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On the Model-based Introduction of New Organizational Processes in an Industrial System

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ABSTRACT

Due to the increasing pressure on companies to change, the introduction of new processes in product development is required. Although studies show that the majority of change projects fail, often because of a lack of planning, no approach for determining what should be done (and when should it be done) to introduce the processes can be found in literature.

Thus, the objective of the present dissertation is to provide an approach for defining the optimal introduction procedure for a new concept[1], while considering all relevant boundary conditions. Since the boundary conditions and the systems to be considered (strategy, people, process, and organization) have complex relationships, a formal approach is necessary. This formal approach is the Introduction Procedure Model, which enables the user to optimize the transition from the current process state (initial state), i.e. before the concept introduction, to the intended process state (target state), i.e. after the concept introduction.

The concept introduction can be considered as a decision process. After the problem definition, the different alternatives for the introduction are modeled. Concurrently, an objective system has to be defined, which is the basis for assessing the identified alternatives. Finally, on the basis of the assessment a decision can be taken. It is not the intention of the defined quantitative model to substitute this decision process, but in fact the Introduction Procedure Model supports the decision process in the areas modeling, definition of the objective system, and assessment.

For the modeling, an information flow perspective is applied. The criteria stability, modularity, and practical constraints determine the possible introduction procedures. To evaluate the performance of a concept introduction procedure, the aspects cost, duration, and quality are applied. Introduction quality is defined as consisting of the aspects performance sustainment, introduction speed, company operability, introduction acceptance, and concept benefit. Finally, to derive a quantitative assessment system, axioms and according metrics are defined and attributed to the objectives of the concept introduction. With this relation between the axioms and the objectives, an assessment system for the concept introduction in a company is established.

To proof its applicability, the Introduction Procedure Model was verified in a case study with Tetra Pak Carton Ambient, a system developer in the liquid food packaging industry.

Since the phase schemes and procedures of the implementation process from literature only provide a high-level view on the implementation procedure, a process model of the implementation was developed. This Introduction Process Model describes the activities that should be conducted, the products that should be produced by the individual activities in the process (outputs), and the inputs that are used by these activities to produce those outputs. Moreover, an approach for tailoring this generic Implementation Process Model to the project-specific needs is presented.

Although personnel-related implementation activities (information, motivation, and qualification) are widely treated in literature, they are only treated qualitatively. Therefore, a quantitative approach (Personnel-Related Activity Model) was defined to support determining the right strategy for information, motivation, and qualification of the personnel. Its main

[1] Since the present dissertation deals with method and process implementation in companies, the relevant characteristics of a new process or method to be introduced are its elements (activities), relations, and the responsibilities. From this high-level point of view, there is no difference between method and process. Therefore, the term concept is used throughout the present dissertation, comprising method and process.

objective is to determine the cost-value-ratio of the personnel-related implementation activities and thus to allow an optimization of cost versus effects.

Each of the developed models (i.e. the Introduction Procedure Model, Implementation Process Model, and Personnel-Related Activity Model) provides a different view on the implementation process. The (joint) application of these models can yield significant benefits and savings.

CONTENT

FIGURES

SYMBOLS

ADN	[-]	Number of Activities with New Activity Relations and Activity Relations to be Disintegrated
AIA	[-]	Activity Introduction Advancement
AIS	[-]	Activity Introduction Scope
CAI	[-]	Number of Concept Activities to be Introduced
CRI	[-]	Number of Concept Activity Relations to be Introduced
DTR	[-]	Number of Disintegrated Team Relations
ICI	[-]	Introduction Cost Index
IDI	[-]	Introduction Duration Index
MIA	[-]	Module Introduction Advancement
MIF	[-]	Importance Factor of Modules Introduced
MRI	[-]	Number of People Involved in the New Concept Integrated in One Team
NAI	[-]	Number of Activities Introduced
NAR	[-]	Number of Activity Relations Introduced
NCN	[-]	Number of Context Activities that are Not Removed
NRI	[-]	Number of Activity Relations Introduced
NRN	[-]	Number of Context Activity Relations that are not Removed
NTR	[-]	Number of New Team Relations
PCC	[-]	Personnel Cost of the Context Activities to be Disintegrated
PCM	[-]	Personnel Cost of the Introduced Concept Activities
PDI	[-]	Project Duration Index
PEI	[-]	Parallel Execution Index
PIC	[-]	Number of Projects until the Next Transition
PIN	[-]	Number of People Involved in the New Concept
PWC	[-]	Number of Projects until the Introduction Completion for the Worst Case Introduction Alternative
RCC	[-]	Resource Cost of the Context Activities to be Disintegrated
RCM	[-]	Resource Cost of the Introduced Concept Activities
RDI	[-]	Number of New Activity Relations
RIA	[-]	Activity Relation Introduction Advancement
RIS	[-]	Activity Relation Introduction Scope
RND	[-]	Number of Activity Relations Not Disintegrated
SLI	[-]	Surplus Load Index
TCI	[-]	Total Number of Concept Activity Introductions
TCP	[-]	Total Personnel Cost of the Context Activities to be Disintegrated
TCR	[-]	Total Resource Cost of the Context Activities to be Disintegrated
TCS	[-]	Team Change Scope
TIF	[-]	Team Integration Factor

TMI	[-]	Total Module Importance
TNR	[-]	Total Number of New Activity Relations
TPC	[-]	Total Personnel Cost of the Concept Activities
TRC	[-]	Total Resource Cost of the Concept Activities
TRD	[-]	Total Number of Activity Relations to be Disintegrated
TRI	[-]	Total Number of Concept Activity Relations Introductions
TTR	[-]	Total Number of Team Relations

ABBREVIATIONS

CE	Concurrent Engineering
e.g.	For example
et al.	Et alii (and others)
i.e.	That is
n.a.	Not applicable
QFD	Quality Function Deployment
SWOT	Strengths Weaknesses Opportunities Threats analysis
TPCA	Tetra Pak Carton Ambient
V&V	Verification and validation
VVT	Verification, validation, and testing
VVT PM	VVT Process Model
VVT S&P	VVT Strategy and Planning Procedure

1 Introduction

The following chapters introduce the topic of the present dissertation and its context. Change is a constant factor in modern business. The necessity to change has various sources, but not all change efforts are successful. Therefore, in the first chapter the **reasons for change** and **success factors** of change initiatives in companies are described. However, not all of these success factors are adequately supported by tools (**methodological gap**), which highlights the need for further research.

Change can occur in different areas and in different forms. Therefore, in the second chapter the **scope** of the present dissertation is discussed. Based on the defined scope and the identified methodological gap, the **dissertation objective** is described in the third chapter.

Chapters one to three answer the question of what is treated in the present dissertation. However, to clarify in which thematic area the present dissertation is embedded, the term **implementation is defined and classified** in the fourth chapter, and the **relation between strategy, process, and method** is clarified in the fifth chapter.

1.1 Problem Description

Companies constantly try to adapt to the changing environment. This is one of the **reasons for change,** which are described along with the **success factors** of change initiatives in this chapter. There is a **methodological gap**, since not all of these success factors are adequately supported by tools or methods, which reinforces the need for further research.

In this chapter, the **reasons for change** and success **factors** of change initiatives in companies are described. However, not all of these success factors are adequately supported by tools (**methodological gap**), which highlights the need for further research.

The product development process not only defines the product, but essentially also defines the production, use, and disposal of the product. Thus, the quality of the system development process determines the success or failure of a product in the market to a large extent. Product development can be a major competitive lever for a company. Its importance has increased with the heightened pace of new product introductions.

