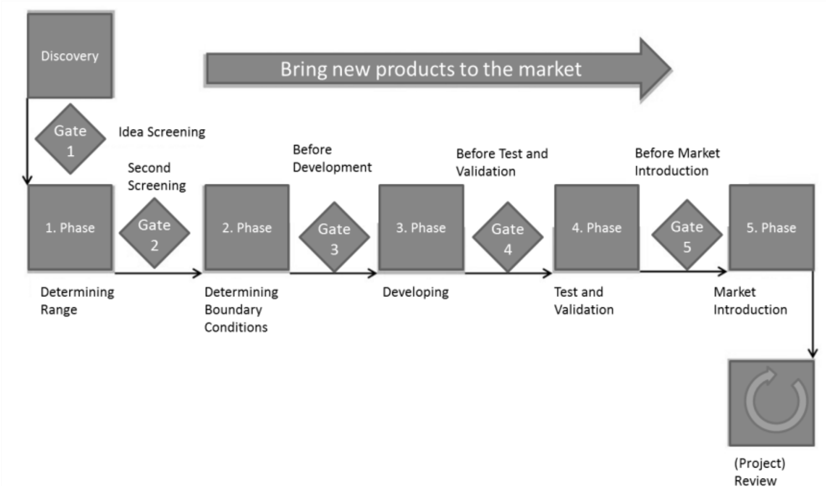


Figure 50: Stage Gate Process of the Second Generation (Cooper R. G., 2010)

The whole concept emphasizes the object-oriented thinking structure and suffers in principle the same problem with phase logic. It describes only the individual product or project but leaves out the surrounding execution system. Cooper himself is aware of that, but the according additional information that considers the whole system is hidden in the textual description or stated in entirely different publications that go beyond the individual project. As he states in (Cooper, 2008):

The gates in a Stage-Gate system are important facets of portfolio management. Here management undertakes in-depth evaluations of individual projects one at a time. Gatekeepers meet to make go/kill and resource allocation decisions on an ongoing basis (in real-time) and from the beginning to the end of the project. Be sure to utilize portfolio reviews as well. These reviews are more holistic, looking at the entire set of projects, but obviously less in-depth per project than gates are. Portfolio reviews take place periodically**: two to four times per year is the norm**. (Cooper, 2008)

The Stage-Gate model itself though does not reflect this and may not be able to, as it would require the ability to model iterative and linear concepts together.

The gate model also does not solve another problem that occurred for several interview partners in their organization: namely the question of when does an actual project start? Projects are usually official organizational institution, funded and understood as such. Cooper's model implicates that even the initial idea screening is project specific and officially managed as such. According to the interview partners, this assumption is unrealistic for real life organization where resource allocation processes need to be considered as well. This, however, can only be done if the ideas are sufficiently well developed and show promise.

Organization strictly following the phase or stage-gate approach would face the problem that development activities, especially in the early phases, may not get official recognition and resources because they are not "in a phase" where they are officially worth of recognition and according resource allocation.

The other problem with the stage gate or milestone approaches is as follows: While it is undoubtedly helpful to define the activities to be done during a phase according to the name of the phase, in reality, such a plan rarely works out. Consequently, either people are stuck with officially doing things they have been long finished, or they are supposed to do activities they cannot do yet. The not-so-rare alternative is to ignore the definitions of the process model. Cooper himself acknowledges that as he has introduced the concept of fuzzy gates in the same publication (Figure 51).

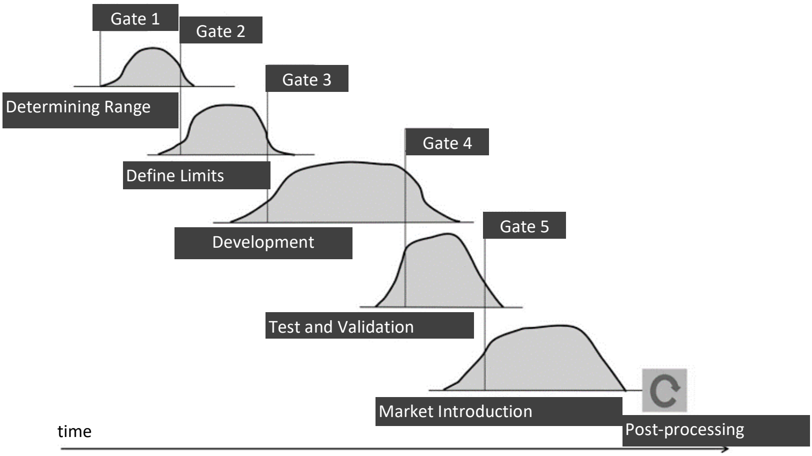


Figure 51: Fuzzy gate principle in a stage-gate innovation processes approach (Cooper R. G., 2010)

The idea of fuzzy gates is in principle that they define that there are fixed gates and official stages in a process with clearly defined tasks. However fuzzy gates are not that strict and allowed be ignored to a certain degree where necessary when sub-tasks of other process steps still are not complete.

That is a pragmatic approach, but this kind of fuzzy logic is incompatible with formal execution systems that require precise definitions instead of the processual equivalent of Schrödinger's cat – as long as no one (from the management) looks we are kind of in one phase and kind of in another.

3.3.2.2 Subject-Oriented Interpretation of Innovation and Innovation Management

The phase or stage concepts are widespread, but the previous observations show that while it seems to be nice simple, upon closer consideration, the input-task-output or stage-gate approach has severe limitations and logical faults.

These limitations become more evident upon comparison with a subject-oriented interpretation:

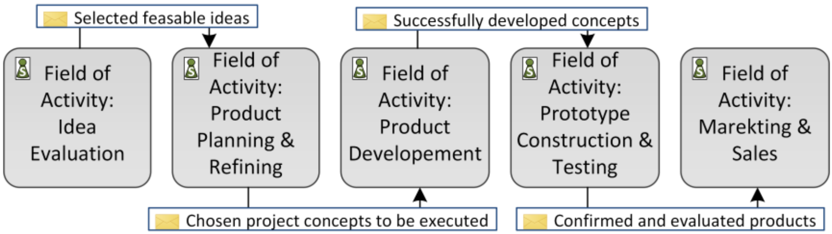


Figure 52: SID of a subject-oriented interpretation of the Innovation Management phase-based process (compare to Figure 48)

In the interpretation, all phases or stages are converted to subjects or "area of activity". Their labels essentially remaining the same. The only additions are the messages specifying what is being transferred from one area of activity to the next.

Reactions of interview partners upon reviewing the model, in most cases have been along the lines of mentioning that it almost the same as the original model. Being extensively familiarized with the phased based description approach, some interview partners even perceived the subjects as phases[32].

The important difference is that the implicit nature of subjects and the descriptions of the messages make it clear that each time completely different things are transferred, instead of a single "thing" that actually passes through all phases. In each subject, the input is transformed, possibly combined, and/or extended. In hindsight, of course, it could be traced at what point in time something passed through which area of activity. However,

[32] What could not be deducted was whether the interview partners, even after explanation, did simply not understand the implications of the concept of subjects, or if rather their concept of "phase" actually was already very close to that of a subject. Seemingly, Interview partners showed an interesting flexibility when bridging the conceptual gap between "a linear task with subtasks", "a phase of an object", and an active process element or subject.

during the actual execution of such a process, it is much easier to think in terms of active units or subjects. Subjects that have to transform (information) objects in order to provide them to and make them usable for other subjects. Especially in the early areas of activity, where concepts are vague or need to be found at all, this is much more convenient than trying to express the passive self-metamorphosis of something that will not stay the same thing.

In addition, in this model, the concept of the knowledge funnel is captured, while being a formal, executable process model and not only an arbitrary explanation means.

In this case, the subject-oriented interpretation does clarify some difference on a formal level. However, as it is a direct interpretation, it does not break from it, nor does it really depart from the object- and single-instance-oriented nature of the phase/stage-gate model. Therefore, it lacks descriptions of the activities that lay outside the bounds of this scope, containing aspects that are covered by other description approaches.

3.3.2.3 An Alternative Interpretation

The choice made here was to interpret all phases as single subjects that work with multiple data objects, implicitly reducing the number of elements in each stage. As mentioned, this matches the knowledge funnel concept and better handles the description of the early phases that are concerned with combination and filtering of more vague concepts. However, it was also argued that the phase-based or stage-gate approach is a viable description choice for the later phases (3-5) when there are individually identifiable concepts that could be considered as projects and be handled as such. In the interpretation model, that notion of continuously developed projects is completely lost. Taking the findings of the following sections 3.3.3 and 3.3.4 into account in advance and trying not to lose the project character where applicable, the model could have been described as depicted in Figure 53. Here the later phases are combined into a multi-subject and represented in its behavior diagram rather than individual subjects.

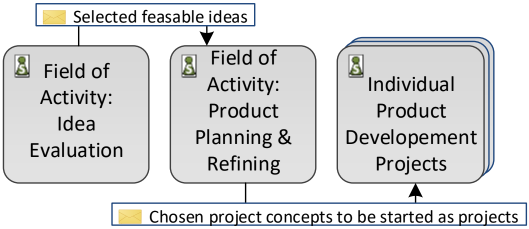


Figure 53: Alternative subject-oriented Interpretation of the phase-approach incorporating the findings of the 3.3.3 and 3.3.4

3.3.3 Model of Weigt and Seidel

The previously described phase-based process model is concerned with the scope of a single innovation or product development. As already mentioned there, as well as in the general considerations of Strategic Product Planning in section 2.1.2, it is obvious that for a complete executable process model activities outside of that scope need to be considered as well.

The following process description approach of (Weigt, 2008) which itself is based on (Seidel, 2005) was chosen for consideration because it tries to fill the aforementioned gap. It does so, however, using the concepts of the linear description approach and therefore is very informal, as can be seen in Figure 54.

The model depicts Strategic Product Planning as a system where the actual product development tasks for innovative products are directly or indirectly influenced by other activities. Those activities are concerned with using information in order to, supposedly, created general company strategies, develop production systems for new products, or to do research and development for new technologies that could be used for product innovations.

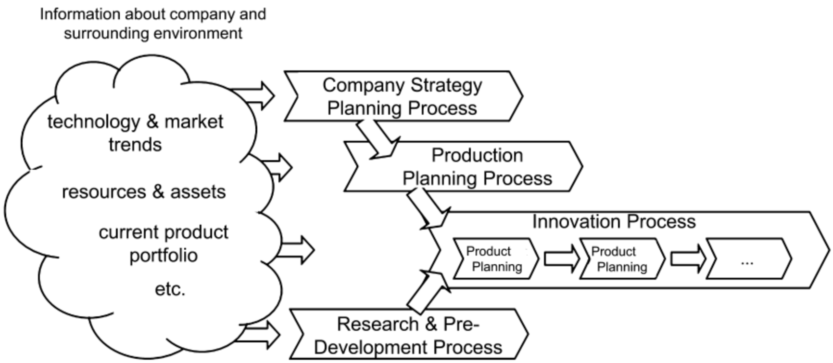


Figure 54: Strategic Product Planning According to (Weigt, 2008)

The model tries to express the necessity of different types of information inputs by modeling an amorphous cloud containing labels for (passive) information objects. From the cloud, standard arrows point towards the chevron-shaped actual process arrows indicating an impact of the contained information on those processes. Equally, impact arrows that not described in more detail, lead directly from the R&D Process or the Production Planning Process or indirectly from the Company Strategy Planning process into the "Innovation Process".

Consequently, Weigt is an excellent example for the limits of the classical, linear description approaches when trying to go beyond individual project concepts. Apparently, the model is not formal as the usage of the generic cloud indicates from the start. The model also lacks a formal specification of how the other inter-process impacts will or should occur.

The subject-oriented interpretation of the model tries to clarify some of those aspects based on the contained information given in (Weigt, 2008), but it cannot fill all gaps.

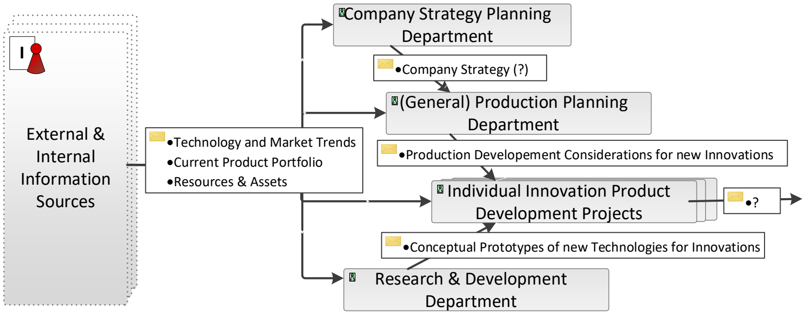


Figure 55: Subject-Oriented Interpretation of Weigt/Seidel Model

When using PASS, the ominous cloud can simply be interpreted as a subject that sends the contained information to other subjects. How that information is gathered or at what points in time is not specified. By the nature of the send messages though, the information sources could be internal data collection services, such as accounting or organizational archives. Other information must naturally come from external sources either, e.g., consulting agencies or may be the result of internal units specialized on surveying and collecting possibly relevant data from external contexts. The subject is modeled as a multi- and interface-subject to represent the various sources, as well as their unspecific nature that includes single occurrence information flows as well as continuously running data-collection services.

In contrast, the Company Strategy Planning Department, as well as the Production Planning Department, interpreted as single-subjects executing their respective, continuously running processes only once per organization. Finally, the Weigt-Model indicates that actual “Innovation Product Development” occurs multiple times as production-planning sub-processes indicate. This concept, again, is interpreted as a multi-subject – each representing a linear project running from start to end.

The interpretation does not solve a few content problems of the original model. First is the unidirectional flow of information that is at least somewhat unlikely, especially in the case of product and production development that should be done in congruence with each other. Furthermore, it is highly likely that a company strategy will have an influence on the actual product development directly and also will at least give partial directions to R&D. To the contrary, while the strategy might have some influence on production development, as indicated by the process model, it may be less directly than on the actual product development.

However, while being flawed, not executable, and foremost an example for the consequences of using the limited thought structure of classical description concepts, the model establishes a few concepts that will also be used later on. Mostly that is the existence of multiple areas of activity that influence each other but run in parallel. Also, these activities are not necessarily linear and/or are executed in lockstep. The more general areas may instead contain continuous processes while others are instanced and executed in the linear project fashion. Most of that information, though, stems from the textual descriptions and not the graphical process model itself.

3.3.4 Three Cycle Model

The three-cycle model was the most influential input for this work. It was conceived by the Heinz-Nixdorf-Institute (HNI) in Paderborn under the direction Professor Jürgen Gausemeier in cooperation with Christoph Plass and publicized in (Gausemeier, Ebbesmeyer, & Kallmeyer, 2001) and more recently in (Gausemeier & Plass, 2014) or online in (Heinz-Nixdorf-Institut, 2017).

At its core, it tries to explain the complex relationships of all activities that are possibly involved during product development. It does so on a broad, abstract level and without detailed sub-process description. The activities range from the creation of the first vague business ideas to market entry of fully developed products. In its three cycles, it discerns the general activities of (strategic) product planning (first cycle), product development (second cycle) and production system development (third cycle). (See Figure 56)

As the title suggests, for this work only the first cycle, Strategic Product Planning, is of relevance. However, the task area of "Conceptual Design of the Product" is the inter-connecting point with the other two cycles and therefore none of the three cycles can be considered entirely independent. Activities of the first cycle try to describe a systematic development approach with completed development concept(s) as the result. The concept is then to be further developed into a product through the activities of the other cycles. The approach is supposed to guide adopters from the earliest glimpse of future success to promising and complete product concepts ready to be developed. In this regard, it is very similar to the ideas of general Innovation Management, here, however, described as a cycle.

The cycles of the Three-Cycle-Model try to express the general continuity of all activities. Implicitly, they do not occur once for a single product. Instead, they should be executed continuously within an organization for multiple product-concept development projects in parallel.

When tasked with interpreting the Three-cycle-model, almost all interview partners tried to interpret the boxes within the cycle as phases of a single instance process, again proving the predominance and consequence of the limited input-task-output description approach. The single interview partner not following that line of thought, by chance, was involved in the genesis of the model and could emphasis on the fact that those boxes are explicitly not to be considered as classic process phases but rather as areas of activity. That consideration though seemed to be lost on most model readers, even on researches at the HNI.

3.3.4.1 A Linear Interpretation

As part of the ADISTRA Project (ADISTRA, 2015)/ (Gausemeier, et al., 2016) the HNI has created a process model using OMEGA notation that tries to detail-out the three-cycle model (Figure 57). As the OMEGA notation is using classical linear input-task-output logic, so does the interpretation.

The inherent problem with this derivation or depiction and its inability to represent the actual cyclic nature of the original model is not necessarily easy to grasp on first glance.

One indicator is that by using classical chevron shaped process-arrows, the graphical model gives the impression of being a singular linear process flow. However, there is actually only one point of interaction modeled between two areas of activity, that being between Foresight/Forecasting and Product Discovering. Otherwise, when considering the semantics of the used OMEGA notation, all areas of activity are independent or only vaguely coupled through a generic "data store" symbol applied to all modeled tasks. Theoretically, this implies the possibility of usage of information across all areas, however in a very generic, non-specific, and informal way.

To further understand the inherent problem of this approach, a more detailed analysis is necessary. As the official model in its publicized version does contain detailed information, this analysis has been conducted with a process model (Figure 58) that was derived from the general process model in Figure 57 by the HNI themselves. The model was tailored to and supposed to be executed by the administration of a small German enterprise specialized in aluminum forming of car parts.

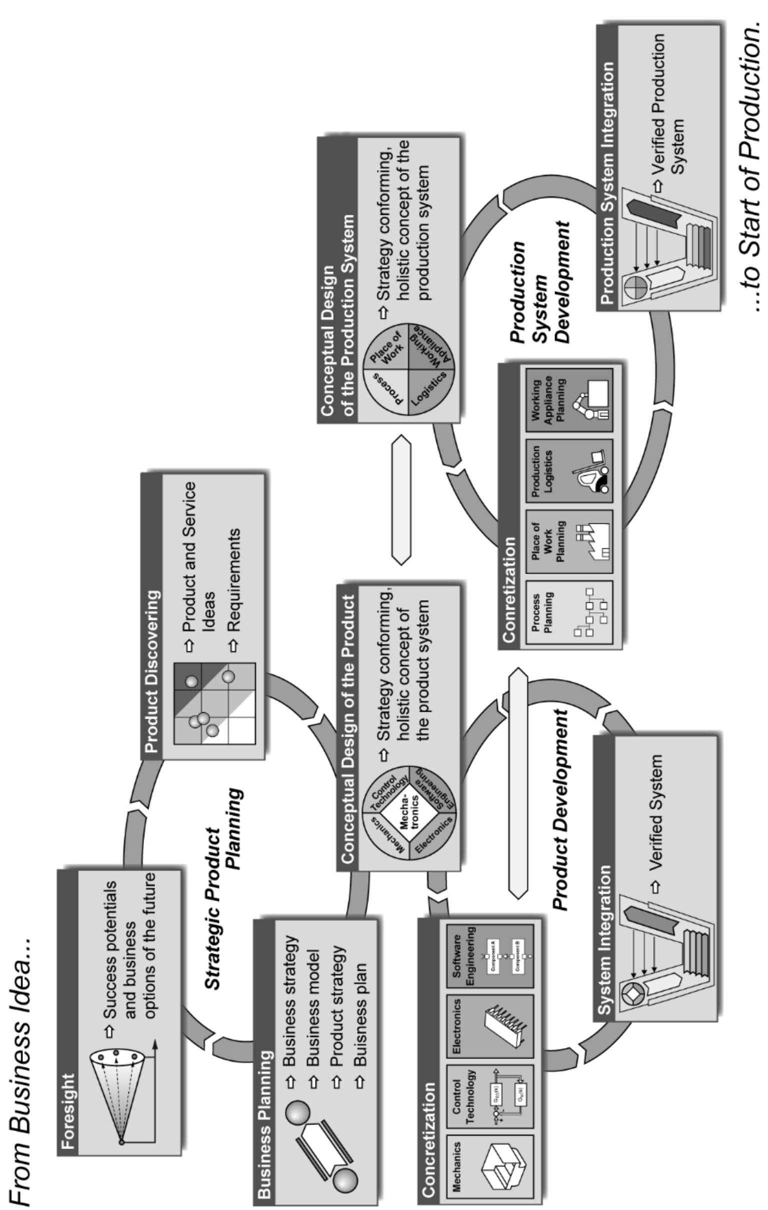


Figure 56: Full Three cycle Model (Heinz-Nixdorf-Institut, 2017)

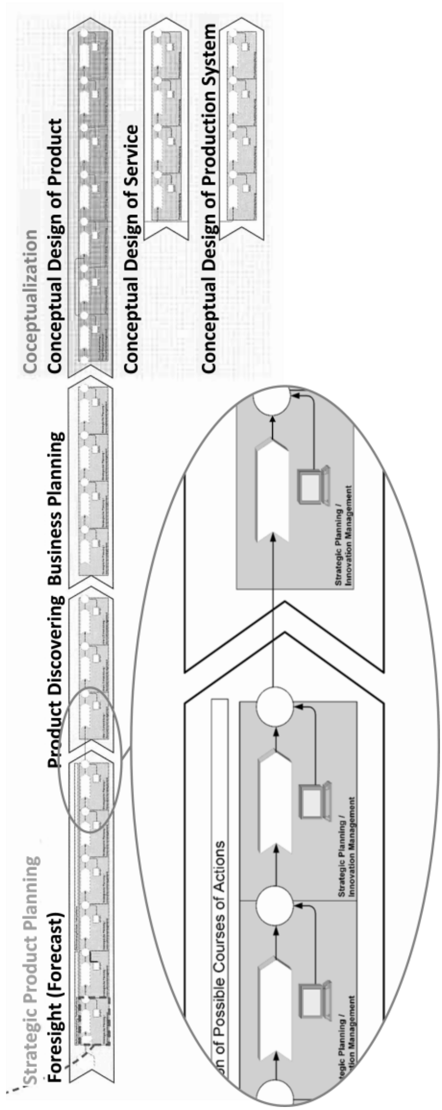


Figure 57: Layout sketch of a process model in OMEGA notation attempting to linearize the Gausemeier cycle (Gausemeier, et al., 2016) (Detailed task description are not disclosed)

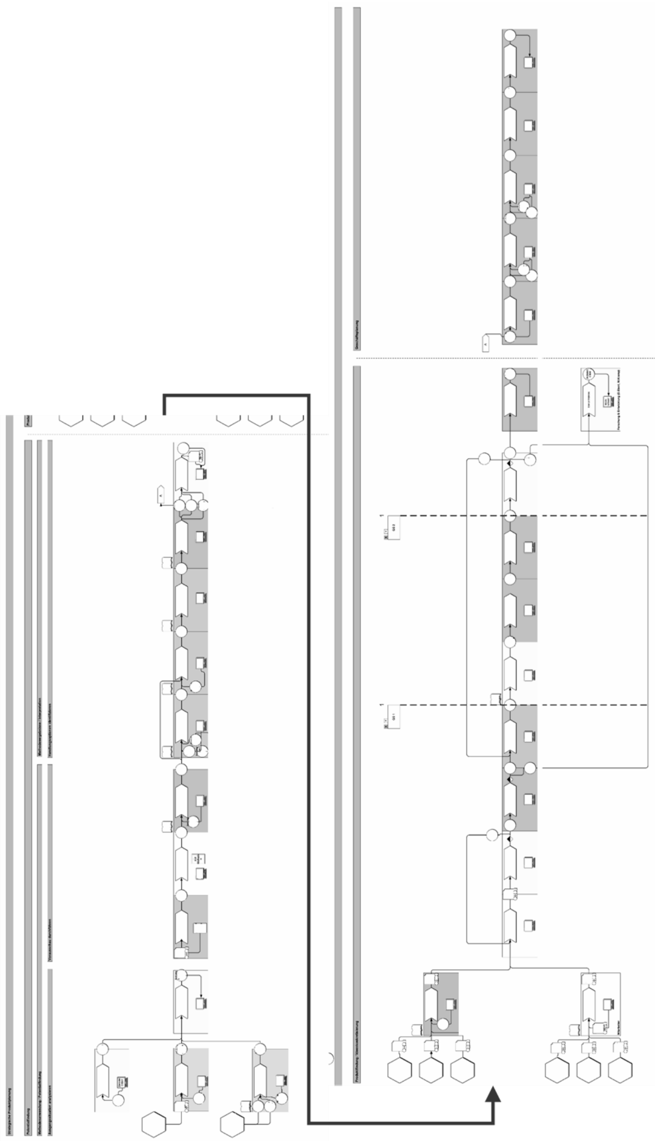


Figure 58: Sketch of a process model in Omega notation derived from the linear referential process model in Figure 57 to specify the SPP activities of small German enterprise

For that model, more-detailed information was available. Similar to the referential model, the derivate is seemingly linear. However, it is comprised of three different and independent sections that are not truly connected in the process model, thereby in principle breaking the concept of the Three-Cycle-Model. The linearity could also hold not true when the details of the models are considered.

Figure 59 brakes down that model to the principal tasks and identifies for each task two aspects.

The first aspect that is identified is the principle scope or abstraction anchor that is used to describe a task. E.g., whether the task is an active description that defines the action of the executing company (subject) or whether it is a passive description, defining the action to be done on an information object such as a “trend” or an “idea”.

Besides these, the second aspect analyzed is the consideration of what matter of temporal or causal description is used in the task.