For this reason, companies continuously try to optimize the product development process with respect to time, cost, and quality. Trygg (1993) examined 109 of the largest, randomly selected Swedish companies in the machinery and metal-working industry. He showed that more than 50% were working on programs to improve the product development process. Smith and Reinertsen (1995, p. 15 ff.) see the key objectives of the improvement initiatives in increasing the development speed, reducing the product cost, improving the product performance, and decreasing the development program expenses.

The key success drivers for product development have been investigated by several researchers, e.g. Wheelwright and Clark (1992), Cooper (1993), and Griffin (1997). Some of the most important success drivers they have determined are:

§ Implement more sophisticated formal processes
§ Implement new market research and engineering design tools
§ Have more front-end activities
§ Test and validate designs before hard tooling
§ Emphasize completeness, quality, and consistency of activity execution

Some of these key success drivers directly indicate that new approaches have to be implemented in the company. But having more front-end activities and testing and validating designs before hard tooling also necessitates the use of new and sophisticated methods, as the SysTest project has shown (see Hoppe and Engel 2005, p. 12). The emphasis on completeness, quality and consistency of the activity execution in the product development requires a continuous improvement of the activities, since what is quality today can be outdated tomorrow. Thus, the introduction of new methods is often necessary to

- reduce time and cost of the product development process,
- improve the product development quality (flexibility, efficiency, etc.),
- reduce the product cost, or
- improve the product quality.

These key success factors are triggered by the increased complexity of the environment in which the company acts. The main reasons are (see, e.g., Wenzel 2002, p. 1; Rich and Mifflin 1994, p. 105):

- a globalization process that already affects niche markets as well as small and medium sized enterprises, which is reflected in a worldwide distribution of development and production,
- fragmented customer expectations, uncertain public policy environment, and shortened product lifecycles,
- improving information and communication technologies, which are at the same time result and precondition for distributed organizations, and
- increasing the importance of knowledge-based products, services, tools, methods and organizations.

Organizational changes are triggered by other changes (Greif et al. 2004, p. 138). Triggers can be, e.g., innovations, market changes, new technologies, or organization mergers. Robbins (2003, p. 556) gives an overview on different types of triggers with some examples (see Figure 1).

Triggers	Examples
Composition of the workforce	Increasing cultural differences
	More academic specialists
Technology	Faster and cheaper computers
	New mobile communication systems
Economic crisis	Dot.com crisis
	Crash of Enron
Competition	Global competition
	Increase of e-business
Societal trends	Birth decrease
	Internet chat
Global politics	Terrorism
	Conflicts in Middle East

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Figure 1: Triggers for organizational change (adopted from Robbins 2003, p. 556)

It is important to note that the triggers for change and their specific effects vary in the course of time. Moreover, although this list suggests that the triggers are not related to persons, organizational changes are generally initiated by persons from or outside the company (Greif et al. 2004, p. 139). Greif et al. (2004, p. 140) explain organizational changes through a set of hypothesis. First, they claim that organizational changes can be triggered by a variety of impulses, requests, or concepts in or outside the organization. Second, the probability of triggering a change depends on the following aspects:

- Influence and credibility of the multiplicators
- Knowledge about the change concepts and the general expectation that their application promises success
- Priority and urgency in comparison to other running or planned changes or the risks of postponement or inactivity
- Positive result of a trade-off between risks and benefits through the decision-makers
- Positive result of the trade-off between cost and available resources

In addition to the above described change triggers, the increased product complexity poses a challenge to the developers. They need effective and efficient method and tool support to cope with this complexity. The higher product complexity has various sources: Increased requirements with regard to functionality and efficiency of the products, diversity and distribution of knowledge, information, and resources, and implementation of new approaches in the product, process, or information system are only some examples (Wenzel 2002, p. 1). The increased complexity of product development can also be detected in the automotive industry. For example, the number of produced cars for one specific model at BMW has risen from approximately 90,000 (1970) to over 500,000 (2000). In the same period, the number of legal regulations more than tripled from approximately 80 to more than 300 (Frischkorn et al., 2000).

The increased number and diversity of system elements (number of models, regulations, etc.) is only one aspect of complexity. In fact, a higher number and diversity of elements makes a system more complicated, but the system complexity also depends on the system variability in the course of time (Ulrich and Probst 1995, p. 58).

According to Dörner (1979 and 1989)[2], the complexity of a problem or system depends on (1) the number of characteristics to consider, (2) the number of relations between the characteristics (interdependence), (3) the change of the relations between the characteristics (dynamic), and (4) the lack of transparency of the relations between the characteristics.

According to this definition, a problem or a system would have maximal complexity if it had an unmanageable number of characteristics, which would all be connected with relations that change dynamically, are not ascertainable (not transparent), and thus are not predictable (Greif et al. 2004, p. 80).

Modern development of complex products requires a large number of people (often in a decentralized structure or only loosely connected by a supplier-integrator relationship) who design hundreds of components, necessitating thousands of coupled decisions (see, e.g., Eppinger 2001b, p. 283). Moreover, modern product development is highly iterative in nature (see, e.g., Browning et al. 2002, p. 443; Eppinger et al. 1997, p. 112), which is caused at least partly by the system variability in the course of the development[3].

But the system variability in the use phase has also increased in the last decades. Fricke (2005) shows the trend in the automotive industry to include more functions in the car in the form of electric / electronic components. In 1970, the functions based on electric / electronic

[2] Cited in Greif et al. (2004, p. 80).

[3] Coupled decisions (see, e.g., Eppinger 2001b, p. 283) or activities (see, e.g., Browning 2002, p. 186) are triggered, e.g., by the relations between the product functions and components.

components were mainly restricted to electronic injection, check control, speed control, and central locking. In current car models, the number of functions based on electric / electronic components has increased dramatically. This is confirmed by Kohen (1990, p. 2), who describes the increasing importance of software and electronics in high technology products (see Figure 2).

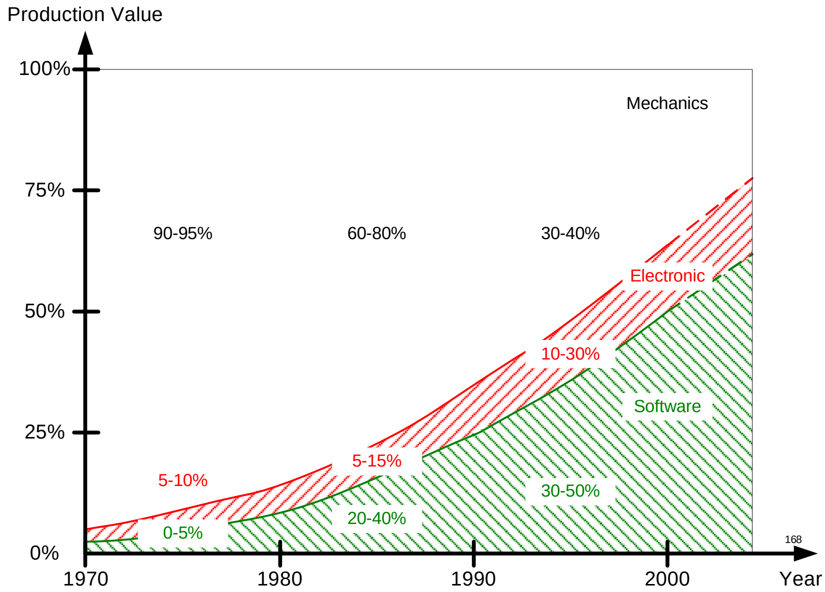

Figure 2: The shifting composition of investments in high technology products (adopted from Kohen 1990, p. 2).

The effect of this shift to software and electronics is that the product has much more "states", which is equal to a higher variability and thus complexity. However, it is important to note that complexity is subjective. On the one hand the development of an ABS is certainly a complex endeavor for the engineer, but on the other hand the ABS reduces the perceived complexity for the driver, who is supported in his driving task (Wenzel 2002, p. 5).

New approaches and methods are needed to handle the increased complexity with respect to the product and with respect to its development. This is reinforced by the Workshop Report for the Air Force/LAI Workshop on Systems Engineering for Robustness (Lean Aerospace Initiative 2004, p. 6; emphasis added): "There is a need for common terminology and *methodologies* across stakeholder boundaries to ensure more effective collaboration on a complex endeavor".

At the same time, this report emphasizes that there is a "significant challenge (both organizationally and culturally) in inserting robustness methods into existing programs" (Lean Aerospace Initiative 2004). This insight can certainly be transferred to methods in general.

The significant challenge mentioned often leads to failure in the concept introduction. Accordingly, different studies (e.g., Minor 1999, Nagler-Springmann 1999, ILOI 1997) show that the majority of operational change processes fail.

However, beside the increased complexity of products and the product development, there are also other trends that require organizational change. Carnall (2003, p. 14) confirms that the competitive environment is changing faster than ever on a global scale. Pressures on the company are, e.g.:

- Transition from growth to maturity in the market, which means overcapacity, more competition, and fewer, larger players
- Competition on a global scale

- Managing the transition from a broad range of skills and local market to a narrow range of skills and global market
- Entry of small aggressive competitors into niche segments, challenging the market leaders
- Shift from an integrative (control of all elements) to a specialized (capability in one or few key elements) position in the value chain
- Increasing speed of business processes, especially time to market

These pressures can make organizational change necessary. Organizational change is not only the change of processes or structure, but it can have the form of business acquisitions or mergers, culture changes, restructuring, new business strategies, etc. (Mourier and Smith 2001, p. 14). However, the focus in the present dissertation is on the process and the corresponding structural changes.

Chandler (1994, p. 24 ff.) highlights the industrial developments from the 1960s to the 1980s, which drove corporate change in the 1990s and are still driving change today. He relates today's challenges (e.g. rapidly changing technology, intensified competition, and turbulent markets) to a cycle of corporate expansion, contraction, and restructuring. To illustrate the possible devastating effects of technological innovation on company success, Henderson and Clark (1990, p. 19) use an example from the computer industry. Between 1962 and 1986 five distinct technologies appeared in the area of computer chip manufacturing, each substituting its predecessor. The company that led the market with the first generation of technology did not succeed with the new technology and consequently lost the market lead. When the third technology generation appeared, the new market leader in turn could not change fast enough and was substituted by another company. This situation occurred again for every new technology emerging in the market; no company was able to change fast enough in order to cope with the new technology and keep the market lead. This example shows that change can be difficult and that many companies do not succeed.

Mourier and Smith (2001, p. 13) confirm that most of the change efforts in companies fail. They cite statistics which show that approximately 90 percent of Business Process Reengineering initiatives do not deliver the expected breakthrough results (Kearney 1997[4]) and that fewer than 50 percent of restructuring, de-layering, or downsizing initiatives achieve the targeted cost reductions and productivity improvements (Schneier et al. 1992[5]). Moreover, they have conducted their own study, where they asked 210 North American Managers about the success rate of change initiatives at their company. The result was that 70 to 75 percent of the change initiatives fail to meet the key stakeholders' expectations (Mourier and Smith 2001, p. 19). The managers attribute this, among other things, to a lack of well-articulated objectives and planning. The study of Mourier and Smith confirms other studies in this field, which show an average success rate of 30 percent across various types of organizational change initiatives (see, e.g., Tenner and DeToro 1997, Troy 1994, Tomasko 1993[6]). These numbers highlight the scope of the problem: The high amount of failed improvement initiatives means on the one hand missed opportunities for organizational improvement; on the other hand it means that much effort and resources were wasted (Mourier and Smith 2001, p. 20). The lack of a plan for the implementation is described as one of the most important reasons for this high failure rate of change initiatives (Mourier and Smith 2001, p. 25). Thus, Mourier and Smith (2001, p. 57) suggest to work from an implementation plan, which defines

[4] Cited in Mourier and Smith (2001, p. 13).

[5] Cited in Mourier and Smith (2001, p. 13).

[6] Cited in Mourier and Smith (2001, p. 194 ff.).

deliverables, schedule (including milestones), responsibilities, communication strategy, and a control system. Moreover, a plan for the actual introduction should be developed, since it allows selecting the optimal procedure with respect to cost, time, and quality. Also Davidow (1994, p. 134) points out the importance of an implementation plan as element of the change strategy, which should include action steps and major milestones.

Greif et al. (2004) present a survey about factors for success and failure of change management. They conducted 346 interviews in 211 organizations and seven countries. One interesting result is that an average of 25% of the interviewees identified characteristics of the project organization as reason for weaknesses of the change project (Greif et al. 2004, p. 305 f.). The mentioned project organization characteristics are above all temporal and structure related planning, as well as a lack of farsightedness in the feasibility of the measures or steps.

ILOI (1997) confirm the high number of failed change initiatives. Their study shows that four out of ten change projects achieve less than 60% of the initial project goals. Approximately one third of the companies have to update the results of the change projects by an average of 50% (ILOI 1997, p. 7 f.). Successful change manager have to apply a systematic change controlling. This includes to precisely formulate the objectives and the prerequisites for achieving these objectives, and to define criteria for measuring the degree to which the objectives have been achieved (ILOI 1997, p. 8). Thus, a plan for the actual introduction seems to be a crucial factor. Successful change initiatives do not only yield the expected benefits in terms of, e.g., customer orientation or cycle time reduction, but they cost on average 25% less and are on average 16% more time efficient than less successful projects (ILOI 1997, p. 9).

Experts see the reason of the high failure rates of change initiatives to a lesser extent in a lack of new, appropriate methods to be introduced, but rather in a lack of methods for “designing” the implementation and change processes (Viertlböck 2000, preface). Zanker (1999, p. 150), e.g., emphasizes that there is not enough importance attached to the introduction of methods and proposes this as a future research area.

It is critical for the success of the concept introduction to have an overall concept. It is essential to plan the change process and to integrate change measures in the overall concept in order to avoid local optimization. Moreover, an exact analysis of the as-is state is necessary to create comprehensive process understanding and problem awareness (Viertlböck 2000, p. 94).

Summary

Several factors are the **sources for the increasing pressure** on companies to change, among them the globalization process, higher customer expectations, and increased product and product development complexity. Above all the increased product and product development complexity requires introducing **new approaches** in the product development for **mastering this complexity**. However, studies show that a **majority of change projects fail** to reach the expected benefits. These studies also show that for a successful introduction of new approaches, the implementation and specifically the **introduction has to be carefully planned**. Yet, despite its importance there is no approach that allows determining the **optimal introduction procedure** for a new approach with respect to time, cost, and quality. This **methodological gap** shall be filled by the present dissertation.