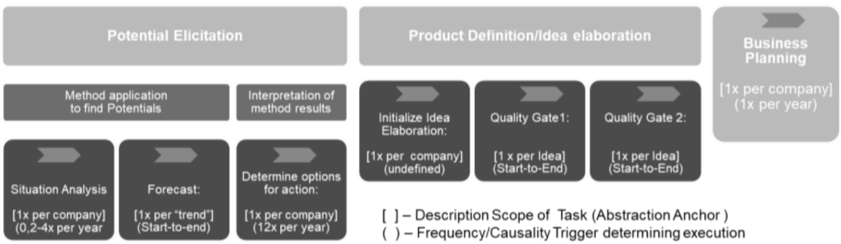


Figure 59: Analysis of the structure of the model in **Figure 57** showing the discrepancies in the execution logic with to arbitrary changes in the considered of scopes and temporal descriptions

As can be seen in Figure 59, both aspects vary widely from task to task, shattering any illusion of having a coherent an executable model. The scope continuously changes between active description for the executing company, of which there is only one, to the passive description for "trends" and later for "ideas" of which there are necessarily multiple instances that all need to pass through screening and gates.

More importantly, though, there is a constant change in the temporal and processual description logic of the individual tasks. On the one hand, the classical input-task-output/start-finish logic is used to describe the passive handling of individual trends or ideas, akin to the phase model of section 3.3.2. Here, temporal and causal logic is congruent. However, these linear tasks are flow-wise directly embedded between tasks that, according to their textual description, are only linked to them causally, but not necessarily temporally[33]. The temporal logic of those other tasks is not that of start-to-finish, but rather that of tasks that are iteratively executed upon calendrical events or with a specific frequency. E.g., decision meetings or very general activities that are executed each year or each month.

To make matters worse, the repeated actions all have different frequencies or may not have them defined at all. While the causal logic holds, it makes only sense, when the missing information is given by an experienced consultant familiar with the model. For automatic execution systems that are supposed to run this process, this misleading and utterly wrong as it depicts linear follow up of tasks that are not linear.

Concluding and unsurprisingly considering the findings of chapter 3: while the Three-Cycle-Model is useful to understand general aspects of Strategic Product Planning, linearizing it in OMEGA in order to have a more concrete version is not a valid approach to produce an executable referential model.

3.3.4.2 Subject-Oriented Description of the First Cycle

As shown, a linear process interpretation approach is not very suitable. However, the Subject-Oriented paradigm can be used to create a process

[33] Meaning the information gathered or decisions made will have some impact on the following task, but their execution timing is linked to an arbitrary calendar and not to a trigger within the supposed process time flow.

model that is more akin to the fundamental concept of the Three-cycle model.

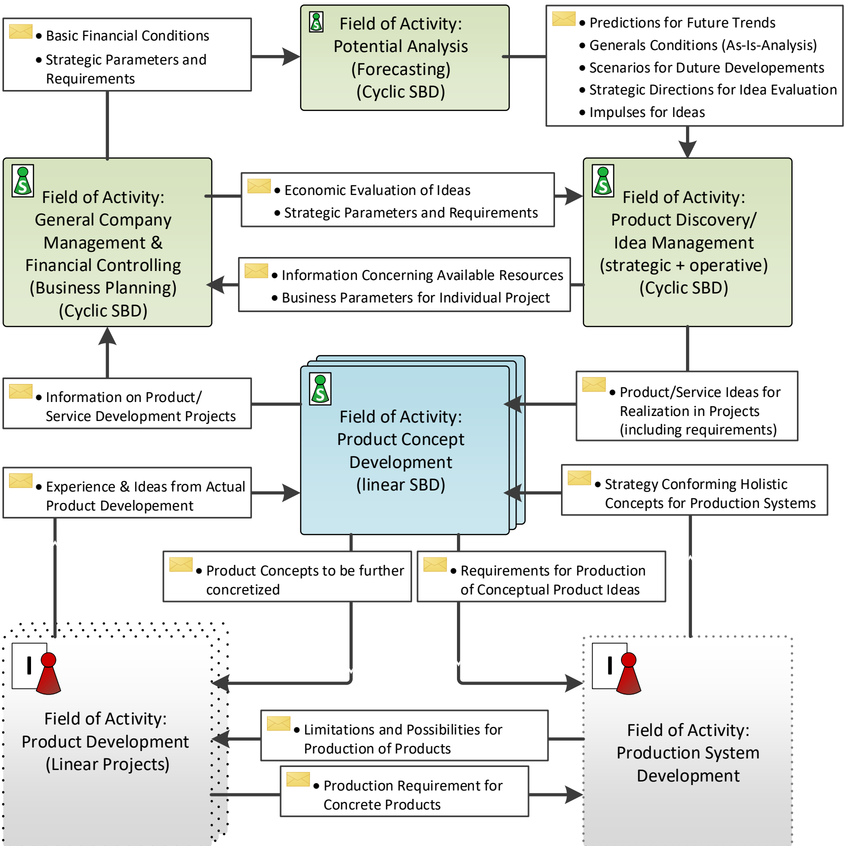


Figure 60: Subject-Oriented Interpretation of the Three-Cycle-Model

The interpretation (Figure 60) is true to the principle cyclic flow of information depicted by the original model. However, it also shows that information is not only conferred unidirectional in a cycle but exchanged between multiple areas of activities, forming a network rather than three clear cycles. This would have been even truer if further information flows had been added to this interpreted model. E.g., from Product Development and Production Development to Potential Analysis and Product Discovery. Information flows that represent a possible input of ideas and trends based on the experience in those areas, which would also be very reasonable within the bound of the original model.

On another note, like in the subject-oriented version of Weigt & Seidel (section 3.3.3), the development of concepts (and the likely following development of actual products) has been identified as a linear field of activity that is instantiated multiple times (once for each concept in development). Therefore, in contrast to the other subjects of the first cycle, "Product Concept Development"[34] is modeled as a multi-subject with linear behavior. This, among other aspects, shows how important the use of descriptions means or a modeling language that is capable of describing both aspects, especially for situations that are composed of project-individual tasks and trans-project tasks.

The model has a few other aspects that need to be analyzed: Like the other interpreted models, it does not contain an explicit product portfolio management or cross-project management, which is only implicated in general by the three-cycle-model as there is no difference between single and multi-instance areas-of-activities in the original.

Also questionable is the decision to have an explicit and single subject for "Production System Development". While visually true to the Three-Cycle-

[34] Terminology wise, the subject could have been labeled as Product Concept Development "Project", as it has project-like character similar to the actual "Product Development" subject. However, based on feedback of interview-partners, the term "project" is in, at least some, organizations reserved for officially sanctioned ventures with formal requirements and funding. Early into the development of a concept, such funding and official acknowledgment is rarely the case, as it would lead to a lot of overhead when still trying to figure out what it is. In consequence, instead of trying to redefined the term "project" or specialized it with a term like "pre-project", it has been dropped from the model's labels. The actual people responsible for that subject/subject instances are not paid to work on a project specifically, but rather to develop new product concepts in general.

Model, the chosen modeling here could give the impression that the development of production systems is a strictly separated task from Product Development. In turn, this could lead to an implementation, where these tasks are executed by strictly separated organization departments, possibly hindering the communication. One of the main propositions of the original model is that Product and Production System Development should be done in unison and with constant information exchange. Therefore, a better approach would be to combine both Interface Subjects and model both development aspect as part the according Subject Behavior Diagram.

This leads to another problematic aspect, namely the transformation of viable product concepts into an actual development project. At the core, the Three-Cycle-Model proposes that concept development and later on actual product development play hand in hand together, as their cycles are interwoven. The interpreted model separates both aspects into two different subjects for two reasons. First, to represent both cycles, but secondly also to acknowledge the organizational difference between conceptual (pre-) development and official projects with allocated resources (as discussed in Footnote 34). Alternatively, the development of a concept into a final product could have been realized as a single subject and within its behavior diagram. This would have been more akin the classical concept of linear progression through a development effort, but here embedded formally in a single context and without caring for a formal separation between in essence similar fields of activity. However, due to the reasons above and due to the problem that the exact point and conditions where and how a project emerges from its pre-development stage will most likely vary widely between organizations or even between different types of development efforts. This way it is represented that this transition occurs, but how exactly is only indicated in the according SBD.

Reception

The reception of this model was mixed. Partly, interview partners understood the nature and considered the subject-oriented interpretation merely as containing more information and being more specific than the original, but fitting its original propositions. Others did not find it wrong but overloaded with information and too complex. Considering the general complexity of the domain, however, that criticism is not entirely avoidable.

3.3.5 Summary of Section 3.3

In this section, several process description approaches have been discussed. This has been done by comparing the original models with subject-oriented interpretations and discussing them with domain experts, to find possible shortcomings.

In general, when asked, interview partners rarely found the subject-oriented models to be different from the original ones. Reaction tended towards the point-of-view that the PASS model stated the same things that were trying to be conveyed with the classical models, showing that it is easily possible to capture the essence and core propositions with the subject-oriented modeling approach. Furthermore, the answers can be understood as an indicator for the hypothesis that the concepts in the minds of the original models' creators already were subject-oriented and they lacked the expressive means to bring their concept into a formal model. Instead, they tried to fit their ideas into a description framework that was not as suitable for that task, making compromises along the way.

On another note, it is hard to discern to what extent the subject-oriented models are faithful to the original models and their propositions. The subject-oriented models bring forth the different concepts deemed important by the originals' authors, but also show that, individually, all models lack certain aspects that need to be covered to represent SPP holistically. Furthermore, as discussed, there are several debatable aspects that are in large parts interpreted by the modeler rather than being direct translations of the original model and its corresponding text. Depending on the pre-knowledge of the reader, and because of the limits of their description means, the original models themselves have only a limited capacity to communicate their actual implications.

Therefore, the interpreted models are significantly contributing to the overall research goal of creating a potentially executable model for Strategic Product Planning. However, it also shows that none of these models individually covers every aspect that is part of strategic product planning and the interpretation are bound by their originals. Consequently, a referential process model needs to be a synthesis from these models and unite the ideas into a singular model.

The corresponding requirements and finale discussions follow in section 3.4.

3.4 Summary and Conclusion of Chapter 3

Chapter 3 examined the hypothesis that there are flaws in existing approaches to describe the processes of Strategic Product Planning, leading to various problems. The hypothesis could not be disproven. Instead, several indicators for the hypothesis were found in the examined description approaches. These flaws hinder the creation of entirely formal yet sufficiently complex process models and thus prevent a simple, non-contradicting adoption into an executable process.

Those flaws are partially built into the individual process descriptions, as their scope is limited. What is missing from all introduced process models is the explicit incorporation of tasks that organize, manage, and control the proposed processes. Notions of such activities do exist and are mentioned in the accompanying literature, but not in the process models themselves. E.g. (Cooper, 2006) does so when considering Product Portfolio Management as Part of Strategic Product Planning (See section 2.1.2). Also (Vahs & Brem, 2015, p. 363 ff.) acknowledge the existence of this type of "controlling activity" – activities like information management, planning, control and coordination of tasks, etc. Particularly in a project-centered context, they note that "Controlling of Innovation Management is of special importance". Moreover, as (Lang, 1994) puts it, those "comprehensive processes that support the product innovation process", naming it "PIC – Product innovation (Project) Controlling" or "procurement" of information.

Why these seemingly essential aspects of Strategic Product Planning have not been incorporated into any existing approaches can only be hypothesized. However, in the context of the observations made here about the classical input-task-output-model, it is most likely that the used description means would have merely complicated models. These limitations, however, are not of a formal nature. The concept of Turing-completeness states that it is theoretically possible to describe any process/mathematical computation using the classical input-task-output-concept. The problem lies within the depiction of corresponding models that possess only one means of abstraction. Therefore, most likely it was the complexity of the resulting descriptions which prevented the model authors from including the controlling aspect into their models. And rightfully so, as it is highly doubtful that, using the classical process description concept, it is possible to create a model that achieves everything at the same time: covering and describing Strategic Product Planning holistically, being comprehensible for humans, and being formal and executable.

Another indicator for the hypothesis of description problems inherent in existing process models (and by proxy in the input-task-output description approach) is that none of the investigated model authors has even tried to employ a formal language, with the possible exception of the attempt to create a linear interpretation for the three-cycle-model using the somewhat formal and defined OMEGA notation. The literature mostly uses informal, freestyle notations framed by textual descriptions to explain concepts rather than formal process modeling languages. Even then, all approaches, with the exception of the three-cycle model, in principle stayed true to the fundamental logic of the input-task-output concept. Thereby they bound their models to the limits of the concepts as analyzed in section 3.1. These limits are not obvious, as – again in theory – every process can be described by the input-task-output concept. Especially for linear and/or small, simple example processes it is quite sufficient when no further (sub-) process descriptions are supposed to be derived from the description. However, when considering human comprehension and the requirement to co-create executable models for complex processual system together with other people, the flaws get more obvious. Hypothetically, the cause of the drawbacks is the limit to a single abstraction mechanism and the subsequent problem of modularizing process descriptions. The most prominent example is the existence of process-tapestries; large monolithic descriptions of large and complex processes which, when printed out, could fill entire room walls – comprehensible for their creators, but utterly incomprehensible for people not familiar with them.

Nevertheless, tapestries are the only way to holistically depict such processes, using the input-task-output concept in a formally correct manner. However, they are inappropriate for referential models used to teach other people. Another example for the limits of the input-output-model is the inability to express linear-causal and iterative process logic in a single model without convoluting it massively.

The consequences of these limits, among others, could be seen in the in the analyzed approaches. A referential process model would need to improve on all the named aspects. Therefore, the requirements for a holistic and still executable process model are derived from the findings and observations of this chapter as follows.

3.4.1 Requirements for an Executable Referential Process Model of SPP

An executable referential process model for Strategic Product Planning must:

Table 9: List of requirements for an executable referential process model of SPP

• Not be limited by an insufficient description approach.
• Be formal, exact, and executable.
• Be understandable by humans to serve as a referential model
  ○ i.e., avoid being overly complex as much as possible
• Represent the complex nature of Strategic Product Planning holistically
  ○ Represent the development of individual product concepts
  ○ Represent the aspects surrounding the individual conceptualization efforts such as (General Strategic Planning and Business Planning, Portfolio Management, Trans-Project Management/Controlling, or auxiliary concepts like Idea-Management, etc.)
  ○ Represent the interactions between these multiple areas of activity and their nature
  ○ Represent external influences and inputs from outside the context of an executing organization
  ○ Represent tasks and activities that occur before there is enough substance for an official project to be started.
  ○ Be able to represent the parallel running of several product developments as well as their gradual reduction
  ○ Represent the linear and cyclic activities of Strategic Product Planning together
• Unite all of the previous aspects in a holistic sound process context

The subject-oriented process modeling approach, together with its predominant modeling language PASS, is the only modeling concept known that has the potential to accomplish these. It has certain drawbacks, primarily due to its uncommonness, which may cause readers to misunderstand the meaning of certain model aspects, especially the SID. However, it is a formal and systematic concept that closely follows the natural structure of human information exchange. The application of the principle to interpret the existing approaches has proven its functionality as well as the ability to capture and express the complex yet important aspect of SPP much better than their originals', while at the same time being executable.

However, all interpretations individually were lacking certain aspects of importance and were still bound to the logic of their original models. Therefore, to meet the research goal of finding a holistic description, it was necessary to create a new referential process model for Strategic Product Planning using the subject-oriented process-modeling paradigm. A model that is partially a synthesis of the investigated process descriptions, but also factors in missing aspects to improve on the previous instances.

This new, resulting model is the consequence of the findings and the core contribution of this research thesis. It is described in detail in the following chapter.

4 The Subject-Oriented Referential Process Model of Strategic Product Planning

This chapter presents and details the result of this thesis: The Subject-Oriented Referential Process Model of Strategic Product Planning. It is the culmination of, and inspired by the concepts, methods, and approaches explored in the previous sections, providing a holistic improvement on or solution to the drawbacks and requirements identified in the previous section.

After a brief introduction, the subject interaction diagram (SID) is explained in section 4.2, followed by an in-depth explanation of the individual subjects and their behavior in section 4.3. Finally, section 4.4 then introduces the scaling and customizing concept necessary to tailor the referential process model to the needs of individual organizations.

4.1 Introduction

The Subject-Oriented Referential Process Model of Strategic Product Planning is a model that holistically captures all aspects of importance for the execution of Strategic Product Planning. It is both understandable by humans as well as executable by machines, thus forming the required conceptual communication layer between humans and their needs on one hand and information systems on the other.

The novelty of this model does not lie within the details of the model. In principle, these are deducted from quoted sources and interviews. The novelty does lie within the logical structure of the model that – due to the usage of the subject-oriented-paradigm – brings many aspects of other description approaches together, clarifies them in context, and embeds them in a formal and executable coherent process frame.

This frame determines the context for the execution of current and future specialized tasks, tools, methods and thinking concept employed in the domain of Strategic Product Planning.

Additionally, due to its broad nature combined with subject-oriented modularization, the model will scale better than other approaches with the same level of detail and formal precision.

4.2 Subjects and Subject Interaction

This section introduces and explains the Subject Interaction Diagram (SID) of the subject-oriented Referential Process Model of Strategic Product Planning. For readers unfamiliar with subject-orientation and its process modeling language PASS, it is advised to see sections 2.3.2 and 2.3.3 for an introduction and detailed analysis to the modeling language in order to understand the fundamental differences between classical and subject-oriented approaches and why it was used for this task

4.2.1 General Structure:

The model contains five fully specified subjects with defined behavior diagrams. They are called “Fields of Activities” to emphasize that the graphical boxes are not process tasks in the classical sense, but rather represent active entities that exchange messages and are responsible for an individual non-linearly organized set of tasks.

An additional, informal and purely graphical notation denotes four of those subjects to have a cyclical or non-ending internal behavior, thereby implying that these subjects are considered to be instantiated only once.

The fifth fully-specified subject is denoted as having a non-cyclical or linear behavior. It is supposed to be instantiated multiple times, which is formally modeled via the multi-subject status of the subject.

The possibility of multiple instances also applies to the two interface-multi-subjects that do not possess a subject behavior diagram. They represent generic support roles that respond to requests or link to follow-up processes not in the scope of this model.

4.2.2 Short Description

4.2.2.1 *Subjects*

The subjects described in the model represent the principle aspects necessary for the holistic execution of Strategic Product Planning. There are five fields of activity:

Strategic Business Planning: Since Strategic Product Planning is useless without the strategy component, the subject contains activities necessary to derive and formulate goals and visions for an organization.

Potential Exploration: The concept of this field of activity is to compile and evaluated information on possible future developments (foresight) with the goal to regularly derive and provide business-, product- or service-ideas, that could be evaluated in future development projects. The abstraction level and extent of the ideas is not a-priori limited and – depending on aspects like the organization size and branch level – can vary from direct improvements to existing products to business ideas that could have an impact on the whole organization structure and product portfolio.

4.2.3 Subject Interaction Diagram

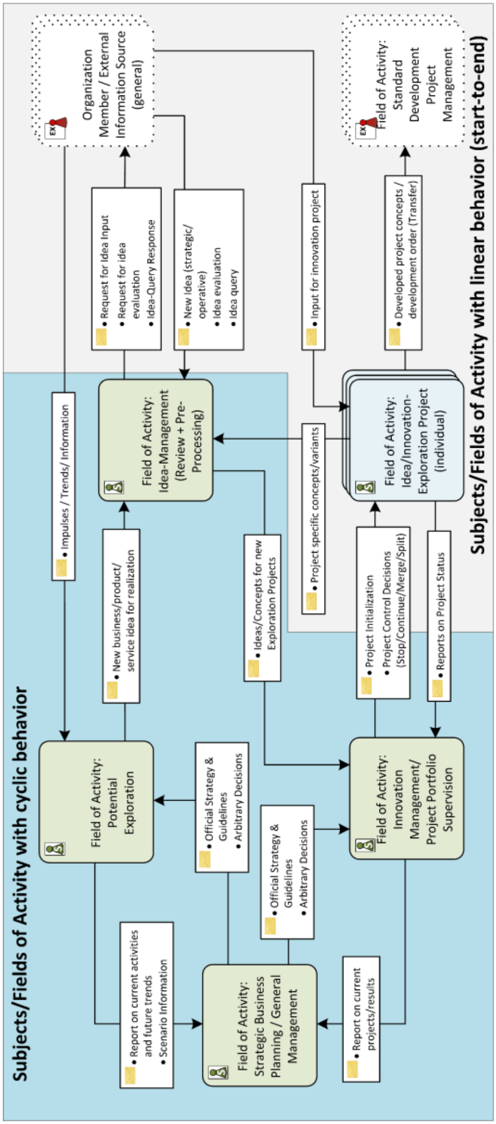


Figure 61: SID of the Referential Process Model of Strategic Product Planning

Idea Management: (or *Knowledge or Information Management*) Ideas of any extent, origin, or impact potential need to be collected, managed, and evaluated with the goal of selecting the most promising concepts and forwarding them to decision makers. Ideas to be managed may come from any *External Information Sources*, *Members of the Organization*, be derived via planned actions and methods (*Potential Exploration*), or be sub-concepts derived within individual *Idea Exploration Project*s.

Innovation Management: While also being a term for the whole management discipline that organizes all activities dedicated towards making an organization be innovative (including SPP), here the "Innovation Management" field-of-activity represents tasks to manage, coordinate and govern ongoing development efforts (projects and pre-project) and align them with current affairs and information.

(Individual) Idea/Innovation-Project[1] Management: Lastly, this activity field comprises the individual efforts necessary to explore and bring a single idea to a state where it can officially be developed in a classical "*Standard Development Project.*" Messages

4.2.3.1 Messages (in alphabetic order)

Note: This section is meant as a cross-reference for the graphical representation of the model. It is necessary to understand the context of each message that is listed here individually. The message descriptions are repeated later on in the individual subject section.

Note: Depending on an organization's size and chosen level of formalism, the possible forms of messages have a broad range. They may be elaborated formal reports spanning many pages of written text, conveyed or stored in an organization's internal information management systems.

[1] Even though the term "project" in this context is debatable, as discussed in footnote 34 of section 3.3.4, it was chooses since the term best represents the temporal-linear structure of these endeavors and the idea that, if promising, it can grow over time and develop into a funded development project.

Equally possible is a scenario where the same information, if at all, is formulated and conveyed purely informal on a personal level in the form of verbal instructions and decisions, or within meetings.

Arbitrary Decisions - Partly due to their usually higher hierarchical position, but also process-wise with regards to the broader scope set of *Business Planning*, the actors there may convey directions for decisions within the domain of corresponding subjects, which may have overwriting power.

Developed Project Concepts / Development Order (Transfer) – This message is the initialization of an actual product or service development project. It contains the whole concept for the project including all previously generated scenarios, boundary conditions, evaluations, etc. From a practical point of view, the conveying of this message may be done as a collection of physical information carriers (folders, USB sticks formal project initialization documents on paper). Equally, it could simply be a change of a project-workspace status in an IT-system, including the configuration of corresponding officers, budget, and billing offices.

Idea Evaluation – This message is the response to the "*Request for idea evaluation":* External experts rating a concept or idea. Depending on the form of the request, the response may also take various forms. E.g., on a personal level, it may range from extensive survey reports on a single topic to on-site renderings of expert opinions and discussion if the request included an invitation. If more elaborated means exist, this information may flow simply in the form of ratings within an online survey system simultaneously done by many external information sources.

Idea Query – Any authorized party may send such a query, requesting information about previously stored concepts or ideas, either because it is their own idea turned in for storing, or in order to see what other concepts have existed in the past or exist in currently.

In many cases, this message may take the form of telephone calls or e-mails. More likely nowadays, though, is the usage of more or less elaborated knowledge management systems and their automatic search functions that allow to anything from simple word-matching queries to customizable, elaborated neuronal-network- and deep-learning-based algorithms.

Sophisticated systems may even send such queries automatically in certain contexts to advise about other things that may interest the user in his given situation.

Idea-Query Response – This is the response concept for the corresponding queries by authorized parties. Equal to the request means, the response may come in many forms, ranging from manually-compiled information sets including physical tokens, to automatically generated lists of information objects available in the digital data storage facilities, be it simple shared folders or state-of-the-art PDM and PLM systems.

Ideas/Concepts for new Exploration Projects – Basically, these are the managed and stored *business/product/service ideas for realization* generated by *Potential Exploration*. However, depending on the quality and scope of general *New Ideas* from employees or ideas generated within specific exploration projects, these may also be forwarded as part of this message to be decided upon whether the concept should be explored or not. The form of this message may comprise anything that may hold information necessary for decision making upon the project concept.

Impulses / Trends/ Information – The message represents any form of information, requested or found, that is required to find and evaluate future impulses, trends, and information on markets, technologies, politics, and so forth. This implies a vast range of forms this message may take. Examples could be simple online search engine results, articles in books, journals or the web, up to explicit reports by professional consultants requested on particular topics.

Input for Innovation Project – Not all information necessary or useful for the exploration of innovative concepts and ideas may be incepted purely internally either before or during a project. Additional external information or evaluations may come in in a myriad of possible forms, be it an opinion uttered at lunch or a formal report by a consulting institution contacted on a particular topic.

New Business/Product/Service Idea for Realization – An idea for a new business, product, or service generated by *Potential Exploration* may be written down or captured in many forms. Typical are standardized characteristic sheets, implemented in the organization's information management system. Other forms may go as far as reports on concepts conveying the whole scenario used to conceive it. On the other hand, it could also be a box containing handwritten scribbles and 3D-printed prototypes. Summarizing, the central concept for this message is to contain as much of the derived information like boundary conditions, requirements, or rough sketches for individual ideas that will be retrieved, further developed, and compared at a later stage.

New Idea (strategic/operative) – These information objects represent any information inputs that do not originate in the specific context of a defined subject.

Classically, senders may be employees that give ideas of how to improve an existing product or production processes on an *operational* level. Since any employee could be meant, valid possibilities also include managers encouraging the exploration of a specific technology or market segments. However, external consultants or competitors could also fit into this category.

Usually, these messages are more concrete ideas than the *Impulses / Trends/ Information* sent to and handled by *Potential Exploration*. Their impact scope may range from rather simple ideas concerned with operative changes to concepts that may influence the strategic setup of an organization if found worthy and set up.

Official Strategy and Guidelines - Form and extent of official strategy and guideline documents will vary widely, ranging from formal documents in printed format to slogans and mottos, to simple statements by individual persons. The form will depend on the efforts and especially on the methods chosen during the execution of the sending subject. Core essence of any strategy information is to set a general, possibly vague direction and or goal for other members of the organization.

Project Control Decisions (Stop/Continue/Merge/Split) – As the name suggest, via this message *Innovation Management* may stop or further allow the exploration of concepts or merge similar exploration efforts.

This may happen in any form imaginable, ranging from phone calls, emails to discussions in the meetings or formal workflows in according process management systems.

Project Initialization – This message formally initializes an exploration effort. As such, its concept is complex. It obliviously should include (access to) all information generated for the concept or idea so far. Additionally, it may contain information regarding budget or due-date restrictions, available resources, and other boundary conditions determined relevant by Innovation Management.

This message may be a simple verbal appointment including handing over of physically stored information. Another variant is the creation of an according project space in an organization's information management and financial controlling system, including setting up access for relevant persons.

Project-specific Concepts/Variants – During the exploration of a specific innovation project many ideas with smaller or larger scope will be collected. Depending on the scope and topic of the project, such ideas may range from variants of detailed solutions to new inspirations for innovative products or even plans to tackle new market or market segments. Conceptually, though, the earlier is more likely than the later.

The actual practical form of this message may range from systematic and complex product description including CAD models and procurement information, maybe within the bounds of a PDM system. In addition, it may include physical file folders containing the collected information or 2D and 3D physical as well as other digital models describing idea aspects.

Report on Current Activities and Future Trends - This results or output of the task area *Potential Exploration* may take various forms, depending on the formal methods and according efforts chosen to derive them. In very informal settings, conveying this information may take the form of chatting at a lunch meeting, while in formal settings it may be comprised out of accurately specified reports tailored to the individual needs of the decision makers. If scenario analysis is used as the basis for strategy development, this report may contain complete scenario information. The message may convey information regarding potentials for new products and services or the evolution of existing concepts. Equally, though, it may contain advice on the discontinuation of current business activities.

Report on Current Projects and Project Results - Again the form of this information object may vary depending on the required level of formalism, necessary or wished-for by the strategic decision makers. Possible forms include, e.g., lunch meetings by chance, regular jour-fix-meetings, monthly, formal reports, or so-called cockpit/dashboard views of project management software systems made available to actors giving traffic light indicators on project status or similar.

Reports on Project Status – Naturally, for *Innovation Management* to compare and decide about projects they must be informed about progress and delays. If chosen, this, of course, may be in the form of formal written reports. However, *Innovation-exploring pre-projects* may not be as formal as real development projects and as such too much formality may be a hindrance. So, this information may equally be conveyed in regular report meetings, informal lunch meetings, or by merely looking up available information in an according project management tool.

Request for Idea Evaluation – In some instances, the evaluation of an idea or concept requires expertise (or at least a second opinion) not directly available to the subject carriers of *Idea Management.* Thus, other individuals may need to be consulted for that task.

The message will usually exist in the form of standard communication means like E-Mail, telephone, and similar. However, it may also take the form of more elaborated means like automatic survey systems that enable mass evaluation of ideas and concepts.

Request for Idea Input – In order to receive ideas, it usually is favorable to initiate the elicitation by setting up programs or otherwise make public that, what kind of, and how ideas or opinions may be turned in. If not done so, it would be entirely left up to chance and individual ambition, especially for standard employees, to turn in ideas.

This message can take many forms: from e-mails directed at specific individuals or group-emails, to public announcements like message boards, or physical idea letterboxes, to give a few examples.

While operational ideas with non-strategic scope are often requested, also ideas or opinions with a potentially greater scope may be requested.

Urgent Idea/Concept (Individual) – In special cases, individual ideas or concepts may be deemed important enough to be forwarded for immediate actions. This message contains all information about the idea or concept necessary to decide whether resources will be allocated or not.

4.3 Subjects and Their Internal Behavior

In this section, each subject from the subject interaction diagram (Figure 61 - p 174) is individually presented. For easier comprehension, each subject is briefly reintroduced in a short characteristics chart with the following structure.

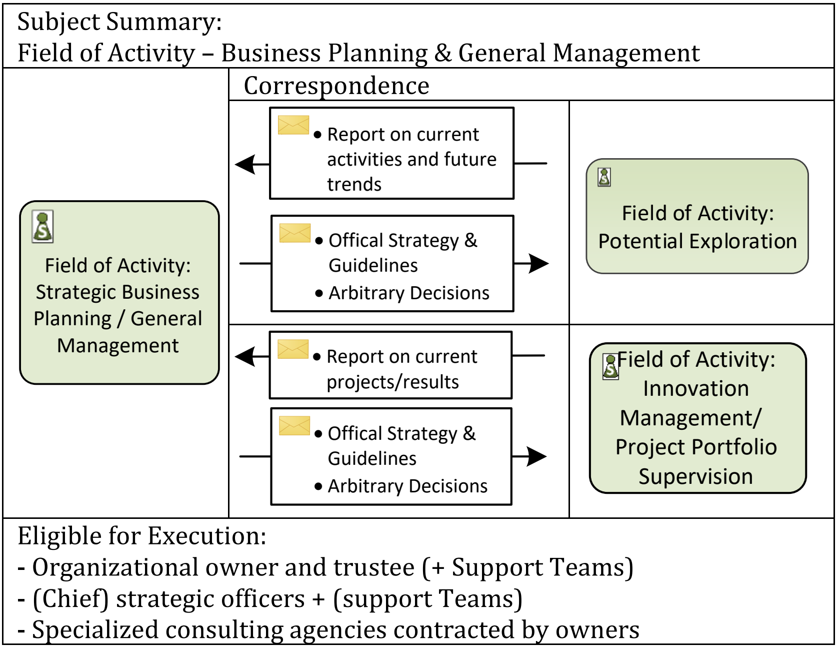
<table>
<tr><td colspan="3">Name</td></tr>
<tr><td rowspan="3">Subject Icon</td><td colspan="2">Correspondence</td></tr>
<tr><td>Incoming and outgoing messages with corresponding subject A</td><td>Icon corresponding subject A</td></tr>
<tr><td>Incoming and outgoing messages with corresponding subject B</td><td>Icon corresponding subject B</td></tr>
<tr><td colspan="3">Examples for persons and/or organizational units and roles that are potentially qualified and could be appointed to execute/supervise the activities described for this field of activity.</td></tr>
</table>

Following the characteristics is an indebt textual definition for incoming and outgoing information and a detailed description of the internal behavior.

For better understanding sometimes ***Base Questions*** are added; fundamental question that should be answered by the responsible subject carrier.

Due to the referential character of this section, the mirroring nature of the modeling language, and with regards to digital versions, the individual descriptions **may share redundant information** that allows the individual text to be understood when looking up an individual element without the direct need to refer to another element.

4.3.1 Strategic Business Planning & General Management



4.3.1.1 General Subject Description

Strategic Product Planning heavily relies on a continuously revaluated, formal business-strategy that considers and incorporates aspect beyond mere product and production strategy.

As argued before, there is a gradient slope between general strategic planning and actual product development. The activities of the *Business Planning* subject are concerned with the former and are likely to be executed by higher organizational units.

This general type of economic or business planning is different from – by name similar – business planning activities for and within individual development projects that are concerned with the economic success of projected ventures.

For non-economic organizations (e.g., government agencies), the tasks described here may not lie within the actual organization, but rather is subject to external boards or political decision makers.

4.3.1.2 Corresponding Subjects

The output of Strategic Business Planning should guide the activities of **Potential Exploration** and **Project Portfolio Supervision**. At the same time strategic consideration, naturally, should take in the status of internal developments as well as reports generated by persons specialized on surveying current and possible future developments.

For potential discovery, the strategy should give directions or at least indicate what potential fields should be explored, while for project supervisors the strategy and business plans should set the environmental variables that the business planning efforts of individual development projects need to adhere to.

4.3.1.3 Messages and interaction

The messages send from Business Planning to both corresponding subjects are identical and represent the results of this field of activity.

Outgoing: Official Strategy and Guidelines - Form and extent of official strategy and guideline documents will vary widely, ranging from formal documents in book format to slogans and mottos to simple statements by individuals. The form will depend on the efforts and especially on the methods chosen during execution of this task field. The core essence of any strategy information is to set a general, possibly vague direction and or goal for other, hierarchical-wise often lower, members of the organization.

Outgoing: Arbitrary Decisions - Due partly to their usual higher hierarchical position, but also process-wise with regards to the broader scope set of this task field, the actors here may convey directions for decisions within the domain of corresponding subjects, that may have overwriting power.

Incoming: Report on Current Activities and Future Trends - The results of task area *Potential Exploration* may take various forms, depending on the chosen formal methods and efforts chosen to derive them. In very informal settings, conveying this information object may take the form of chatting at a lunch meeting, while in a formal setting it may be comprised out of exact specified documented reports tailored to the individual needs of the decision makers. If scenario analysis is used as the basis for strategy development, this report may contain complete scenario information. The message may convey information regarding potentials for new products and services or the evolution of existing concepts. Equally, though, it may contain advice on the discontinuation of current business activities.

Incoming: Report on Current Projects and Project Results - Again the form of this information object may vary depending on the required level of formalism, necessary or wished-for by the strategic decision makers in order to determine the status of in-house development projects and – hopefully – advances. Possible forms include, e.g., lunch meetings by chance, regular jour-fix-meetings, formal monthly reports, or so-called cockpit/dashboard views of project management software systems made available to actors giving traffic light indicators on project status or similar.

4.3.1.4 Internal Behavior

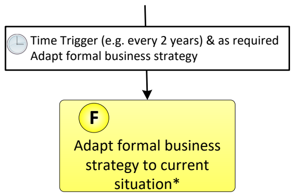
Central activity hub

Strategic Business Planning, within the context of Strategic Product Planning, is a temporal-cyclic activity around a central "activity-hub"[2] from which all activities start individual.

It is comprised of four mayor internal activity tasks that are the core essence of classical economic business planning activities. They should be iterated through in individual intervals defined by the outgoing time trigger transitions of the activity hub.

Formulate/Adapt formal strategy:

> ***Base question to be answered: Where should the organization stand in 5-10 years? What (kind of) goals are to be reached?***



Deriving and formulating an adequate formal strategy for any organization is by no means a fast and straightforward task. In addition, it is hard to evaluate or proven to be effective. Whether the "right" goals were chosen and set in motion correctly, or not, can only be evaluated several years afterward. Still, it is essential to set goals that should be reached in order to have a driving factor within an organization. Such goals may range from new targets for turn-overs or market segment shares, to tackling new markets or technologies, to keeping a specific performance ratio with given resources.

[2] An "activity-hub" is usually a receive state representing a kind of "idle" status for a subject. Organized around it are different tasks and task groups that are triggered either by the reception of messages with defined follow-up procedures or by time triggers, requiring the execution upon the lapse of a certain duration or reaching a certain deadline. Alternatively to triggered events, an activity-hub may also be left via arbitrary decision of its subject carrier "as required", allowing to handle circumstances or special events not anticipated and in need of handling, e.g. outbreak of a civil war in beforehand strategically interesting production location.

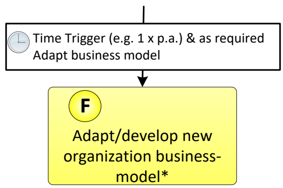
Since generating and arguing about a strategy, especially for larger organizations, is in itself a complex task, it is advised to use systematic approaches and methods devised for this task. One example of a compact yet effective approach is the Vitostra-methodology (Bätzel, et al., 2004) that could be employed here. Other possible step-by-step instructions are given among others, e.g. in (Zweifel, et al., 2016) or in (Gausemeier & Plass, 2014)

A formal strategy may have relevance for more than the area of Strategic Product Planning and as such, according efforts may also be bound to other processes, but a general strategy is necessary for all other efforts (compare section 2.1.2).

In any way, a change of strategy should always be done when unforeseen circumstances require it, but otherwise, it is the slowest iterating task in the model with an advised cycle period of roughly every two years where an existing strategy should be reevaluated.

Adapt/develop business-model(s):

> ***Base question to be answered: What is the current, and what will be the future principle earning and operations modes for the organization?***



To put the base question in other words: How does and how will the organization generate revenues (or optimize the allotted resources[3]) on a principle level within the given boundaries and strategic goals?

A business model is more specific than a general strategy and closer to tactical planning and as such the current business model or business models (plural in larger more segmented organizations) should be reevaluated

[3] For non-revenue-seeking organizations, the term "business model" may not be fitting. An equivalent would be another kind of formal description for "principle mode of operation".

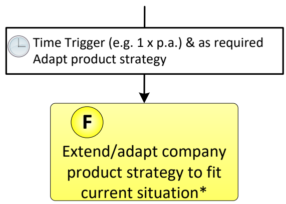
and adapted more often (e.g., once a year) if no special circumstances (e.g., suddenly arising opportunities) require and intervention at an earlier time.

There are a few typically methods that can be employed to express and model existing business models, analyses them and use the gathered information to advance the business model. The most prominent and fast example is the Business Model Canvas approach (BMC) developed by Osterwalder (Osterwalder, et al., 2011). Other possibilities include Business-Model-Templates or Business Model Roadmapping: (De Reuver, et al., 2013).

While financial planning and feasibility checking are essential aspects of a business model, it still is different and more general than a business plan (second to next task)

Extend/adapt company product strategy (strategic product portfolio planning)

Base question to be answered: What products and services are and will be offered (to reach and fit strategy and business model)?



Depending on the viewpoint, the task to create an organization-wide product strategy is the core tasks of Strategic Product Planning or – with an even narrower mind – it IS Strategic Product Planning itself.

A product strategy or planned product portfolio determines with what kind of products, services, and variants that should be offered in general. Abstraction-wise, the consideration here is in between the economic concepts for a general business model such as “market-segments” or similar, and the more concrete realization questions of a business plan or in-depth technical question of how products will be set up or services may be executed. This can be seen in the typical methods (Gausemeier & Plass, 2014) (Gausemeier, et al., 2016) advised for this task such as:

- Product-Portfolio-Analysis
- Variant Planning
- Technology -Roadmap
- Product-Roadmap

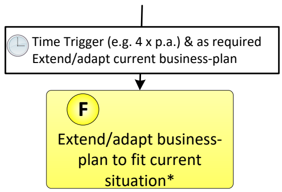
All of them serve to generate a holistic, systematic, and comparing overview over the currently existing and possible future products and services on a more tangible yet abstract level.

Generating an overview is highly reliant on the information and result gathered in individual development projects and potential exploration efforts of the company, described in other areas of activity. The planning goal in this task is the synchronizing of possibilities and trends with strategic goals and business opportunities on a functional/technical level. It is the culmination of those individual efforts.

Like the business model conception, product strategy and product portfolio planning should be executed roughly once a year if no special circumstances require earlier changes.

Create/extend/adapt business-plan:

Base question to be answered: which of the planned and envisioned activates will be executed in the coming time period based on their financial success probability vs. costs ratio?



The business model is concerned with the principle earning mechanism(s), while the product strategy is concerned about the offered products that are either producible and/or the most feasible. Necessarily, both need to be practically applicable and financially sound, given the current status and prospects of an organization.

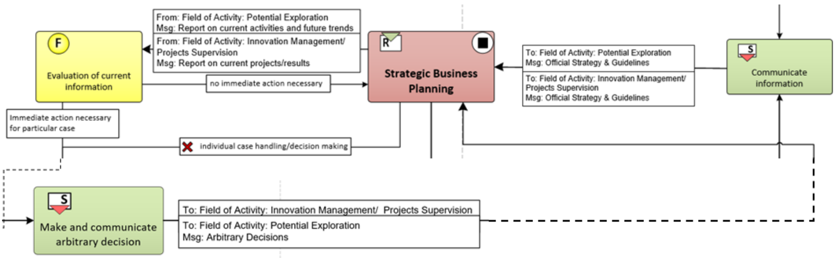
So while technology and marketing wise an investment may be a good idea and – ideally – fit the strategy, the current budget may not allow the resources to start it, or other investments may be more opportune to venture on. The according resource-planning task can generally be described as business planning. While standard business planning includes the whole company, in this context of Strategic Product Planning, business planning may be limited to research and development aspects.

There, quite a few methods that can be employed to forecast and evaluated financial success chances of the organization in general or individual developments. Typical and straightforward examples among others are:

- Net present value method
- Return on Investment
- Break-Even-Analysis
- Pay-off-Method

The employment of these methods should be considered with caution. Once, because at the same time not all projects are the same point of progress and depending on that, the results of the given methods may vary widely in precision and trustworthiness. Secondly, not all evaluation aspects of future development can and should be captured on a financial level. Especially the resources for general tasks like the *Potential Exploration* or Knowledge Management areas of activity play a vital and important role within the process of Strategic Product Planning. Yet assigning a business value (e.g., for personnel or consultants) may be arbitrary.

Handling incoming messages and conveying information



Naturally, information that may concern Strategic Business Planning activities may come in at any time depending on the intervals or occurrences within the other fields of activities. As such, the model naturally envisions the handling of said information. In many cases, such reports may not have any immediate impact on current strategic business planning activities in which case they basically are filed away and used upon the scheduled execution of the four main tasks. Yet, it may occur that some information requires immediate reactions. In that case, arbitrary decisions need to be made and conveyed. That may also be the case without official reports if such information reaches the subject carrier of this field of activity via a non-specified channel[4].

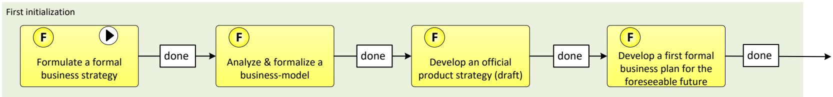
Otherwise, the information generated in this field of activity is regularly communicated within the organization after an update has occurred.

Initialization

Unlike other subjects in the referential process model for Strategic Product Planning, the behavior of Business Planning has a special initialization section. It contains copies[5] of the four main tasks described before, with the difference that they are set in a sequence and form the actual starting point for systematic strategic planning.

[4] Arbitrary actions may even simply be imitated by the "gut feeling" of "the boss"

[5] With the slight difference that the labels semantically only carry the notion of "created new" or "set up for the first time without prior existing elements"



The explicit and somewhat redundant modeling of this section serves two purposes:

The first is to show how to start from scratch if no previous efforts into organization-wide formal strategic planning approach have been made. The initialization section represents the most common, most logical sequence through the four tasks advised to be taken. Either individually, if resources are available to proceed task by task, or – in a minimal setting – in what order the questions behind the four tasks should be answered in a brainstorming-like session.

The second purpose of the section is to have a comparison or linkage point to show the difference between the classical process description approach, that is mimicked here, and the subject-oriented approach employed in general. It demonstrates that a linear process flow can easily be described where applicable. However, beyond that, as is the case here, the methodology allows to formally describe time-based cyclic proceedings that process-wise on the long-term are independent of each other.

4.3.1.5 Complete Behavior Diagram Strategic Business Planning

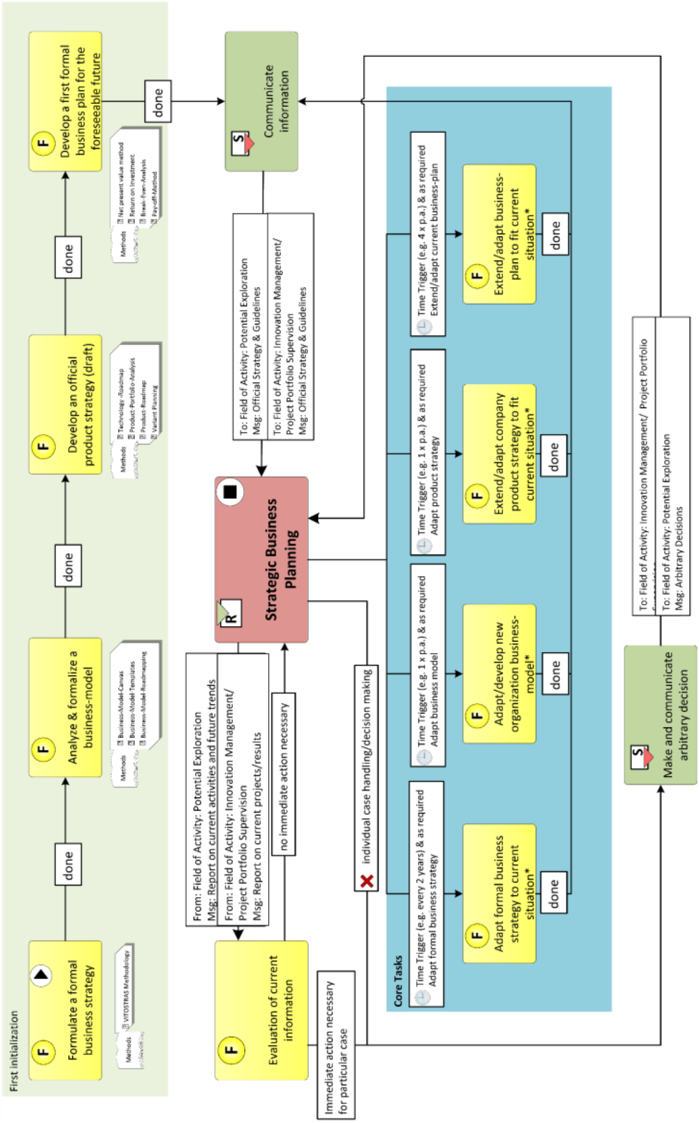


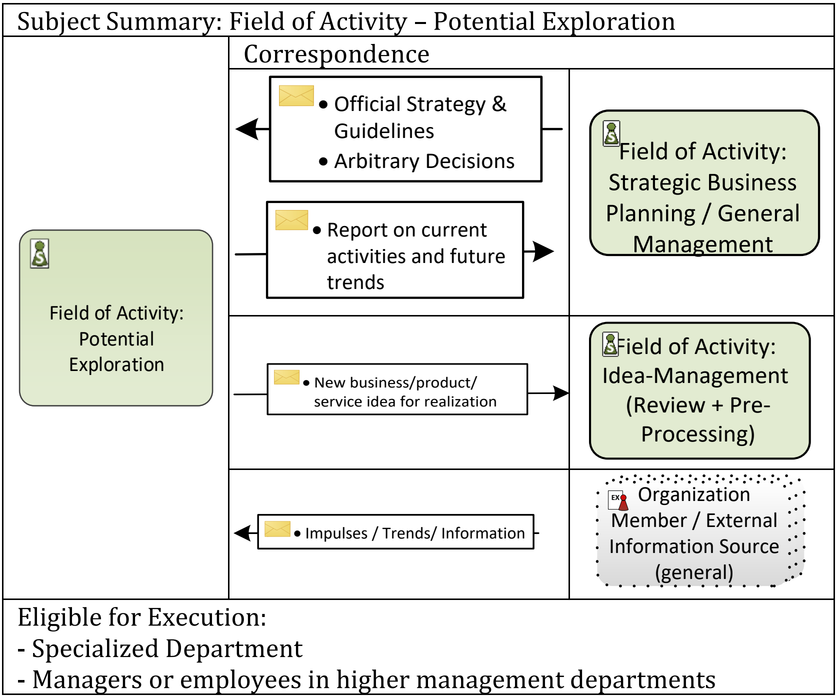
Figure 62: Subject Behavior Diagram for Business Planning (cyclic)

4.3.1.6 Reasons for Subject adoption in the model

"*Business Planning*" and its tasks were adopted from the 3-cycle model. There is no Strategic Product Planning without top-level strategic planning, which is a clearly defined activity. Using messages and timer transitions, it can be modeled that even though there is a principle determination hierarchy between the four tasks, running from general strategy to formal business plan, process-wise, the tasks are independent and influence each other. There does not exist a linear one-way causality. Additional external input via reports and messages may also have feedback effects.

Not directly shown can be the difference between the general business planning task here and their counterpart on an individual level that are part of *Exploration Projects*.

4.3.2 Potential Exploration



4.3.2.1 General Subject Description

The concept of this field of activity is to compile and evaluated information on possible future developments (foresight) with the goal to regularly derive and provide business-, product-, or service-ideas, that could be evaluated in future development projects. This is mainly done in the context of creating and analyzing formal-scenario-based predictions. The abstraction level and extent of the ideas/scenarios is a-priori unlimited and may be fostered by either, the market pull as well as the technology push mechanisms. Depending on aspects like the organization size and branch level, it can vary from direct improvements to existing products to business ideas that could have an impact on the overall organization structure and product portfolio.

The internal workings therefore closely follow the scenario-based approaches of (Gausemeier & Plass, 2014) which are related to the principle complexity handling concepts of (Vester, 2002) and its Sensitivity Analysis.

In contrast to the conceptual-similar activities done within the exploration effort of a single *Idea/Innovation-(Pre-)-Projects,* the scope of *Potential Exploration* is broader. It is more general and open, and not bound to one particular case. It also is a guided, structured, and repetitive approach dedicated to the generation and the combination of project concepts out of unstructured and intangible information. By that definition, it is not a start-to-end workflow, but rather a cyclic combination of several activities to be conducted regularly (yearly) forming the inner clockwork that drives and is the heart an origin of product planning.

This model set-up is one of the novelties in this model, made possible by adopting the subject-oriented description approaches. It frees description efforts from the hen-egg-problem-like dependency on the existence of explicitly identifiable concrete product ideas that would otherwise be necessary for a passive description in a linear approach.

If at a later point in time ideas generated by *Potential Exploration* may be found useful to be further explored, the scenarios created here can be reused or extended.

4.3.2.2 Corresponding Subjects

Potential Exploration takes the instructions of upper management (*Strategic Business Planning / General Management*) into account and reports findings and developments. Otherwise, the resulting findings are stored and processed by *Idea Management*. Finally and next to their own findings, *Potential Exploration* is responsible for capturing and eliciting information regarding future developments may come from *Organization Members* or *External Information Sources* in general.

4.3.2.3 Messages and interaction

Incoming: Official Strategy and Guidelines - Form and extent of official strategy and guideline documents will vary widely, ranging from formal documents in book format to slogans and mottos to simple statements by individuals. The form will depend on the efforts and especially on the methods chosen during execution of this task field. The core essence of any strategy information is to set a general, possibly vague direction and/or a goal for other, members of the organization.