1.2 Scope of this Dissertation

Change can occur in different areas and in different forms. Therefore, in this chapter the **scope** of the present dissertation is discussed.

Introduction means change, where change describes the difference between an initial and a final state. These differences can be along several dimensions. Reiß (1997, p. 8) distinguishes three dimensions of change in a company: strategy change, resource change, and structure change. He sees strategy changes as radical changes, which are caused by strategic re-orientation. Examples for this change type are strategies for internationalization or customer orientation. Resource changes are changes with respect to human, technological, or ecological resources. Technological changes are above all in the area of information and communication. Finally, structure changes do affect the processes and organizational structures in the company. For example, a shift from a product to a process organization leads to a totally different organizational structure. Although this differentiation is valid and reasonable with respect to the areas that change, from this author's point of view it does not adequately reflect that changes usually affect more than one area. For example, an intensified customer orientation (strategy change) has to be accompanied by new processes (structure changes), e.g. in the sales department, and by new ways of communication or customer contact (resource changes). Thus, this type of differentiation is not adequate in many cases.

This view is supported by Greif et al. (2004, p. 57): They question if Lewin's three phases of change (unfreeze, change, refreeze) always occur sequentially and in parallel, or if they are interlaced and are executed non-concurrently. Humans constantly change when they take action. Thus, for the learning process of individuals and groups in fast cycles, destabilization and re-stabilization are micro-processes that can only take seconds.

In contrast to Greif et al., the Price Waterhouse Change Integration Team (1995, p. 7) sees six dimensions as relevant (i.e. possible levers of change) for changes in companies: Markets and customers, products and services, business processes, people and reward systems, structure and facilities, and technologies[7].

The present dissertation concentrates on two aspects within these dimensions: business processes and structure, more specifically on the product development process and team structure. However, the author is fully aware that change in an organization has to adopt a holistic approach. Improvement in only one dimension can have only modest success or may even be a failure (Price Waterhouse Change Integration Team 1995, p. 9). Improved changes always have to include many dimensions: restructuring the organization needs also new processes, reward systems, and technologies to support the new structure. Nevertheless, the approach in this dissertation to concentrate on two dimensions is valid and reasonable, since the introduction of new methods influences only the structure and the process. Useem (1994, p. 50) reinforces the notion of systemic change, which is concerned with what is the best way to improve the different company subsystems together. The individual subsystems are strongly interrelated, so that changes in only one area will be ineffective in most cases. Useem (1994, p. 51) presents the results of four studies in the area of corporate innovation, which show that only a holistic approach to change (systemic change) promises success.

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[7] There are many different ways of classifying the essential components of an organization. Useem (1994, p. 50), e.g., uses an organization's goals and strategies, production technologies and information systems, formal and informal groupings and boundaries, human resource systems, and culture and values. In the area of product development, more specific classifications are applied. Negele (1998; see also Negele et al. 1997) defines the ZOPH model of product development, describing the goal system, product system, process system, and agent system as essential parts of product development. Browning et al. (2005, p. 9) add an equipment (tool) system as subsystem, Martin (2004) presents seven subsystems of product development, including context, intervention, realization, sustainment, competing, deployed, and collaborating system. However, from the author's point of view, these classifications are somewhat arbitrary. Since a model is only a representation of reality (Igenbergs 2001), it inevitably simplifies reality and consequently can only be a view on reality. Platon expresses this in his allegory of the cave (Platon, Politeia 514a), where the models (shadows on the wall) are only one possible view on the reality (outside world). Thus, which is the correct model of an organization (or specifically of product development) depends on the application purpose of the model.

According to Kraus et al. (2004, p. 16), changes can occur in three different ways: Crisis / revolution, renewal / alteration, adaptation / evolution. Kraus et al. (2004, p. 17) differentiate four aspects of change management: Personal / psychological, process, technical, and temporal aspects. In the past the process aspects were often neglected (Kraus et al. 2004, p. 18), although change cannot happen at the push of a button. Steps and development are important characteristics of change, which is even more important for changes in which the people, structures, cultures, and habits have to change at the same time. Change has to occur in a certain order, which also leaves room for resistance. This shows again the benefit of an approach for determining the optimal introduction procedure.

Kraus et al. (2004, p. 104) describe that change can affect humans on six levels, which are: environment, attitudes, know-how, standards and values, identity, and sense. An implementation, as defined in the present dissertation, can lead to a change in the environment in which people operate, a change in the personal attitudes and habits, and may necessitate new know-how that has to be acquired. However, with respect to the actual introduction, only the first two levels are of interest. Introducing a new concept means a changing context (environment, first level) and new activities (attitudes, second level) for the individual.

Ackerman (1997, p. 45) differentiates three types of change: development, transition, and transformation. She describes developmental change as the improvement of a skill, method, or condition, which does not satisfy current expectations. That is, developmental change can be seen as improvement of things that already exist. In contrast, transitional change aims at changing the existing context and implementing something new. A transitional change is characterized by an existing “old state”, a transition state, and a new state, which is known and intended. Finally, she defines the emergence of a completely new “state of being” out of the old state as transformational change (Ackerman 1997, p. 48). Different from transitional change, here the new state is usually not known in advance. Ackerman sees the reason for this type of change in the inability of the organization to handle its current environmental demands. She describes the transformational process figuratively as birth, disruption, death and inspired rebirth. The present dissertation concentrates on describing transitional changes, specifically on providing guidance on how to structure the transition state.

Dove (2001, p. 18) supports the view that there is usually a transition period between an “old” and a new state. Two sources of disruption may affect the transition period. First, the new structure (process or organization) that is introduced needs a fine-tuning before it can fully satisfy its purpose. Second, the new structure interacts with the existing context, which can have undesirable side-effects that need to be resolved. Introducing a change means that one has to deal with a transition period which incurs cost, takes time, and shows operational idiosyncrasies. This is what Dove (2001, p. 18) calls the “toll of transition”.

Bridges (1991, p. 3) emphasizes that it is not the change that causes the problems, but the necessary transition associated with each change. He defines change as situational (e.g. the new job, computer system, etc.) and transition as the psychological process to adapt to the change. Thus, change is external, whereas transition is internal. Although he uses the terms change and transition with a slightly different meaning, he confirms basically the notion that change can be described using the initial state, the transition, and the final or target state. Moreover, he sees the transition as more important than the change (final state), because without transition no change will take place (Bridges 1991, p. 4). In accordance with this line of thought, the present dissertation focuses on transition, i.e. on the actual introduction of the new approach in the company, since the best lever for improving the change process can be found there.

Ackerman (1997, p. 53) complains that too often change is implemented without considering how deep its impact is. According to her, for planning it is essential to pay attention to what the change means and how things will be different in the new state. Therefore, in the present dissertation the target state and the effects of the change (on people, process, and organization) are included in the model for defining the optimal introduction sequence.

Another important issue is the coordination of single implementation initiatives (Price Waterhouse Change Integration Team 1995, p. 113). The commonalities of ongoing implementation initiatives have to be analyzed and the interfaces defined. Defining the interfaces means to establish communication channels to allow mutual support and coordination. However, this is an implementation issue and has to be clarified before the actual introduction is executed.

Depending on the implementation task, it may be essential to successfully cross borders. There are various types of borders, both internal and external: structural / organizational, functional, cultural, language, enterprise, market, and systems / technology (Price Waterhouse Change Integration Team 1995, p. 131). If the relevant borders are not crossed successfully, they can impede change and make the implementation a failure. The presented model allows determining an introduction procedure, which can help to derive where borders have to be crossed.