Incoming: Arbitrary Decisions – General summary for decisions and guidance instructions made by higher hierarchical position. Ideally, they contain decisions made upon information and considerations on a higher abstraction level and scope. An Arbitrary decision for *Potential Exploration* may, for example, be to stop investigating a particular domain or field or to focus on a specific topic or problem.

Incoming: Impulses / Trends/ Information – The message represents any form of information requested and required to find and evaluated future impulses, trends, and information on markets, technologies, politics, etc.. This implies a very broad range of forms this message may take. Examples could be simple online search engine results, articles in books, journals or the web, to explicit reports by professional consultants requested on particular topics.

Outgoing: Report on Current Activities and Future Trends - The results of *Potential Exploration* may take various forms, depending on the chosen formal methods and efforts chosen to derive them. In very informal settings, conveying this information object may take the form of chatting at a lunch meeting, while in a formal setting it may be comprised out of accurately specified documented reports tailored to the individual needs of the decision makers. In a more elaborated version, it may even contain complete scenario information to be used not only for product idea derivation but also for strategy building. The message may convey information regarding potentials for new products and services or the evolution of existing concepts. Equally, though, it may contain advice on the discontinuation of current business activities.

Outgoing: New (rough) Business/Product/Service Idea for Realization – An idea for a new business, product, or service generated by *Potential Exploration* may be written down or captured in many forms. Typical are standardized characteristic sheets, implemented in the organization's information management system. Other forms may go as far as reports on concepts conveying the whole scenario used to conceive it. On the other hand, it could also be a box containing handwritten scribbles and 3D-printed prototypes. Summarizing, the central concept for this message is to contain as much of the derived information like boundary conditions, requirements, or rough sketches for individual ideas that will be retrieved, further developed, and compared at a later stage.

4.3.2.4 Implicated communication

There are two message exchanges not explicitly modeled for *Potential Exploration*.

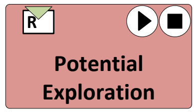
First are messages to *External Information* sources that request information and initialize a response from external and internal sources. Instead of explicit modeling, this type of request activity is described as function states within *Potential Exploration*. The main reason to choose this approach is the broad range of channels and variants this kind of communication can take, ranging from by-chance encounters with information holders, via elaborate market surveying programs and internal continuous improvement process efforts, to explicitly requested input for a single matter.

The second information flow not modeled explicitly is the input from *Idea/Information Management* to Potential-Exploration. The former is not a black box that only receives and stores ideas. Instead, it is a tool for *Potential Exploration* to work with, keep track of and search for previous ventures, find similar approaches or to survey current ideas inside the organization. Process-wise this implicit reflux is contained in the *Impulses / Trends/ Information* – message received from the general *Information Source* subject role, which in this case is being executed by the same subject carriers (people and systems) that are responsible for executing *Idea-Management*.

4.3.2.5 Internal Behavior

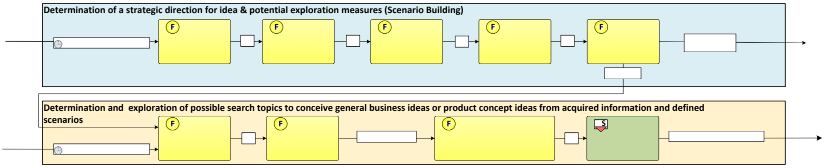
Central activity hub

Same as Strategic Business Planning, *Potential Exploration* is a temporal-cyclic activity around a central "activity-hub" from which all activities extend.



Next to five auxiliary tasks concerned with internal improvements and the handling of communication, the core of *Potential Exploration* are two groups of tasks, concerned with creating and evaluating so-called scenarios. Scenarios are more or less complex models that try to capture and express the most likely future situations and developments. Derived from these then are rough concepts for products and services that could be explored further. Finally, the derived concepts and ideas then are rated, and the most promising examples are forwarded to be explored individually in Idea/Innovation-(Pre-)-Projects.

Scenario Building and Evaluation



These two sections are the core aspect of *Potential Exploration*. In essence, they contain the basic concept necessary to conceive and evaluate a general future-predicting scenario systematically. The goal is to analyze potential risks and chances for the organization and derive (rough/unrefined) product and service ideas from it, in accordance with an organization's strategy set-up. This may also include advice to discontinue or merge products or product groups.

The principle idea is that after information has been collected to build future-describing models, the evaluation follows in a systematic, top-down approach that systematically tries to encircle possible ideas by narrowing down the exploration scope. This starts from a risk and potential analysis based on a general future prediction for the whole organization, followed by the selection of a *strategic search direction* that determines the principle conceptual categories that a product to be planned should fit. This concept matches (Gausemeier, Plass, & Wenzelmann, 2009) with a strong focus on the formal Scenario-Technique Method (Innovations-Wissen, 2016). As an alternative, the Sensitivity Analysis according to (Vester, 2002) could be adopted for the same purpose.

The Scenario-Technique, while being formal and elaborated, and therefore very advisable, is not a fundamental requirement. Other less (or even more) formal approaches with the same goal are valid if they help to generate the answers for the principle questions behind the individual tasks. **Table 10** and **Table 11** list those principle questions behind the function states of the model. Methods and tools are executed with the purpose of finding the answer to them.

Process-flow-wise, the tasks of both sections can be done consecutively and an according transition exists in the model for the choice to continue directly. The sections were separated though to account for the fact that the actual execution may be quite elaborate and the according conceptualizing, scenarios building, and selection tasks may already be time-consuming. Furthermore, real live applications have shown that a split into at least two workshops on different days with the according preparations is very practical.

Table 10: Principle question step order of the task steps within the scenario building section

1. What new information is available that may be relevant for future developments?
2. What are likely course(s) for development within the given and considered information?
3. What potentials and corresponding risks exist for the organization within those scenarios?
4. Which courses of actions are feasible in order to exploit the identified potentials and avoid the risks?
5. Which of those courses should be explored in detail and in what manner?

Table 11: Principle question step order of the task steps within product idea conception

1. What possible general search directions exist for a given scenario and the boundary/market conditions?
2. Which of the previous determined many directions are the most prominent?
3. What kind of product/service concept can be found in the selected directions?
4. Which of the conceived product or idea concepts are most prominent and should be explored individually in a (pre-) project?

Due to the effort to iterate through these tasks, it is advised for an average SME to do them roughly once a year, and use the processing time for other tasks and activity fields for the rest of the year.

Execution-wise, the given activities are mostly done by specialized organization members assigned to Potential Exploration. However, especially the final decision making and choosing of directions will usually involve the higher management[6].

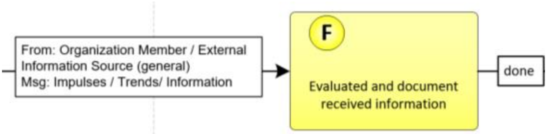
Additional Note:

The Scenario Technique here is applied to generate rough product ideas or advise on the discontinuation of current products. However, Scenarios can also be used for general strategy building (e.g. (Ruijter, et al., 2014) or (Schwenker, et al., 2013)) as well as to the further and detailed exploration of individual ideas and concepts. In both cases, decision-making may be done in the context of other activity fields in the referential process model. The central expertise of future prediction and scenario building, though, is in the domain of *Potential Exploration*. In consequence, the message "*Report on current activities and future trends*" may incorporate whole scenarios, as may be the case with the messages that convey a "*New business/product/service idea*".

Other means for product/service idea conception

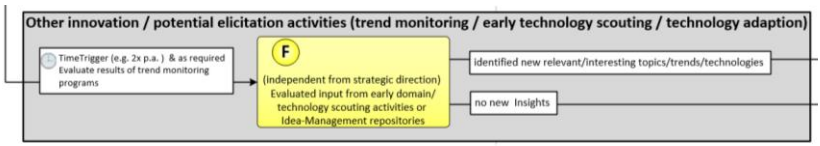
In addition to the systematic pro-active scenario building and evaluation approach, holistic *Potential Exploration* incorporates other means to generate and evaluate new ideas for products and services.

[6] This is a good example for special concept of subject-oriented process descriptions and that subject/area of activity is an abstract concept and as such independent from the subject-carrier. In the given case, the real people considered as "higher management" may become carriers involved in execution of Potential Exploration (they make the decision) while usually being responsible for *Business Planning.*



Base Question: Is the received information of importance or impact for considerations? Moreover, if yes, when (immediate or later) should it be considered and how should it be stored?

The simplest of those means is being the formal recipient for any source of internal or external information that may be related to impulses in markets, emerging trends or similar, even if the received information is then only stored for later uses within the scenario building approach.



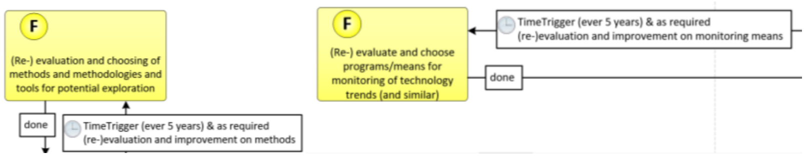
Base Question: has any means of systematic information collection found some useful information?

Similarly, *Potential Exploration* may include the conduction of one or more systematic programs to survey the development of technology and markets. Such programs may be as simple as the subscription to relevant journals, weblogs, and similar. This could also include the regular consultation of agencies specialized in market and technology developments. The regular consultation of professional fortune-tellers or handling programs for industrial espionage would also fit that description but are not advised.

Another type of program or task in this category is the survey of ideas for products and services directly generated by organization members. While the actual collection and processing of such ideas belong to the domain of

Idea-Management (Review + Pre-Processing)[7] the actual prospecting, rating and selection of the incoming ideas in regard to their value as actual product or service concepts in principle lies with *Potential Exploration*.

Improvement of Methods for Scenario Building and Information Collection



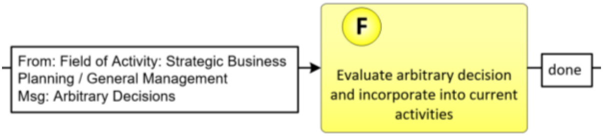
Base Question: Are used methods, tools, and methodologies for potential exploration still legit or are there better options available?

While the principle concept of *Potential Exploration* remains unchanged, the methods, techniques, and tools employed for the tasks should not. Preferably, they should be updated regularly and kept up to date with new developments. Therefore, the process model envisions the reevaluation of the methods and programs described in the previous two sections. These method-reevaluation-tasks are work-intensive and require correspondence with experts on the domains (e.g., universities or professional consulting agencies) as alternatives to intensive research programs into state-of-the-art scientific methods and systems and on how to improve the process of *Potential Exploration*.

The interval advised for this task is roughly five years in correspondence with strategy development. New or by-chance ideas for improving *Potential Exploration* should trigger this self-reflection as required.

[7] By that definition, the organization of the according efforts/ the establishment of the subject *Idea-Management* could be considered a sub-task-area of Innovation Management. If helpful for organizational purposes, that may be valid positon to take. Execution of especially these two subjects may often be done by the same subject carriers/persons.

Taking Instructions



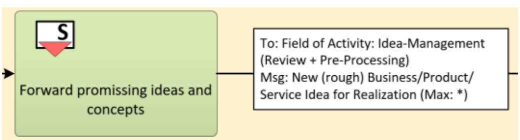
Base Question: How will an arbitrary decision affect operations and how will it be implemented?

The option of direct influence from upper management does exist, for good or worse. Process-wise, the handling of such arbitrary decisions is unspectacular. Upon arrival, the instructions need to be considered and taken into account when executing other tasks. Such instructions may be the immediate and ordered reevaluation of a particular concept, stopping or starting of new programs, or prioritizing and greenlighting a single idea, based upon criteria outside the formal considerations of *Potential Exploration*.

Forwarding Information

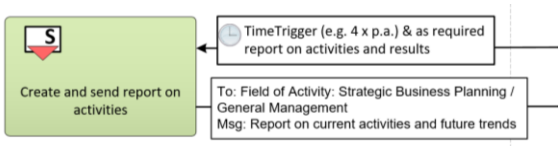
Finally, there are two states in the behavior process where messages are sent.

The first is at the end of the Scenario Evaluation section, where ideas and concepts are entrusted to *Idea Management* either for archiving or to be forwarded to and selected by *Innovation Management* for detailed exploration.



Base Question: What evaluation /score will the conceived ideas get in comparison?

The second communication task to be fulfilled is the compilation and sending of reports on the conducted work for *Strategic Business Planning/General Management*. The proposed cycle time of 4 times per annum is only advisable if next to the scenario building task formal, surveillance programs are in effect that would yield tactical or strategical information with potential immediate urgency. Alternatively, a viable interpretation is that of progress reports on the intermediate results, developed scenarios, selected ideas, or made changes to methods and tools. Since those tasks themselves should be time-based scheduled, a regular reporting system is a more likely variant.



4.3.2.6 Reasons for Subject Adoption in the Model

The exploration of potentials is a fundamental component of Strategic Product Planning. The subject is an adoption from scenario-technique methods based in the context of the 3-cycle model and extended by several aspects for a sustained execution. Added to the linear descriptions are tasks and process flows that complement the execution of these tasks as well as give them a temporal framework that allows for better orientation and understanding of the context in which these tasks are executed.

4.3.2.7 Complete Subject Behavior Diagram Potential Exploration

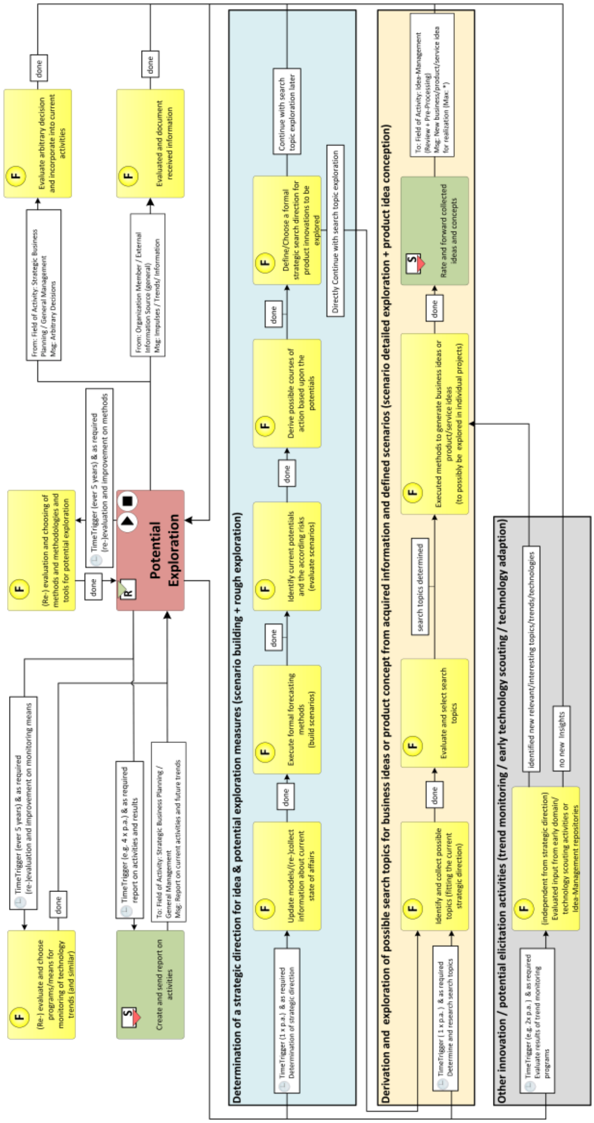
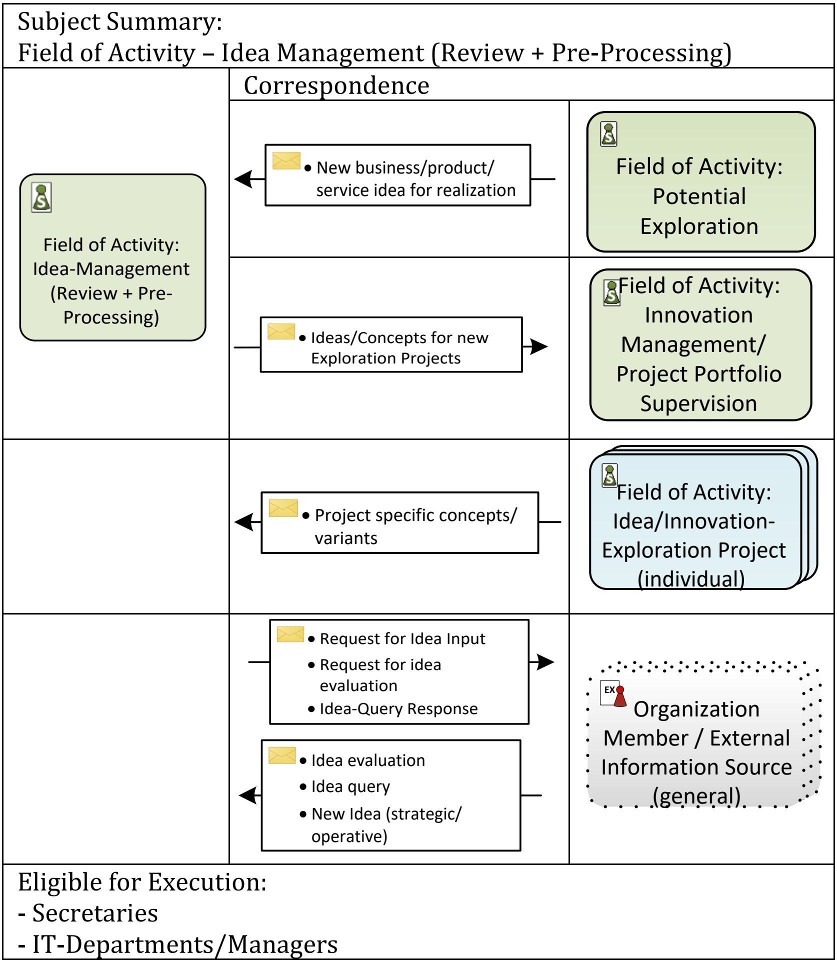


Figure 63: Subject Behavior for Potential Exploration (cyclic)

4.3.3 Idea Management and Review



4.3.3.1 General Subject Description

The review and management of any kind of idea is a sub-discipline of the research domain of knowledge management. This subject focuses on aspects of knowledge management with relevance to Strategic Product Planning, namely the management of individual "ideas".

The core concept is that of an idea broker: to receive and categorize information objects containing idea descriptions from any source and any caliber and either, upon request or regularly, forward those to interested parties[8].

Idea Management is likely to be executed with the support of a more or less sophisticated IT-system, that next to product ideas and concepts may handle ideas from other domains as well, e.g., from continuous improvement efforts (CIP) with scopes like production improvement or employee satisfaction or similar. On the other hand, handling of ideas and concepts may also involve systems from actual product development such as CAD/PDM[9] used in this case to hold sketches or data of existing products. Cross-managing such System – maybe binding them together automatically – and filtering out the information relevant for (strategic) product planning, thus is necessary activity within Idea Management in this context.

It is very likely that *Idea Management* or the management of the according knowledge management systems will involve the same subject-carriers and organization members responsible for *Potential Exploration*. At a minimum, there will be close interaction between both groups.

The problem tackled with this managing and categorizing field of activity, is that the term "idea" is very often used in various similar context across the domains of strategic product planning and innovations management. The spectrum of meaning of "idea" is broad and can range from concrete

[8] This implicitly includes relevant data access control and security measures.
[9] Computer Aided Design / Product Data Management

product or service ideas in various levels of detail, to employee suggestion that came via systems or operative oriented continuous improvement efforts of an organization. (Deutsches Institut für Betriebswirtschaft, 2003) (Koblank, 2014). The subject *Idea Management* a systematic processual description that captures, handles, and combines various levels, extends, and sources of ideas. Thereby, not only the explicitly generated strategic product ideas from Potential Exploration are captured, but also ideas generated by non-experts. Those may not have undergone systematic considerations and lack a formal structure, but may have an equal strategic impact. Thus, the subject envisions the incorporation of employee knowledge also for product innovation on a strategic level in a similar way as suggested by (Vahs & Brem, 2013). Furthermore, concepts from (Nickel, 1999) can be used to foster intake and evaluation of ideas.

4.3.3.2 Corresponding Subjects

Ideas, idea evaluation data, and queries for current and past ideas may come in from any *Organization Member / External Information Source* in general, depending on the chosen publicity level of information. These may be any employees or managers, as well as external experts and similar.

More concrete ideas for projects or products will come in from *Potential Exploration* and also from already running *Innovation Exploration Projects*. In order to start projects, their concepts must be forwarded to *Innovation Management/Project Portfolio Supervision* who then will decide whether to elaborate on or further explore a concept or not.

4.3.3.3 Messages and interaction

Incoming: New (rough) Business/Product/Service Idea for Realization – An idea for a new business, product, or service generated by *Potential Exploration* may be written down or captured in many forms. Typical are standardized characteristic sheets, implemented in the organization's information management system. Other forms may go as far as reports on concepts conveying the whole scenario used to conceive it. On the other hand, it could also be a box containing handwritten scribbles and 3D-printed prototypes. Summarizing, the central concept for this message is to contain as much of the derived information like boundary conditions, requirements, or rough sketches for individual ideas that will be retrieved, further developed, and compared at a later stage.

Incoming: Project-specific Concepts/Variants – During the exploration of a specific innovation project many ideas with smaller or larger scope will be collected. Depending on the scope and topic of the project, such ideas may range from variants of detailed solutions to new inspirations for innovative products or even plans to tackle new market or market segments. Conceptually, though, the earlier is more likely than the later.

The actual practical form of this message may range from systematic and complex product description including CAD models and procurement information, maybe within the bounds of a PDM system. In addition, it may include physical file folders containing the collected information or 2D and 3D physical as well as other digital models describing idea aspects.

Incoming: New Idea (strategic/operative) – These information objects represent any information inputs that do not originate in the specific context of a defined subject.

Classically, senders may be employees that give ideas of how to improve an existing product or production processes on an *operational* level. Since any employee could be meant, valid possibilities also include managers encouraging the exploration of specific technologies or market segments. However, external consultants or competitors could also fit into this category.

Usually, these messages are more concrete ideas than the *Impulses / Trends/ Information* sent to and handled by *Potential Exploration*. Yet their impact scope may range from rather simple ideas concerned with operative changes to concepts that may influence the strategic setup of an organization if found worthy and set up.

Outgoing: Ideas/Concepts for new Exploration Projects – Basically, these are the managed and stored *business/product/service ideas for realization* generated by *Potential Exploration*. However, depending on the quality and scope of general *New Ideas* from employees or ideas generated within specific exploration projects, these may also be forwarded as part of this message to be decided upon whether the concept should be explored or not. The form of this message may comprise anything that may hold information necessary for decision making upon the project concept.

Outgoing: Urgent Idea/Concept (Individual) – In particular cases, individual ideas or concepts may be deemed important enough to be forwarded for immediate actions. This message contains all information about the idea or concept necessary to decide whether resources will be allocated or not.

Outgoing: Request for Idea Input – In order to receive ideas, it usually is a favorable idea to initiate the elicitation by setting up according programs or otherwise make public that, what kind of, and how ideas or opinions may be turned in. If not done so, it would utterly be left up to chance and individual ambition, especially for standard employees, to turn in ideas.

This message can take many forms: from e-mails directed at specific individuals or group-emails, to public announcements like message boards or physical idea letterboxes, to give a few examples. While operational ideas with non-strategic scopes are often requested, also ideas or opinions with a potentially greater scope may be requested.

Outgoing: Request for idea evaluation – In some instances, the evaluation of an idea or concept requires expertise (or at least a second opinion) not directly available to the subject carriers of *Idea Management.* Thus, other individuals may need to be consulted for that task.

The message will usually exist in the form of standard communication means (E-Mail, telephone, etc.). However, it may also take the form of more elaborated means like automatic survey systems that enable mass evaluation of ideas and concepts.

Incoming: Idea evaluation – This message is the response to the "*Request for idea evaluation":* External experts rating a concept or idea. Depending on the form of the request, the response may also take various forms. E.g., on a personal level, it may range from extensive survey reports on a single topic to on-site renderings of expert opinions and discussion if the request included an invitation. When more elaborated means exist, this information may flow, e.g., in the form of ratings in an online survey.

Incoming: Idea Query – Any authorized party may send such a query, requesting information about the previously stored concepts or ideas, either because it is their own idea turned in for storing, or to see what other concepts have existed in the past or exist currently.

In the most simple and old-school cases, the message takes the form of telephone calls or e-mails. More likely nowadays, though, is the usage of more or less elaborated knowledge management systems and their automatic search functions that allow to anything from simple word-matching queries to customizable, elaborated neuronal-network- and deep-learning-based algorithms.

Sophisticated systems may even send such queries automatically in certain contexts to advise about other things that may interest the user in his given situation.

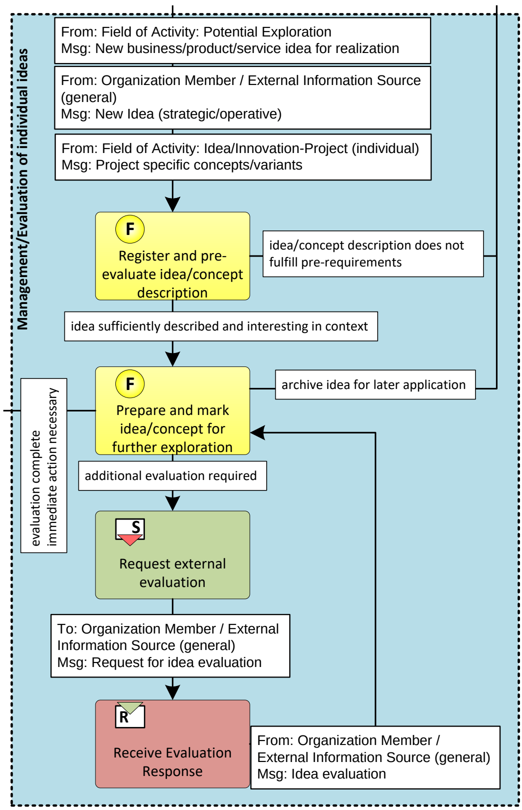
Outgoing: Idea-Query Response – This is the response concept for the according queries by authorized parties. Equal to the request means, the response may come in many forms, ranging from manually compiled information sets including physical tokens, to automatically generated lists of information objects available in the digital data storage facilities, be it simple shared folders or state-of-the-art PDM and PLM systems.