Summary

This chapter has shown that change can occur along **several dimensions**. Successful change has to adopt a **holistic approach**, i.e. consider all of the dimensions. However, since the introduction of new methods affects primarily the **process** and **team structure**, the present dissertation focuses on these areas. Although the procedural aspects of change are very important, they are not investigated extensively in literature. Thus, the present dissertation specifically examines the **procedural aspects of an introduction**. Change can affect humans on six different levels, yet the investigated process changes and introduction of new methods affect only the first two levels through a **changing context** (environment) and **new activities** (attitudes). From the different types of changes, the present dissertation concentrates on the **transitional change**, where the new, target state is known in advance. Since the **transition** between the existing, initial state and the target state is very important, it is in the focus of the present dissertation.

1.3 Dissertation Objective

1.3.1 Objective Description

The previous two chapters have discussed the methodological gap (see chapter 1.1) and the scope of the dissertation (see chapter 1.2). Based on these constraints, the **dissertation objective** is described in this chapter.

In the past three years the Institute of Astronautics participated in the project SysTest, a project funded by the European Commission under the 6th Framework Programme. The two main SysTest products, the VVT Strategy & Planning Procedure (VVT S&P) and the VVT Process Model (VVT PM), were evaluated in six different pilot projects. The results of the pilot projects have shown that the application of the SysTest products has been very successful. These new methods have the potential to improve the product development process with respect to cost and duration, and to improve the product quality. However, the pilot projects have also indicated that the success of the SysTest products strongly depends on how they are introduced in the company.

Additionally, studies show that the majority of attempts to introduce new methods and tools fail. Therefore, the goal of the present dissertation is to define an approach that allows determining the best procedure for introducing new methods. In literature, the terms "introduction" and "implementation" are often used interchangeably, although they have a slightly different meaning. They differ in two aspects: First in terms of breadth of the activities that are encompassed, and second in terms of the temporal dimension of the considered activities (Zeyer 1996, p. 7)[8].

First, introduction comprises only those activities that are actually changing the context (process, organization, etc.) or the concept (implementation object), whereas implementation includes also the activities supporting the introduction.

Second, from a procedural point of view, introduction considers the execution of the change in the organization structure, process, etc. In contrast, implementation has a much broader view on the process, beginning even from the idea and initiative for change until the control of the change results. This extended view of implementation stems from the insight that the introduction success is attributed to a big extent to activities before and after the actual execution phase (see Figure 3).

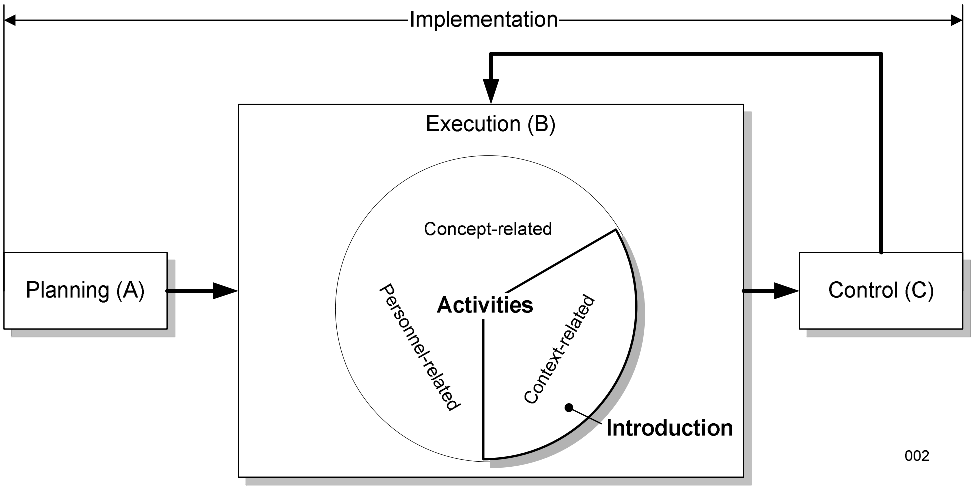

Figure 3: Difference between implementation and introduction.

Since concept introduction is an important area, one aspect of this topic was already treated in a previous dissertation at the Institute of Astronautics (Wehlitz 2000), where the introduction of a Product Data Management (PDM) system in a company was analyzed with focus on defining the optimal data management in the PDM system. This dissertation however has a broader focus on the concept introduction in general. In the following paragraphs, the dissertation objectives are described in detail.

There is a considerable amount of literature in the area of concept implementation. The vast majority describes the implementation approach qualitatively, that is recommendations for actions to be taken are mainly given in a heuristic manner. This means that the interested reader/practitioner is rather provided with statements about what he could do to prepare the concept implementation than with clear advice about what should be done (and when should it be done) to *introduce* the concept.

This dissertation aims to close that gap. Therefore, the central research question the dissertation tries to answer is:

*What is the optimal **introduction procedure** for a new concept[9], considering all **relevant boundary conditions**?*

---

[8] See also chapter 1.4 for a more detailed discussion of the terms implementation and introduction.

[9] New approaches (e.g. methods) that are introduced in a company are often referred to as concepts in literature (see, e.g., Zeyer 1996).

This research question mentions two important aspects: (1) the optimal introduction procedure and (2) relevant constraints. These two aspects and their meaning for the dissertation objectives are described in the following paragraphs.

To define the optimal introduction procedure, it is assumed that the concept to be introduced is given. That is, the concept activities, their relations with each other, and the intended relations with the context[10] activities are known and can be considered as an input to the introduction procedure.

Determining the optimal introduction procedure therefore basically means to determine the optimal steps for introducing the new concept. This is not trivial for at least two reasons.

First, the amount of possible introduction procedures is not manageable for a person. Just consider for example the introduction of six new activities in a process. Since this is a permutation problem, the number of possible sequences for introducing these six activities in the existing process is 6!. Thus, there are 720 different sequences for introducing six activities. Certainly, most of the 720 possibilities in the above example are either not reasonable, or very similar. But, nevertheless, the example shows that the sheer extent of the solution space does not allow a formal and comprehensive evaluation without tool support.

Second, the quality of the introduction procedure depends on several boundary conditions. To find the optimum, the strategy, the process, the people, and the organization have to be considered. Since there are complex relations between those systems, a formal assessment system for the concept introduction is necessary. In this way the relevant constraints, i.e. the second aspect of the research question, can be considered.

Therefore, the dissertation objective is to define a quantitative model:

Dissertation Objective - Quantitative model of the introduction procedure*: Define and implement a quantitative model of the introduction procedure, which enables the user to determine the optimal procedure for a concept introduction, while considering relevant constraints.*

1.3.2 Method Definition

It is important to note that the objective of the developed Introduction Procedure Model is **not** the **optimization** of the target state. It is assumed that the target state is already fully defined and given. In contrast, the objective of Introduction Procedure Model is to optimize the **procedure** to achieve the target state.

The basic assumption of the presented approach is that the initial state (i.e. before the concept introduction) and the target state (i.e. after the concept introduction) of the process are given. Thus, the focus of the defined approach is the procedure to come from the initial to the target state.

The relevant characteristics of a new concept to be introduced are its elements (activities), relations, and the responsibilities. From this high-level point of view, there is no difference between method and process. Therefore, the term concept is used throughout the present dissertation, comprising method and process.

[10] With respect to an implementation, the existing process and organization structure in a company is often referred to as implementation context in literature (see, e.g., Zeyer 1996).

It is important to note that the defined approach is **generic**, i.e. it is applicable irrespective of the type of process or method[11] to be introduced.

1.3.3 Summary

Experiences from the SysTest project have shown that for the success of a new method or process, it is **important how it is introduced** in the company. Additionally, studies show that a **majority of change initiatives fail**, often because the **procedural aspect** of the introduction was not taken adequately into account. Therefore, the objective of the present dissertation is to develop an approach that allows **determining the optimal procedure** for the introduction of a new method or process in a company, while considering all **relevant constraints**.

1.4 Definition and Classification of Implementation

In this chapter, the **relation of the terms** implementation and introduction is examined and defined. Moreover, the implementation of new concepts in an industrial environment is put into the **context of other change approaches**.

The term “implementation” stems etymologically from the Latin word “implementum”, which means “filling”, from Latin “implere”, literally “to fill in”, from “plere”, “to fill” (ProZ 2004). It is used widely in the engineering disciplines and the associated verb has changed its meaning to “carry out” or “accomplish”, especially to give practical effect to and ensure actual fulfillment by concrete measures (Tarlatt 2001, p. 41; Daniel 2001, p. 15; Merriam-Webster 2004).

Daniel (2001, p. 15) sees implementation as the realization of solutions that are in a conceptual form and have to be transferred into concrete entrepreneurial actions. Basically, the target is always to fit a new object in an existing context. The implementation of a strategy does not happen at a certain point of time, but is the result of a sequence or network of activities depending on each other. Therefore, implementation has to be considered a process with the goal to realize the defined strategy as effectively and efficiently as possible.

In literature, the terms “introduction” and “implementation” are often used interchangeably, although they have a slightly different meaning. They differ in two aspects: First with regard to the breadth of the activities that are encompassed, and second with regard to the temporal dimension of the considered activities (Zeyer 1996, p. 7; see Figure 4).

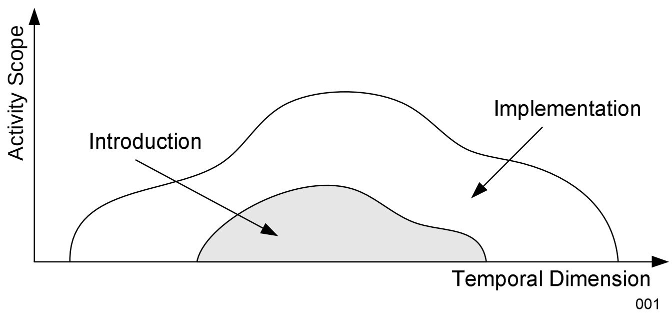

Figure 4: Different scope and dimension of implementation and introduction.

Implementation basically stands for an intended and planned change of an actual state to a target state by introducing an object. In general, the structure of this implementation object is

[11] However, the focus of the present dissertation is the concept introduction in the product development process. Therefore, only product development processes and methods are considered.

variable and has to be adapted during the introduction. Implementation comprises therefore activities for the actual introduction of the implementation object (activity oriented character, e.g. adaptation of the implementation object, process restructuring) and measures supporting the introduction activities (supporting character, e.g. personnel motivation and information, definition of the implementation supporting organization). Thus, introduction comprises only the activities that are actually changing the context (process, organization, etc.) or the concept (implementation object), whereas implementation also includes the activities supporting the introduction. That is, implementation encompasses a broader activity scope.

From a procedural point of view, introduction considers the realization of the change in the organization structure, process, etc. In contrast, implementation has a much broader view on the process; it already starts with the idea and initiative for change until the control of the change results. This extended view on implementation stems from the insight that the introduction success is attributed to a big extent to activities before and after the actual introduction phase.

Traditionally, implementation was often considered a phase or sub-process of a bigger procedure (Daniel 2001, p. 16). According to this view, the implementation phase follows a planning or development phase and ends before the control phase, where the success of the implementation is evaluated. Daniel (2001, p. 17) argues that this view does not adequately consider the various behavior related and pertinent problems that occur in the company praxis. Often individual resistance or inherent necessities require adapting the implementation plan during the actual implementation procedure. In general, implementation activities that are initiated only after the planning phase often take effect too late. Furthermore, the implementation success strongly depends on implementation activities that already accompany the implementation planning. For example, an early involvement of the affected persons may increase their participation and reduce resistance during the implementation.

Therefore, Daniel (2001, p. 18) suggests to see implementation as a procedure that encompasses all activities which ensure the later application success of the implementation object in the implementation context, regardless of when these activities are conducted. However, the control activities at the end of the procedure are not included in his implementation model. Control activities measure the success of the implementation in terms of fulfillment of objectives (cost and duration) and realization of the implementation content. Thus, the efficiency of the implementation procedure is ensured. They furthermore help to avoid lapsing back into old behavior structures (erosion effect). Therefore, the author suggests seeing control activities also as part of the implementation process.

There are three different interpretations of the term implementation, which differ in their width of interpretation (Tarlatt 2001, p. 42):

1. Implementation as the exercise to realize a specification as exactly as possible, without changes (constricted interpretation)
2. Implementation as the process of adapting to existing conditions, considering situational characteristics (medium interpretation)
3. Implementation as overall process of realization and change, where diagnosis and control activities are also included (wide interpretation)

In the present dissertation, the wide interpretation (no. 3) is applied. Hence, implementation here includes planning, realization, and control of the transfer of the implementation object into the implementation context. Introduction, in contrast, encompasses activities related to the organization structure and process in the execution phase. Here, implementation also considers activities related to personnel aspects (motivation, information, etc.) and the adaptation of the implementation concept. Figure 5 illustrates the different connotations of implementation and introduction.

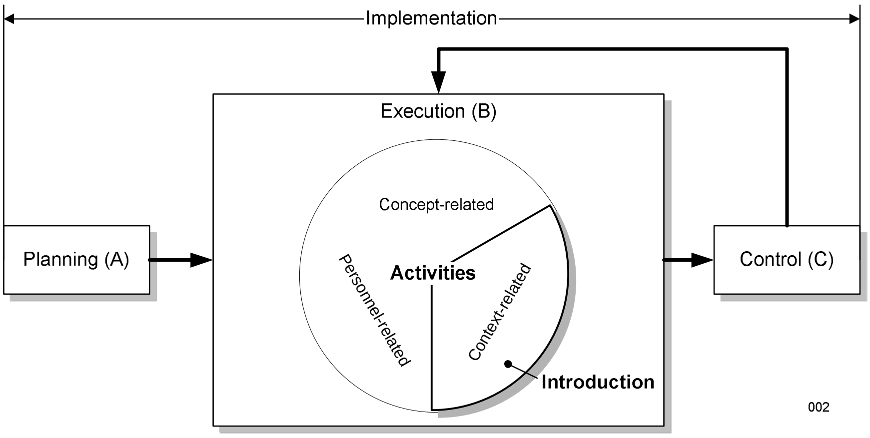

Figure 5: The difference between implementation and introduction.

In the execution phase, implementation comprises all three aspects: concept, personnel, and context. In contrast, introduction is equal to context-related activities in the realization phase. Moreover, implementation includes also the phases planning and control.

Lehner (1996, p. 77) describes different views on implementation in literature. He identified two extremes. On the one hand implementation as a full integration of formulation, realization, and evaluation, on the other hand a replacement of formulation with implementation. However, Lehner (1996, p. 79) argues for a third possibility: the separation of formulation and implementation. The present dissertation follows this argumentation.