4.3.3.4 Internal Behavior

Central activity hub

As with all activity hubs, this is the idle state from where all activities in *Idea Management* originate from.

Idea Pre-Evaluation



Base Questions in sequence:

1. Does a collected idea fulfill the minimum requirements to be further considered in Strategic Product Planning?
2. Is the idea sufficiently well described or is additional work necessary (+ what kind of work)?
3. Does the idea require immediate attention at the time of arrival (is it urgent)?

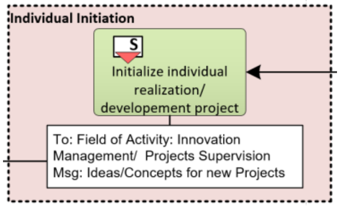
This is the core processual task-block of idea management and describes the principle handling of any type of idea being received by idea management, be it simple input from some external source, or extensive concepts from *Potential Exploration.*

After reception, the responsible subject carrier first must inspect whether the concept or idea fits formal criteria regarding the form of its description and its relevance. Only if such previously determined formal criteria (e.g., correctly filled out forms, principle topical relevance) are met, the idea or concept will be stored for later reuse. This is also a filter for concepts that may be good ideas but have no direct relevance for (strategic) product planning[10].

After the initial check, the preparation of an idea or concept description for archiving is done. This may be an extensive task, including in-depth evaluation and rating of the concept. Nevertheless, at this point in the process, this is not as extensively as it would be the case within *Potential Exploration* or the actual exploration of ideas in *Innovation Projects.* Equally possible to reflect this task is the complete automation or automated guidance of the input giver via an implemented IT system, without any human interaction at this point.

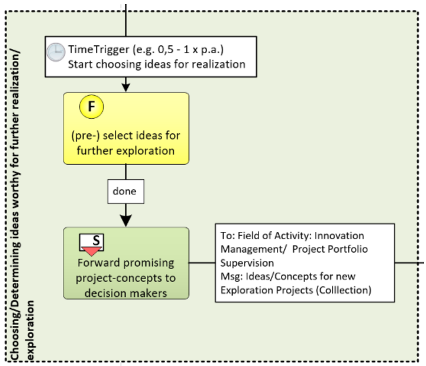
[10] Of course, such, possibly great, ideas should not be disregarded, but instead should be sent off to relevant places not included in this model because their domain does lie outside of Strategic Product Planning.

In some cases, especially if the concept or idea is rather extensive or elaborated, it may be necessary to request further information regarding the evaluation of its soundness or to complete the description.



Afterward, the idea will be collectively stored for later reuse in batch processes running periodically. In some cases though, an idea or concept may be found so worthy or so urgent that it should directly be presented to management to decide upon further measurements.

Regular compilation and forwarding



Base Question: Which of multiple ideas and concept collected in the previous time period is in comparison important enough to be brought up to the attention of decision makers?

The collection of ideas is a reactive process, executed individually with the reception of a new idea at any point in time. However, if *Potential Exploration* is working iteratively, multiple-ideas are to be expected in batches every time a cycle in *Potential Exploration* has finished.

The tasks described here should be matched to that cycle and be synchronized with the logical follow-up-task in *Innovation Management/Project Supervision* where regularly it is being decided which of the proposed ideas will be further explored or not. The typical cycle time is one year.

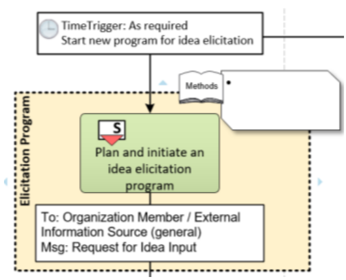
Before that, it is the task of *Idea-Manage*ment to regularly prepare the archived concepts of the previous time period and select the most promising idea for presentation. Possibly the selected ideas may be grouped into different categories if the amount of ideas and the size and structure of the organization is sufficiently large. Similar to the pre-evaluation after an idea has been received, the task of *Preparation and Pre-selection*s itself may be somewhat complex and may involve elaborated methods for structuring, grouping and consenting about selection between multiple individuals. Equally, preparing a chosen idea for presentation may require quite some work in order to bring forth the most important and interesting aspects in a compact and understandable format.

If automatic systems and methods chosen for evaluation are of a stricter nature and systematically applied, the selection may be shorter than in a case where criteria for selection must be evaluated manually. The number of ideas selected for presentation is chosen arbitrarily and depends on their quality, quantity, and the capacity of the organization.

Elicitation Program Initialization

Base Question: Should, and if yes, what kind of programs for idea elicitation should be initiated in general, or to support the activities of Potential Exploration and Concept Evaluation Projects?

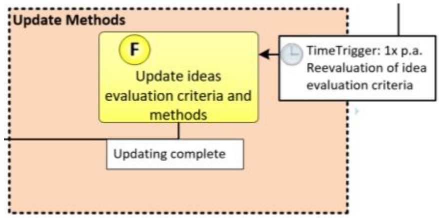
In order to receive ideas, it usually is favorable to initiate the elicitation by setting up programs or otherwise make public that, what kind of, and how ideas or opinions may be turned in. If not done so, it would completely be left up to chance and individual ambition to turn in ideas, especially for standard employees.



Process-wise, there is no defined point in time or specific triggering event that may indicate the initialization of this task. In some cases, this is done regularly in the form of an on-going continuous improvement effort. In other cases, this may be a specific call for ideas to extend a given scenario explored within an *Exploration Project* or even to determine possibly interesting topics to be investigated by *Potential Exploration*.

Method Update

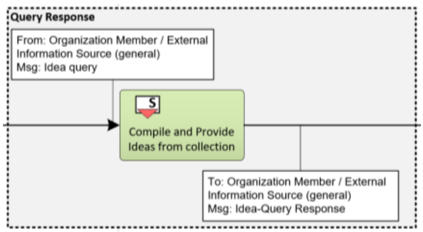
> ***Base Question: Are the criteria for determining the worth of an idea or concept good, or are they preventing innovation? Are the method and tools for managing the ideas and their evaluation good or are there better options?***



As previously in *Potential Exploration,* the evaluation of grouping criteria and methods used for ideas will not remain constant. They vary from the beginning depending on requirements and will change over time to keep up with new needs or considerations deemed necessary for the organization. Important is that they change and that this change is embraced systematically as part of the process.

While ad-hoc changes are possible, it is advised to adjust these on a regular basis (e.g., once a year or less) in order to keep the criteria adequate and up-to-date.

Query Response



This task is included for completeness reasons. The handling of queries of any type is in many scenarios imaginable; an automated task handled by the knowledge management system or at least search functionality of a shared folder. With less sophisticated systems, of course, manual work is required for this task. Naturally, the answer of queries should only be viable if the sender is authorized to access this potential classified information.

4.3.3.5 Complete Subject Behavior Diagram of Idea Management

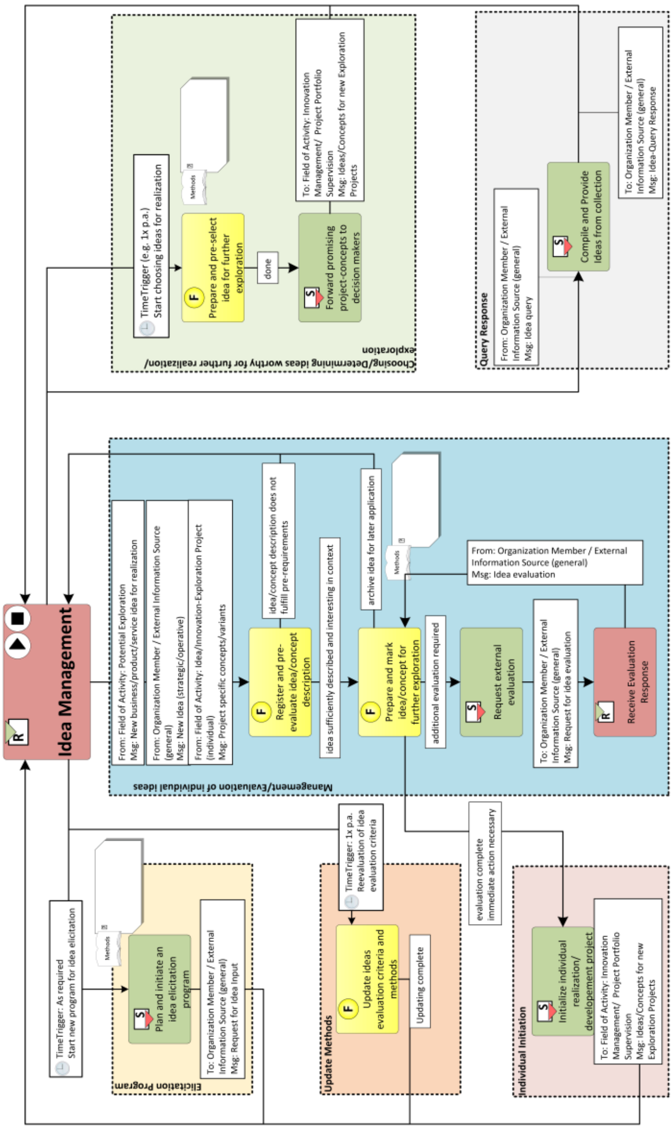


Figure 64: Subject Behavior Diagram for Idea Management (cyclic)

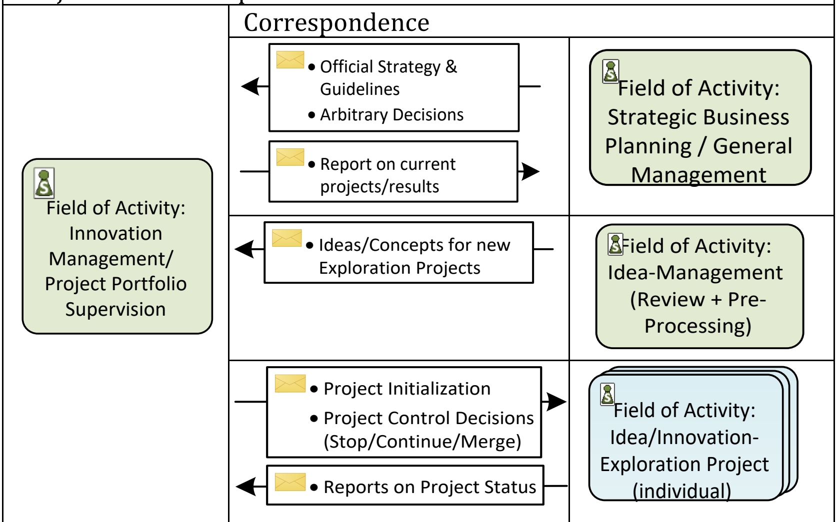
4.3.3.6 Reasons for Subject Adoption in the Model

In classical description approaches, the supplemental tasks of this subject seem to be left out or deemed insignificant as a “simple” support process. However, the management and handling of information objects is a rather central and important field of activity in the process landscape and governs the flow of information. The explicit modeling also allows to have a distinctive discussion about automation and storing concepts for information within SPP efforts.

Equally and most importantly, due to the subjective description, it is possible to focus here on differing and handling “ideas” according to their scope. Origin and types of incoming messages for this subject show three principal types of ideas that in classical approaches would be subject of three different process descriptions. Focusing this subject on the handling allows the description to depict that ideas with potential might come from anywhere at any time without having to break the integrated process of *Potential Exploration* or *Innovation Exploration (Pre-) Projects.*

4.3.4 Innovation Management and Project Portfolio Supervision

Subject Summary: Field of Activity – Innovation Management / Project Portfolio Supervision



Eligible for Execution:
- Organization heads/owners
- Higher managers
- (Chief) strategic officers + (support Teams)

4.3.4.1 General Subject Description

While actual innovation work is described and done within the linear context of *Idea/Innovations Projects*, the management of several of these projects together is a cyclic task bound more to general economic conditions and arbitrary decision-making rather than the actual value of individual innovation or innovative potential.

For actual execution of these tasks, a decision board – possibly made up of persons responsible for individual exploration projects and higher management – is more likely than individual decision makers.

Together they should regularly review and compare the progress of several exploration projects to either stop them or encourage continuation. Furthermore, they may select ideas for new concepts and ideas and initializes their exploration in new projects.

Additionally, in an integrated environment, the same board may be responsible not only for the management of innovation exploration efforts in the context of Strategic Product Planning but also for the management of ongoing product development projects that may be the result of the pre-explorations.

4.3.4.2 Corresponding Subjects

Innovation Management supervises the management of individual Idea/Innovation-Exploration Projects.

For this purpose, Innovation Management needs to consider reports from the projects and heed an organization's general strategy and guidelines or changes therein, as well as arbitrary decisions from Strategic Business Planning / General Management to whom they are responsible for reporting on progress or delays in developments.

Ideas for new Innovation Exploration Projects are stored and received from Idea Management.

4.3.4.3 Messages and interaction

Incoming: Official Strategy and Guidelines - Form and extent of official strategy and guideline documents will vary widely, ranging from formal documents in printed format, to slogans and mottos, to simple statements by individual persons. The form will depend on the efforts and especially on the methods chosen during execution of the sending subject. The core essence of any strategy information is to set a general, possibly vague direction and or goal for other members of the organization.

Incoming: Arbitrary Decisions - Due partly to their usual higher hierarchical position, but also process-wise with regards to the broader scope set of *Business Planning*, the actors there may convey directions for decisions within the domain of corresponding subjects, that may have overwriting power.

Outgoing: Report on Current Projects and Project Results - Again the form of this information object may vary depending on the required level of formalism, necessary or wished for by the strategic decision makers. Possible forms include, e.g., lunch meetings by chance, regular jour-fix-meetings, formal monthly reports, or so-called cockpit/dashboard views of project management software systems made available to actors giving traffic light indicators on project status or similar.

Incoming: Ideas/Concepts for new Exploration Projects – Basically, these are the managed and stored *business/product/service ideas for realization* generated by *Potential Exploration*. However, depending on the quality and scope of general *New Ideas* from employees or ideas generated within specific exploration projects, these may also be forwarded as part of this message to be decided upon whether the concept should be endeavored or not. The form of this message may comprise anything that may hold information necessary for decision making upon the project concept.

Outgoing: Project Initialization – This message formally initializes an exploration effort. As such, its concept is complex. It obliviously should include (access to) all information generated for the concept or idea so far. Additionally, it may contain information regarding budget or due-date restrictions, available resources, and other boundary conditions determined relevant by Innovation Management.

In form, this message may be a simple verbal appointment including handing over of physically stored information. Another variant is the creation of a project space in an organization's information management and financial controlling system, including setting up access for relevant persons.

Outgoing: Project Control Decisions (Stop/Continue/Merge/Split) – As the name suggests, via this message *Innovation Management* may stop or further allow the exploration of concepts or merge similar exploration efforts.

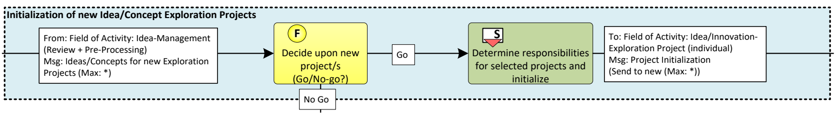
This may happen in any form imaginable, ranging from phone calls, emails to discussions in the according meetings or formal workflows in according process management systems.

Incoming: Reports on Project Status – Naturally, for *Innovation Management* to compare and decide about projects they must be informed about progress and delays. If chosen, this, of course, may be in the form of formal written reports. However, *Innovation-exploring pre-projects* may not be as formal as real development projects and as such too much formality may be a hindrance. So, this information may equally be conveyed in regular report meetings, informal lunch meetings, or simply by looking up available information in a project management tool.

4.3.4.4 Internal Behavior

Since Innovation Management is a subject with cyclical nature, all tasks start and end in the activity hub. The tasks are triggered either by the advent of calendrical events (dates or time), or due to the reception of specific messages.

Exploration Project Initialization

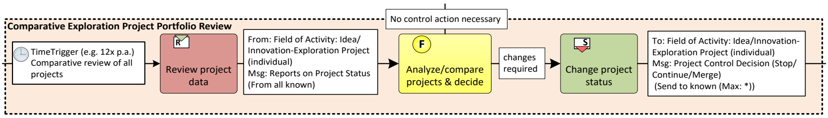


Base Question: Which of received ideas have enough potential to explore them further considering the available resources?

Whenever a new idea is presented to management, it must be decided individually whether the idea is promising enough that to explore it further under the current economic and personal situation. Due to the cyclic set up of *Potential Exploration* and *Idea Management,* the majority of the triggering messages with the proposed ideas and concepts will come in batch once a year. However, in special circumstances, immediate reactions in cases should be brought forth outside the general yearly cycle.

If found worthy, a party responsible for the exploration of the concept will be determined and put in charge of the new *Innovation Exploration Project* together with all information deemed necessary.

Comparative Portfolio Review of Exploration Projects



Base Question: Which of the running exploration projects should be continued, which should be stopped or at least put on hiatus, and which might be combined with other concepts?

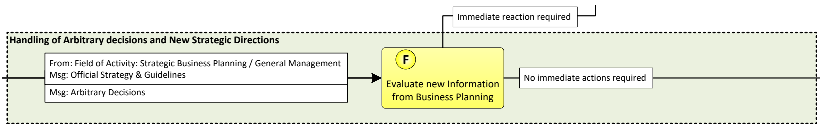
The main task of Innovation Management in the context of Strategic Product Planning is the regularly, comparative review and controlling of all ongoing *innovation exploration projects.* All active projects together form the current exploration project portfolio of the organization that needs to be managed. This activity is advised to be done every month/every four weeks. However, bi-monthly or quarterly reviews are also a possibility and left to the preferences of the organization and its project management approaches.

During the review it is decided whether to continue work on concepts, to stop their exploration, or promote them to real product development projects. Other decision options allow to merge similar concepts and ideas that may benefit each other, split a project into multiple if a concept has enough potential, postpone work for later exploration, or reactivate an older project that got postponed before.

The task itself, though, is non-trivial: To simply state "analyze and compare the project" is an understatement, since the task is rather large and requires a considerable amount of data as well as methods able to compare exploration efforts of various content, with different impact factors, and that may stand at different points in their development. E.g., a barely just started consideration of a new production technology should be considered differently than an almost finished concept for a new product variant that had been in (pre-)development for over a year.

As an additional challenge, methods should be at least somewhat robust enough to fend off political infringements within the organization that may want to stop or foster exploration and development efforts not based on their objective potential, but rather on the social interaction of their responsible stakeholders.

Handling of Arbitrary Decisions and New Strategic Directions



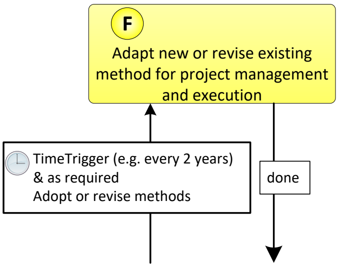
Base Questions: How will new or changed strategies, guidelines, and arbitrary decisions affect future operations? Do they have an impact on current activities?

Process-wise, this task is unspectacular. *Business Planning* at any point in time may release new *Strategic Direction and Guidelines* that may have an impact on current development efforts. This influence may go even as far as making *Arbitrary Decisions* outside the considerations of *Innovation Management*, be it for good, in the form of bold and daring new concepts not deemed worthy by conventional means, or for bad, in the form of ill-advised gut feelings that prevent taking new directions in product strategy.

Should any of these messages be received, *Innovation Management* must consider them and evaluated their impact on current activities. If the immediate reaction is necessary, the status of exploration projects may be changed ad-hoc. Otherwise, the information will be considered in the next project portfolio review or upon new project initializations.

Method Review

Base Question: Are the currently used management and evaluation methods sufficiently good or are there better approaches available?



In order to stay up-to-date, it is not only necessary to review the exploration project portfolio, but also the methods used for that mean. The selection of project management methods and tools as well as evaluation criteria is of course not a very frequent activity. Nevertheless, it is necessary.

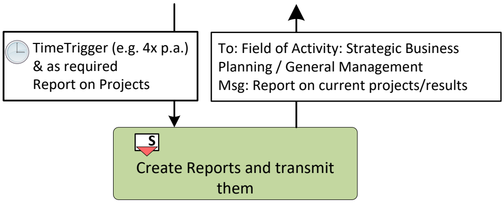
As any of these kinds of "meta-evaluation", the main idea is to verify that the current means and policies are adhered to and serve their purpose, and to change or replace them if they are, e.g., only a hindrance or better, maybe simpler, approaches are available.

Aspects touched by this include scoring systems used in the project portfolio review, set criteria in milestone definitions, or the width of clearance around specific criteria to be met in order to continue an idea. (Lang, 1994) discusses the principles of various methods for this purpose.

On an even grander scale, this re-consideration may affect the whole setup how exploration projects are conducted and managed, e.g., whether to drop a long time used milestone concept in favor of an agile approach, e.g., SCRUM (Schwaber, 2004).

Activity Reports

This task implies the frequency by which reports to higher (strategic) management should be made. Four times a year is given as a reference value, but may be changed depending on the wishes of the responsible managers.



Form and type of these reports may vary (see message description).

4.3.4.5 Reasons for Subject Adoption in the Model

The inclusion of this subject into the referential model is the origin of this research approach. It was the first step to formally include iterative, time-based control structures that govern linear projects descriptions, into a holistic process model of Strategic Product Planning.

Only the subject-oriented approach allowed to formally capture these aspects, as they do not fit into the logic of start-to-finish, one-idea-only-considering stage-gate process models or similar. Namely, aspects such as the processual handling of budget restraints that may stop even good ideas, timed delays that postpone development to wait for the "right moment", or thoughts on merging concepts and ideas.

As Cooper notes and requires project portfolio reviews:

Build in periodic portfolio reviews to force rank your projects. Setting up a gated process is an excellent first step, but it is not enough. One problem is that projects are evaluated one at a time at gates, but are never compared against other projects. (Cooper, 2006)

And further:

These reviews are more holistic, looking at the entire set of projects, but obviously less in-depth per project than gates are. Portfolio reviews take place periodically: two to four times per year is the norm. (Cooper, 2008)

These quotes again show where the limits of stage-gate approaches lie, but that their authors are aware of that problem. The *Innovation Management* subject allows the modeling of these periodic portfolio reviews in a coherent formal way.

This is especially important under the insight that especially *Innovation Projects* rarely run smoothly and in lockstep that would allow to compare them easily. More often they run in parallel but unsynchronized and with different progression rates. Still, mechanisms are needed to manage and guide them.

As far as known, this process model is the only one that ties-in these portfolio-management approaches into a processual frame. No other formal process model approach can handle joining and merging of sub-process instances or temporary hiatuses. The latter are especially necessary where a strict predetermined process frame might be more a hindrance rather than a help.

4.3.4.6 Complete Subject Behavior Diagram of Innovations Management / Project Portfolio Supervision

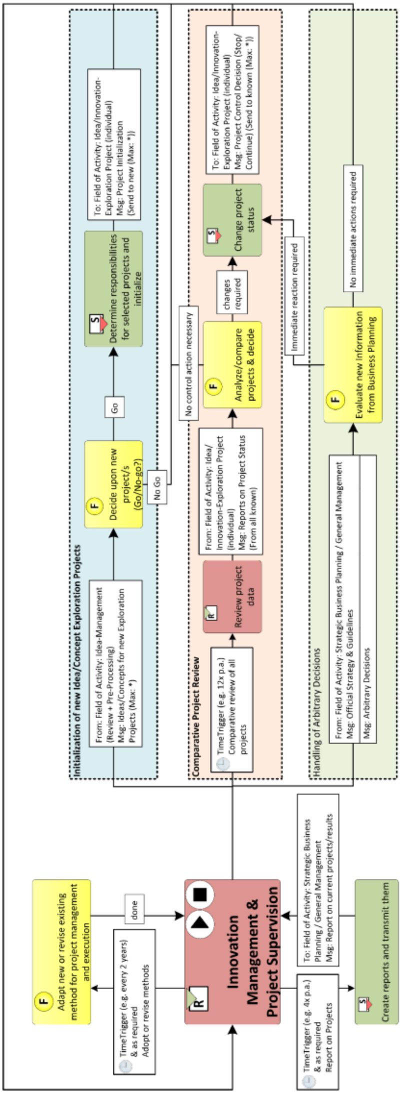
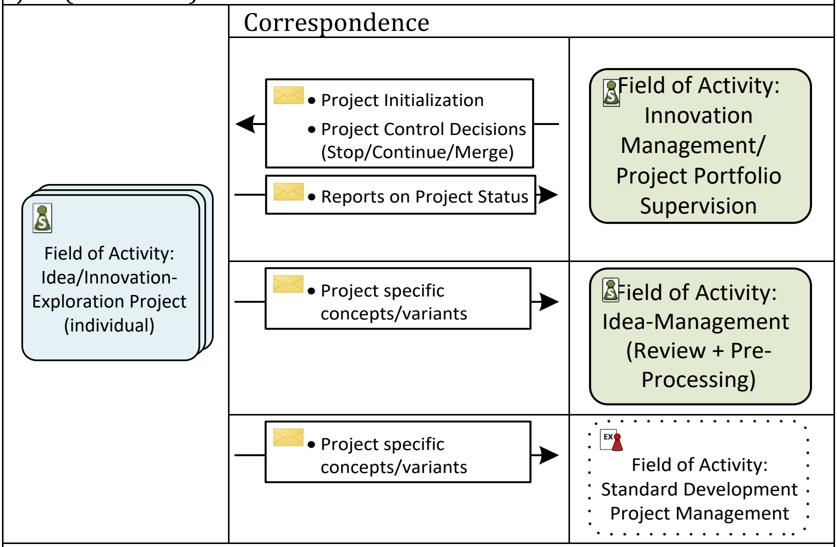


Figure 65: SBD for Innovation Management/Project Portfolio Supervision

4.3.5 Idea/Innovation Exploration Projects of Strategic Product Planning

Subject Summary: Field of Activity – Idea/Innovation-Exploration Project (individual)



Eligible for Execution:
- Development Managers
- Lead employees

4.3.5.1 General Subject Description

As soon as any idea or concept has been sufficiently identified as a trackable content package, work done on it can be considered and organized as a project. The process model supposes that this is rarely the case (though not impossible) while the information and scenarios that one or multiple ideas may be based on, is still boiling through *Potential Exploration*, or while the idea to be explored is merely a few scribbles or suggestions coming from a random member of the organization. However, when such a state has been reached, the idea or concept can be explored individually if selected and determined potentially worthy by *Innovation Management*.