Yet, since the focus of this work is on modeling the implementation process quantitatively to support the implementation planning, only those aspects are modeled that are relevant in this context. Therefore, the planning and control activities are not considered in the quantitative model. Through modeling relevant aspects of the implementation realization phase (focus), which include structure, process, and personnel aspects, the quantitative model should provide the user with a tool to support the implementation planning (application). Figure 6 depicts the relation within the implementation process and the relation of the quantitative model with it.

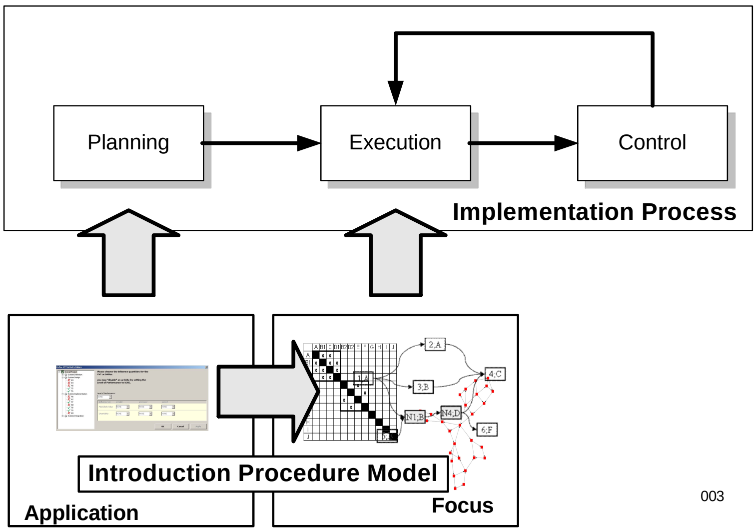

Figure 6: Relation of the quantitative model with the implementation process.

The central implementation objective is the realization of a sufficient application of the implementation object in the implementation context. This central objective can be subdivided in several sub-objectives, which include personnel-related and pertinent objectives. With respect to personnel, the objective is to create acceptance and avoid reactance. Pertinent objectives include quality, cost, and duration objectives (Daniel 2001, p. 31).

During the implementation process, various resistances can occur, which may endanger the implementation success. Therefore, to achieve a high or at least sufficient acceptance of the implementation among the personnel is a prominent necessity in the implementation process. Lacking acceptance may make the implementation more difficult, reduce the implementation success, or even lead to a failure of the implementation. Therefore, to achieve acceptance is often considered the main objective of the implementation. Acceptance includes a positive inner attitude of the people affected towards the implementation and the corresponding behavior. Reactance is the counter pole to acceptance. Reactance is constituted of a negative inner attitude towards the implementation and the corresponding (negative) behavior. If the objective to establish sufficient acceptance among the personnel cannot be achieved, avoiding reactance can be considered a sub-objective to secure acceptance.

Today, the notion of resistance as important aspect of change is generally accepted. However, Harvey (1997, p. 36) challenges this view and claims that resistance to change does not exist. He argues that the concept of resistance does not explain why some people resist change while others seek change (otherwise no change would happen), and why some of us want change on some days and resist change on others. The subject of resistance is not change, but punishment. According to Skinnerian theory, people are not resistant to change per se, but are resistant to punishment, i.e. averse stimuli. Thus, Harvey (1997, p. 37) suggests searching for those conditions that make change rewarding or punishing.

Although the resistance to adverse stimuli is certainly an important root cause, it cannot explain every aspect of resistance to change. People exhibit a diffuse, inexplicable fear of the new, which cannot be attributed to distinct averse stimuli. Moreover, since behaviorism is certainly not able to explain all aspects of the human behavior, it is not hard to imagine that the attitude towards change may vary interpersonally and in the course of time.

Quality, as the first aspect of the pertinent objectives, has various facets. One facet is the complete, loss-free, and error-free introduction of the implementation object in the context, where an adaptation of the context and the concept may be necessary. Another facet of the implementation quality is the operability of the company during change.

With respect to cost, the target is to have only low overall costs during the implementation and to ensure a high transparency of all occurring costs. Costs can be divided into basic costs and imputed costs. Basic costs include non-recurring costs and consequential costs. Non-recurring costs are for example costs for employee qualification or consultancy services. Consequential costs may occur when wages have to be increased due to a higher qualification of the employees. On the other hand, imputed costs are for example the temporally restricted assignment of employees to implementation activities or the so-called opportunity costs due to missed contracts.

The third aspect of the pertinent objectives is the implementation duration. In general, a short implementation duration is beneficial, since in this way the “normal” company activities are not influenced as long (Daniel 2001, pp. 32-35).

Tarlatt (2001, p. 44) considers the following activities the main tasks of the implementation, which aim to ensure reaching the objectives:

§ Ensure that the people affected and involved understand all expected consequences and changes that will result from the implementation

§ Assign responsibilities for the implementation activities

- § Create necessary organizational structures and entities (e.g. implementation teams and control board) for the implementation
- § Identify employees with the necessary capabilities and mobilize them
- § Motivate employees to work for and be committed to implementation
- § Apply a clear and efficient operative planning system
- § Identify and overcome resistance and reactance towards the implementation object
- § Specify and concretize measures of the strategy implementation (e.g. information systems, qualification measures, etc.)
- § Operationalize the optimal and efficient combination of implementation measures
- § Introduce an implementation control in order to be able to correct or adapt measures on time in case of deviations between the targets and the actually achieved results
- § Analyze and resolve conflict situations

In the preceding text, the terms implementation object and implementation concept were used several times. The implementation object is equal to the problem-adequate solution that has to be introduced. On the other hand, the context represents all affected aspects in the company (Daniel 2001, p. 15). Thus, the implementation object is introduced in the implementation context during the implementation.

If it is accepted that the citation “preferably a 70-percent-concept supported by all employees, instead of a 100-percent-program, which nobody wants” (Daniel 2001, p. 20) should be the basic rule for the implementation, the implementation has to be considered a coordination process where the problem-adequate solution and the context-adequate solution have to be mutually adjusted to each other. Good implementation therefore means a high degree of both object optimality and context compatibility. Thus, it is necessary to manage the implementation (i.e. implementation management) to be successful (Daniel 2001, p. 20).

In literature, management is often described as consisting of a functional and an institutional aspect. The functional aspect encompasses all activities that ensure the successful implementation realization. With respect to the institutional aspect, implementation management means all persons that are consigned with implementation activities, including their position in the organizational structure. This work focuses on the functional implementation management (Daniel 2001, p. 21; Zeyer 1996, p. 11).

The purpose of the following paragraphs is to clarify the relationship between implementation (the thematic area of the present dissertation) and other, related approaches. These approaches include Change Management, Organizational Development, Organizational Learning, and Business Process Reengineering (BPR), which are only four examples from the variety of existing change approaches.

Implementation may not be considered an equivalent to Change Management. Change Management rather considers the global change in the company, thus concentrating on a holistic view (Tarlatt 2001, p. 45, Zeyer 1996, p. 26). Change Management is an instrument to achieve a general willingness of the employees to change. It often has a long-term view of change in the company, having to be effective over a long period of time and over many process cycles. In contrast, implementation means a one-time change in the company. Another difference can be seen in the trigger. Change Management intends to define the long-term, planned change in the company, trying to achieve elementary attitude changes, whereas implementation is the reaction to current inner and outer conditions. However, implementation is necessary also in the case of active, planned changes. Therefore, Tarlatt (2001, p. 46) sees implementation as including the realization of active and reactive strategies, whereas Change Management only encompasses planned, active strategies.