The subject *Idea/Innovation Exploration Projects* describes the principle approach for this task of deriving concrete and sound concepts for actual product development projects out of merely roughly sketched ideas. On the other hand, an alternative outcome may be the insight, that the development or exploration of a specific direction may not be the most appropriate venture to undertake. A "sound" concept implies a project plan for the development of a product or service that fits into the strategy of an organization and, at least by early estimates, is potentially profitable or resource efficient enough to deem the actual, usually costlier development worthy.

This actual development is usually done in the context of a standard product or service development project implemented by an organization and out of the scope of Strategic Product Planning. Such approaches may consider the work described for the *Exploration Projects* as the earliest stage/gate or in their process description (Gate 0).

The noteworthy difference of the subject *Exploration Projects* to other subjects in the model is as follows. First that model-wise, it is a multi-subject, and secondly, it has a linear start-to-finish nature where all other subjects are cyclical single-instance-subjects. This construction expresses that at any point in time there may be multiple instances of *Exploration Projects*, each at a different "stage" of development and each individually with the potential to be the origin of actual product development efforts.

Therefore, the organization of this process may be following the well-defined stage-gate approach if such is defined for the organization. The aspect of its exact execution process is left open for adaptation. The model describes the principal tasks and therefore is compatible with stage-gate configurations as well as agile or time-boxed iterative approaches[11].

[11] Due to the highly volatile and rather unpredictable nature of innovations agile approaches are advised to be taken, since they tend to handle developments efforts with uncertain extend better (Highsmith, 2010).

Next to being an implemented workflow in an organization's IT systems, the responsibility for the execution of *Idea/Innovation Exploration Projects* will usually lie in the hands of a capable manager or stakeholder. She or he may be a member of the same team of potential subject carriers that may be responsible for *Potential Exploration* or a specialized employee that is a candidate not only for managing the actual product development but also the whole life-cycle of a product. Depending on the extent of the exploration effort, this (pre-) project manager may be supported by a team of experts conscripted and responsible for the execution of individual tasks.[12]

4.3.5.2 Corresponding Subjects

Initialized and managed by **Innovation Management/Project Portfolio Supervision** the activities of each *Exploration Project* may be the origin of one or potentially even multiple **Standard Development Project** and its management efforts. During exploration, the storage and recall of new (sub-) ideas or concepts may be done using the means and systems provided by **Idea-Management**.

4.3.5.3 Messages and interaction

Incoming: Project Initialization – This message formally initializes an exploration effort. As such, its concept is complex. It obliviously should include (access to) all information generated for the concept or idea so far. Additionally, it may contain information regarding budget or due-date restrictions, available resources, and other boundary conditions determined relevant by Innovation Management. In form, this message may be a simple verbal appointment including handing over of physically stored information. Another variant is the creation of an according project space in an organization's information management and financial controlling system, including setting up access for relevant persons.

[12] Note that in the case of larger teams, it may be advisable to further specify the model and distribute the tasks of this subject among multiple subjects described in a sub-process model

Incoming: Project Control Decisions (Stop/Continue/Merge/Split) – As the name suggest, via this message *Innovation Management* may stop or further allow the exploration of concepts or merge similar exploration efforts.

This may happen in any form imaginable, ranging from phone calls, emails to discussions in the according meetings or formal workflows in according process management systems.

Incoming: Input for Innovation Project – Not all information necessary or useful for the exploration of innovative concepts and ideas may be incepted purely internally either before or during a project. Additional external information or evaluations may come in in a myriad of possible forms, be it an opinion uttered at lunch or a formal report by a consulting institution contacted on a particular topic.

Outgoing: Reports on Project Status – Naturally, for *Innovation Management* to compare and decide about projects they must be informed about progress and delays. If chosen, this, of course, may be in the form of formal written reports. However, *Innovation-exploring pre-projects* may not be as formal as real development projects and as such too much formality may be a hindrance. So, this information may equally be conveyed in regular report meetings, informal lunch meetings, or simply by looking up available information in an according project management tool.

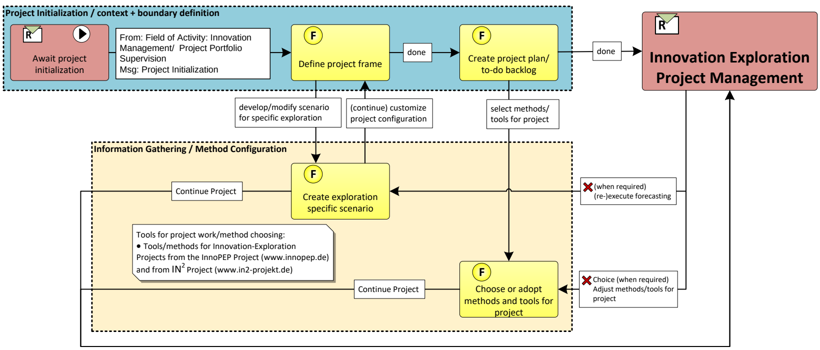
Outgoing: Project-specific Concepts/Variants – During the exploration of a specific innovation project many ideas with smaller or larger scope will be collected. Depending on the scope and topic of the project, such ideas may range from variants of detailed solutions to new inspirations for innovative products or even plans to tackle new market or market segments. Conceptually, though, the earlier is more likely than the later.

The actual practical form of this message may range from systematic and complex product description including CAD models and procurement information, maybe within the bounds of a PDM system. In addition, it may include physical file folders containing the collected information or 2D and 3D physical as well as other digital models describing idea aspects.

Outgoing: Developed Project Concepts / Development Order (Transfer) – This message is the initialization of an actual product or service development project. In concept, it contains the whole concept for the project including all previously generated scenarios, boundary conditions, evaluations, etc. From a practical point of view, the conveying of this message may be done as a collection of physical information carriers (folders, USB sticks formal project initialization documents on paper). Equally, it could be merely a change of a project-workspace status in an IT-system, including the configuration of corresponding officers, budget, and billing offices.

4.3.5.4 Internal Behavior

Project Initialization & Configuration



Base Question: What are the principal goals, tasks, and boundary conditions for the exploration project?

After initializing the projects, the standard task to be done is to define the project frame and compile further information according to the management and organization standards in the given organization.

Afterward or in correspondence, an adequate plan for the exploration project needs to be conceived. The actual type of this plan depends on the chosen organization principle for the project. In a rather classical setting with milestones, a project plan typically may be a detailed Gant-chart with clearly defined deadlines and project work packages. If agile approaches, e.g., SCRUM (Schwaber, et al., 2010), have been chosen, the plan consists of long a term to-do backlog containing the principles task in a general format, while only for the closer future (the first sprint) more detailed planning is done in the form of sprint-backlog conception.

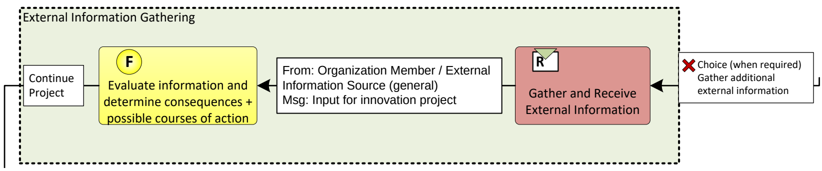
Both tasks may be supplemented by two other activities that are advised to be executed in the beginning, but can also or additionally be executed at a later point in the exploration project:

If not done before or not in existence yet, a detailed scenario (in terms of "Scenario Technique") may be conceived or extended and analyzed in order to more clearly define the borders of the exploration project.

Equally adaptable at a later point, but advised to be at least briefly considered at the beginning of the exploration project, is the selection and adaption of methods and tools for project management as well as for the actual exploration tasks.

Due to the closeness in nature between this subject and standard approaches of Innovation Management, there is a wide range of research available that may help with the configuration of such ventures. Examples are the results of the German federal funded research projects Innopep (Innopep, 2015) or IN² (IN2, 2015).

External Information Gathering

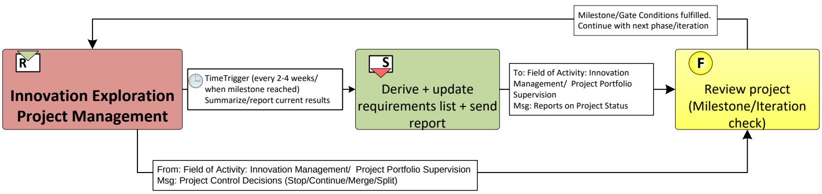


Base Question: What will the impact of new information be on the project?

This section of the model describes that at any point during the project it is possible and possibly necessary to consult information sources outside the direct scope of the project. Naturally, in many cases receiving information would first require a request. Such a request is either implicitly conducted, e.g., when doing a simple web-search. Other requests that are more extensive may be initialized by *Idea Management*.

Execution of this task-block is only triggered upon individual need and not by specific messages or time-based events.

Project Management

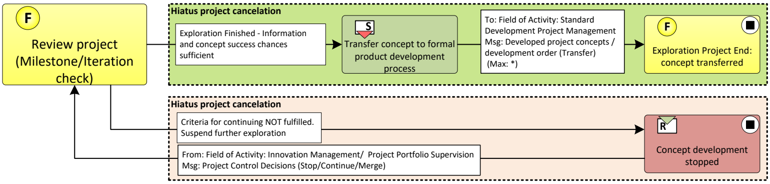


Base Question: What is the current state of the exploration project and how should it be continued?

The exploration project as a whole should be regularly (every two to four weeks) be summarized, documented, and reviewed. This is true for any project management approach taken, be it milestone-based or agile.

At the end of a milestone-phase or sprint/iteration, or upon addition external directions, it must be decided how to continue with the exploration project. The standard case is simply the continuation of the project. If an agile approach was taken, choosing to continue with exploration will coincide with the formal (sprint) planning of tasks and actions for the next iteration as well as back-log changes.

Project Closure



Base Question: Are the derived product concept and ideas worth it to be developed, or not?

Based on either the findings within the exploration project, the reaching of a particular milestone, or on external directions the project eventually will end. Ideally, a sound project concept for the development of one or more products will have been devised and the according development projects are initiated. In scenarios with a fixed and integrated stage-gate process, the transfer may be replaced by the simple declaration of the new process phase with tasks that do lie outside the domain of this referential model.

Like any proper research, the findings of the exploration project may not turn out to be fruitful or simply not fitting the current condition of an organization, so neither further exploration nor starting of actual product developments is an option. In that case, the exploration effort may simply be stopped. However, there is a chance that an old idea put on hold may be reactivated at a later point in time.

A third possibility connected to the reactivation is not explicitly shown within this behavior diagram since its impact is actually outside its scope. Namely, that would be the formal merging of two exploration projects for various possible reasons. Among those reasons are similarities between ideas or forced budget cuts that foster the need to find synergies. If such a merge was to be initialized, it would affect especially the (IT) databases of the two projects that are to be merged – data on concepts as well as organizational data about the projects. In a milestone scenario, it is likely that a change to the formal status of the new resulting project needs to be conducted. In an agile scenario, simply the tasks for the next sprint/iteration would need to be planned for the sprint.

Similarly, a split could be initialized if the exploration efforts should turn out so productive that multiple ideas and concepts spring forth that are found worthy to be considered in an individual context.

Note: the actual execution of splits and mergers are done by *Innovation Management.* The convenience of that task depends on the used storage and management system and may be non-trivial if not supported.

Exploration: General Note

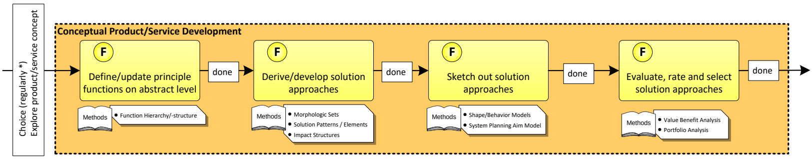
In accordance with the three-cycle model, the actual exploration is divided into three groups, each containing the principles tasks to explore one aspect of a concept or idea.

These three aspects are: First, the actual conceptualizing of the product or service. Secondly, the conceptualizing of corresponding production or provisioning systems for the product or service. Lastly, the business and financial considerations and prediction accompanying the other two technical oriented task blocks.

There is no general event or time-trigger that initializes and prioritizes the execution of one task group over another. Instead, the execution of tasks or corresponding methods is up to the given requirement of a particular situation. With a milestone plan, this may be predetermined, while in an agile environment, it will be decided for every sprint individually which task or method will be executed to what extent in order further explore an idea. In both cases, tasks of all three blocks will be visited multiple times during the exploration process, rarely though with the same exact level of detail.

As mentioned in the general subject description, especially in a broader context the whole subject of *Innovation Exploration* may need to be further split up and detailed in a sub-model with individual subjects. Such a specialization from this referential model would most likely contain individual subjects for all three task blocks and further specialize it.

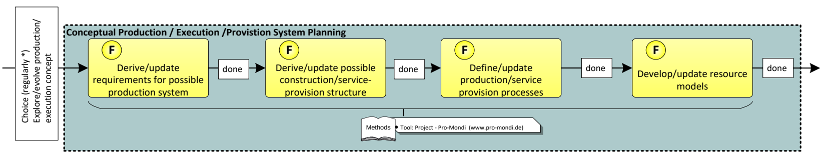
Exploration: Task Block Product / Service Development



Base Question: What is necessary to create a successful product or service?

The four tasks described here are the basic concept of any product or service development process during early conceptualizing. The named task and proposed methods are a structured approach that is geared towards finding solutions and select alternatives; first on a rather broad and abstract scale and in later iterations on an actual pragmatically, technical level.

Exploration: Task Block Production / Execution /Provision System Planning



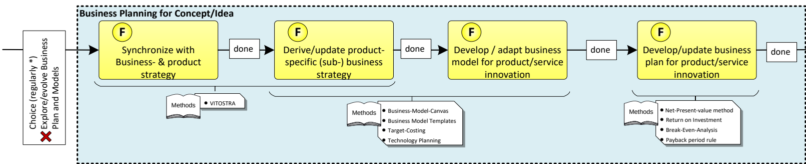
Base Question: How can the designated product or service be produced or provided?

The conceptualizing of a production system for physical products or provisioning systems for services, while the product or service itself is still only an abstract idea, is a concept that is rarely covered in research. However, since production and provision concerns may have a substantial impact on product and service design, it should seem natural to explore these in parallel to the actual product and service conceptualizing from an early point in time on.

The task follows the same principle systematic approach of sketching out solutions; first on a rather broad and abstract level and then working on more and more concrete models that specify the processes or boundary conditions relevant to bringing forth the product or service.

An example of research on systematic methods and tools for this task blocks is the Pro-Mondi Project (Pro-Mondi, 2015). Also, the reports of the ADISTRA project (Gausemeier, et al., 2016) is concerned with methods and tools for the integrated conception of development request that consider product and production system in parallel.

Exploration: Task Block Business Planning for Concept/Idea



Base Question: Does a product or service concept fit the given business and product strategies? Is the concept financially sound under the given strategy and is its type and timing of market entry well chosen?

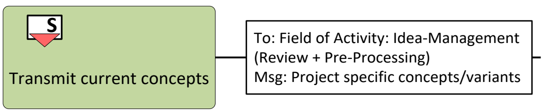
The final task block explicitly described for the exploration of innovative product and service concepts is a reminiscence of subject *Business Planning* on an idea-individual level. This is due to the two possible interpretations that task of business planning may have in the 3-cycle model. While the general interpretation is represented by the subject of the same name and is concerned with an organization as a whole, planning and evaluation of business aspects is also necessarily done in detail for the exploration of individual ideas and concepts.

The consideration includes planning for market entry strategies and timing as well as constant consideration and surveillance of possibly similar offerings or efforts by competitors.

At later points in the development, economic evaluation tasks may be done as part of the other two blocks, especially with considerations about the production and the production cost. However, especially during early development, rough financial calculations and conception of general business plans may not be bound to concrete product plans.

As such, this task group's tasks are mirroring the tasks of general business planning, starting with the alignment of the current concepts with the given business and product strategies. Following are the conception of an individual business strategy, an individual business model, and finally, a business plan to finance and market the idea in accordance with currently given and available information.

Transmission of (intermediate) Results



For completeness reasons, the referential model captures the intuitive idea, that all conceived (sub-) concepts and ideas should be subjected to and handled by the systematic knowledge management efforts of *Idea-Management*. Either simply for storing, but also to further serve as inspirations or comparisons in *Potential Exploration* or parallel running *Innovation Exploration Projects*.

4.3.5.5 Complete Subject Behavior Diagram

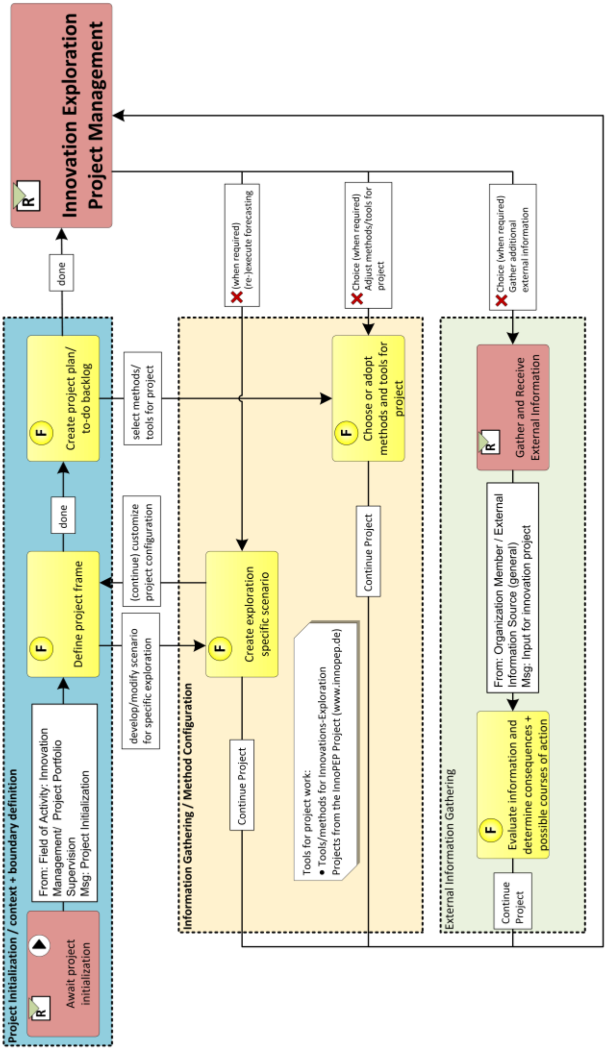


Figure 66: Subject Behavior Diagram Idea/Innovation-Exploration Project (Part 1)

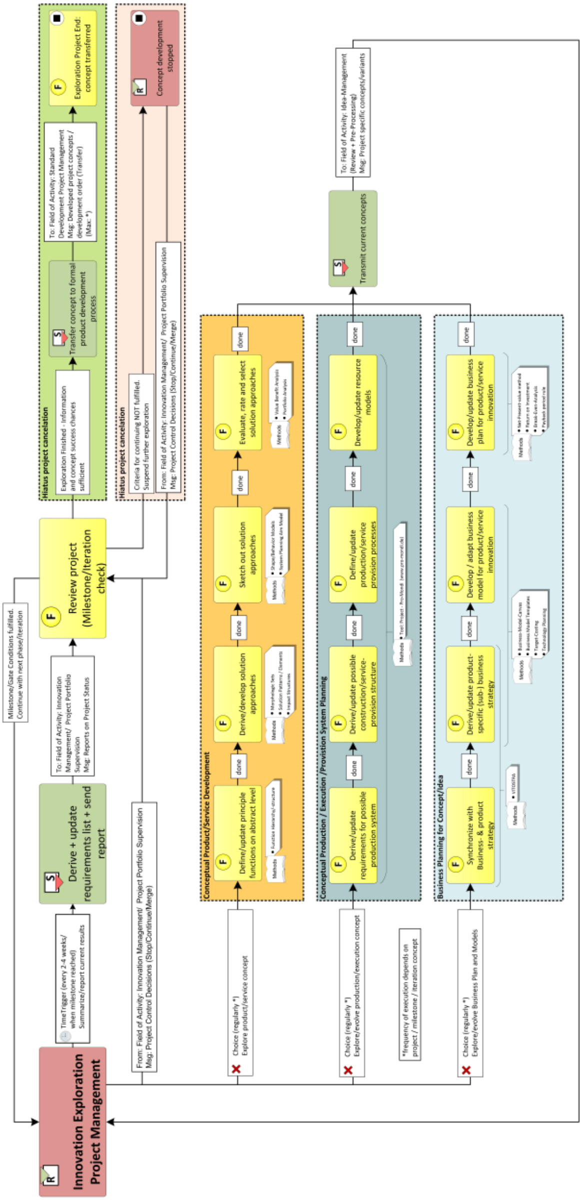


Figure 67: Subject Behavior Diagram Idea/Innovation-Exploration Project (Part 2)

4.3.5.6 Reasons for Adoption and Design

This subject represents the core aspect of product development, found in all process models for (strategic) product planning and is as such required to be implemented. The essence is the exploration and focus of a single idea.

While this subject, in principle, is very similar to the mentioned approaches, the existence of other subjects in the process model clearly illustrates that this "Stage" or "Gate 0"[13] of standard product planning concepts is more complex than a linear description approach can show.

One conceptual difference to approaches focused on singular product development is the split into two subjects between concept exploration projects and (not further detailed) actual product development projects. This supports the orientation and matching with other models, without dwelling too deep into actual product development that is outside the scope of Strategic Product Planning. However, especially in agile execution scenarios, the transition from this pre-development-subject to a formal standard development may not occur explicitly. It instead may be determined by a gradual shift of tasks during the sprint/iterations from broad general conceptualizing towards actual design and detail planning of products without ever being formally considered as having changed a stage or scope[14]. For more formal process execution systems, there has been much research done trying to determine and formalizing the decision point where such a transition may and should occur (e.g., the Innopep project (Innopep, 2015)).

The subject itself could have been detailed out further and gone into much more details. However, due to the referential character of the whole

[13] A typical descriptions for early and conceptual project phases found e.g. in the stage-gate concept at Siemens (see Figure 20).

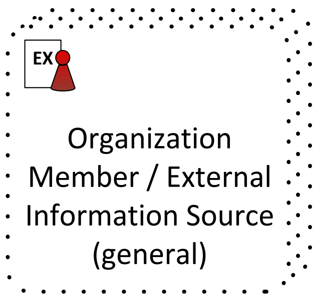
[14] As there is no reason to spent thoughts and energy on a formal definition when they are better spent on actual development.

model, this level was chosen with a focus on enabling its adoption in scenarios with agile as well as classical stage-gate approaches for the actual execution of this reference process.

4.3.6 Interface Subjects

Reminder: Interface subjects are actors without a defined behavior within the bounds of a given model. Giving no behavior diagram may have various reasons: the behavior may be defined in another process model, the subject may be a technical system only reacting towards request, but without a complex process flow, or simply because it is not important or impossible to describe how messages are created within the model.

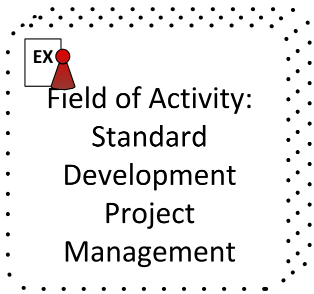
4.3.6.1 Organization Member/External Information Source (general)



The subject *Organization Member / External Information Source* represents any information source or message origin that may be involved in the task of Strategic Product Planning and that is not covered explicitly by the other subjects.

There may be more instances of this multi-subject than any other subject in the process. The senders and receivers of the messages could be, depending on the message, in principle anyone from general employees or managers of the organization to persons or institutions from an external context like consulting agencies, research institutions, and similar. Also, technical systems, e.g., in case of standard web-searches via google or similar, would fit the intended range of active elements viable to take this role in the process of Strategic Product Planning.

4.3.6.2 Standard Development Project Management



The result of the activities of Strategic Product Planning should be sound product concepts that may still need more detailed development work but are otherwise well refined. Typically, that actual product or service development is done and organized within the context of a project represented by this subject.

As mentioned in section 4.3.5, the transition from pre-development into an actual funded project may be gradual as both are essentially very similar and only the level of abstraction is gradually reduced and more concrete. However, due to most current organizations, as was the case with all of the interview partners, have a strict separation between strategic considerations and concrete product development efforts; the referential model also recognizes and depicts this official transition.

4.4 Scaling and Customizing the Model

The previous sections described in detail the Subject-oriented Referential Process Model of Strategic Product Planning. However, a reference only serves the purpose of being a principle idea that can and should be applied to real-life circumstances. While due to the usage of PASS even the referential model is executable by a computing system, it does not mean that the reference will fit any given scenario as it is rather general.

Therefore, any organization trying to implement Strategic Product Planning based on the model will customize and scale the process to its own needs and preferences. This section describes the principal procedure for scaling and customizing the reference process.

The resulting application processes may be different from each other: The smaller the company, the closer all activities range thematically, and only one or two people may be responsible for the formal execution of tasks. Furthermore, not all subjects may be implemented, and parts of the decisions making may be left to chance, personal interactions, and gut feelings.

On the other hand, large corporations or agencies are likely to have a clear distinguishing not only between the five defined fields of activities, but they may even have specialized subjects and according subject carriers for individual tasks. In larger organizations, also the information sharing mechanism must be implemented more formally.

The process model here defines the most elemental characteristics of such a systematic approach, with the messages and the requirement to generate and evaluated them on a regular basis. In reality, this may lead up to complex knowledge management systems based on the according theories. Such systems may incorporate supporting IT data warehouses or big data approaches allowing the employees responsible for business planning direct access to information with relevance for them or even automatically bringing information with possible relevance up to their notice. At the other end of possibilities, the same functions may be fulfilled by able-minded people compiling and reporting information of interest at the right time and place.

In any way, it is up to the stakeholder to determine what is best for their given situation and use the model as a guideline and the following steps as step-by-step help to come to a decision.

4.4.1.1 Checklist for Adoption and Scaling

The following checklist has been created as a guide for stakeholders to adopt and scale the subject-oriented referential process model of Strategic Product planning for their organization and tailor it to their needs.

Table 12: Checklist of principle tasks for scaling and customizing the referential process

1. Determination of Boundary Conditions: Boundary conditions are factors with impact on later decisions in this list. Examples are, e.g., responsible personnel, available budget, formal goals, personal preferences of owners, etc.
2. Choosing of the Subjects/Fields of Activities to be Formally Implemented: Implementing a subject means, determining personnel or IT systems that will be made responsible for the formal execution of the according tasks (subject carriers). It is not necessary to implement all subjects formally. For example, in smaller organizations, *Business Planning* may be left entirely unofficial and up, e.g., to gut feeling of an organization's owner. Equally, the concepts of *Idea Management* can be reduced to giving specific direction about how to handle and save documents instead of installing an actual manager for the corresponding tasks. If subjects are not formally implemented communication from and to them may not exist explicitly. Furthermore, in scenarios using a workflow engine for executing SPP processes based on the PASS models, it may be necessary to split up subjects further, if their work tasks are to be distributed among more roles. (e.g., in case of exploration projects)

3. Concretizing and Labeling of Messages, their Channels and Information Objects:

The messages descriptions of sections 4.2 and 4.3 contain descriptions for possible forms a message may take. Upon customizing the messages, the following decisions should be made:

- exact denomination for a message in the organization's context
- determination of the communication channel or transportation medium for the message (E.g., a simple email plus attachments vs. an elaborated workflow within, e.g., a Microsoft Share-Point server solution.)
- determining the form and expected content of messages (formless vs. specific format including mandatory data)

4. Customizing Behaviors:

Even though a subject may have been selected for implementation, its behavior may not fit a given use-case. In order to customize behaviors, functions may be removed, relabeled, combined or split up. Possible reasons may be that the wording needs to be attuned to an organization's standard vocabulary or specific tasks (e.g., creation of a formal strategy) may not be relevant, where others are.

If subjects have been split up, the tasks within the original behavior must be distributed between them and, if necessary, communication added. This is of particular importance in the field of activity of *Idea/Innovation Exploration Project* when adopting a classical stage-gate approach that may require extensive and detailed process definitions.

Naturally, additional tasks may be added and/or task in the behavior may be split up into sub-tasks if addition methods or specific actions are required.

5. Choosing Formal Methods and Tools for the Execution of Tasks:

The model contains many suggestions for existing formal methods and tools for the actual execution of tasks and the creation of communication. In addition, an organization's own methods or newer methods may be introduced.

In some cases (e.g., integrated scenario technique), a method may also span multiple tasks and thus summarize them. Detailed descriptions, including estimations for efforts various methods in the context of Strategic Product Planning, can be found, e.g., on (2016)
6. Choice of Intervals for Cyclic Subjects and Tasks: The model makes suggestions for intervals in which cyclic tasks should be executed or at least brought to a user's attention with high priority. The exact times, though, are up to debate.
7. Exploration Project Configuration For *Exploration Projects,* it first must be decided what principle development management approach should be taken (phase or agile) and then according plans should be made. In principle that could be decided for each exploration project individually. The referential process model covers both. The choice depends on the general preference of the adopting organization and their standard product development process. Furthermore, a transition concept between concept-exploration and product development projects must be defined. Classically, that will be the definition of a formal product development order or development mandate contained in an explicit data artifact. Alternatively, it can be agreed on using a continuous development approach where there is no split between exploration and actual projects and the extent is implicitly determined via the number of resources assigned to the individual effort.
8. Assignment of Responsibilities for the Execution of Subject (match potential Subject Carriers) The last step is an initial assignment of responsibilities for the areas of activities of Strategic Product Planning to actual employees (subject-carriers) that will execute the according task. (Excluding tasks that are fulfilled by automated systems).

4.5 Summary

The subject-oriented referential process model for Strategic Product Planning (SPP) fulfills all requirements determined from the theoretical weaknesses of the classical input-task-output concept in general, while at the same time avoiding the drawbacks of previous attempts to describe the flow of activities in SPP.

Naturally, the knowledge contained in the referential model itself is neither arcane nor new. The novelty and achievement of this subject-oriented model lie in its holistic concept, which combines all aspects of SPP and gives them an easily comprehensible structure and form. The model is formal, executable, and contains linear-causal as well as iterative aspects at the same time, thereby simply and directly uniting all concepts from the previous sections and models. It is the paradigm of subject-orientation that allows this definition of a framework for SPP including all necessary areas of activity: *Business Planning, Potential Exploration, Idea-Management* and *Innovation Management* together form the context for what other approaches are usually limited to: the individual *Idea/Innovation-Exploration Projects*.

The model is a relatively simple, yet systematic instruction. It can be used as a reference for organizations interested in adopting systematic SPP and allows interested stakeholders to adopt and scale the model to their needs.

5 Proofs of Concept

The subject-oriented referential process model of Strategic Product Planning is meant to represent its complex domain holistically and be understandable for humans as well as formal and executable by computer systems at the same time. However, this is a hypothesis that needs to be tested. As with any hypothesis, it cannot be ultimately proven to be correct. Instead, multiple attempts at testing out and validating the model have been undertaken.

Consequently, the proof of concept chapter of this thesis is four-fold:

During analysis and development of the model, it was verified in interviews with several stake experts responsible for strategic product planning activities in their respective organizations (5.1). Secondly, the model has been subject to an in-depth third-party review to re-evaluate its conformity with the given sources without prior knowledge (5.2). Thirdly, to evaluate its scalability, the process model was tailored to the needs of a single company to test if the systematic was able to match their management structures and cover their process requirements (5.3). Lastly, to verify the formalness and feasibility of execution on an IT System, the model was tested in the cloud-based execution environment of the Actorsphere (5.4).

5.1 Validation with Interview Partners

As mentioned in the introduction, during its development, the referential process model consecutively was presented to, discusses, and validated with stakeholders from different organizations. Due to the limited time frame of the interviews, discussions were mostly limited to the SID and the general concept of having a subject-oriented model at all. The feedback gained, went into further developing the model. Consequently, no interview partner reviewed exactly the same model, but rather iterations of improved versions.

Many of the results of the interview series already were discussed in the section about general weaknesses of subject-orientation. In all cases, interview partners first needed to acquaint themselves with the subject-oriented concept and the specialties of the PASS notation. They all explicitly noted their unfamiliarity, with one downright rejecting the idea, as he preferred the phase-thinking concept and "would stay with what he is used to". Less directly, problems were mentioned, e.g., by the first interview partners (Faltus, Götz, and Porstendörfer), that the term "subject" itself was confusing and something like "actor" or "role" would be more suitable descriptors[1,2].

However, after getting used to the concepts, most viewers appreciated the model. It was understood as "instruction" for people and that the model really could express what is happening at an interview partners' organization, as "it fits content-wise"

Further acknowledgments of improvements of the referential model include:

- Understanding it as a reasonable mix between classical process description and overall abstract company description with network structure
- Understanding the useful separation of cyclic and linear process concept, partially explicitly mentioning it as a positive aspect.
- Welcoming that the model shows potential discovery as something different from standard project development that still does cost money even though it is not part of a specific project.

[1] These, however are terms already associated with established concepts in IT context that are different from the concept of a subject and therefore were not adopted.
[2] This led to the addition of explicitly denoting subjects as "areas of activities"

- Being inspired by the model to adopt technology for specific purposes and directly mapping its function to a model aspect: "a (software) agent that actively scouts for external information".
- Understanding and noting that this type of process model/description approach is able to structure processes deemed impossible to be structured with classical means.
- Appreciating the more substantial detail of the model in contrast to the other approaches, though while also noting the unavoidable increase of complexity.

Summarizing, beyond the general unfamiliarity with the thought structures of subject-orientation and given the short time frame for grasping the model of roughly 20 minutes, all but one interview partner in principle found the model to be an interesting and an improvement. Beyond initial terminology issues, no one found weaknesses or obvious conceptual flaws nor aspects that were not covered by the model. However, there was a warning that should be heeded when using the referential process model. Namely, that activities, such as Strategic Product Planning, are always at least to some degree creative processes. Those require a certain level of freedom and rigid workflow may hinder it. This observation can be agreed with and is akin to the model's intention of being a guide for execution that can and should be fitted to individual needs.

5.2 Validation via In-Depth Review

One validation of the referential model was done via an in-depth third-party review. For that purpose, the model was given to a student of business engineering and was analyzed in detail over the course of four months as part of a master thesis (Dörflinger, 2017). To avoid conflicts, the model-reviewer was not made aware of the origin and was given the explicit goal to test the hypothesis that the model was free of faults, errors, and contradictions, and that no important aspect was missing from it.

The review found minor improvement suggestions for several behaviors and led to debates regarding different interpretations of the model. Otherwise, however, no problems or missing aspects could be found and therefore the hypothesis could not be disproven with that experiment.

5.3 Validation of Scaling Concept: Use-Case Fischer

In order to evaluate the scalability of the model and its ability to be adapted to individual requirements, a case study was conducted together with the small southern German enterprise Fischer IMF. The goal was to use the model as the reference, follow the tailoring checklist in order to derive a customized model for the company, and verify the model together with the stakeholders at Fischer.

The original SID of the scaled model is depicted in Figure 68. The subjects *Potential Exploration* (*Potentialfindung*), *Idea-Management*, *Strategic Business* planning, and the individual *Idea-Exploration project* were adopted. Due to the small size of the management organization (roughly five persons overall, including the founder and CEO) at Fischer IMF, the behaviors were trimmed and streamlined. Also due to the size, the choice was made not to incorporate the subject of *Innovation Management* formally. The according tasks are expected to be informally executed in regular general business meetings which are represented by an interface subject for this decision-making body (*Entscheidungsträger/ Bewertungsgremium für Ideen and Projekte*). Also due to the requirement of Fischer, the *Information Source* subject was split up into two interface subjects, to explicitly mention the roles of employees in contrast to general, possibly external information sources. Lastly, various messages were renamed to better reflect the vocabulary used at Fischer IMF.

Overall, scaling was successful, and no problems could be found with the proposed procedures, neither during scaling and tailoring nor during the verification interviews with the stakeholders. The problems found were, again, mostly due to unfamiliarity with subject-orientation and the subsequent need to familiarize oneself with this notation style. Otherwise, the model was found fitting the intended procedures at Fischer IMF, and it was at least stated that the tailored model would be used for training and discussion about SPP concept in the future. Again, the hypothesis that the model is easily scalable and can be adapted to requirements of different organizations could not be disproven.

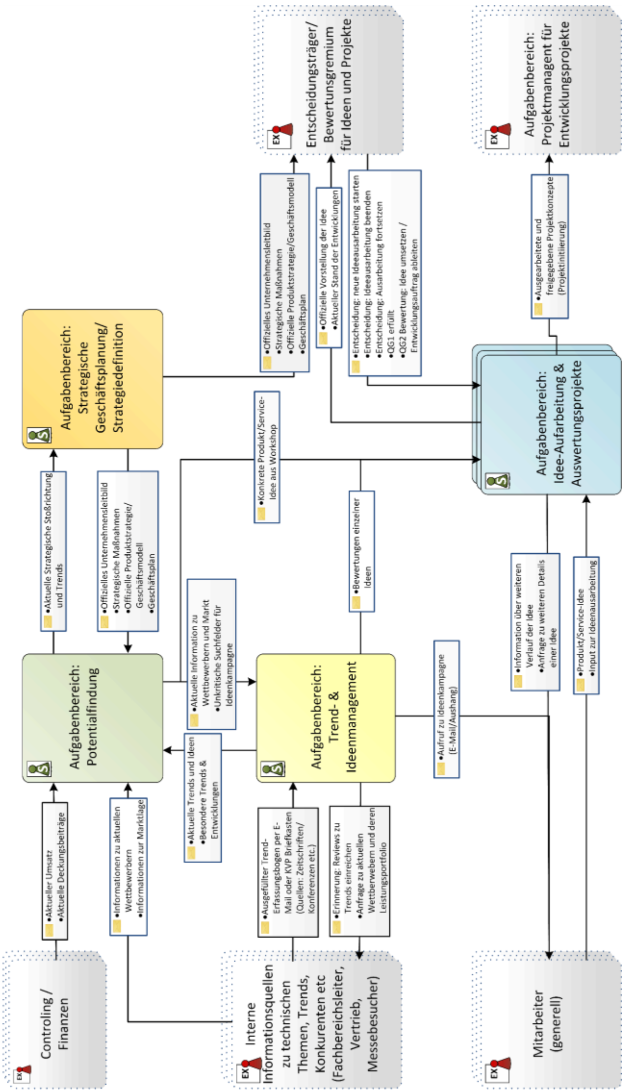


Figure 68: SID of a scaled and tailored SPP process for Fischer IMF (German original)

5.4 Verification of Formal Digital Execution

The most significant contribution and claim of the subject-oriented referential process model of Strategic Product Planning is it formalness and the corresponding ability to be executed on digital platforms. Therefore, the hypothesis that this is possible had to be tested.

5.4.1 Modeling Tool and Compiler

For this purpose, the model hat to be created not using simple pictures and drawings, but rather as a wholly connected, coherent, and digital model graph. At the time of creation of the referential model, the only tool to create PASS diagrams was the Metasonic S-BPM Suite (Metasonic, 2018). For various reasons (the bankruptcy of Metasonic among them, as well as their closed-source model) another PASS modeling tool had to be created for this thesis.

Several variants for development were contemplated, including the creation of web-based solutions from scratch. However, in the domain of business IT, acceptance of standalone proprietary solutions is rarely welcomed. A solution with standard tools for business users was deemed a more practical approach, as it was expected to make users more accepting when having a guarantee that their models would be usable even without constant support. Therefore, the choice fell on the creation of a plug-in for Microsoft Office Visio.

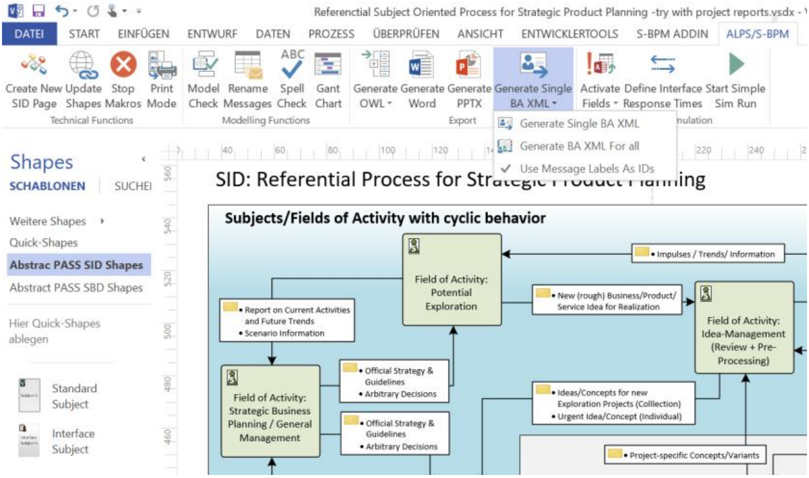


Figure 69: Interface of the Microsoft Office Visio PASS modeling toolset created for this thesis with compiler dialogue for export to the Actorsphere

For reasons of transportability, the plug-in was developed using the sub-optimal programming language Visual Basic for Applications and the built-in macro editor and embedded directly into the stencil sets. The development project currently encompasses ca. 26.000 lines of code split over 42 different classes.

This includes a model checker that can verify the semantical coherence of the PASS model and compiler that is able to translate a given, coherent, process model into .xml file definitions that can be loaded into and executed in the Actorsphere of the company ActNConnect.

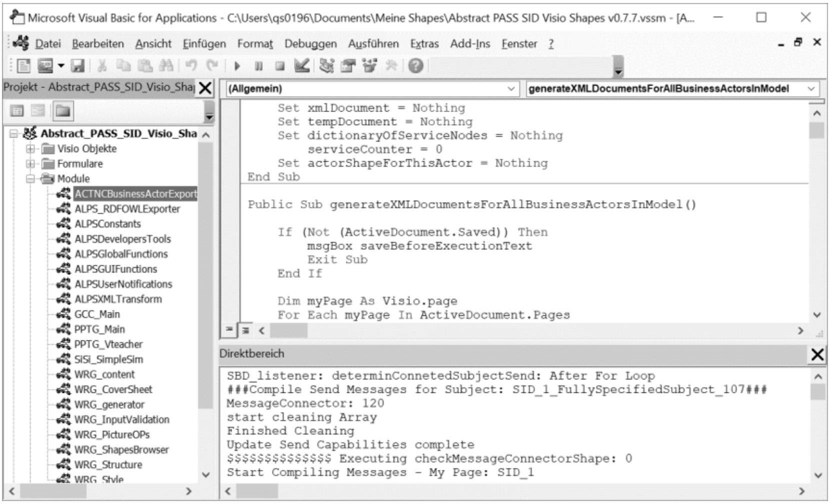


Figure 70: Screenshot from the VBA development project for the Business Actor export.

5.4.2 The Actorsphere

The Actorsphere is a web- or cloud-based workflow engine platform that works according to the execution principle of PASS. It was created by the company ActNConnect (ActNConnect, 2018) and, next to Metasonic's suit with its proprietary models, it is currently the only directly available and running solution to execute PASS models (Fleischmann, et al., 2017).

Access to the Actorsphere was generously granted by the company for this research.

It must be noted that, for marketing reasons and differentiation from competitors, the company decided to adopt a slightly different set of vocabulary. Foremost that applies to the term "subject", which is replaced by the term "actor"- hence the "Actor"-sphere is still a workflow engine for subject-oriented processes models. Beyond the vocabulary and a different graphical definition set, ActNConnect uses standard PASS concepts.

Therefore, a transfer of the model to the Actorsphere is possible. However, as mentioned, an according compiler had to be created first.

The complete workflow SID for creating and converting the model and executing it on the Actorsphere is shown in Figure 71.

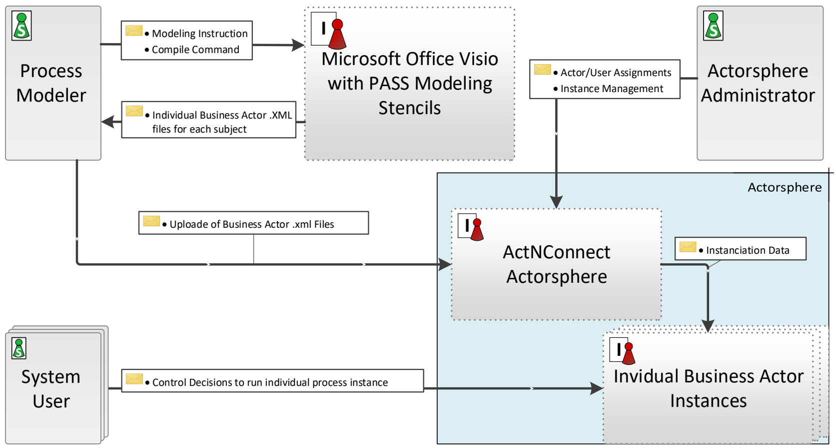


Figure 71: Conceptual Usage Process of the Actorsphere

The Actorsphere is well developed full-size workflow execution platform intended for usage by organizations of all sizes. In order to use and execute subject-oriented process models, these must be converted and uploaded to the Actorsphere. This is a non-trivial process and detailed in the next paragraphs.

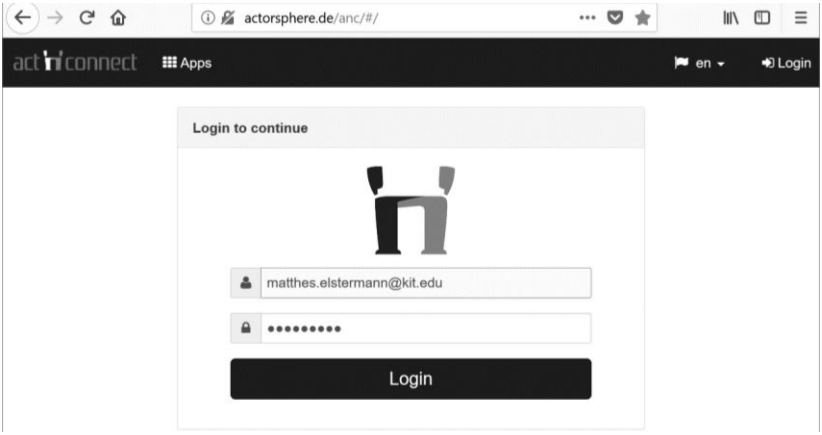


Figure 72: Login screen of the Actorsphere

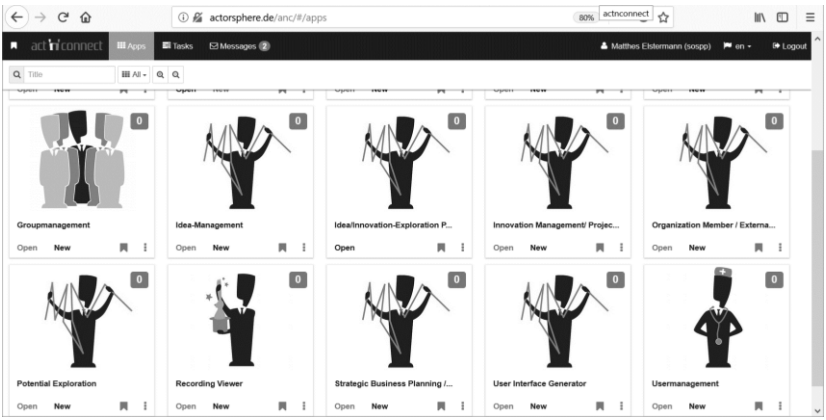
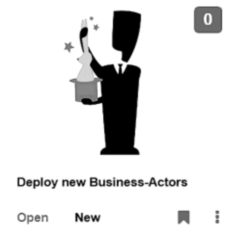


Figure 73: Main GUI of the Actorsphere with available business actors (subjects) that can be executed (administrator view)

After having logged into a user account with sufficient administrator rights, a user has access to various functions. Any of those functions are business actors themselves and handle for most parts accordingly, be they user created or be they standard functions that are provided by the system from the start, such as model/business actor or user management.

5.4.2.1 Upload of Actors



In order to execute Subject-Oriented models, first, it is necessary to upload (deploy) the new model elements to the Actorsphere.

The following screenshots illustrate the according upload task for the subjects of the new referential process model of Strategic Product Planning. The actual business actor .xml Files used here have been created beforehand with the business actor export function of the MS Visio tool (see previous section).

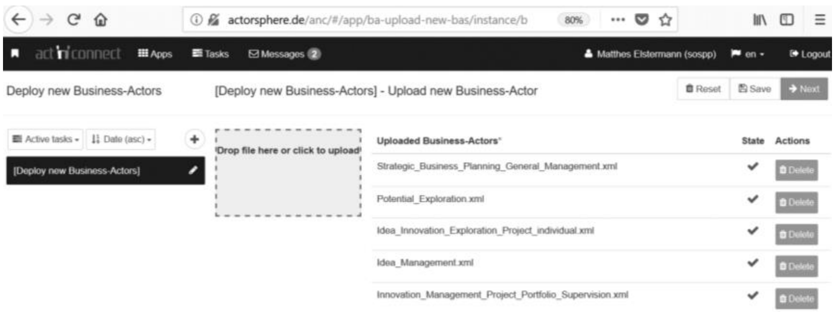


Figure 74: Upload screen for business actor .xml files

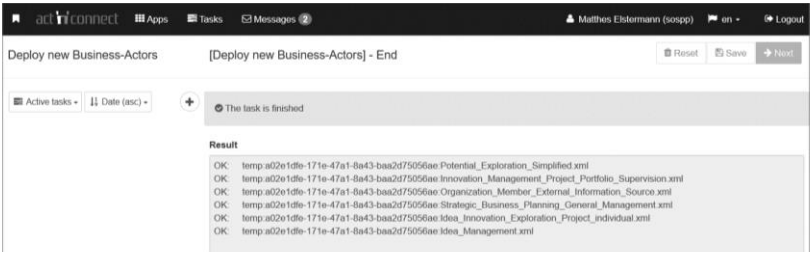


Figure 75: Successful upload of business Actor .xml Files of the referential process model.

5.4.2.2 Users, Groups, and Actor-Assignment

In addition to the process models themselves, a real-life process execution environment such as the Actorsphere usually poses some kind of user management functionality that enables admins to create and manage access accounts for human or technical users. Furthermore, these the functionality is required to manage the rights of users to start of access different process. E.g., a senior manager can be granted access to budget control processes that would be accessible to facility managers at a lower level.

In order to do so requires a mapping between the users and the process elements to be executed. Next to a direct assignment of users to task elements, in the Actorsphere as well as any other workflow execution system, the concept of user groups, so-called "roles" is applied[3].

In classical process environments, these groups of users or roles are imported into the modeling environment, and then individual tasks are amended with information that they are eligible for execution by these roles.

[3] This established concept or meaning of the term "role" in context of process modeling and process execution is one of the reasons why the term of "subject" should not and cannot be replaced with other words such as "role". It may be similar and obviously related, but it is another concept that has a different meaning.

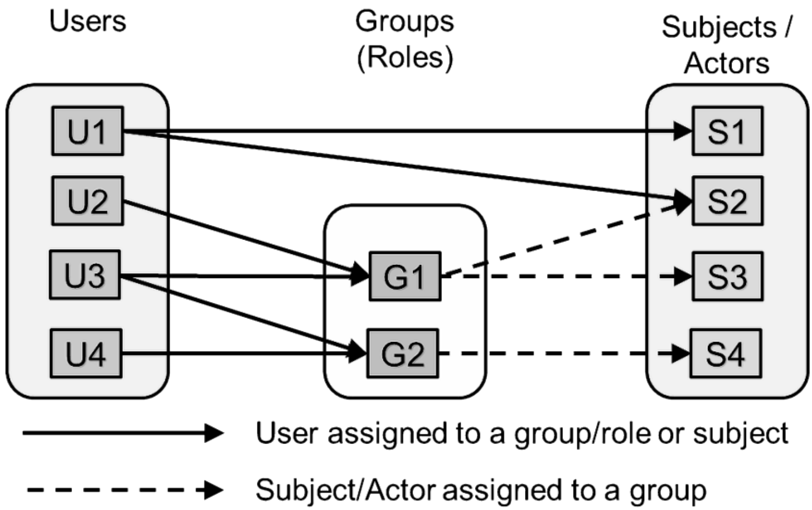


Figure 76: Matching users and subjects via groups

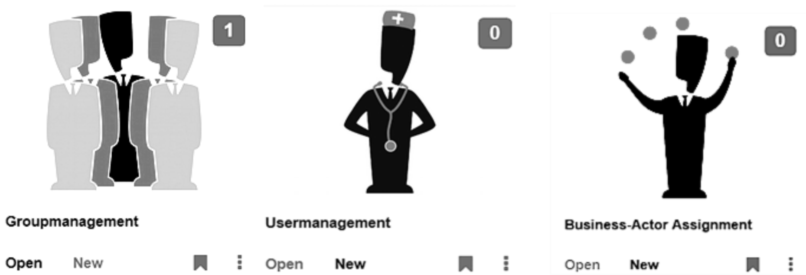


Figure 77: Actorsphere Icons for User and Group Management and Actor-Assignment

In the Actorsphere, the matching is done in a two-step manner, as is depicted in Figure 76. To do so, first, the groups need to be created (Group Management). Afterward, users can be assigned to these groups (User Management) and the groups can be given the rights to execute Subjects (Business Actor Assignment). In special cases, the last function can also be used to assign users directly to specific Subjects.

The assignment is necessary to give a user any acting capability. A newly created users has no execution rights to any actor but the default ones.

The following screenshots demonstrate the according configuration tasks in the Actorsphere.

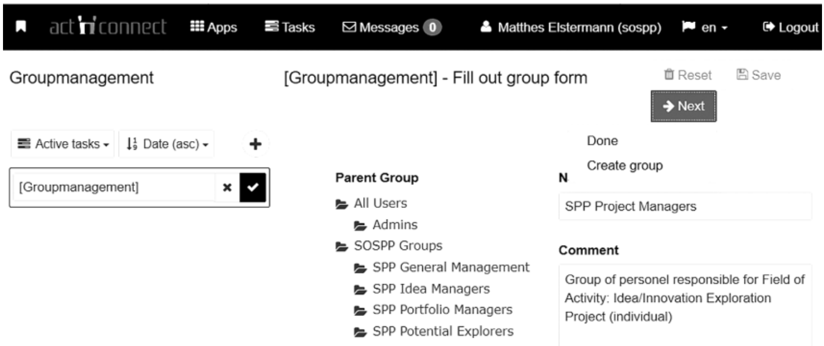


Figure 78: Screenshot group creation within the Actorsphere

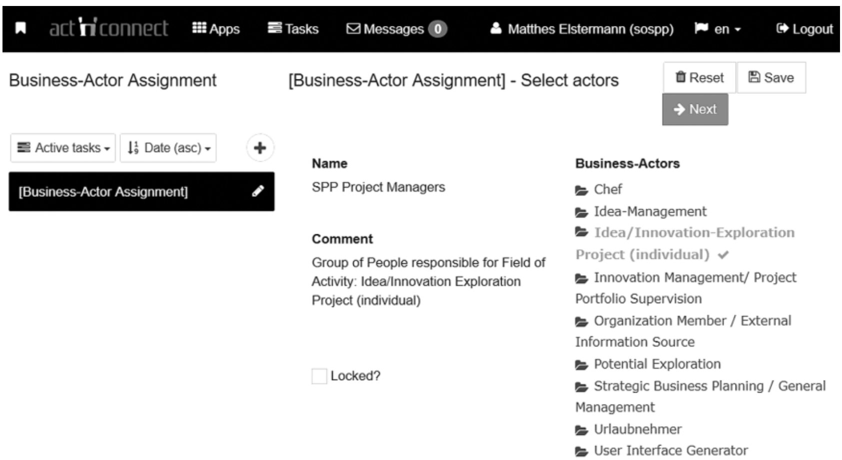


Figure 79: Screenshot Business-Actor (Subject) assignment (Group→ Subject)

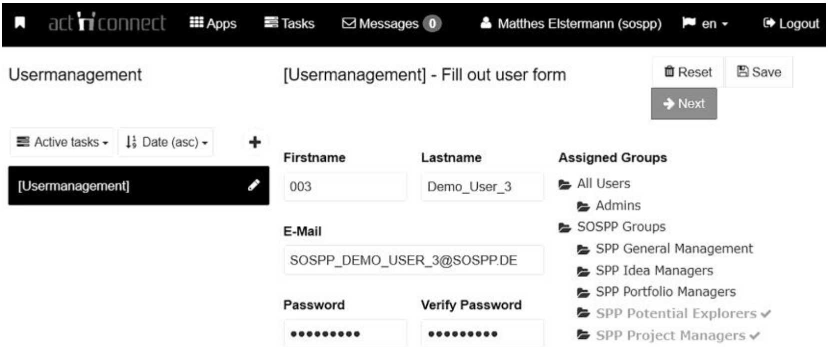


Figure 80: User creation dialogue with group assignment (User → Group)

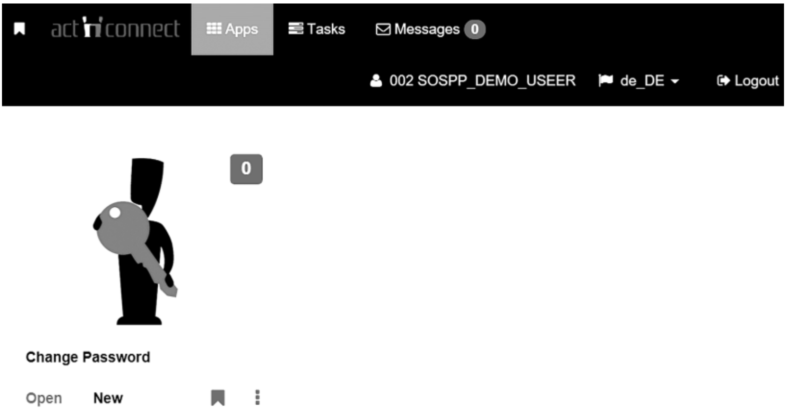


Figure 81: New user without any assigned subject/groups

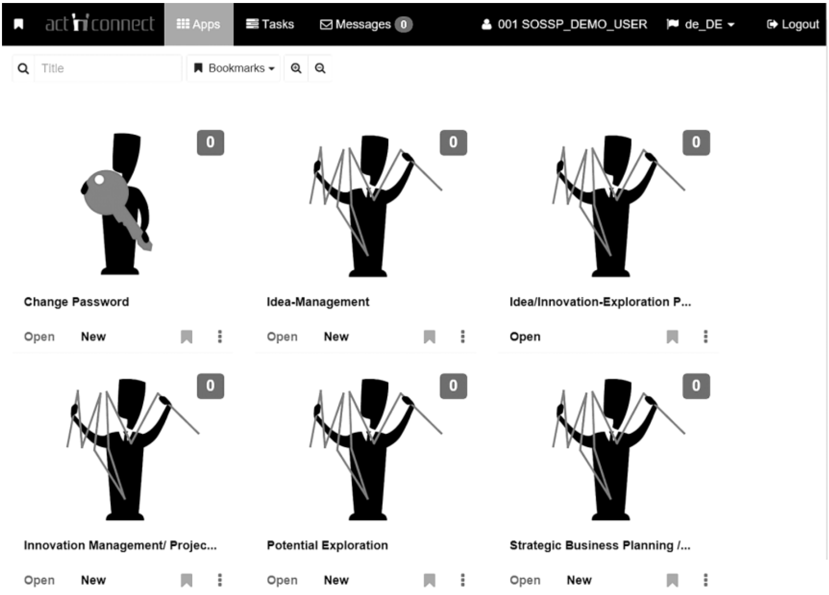


Figure 82: User with access to all SPP Subjects and the ability to start "New" instances

For the evaluation, a use-case scenario with 4 users[4] has been created that connectional represent a small enterprise with very view actual people involved in the tasks of Strategic Product Planning and multi-responsibilities for the existing users.

The users were assigned to one or more groups. As can be seen in Figure 78, the groups are 1:1 matches with the SPP subjects, to avoid artificially increasing the complexity of the use case scenario.

Configured in this manner, the Actorsphere could be used to test the execution of the referential process model as intended.

[4] As can be seen in the screenshots these accounts are the author, Matthes Elstermann, as well as Demo_user_1, Demo_user_2, and Demo_user_3.

5.4.2.3 Model Execution on the Actorsphere

As can be seen in Figure 82, a user with sufficient rights can start a new process – for most subjects, there is the option to start a "**New**" subject/actor instance. The exception is the subject for "Idea/Innovation Exploration Projects", as instances of these processes should only start upon green-lighting from Innovation Management and the subsequent message to start a project (see section 4.3.4). The other areas of activity should only be instantiated once within an organization. If users cannot be trusted to adhere to this non-formal restriction, it would have been possible also restrict that by adding another "Starter" Subject only available to an admin in order to enforce that restriction. However, for simplicity reasons, in the use-case scenario, the creation of multiple instances would be possible.

Upon starting an executing an instance of a subject, the user is shown all options available to him in a given state of the SBD. Figure 83 shows how that does translate for a user currently in the central activity hub of strategic business planning.

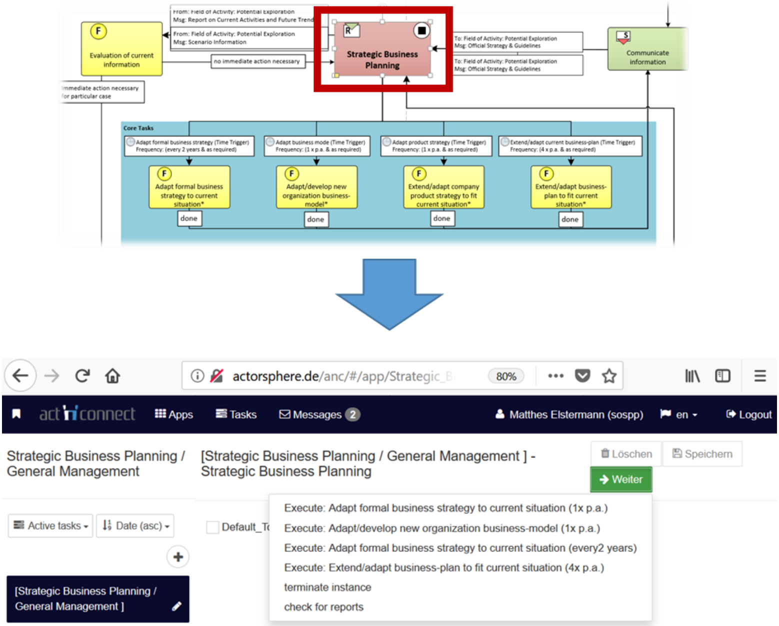


Figure 83: Excerpt from the Behavior Diagram of Strategic Business Planning (See Figure 62) and how it is shown during execution in the Actorsphere

The following screenshots depict another workflow in the Actorsphere showing the details of actual sending and receiving messages.

Figure 84: Executing the State "Decide upon new project/s" in Innovation Management

After the decision to "Go" for the project has been made Figure 84, the send state is executed automatically by Actorsphere. Sending of the project initialization message generates an instance that can be received by all users that are allowed to execute the According Idea Exploration Project subject.

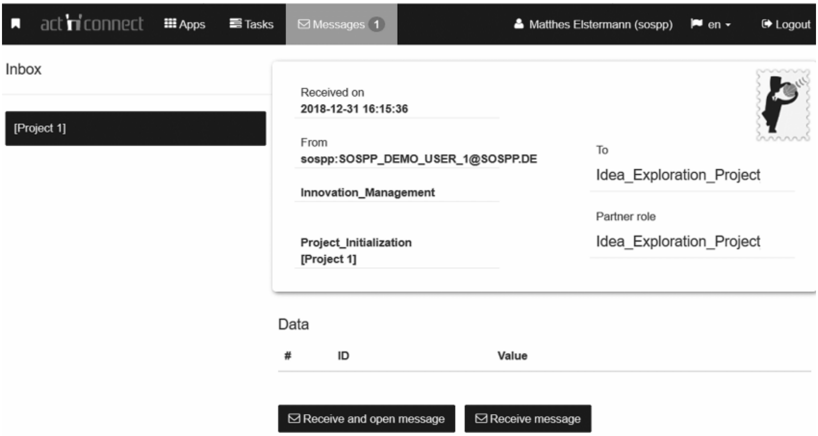


Figure 85: Message reception dialog for a new exploration project message

After the message has been actively received by a user (not a subject) (Figure 85) a new instance of the according subject is available and the user can access and start it (Figure 86 and Figure 87)

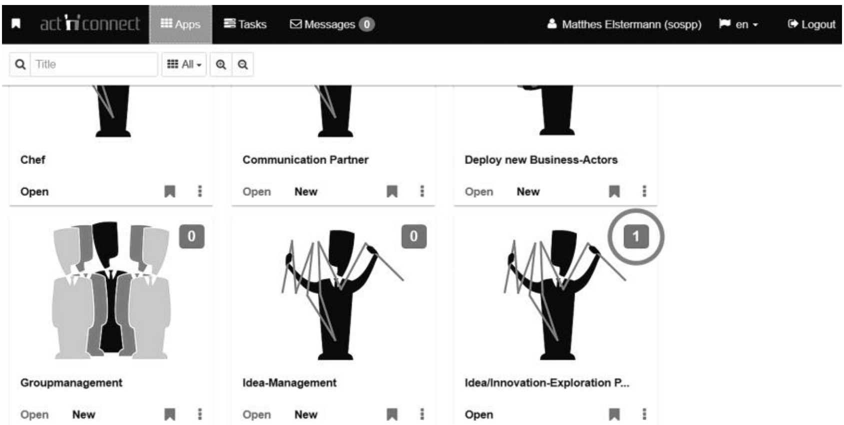


Figure 86: After the reception of a “Project initialization message” one Instance for a new Project is available and can be executed.

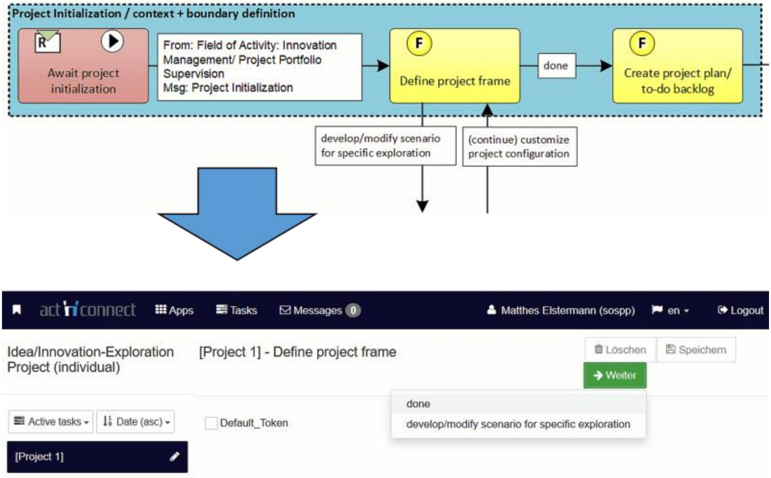


Figure 87: Project Initialization - Excerpt of original model and Actorsphere

The complete depiction of all workflow steps within the model cannot be given in printed form. However, the shown examples should provide good insight into the working and principles of the IT system that was created via the described activities. While only a prototypical system, lacking actual data elements or the embedding of external applications that would most likely be part of an actual life application, this proof of concept works well and demonstrates that the new referential process model is indeed executable as intended.

5.5 Summary and Discussion

Chapter 5 discussed the efforts and activities taken to validate and verify the new referential process model for Strategic Product Planning.

This proof of concept was threefold. First, already during the creation of the model within a continuous improvement process, the model was subjected to validation with several expert interview partners, testing, validating, and improving it. The major issue found there was the unfamiliarity with subject-oriented models in general that made it not always easy to understand the concept of the model. Otherwise, no problems could be found or aspects and concerns of the interview partners went into the model as improvements, culminating in its current version.

The second validation stage was an in-depth review by a third-party examiner that had the explicit task of finding discrepancies and weakness in the model in context a wide canon of literature on the topic of Strategic Product Planning. Here, again, only minor issues were found and also incorporated into the model.

Finally, the ability of the referential process model to be executed digitally had to be tested. This was done using the Actorsphere execution environment of ActNConnect. The results of that extensive development and validation effort are simple: it works very well, and the referential process model can automatically be translated, uploaded, and executed in the Actorsphere, as was planned and intended, thereby proving the feasibility of the approach.

Summarizing the following statement can be made: The hypothesis that the model does meet all requirements and is indeed an improvement over the previous attempts has been tested. That hypothesis could not be proven wrong. Therefore it can be assumed that, for the time being, the created referential process model does fulfill all requirements and all intended purposes very well.

6 Conclusion and Outlook

6.1 Conclusion

The goal of this thesis was to improve a situation where it was not easy to implement an IT system that could support and execute the processes and workflows of Strategic Product Planning; a situation where there was a bi-directional gap between operative processes and high-level management concepts in this domain.

This situation has been remedied with the creation of a new subject-oriented process model that fulfills all the requirements for such a tool and serves as a reference for humans and instruction for IT-systems alike. However, the model is only one of the contributions of this thesis.

First, it had to be understood why the initial approach of simply adopting an existing formal referential process model had failed and why specific aspects did not fit together as intended even though they seemingly should have. The reason was unclear, and could not be found in the theoretical foundations of the domains of Strategic Product Planning and Innovation Management. Consequently, in-depth research was conducted to investigate and understand the classical description mechanisms for processes. Problems were found with those means. However, their negative consequences can only be seen and understood when they are used for large, complex process descriptions. Analysis of the problem was further complicated by the fact that the weaknesses and drawbacks of the classical description models cannot be explained on a merely theoretical level, as according to the principle of Turing completeness, the classical linear input-task-output process mechanism is in fact perfectly capable of describing any processual situation imaginable.

The actual problem or question, therefore, is how simple and how easily complex circumstances can be described without mistakes and how comprehensible the resulting models of complex processes would be for humans.

The hypothesis developed and tested in this thesis is that process models created according to the classical input-task-output concept, and covering the entire domain of strategic product planning, would be – if valid – too large and too complex. As a consequence, the authors of prior description approaches intuitively chose to keep their processual descriptions limited and straightforward, reduced to single aspects and using only informal modeling that allowed for imprecise process models not hindered by formality issues. They created models that could depict one or two aspects very clearly, but that left out allegedly unimportant details concerned with interactions and actual execution. In turn, this increased the chances for misunderstandings and reduced the applicability for people without the missing information.

From this observation, the challenge of finding a remedy arose. Since the problem does lie in the actual description concept, first an alternative process description means was required and found in the paradigm of subject-oriented business process modeling. The approach was carefully considered for the task, first on a theoretical level and subsequently during analysis and retracing of the existing approaches. The results of the according investigation were promising and therefore the paradigm of subject-orientation and the according process modeling notation PASS were chosen as the foundations to create the new holistic model.

The model is more extensive and, in contrast to prior attempts, it is also formal. Even so, it could be hypothesized that it does indeed cover all aspects necessary for the holistic execution of Strategic Product Planning and that it can be understood by humans and IT systems alike. This hypothesis has been tested through various means. During these verifications, it has not been disproven and stands together with the model as the successful result of this thesis.

6.2 Outlook

Content-wise, the new referential process model is complete and covers the domain of Strategic Product Planning extensively. The chosen level of detail should be the right nuance between a broad general view and an in-detail explanation for the execution. The single Innovation Exploration Project with its separate task-strands of product/service planning, production planning, and business planning, could have been further divided into multiple individual subjects. However, that is a debatable opinion and could be done as part of customization.

The only thing left would be to not only have a proof-of-concept implementation as shown in the thesis but rather have a productive real-life test. Therein the model would be customized and run in a workflow engine that is part of an actual organization's IT infrastructure, containing actual databases, users, and tools to execute methods. Due to the high level of Strategic Product Planning, the scope such an effort would require, and the trust necessary to base a whole organization's planning activities on this new concept, this was not possible for this research. Nevertheless, the plan is to further improvement and refinement the model should according assessment opportunity arise.

Otherwise, for the future, another research direction can be deducted from the creation of the model:

Even while the model is formally executable and much more holistic than previous approaches, it is conceived with standard PASS. PASS may be subject-oriented and more suitable than the classical approaches, but it also makes models be formally strict *definitions* that, in theory, would need to be adhered to precisely. As a referential model, however, it should be understood as a *specification* and advice rather than a strict definition. Informally, this is no problem, as interested humans can simply take the model and create their own derivatives from it.

In contrast to the inheritance or extension mechanisms of formal object-oriented programming languages that allow formal extensions and especially derivatives of specifications, PASS does not possess such a feature. To overcome the strict definition nature of PASS, an abstract extension mechanism based on the concept of the subject is needed, and the standard referential process model could be reconceived as a specification model rather than isolated process definition.

Such a modeling mechanism would allow implementing and customizing the referential model not only on paper, but also digitally with an according modeling environment that would allow the user to interactively decide which parts of the specification to implement in what way, and which to leave out. It would warn the user when he has broken the specification and would also allow combining the specifications of the Strategic Product Planning process with other specifications that are given, e.g. organization-internal definitions of how specific processes are supposed to be run.

Figure 88 sketches the idea of such an abstraction mechanism over multiple layers of subjects that would allow for far greater flexibility and freedom in modeling and specifying processes.

However, such considerations are far beyond what is currently possible with business process modeling, even with the advanced concept of subject-orientation.

Before such a research endeavor is begun, more manageable steps should be taken that would improve the existing modeling capabilities. Such steps could include improvements to the current modeling tools that could be extended by various features. Such features could be the ability to simply split and merge behaviors and subject during modeling, or the implementation of a macro function to simplify the modeling of trilateral agreement processes.

Nevertheless, the overall idea and the hope for the future would be to create a holistic unified modeling concept that embraces the subject-oriented paradigm, including the conceptual layered abstraction idea, and integrates its active descriptions with the passive description means of object orientation, in order to come as close to the human language as possible in regards of process modeling. This could give humans better means to express their ideas for the processes they are involved in and discuss together what should be done and what not – and all of that guided by technology, not dominated by it.

For now, though, only the results and findings of this thesis are available to be transferred to other process description endeavors in the field of engineering and information management, far beyond the scope of Strategic Product Planning and its execution.

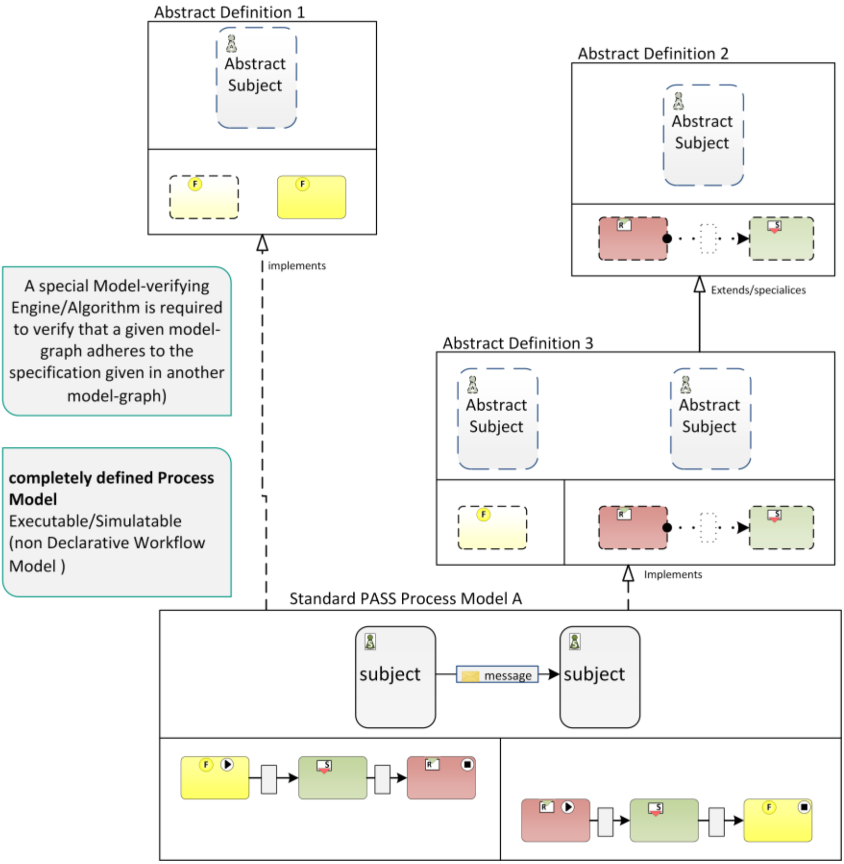


Figure 88: Hypothetical Abstraction Layer Concept for PASS

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