Zeyer (1996, p. 24) adds another dimension for differentiation. He considers the style of implementation with the two extremes transformation and evolution. However, with respect to this factor both Change Management and Implementation have to be attributed to transformational approaches. Figure 7 depicts the difference between Change Management and implementation graphically along the dimensions strategy type, view, and change scope.

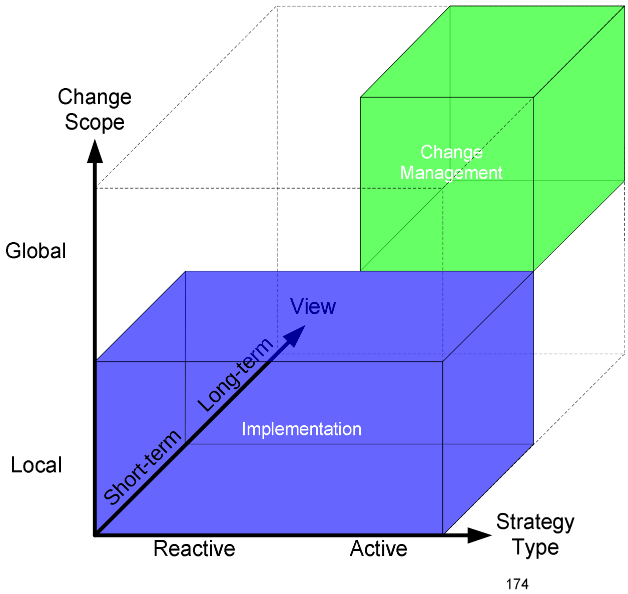

Figure 7: Difference between the terms Change Management and implementation

Similar to Change Management, Zeyer (1996, p. 25) sees the difference between Organizational Development and implementation primarily in the considered time horizon, where the objective of Organizational Development is the long-term change.

Organizational Development is defined as the set of planned activities for the improvement of economic and social conditions in the enterprise (Zeyer 1996, p. 25). It includes a repetitive application of planned measures in the long run, and the consideration of behavioral sciences and the employee interests. Basically, implementation initiatives are more management-oriented, whereas Organizational Development initiatives are more employee oriented, although both approaches have the personnel-organizational aspect as a central issue. Apart from that, Organizational Development aims at introducing change on a global scale.

In the 1960s, seminar and consultation concepts for planned organizational changes were defined under the name Organizational Development. The basis for these concepts was Kurt Lewin's model for the description of organizational changes (Lewin 1944; see Figure 8).

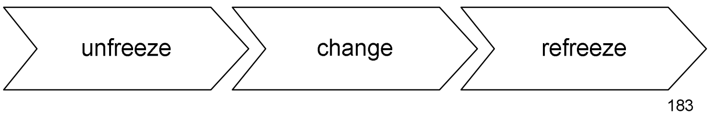

Figure 8: Lewin's three phases of organizational change.

The situation in the organization before the change is described as an equilibrium of competing stability and change forces, which is stabilized through structures and individual habits (Greif et al. 2004, p. 56). Thus, in a first phase, these stabilized organizational structures and processes have to be "unfrozen". In the second phase, the actual changes take place ("change" or "move"). Finally, in the third phase the successful changes have to be stabilized again ("refreeze"). Lewin assumed that changes cause resistance, because stabilized habits, rules, and behaviors are disturbed. For successful change, these barriers have to be overcome. Lewin's three phases describe the basic concept of Organizational Development, which is still valid today: Changes follow the described three phases and need a distinct starting point. Change causes resistance, which has to be analyzed and overcome. Moreover, changes have to be stabilized and consolidated to be effective in the long run (Greif et al. 2004, p. 58).

The philosophy of Organizational Development contains three basic ideas (Kraus et al. 2004, p. 29):

- The people and groups affected are actively involved in the development and transfer of solutions
- Problems and chances are used as starting point and incentive for changes
- Change measures are continuously managed and designed

Organizational Learning, another change approach, focuses on supporting learn processes in the company. Instead of transformation, Organizational Learning intends rather to change the organization in an evolutionary way (long-term view), yet initiates changes both from a global and a local perspective. The long-term orientation of Organizational Learning requires that it is a planned, active approach, since it is not able to react fast to changes in the environment (Zeyer 1996, p. 26).

The term Organizational Learning was introduced by Argyris and Schön (1978). Their approach for organizational change is based on the change of thinking and acting of the organization members through the stimulation of self-reflection processes in groups. Argyris (1998) observed that most of the people do not think about how they learn and that they do not have knowledge about how to learn efficiently. If someone is too convinced of himself, he does not reflect about his own weaknesses and the necessity to improve his own behavior. According to Argyris and Schön (1978), a group can improve its learning concept by reflecting about its own learning processes. Higher stages of learning can be achieved (see Figure 9) by different types of self-reflection.

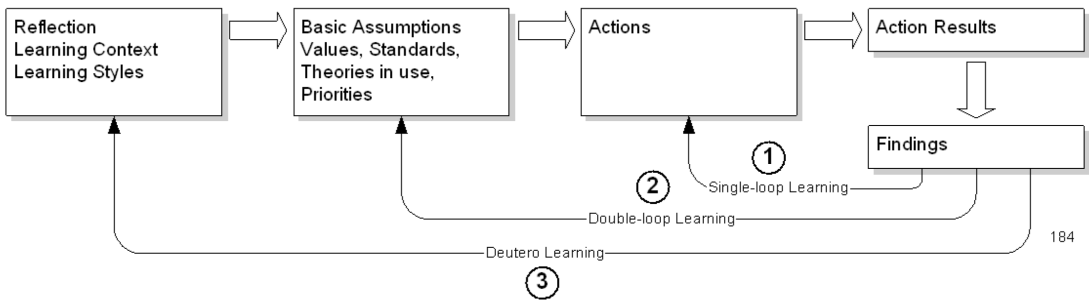

Figure 9: The three types of learning (adopted from Argyris 1998)

The three learning stages differ in terms of the feedback or reflection type. In the first stage, single-loop learning, the achievement of the objectives is examined, and, if necessary, corrective actions are taken. The basic assumptions, values, and standards are not questioned (Kraus et al. 2004, p. 35). The main goal at this stage is to “do the things right”. At the second learning stage (double-loop learning), the learning system (individual, organization, etc.) does not simply apply the usual basic assumptions, standards, and values, but reflects them and tries to find better assumptions, standards, etc. for this problem. The main goal at this stage is to “do the right things”. Finally, in the third stage (deutero learning) the system has the ability to learn learning. The organization is able to reflect about their single-loop and double-loop learning and comes from a purely adaptive correction of failures to an active and anticipatory learning behavior. Reinhardt (1993) added a third stage, triple-loop learning, to account for learning in organizations. Triple-loop learning includes reflecting single- and double-loop learning and to create the prerequisites for a permanent self-reflection and learning on the organizational level.

The higher stages of learning can be achieved through common reflection meetings, lead by a moderator, in which the executives and other employees learn to reflect their own behavior and see that they can improve their learning behavior at all levels (Greif et al. 2004, p. 69). In order to create a learning organization, the following conditions are important (Kraus et al. 2004, p. 37):

- An infrastructural framework that enables and simplifies learning has to be created
- The people have to be stimulated and enabled for learning
- Learning has to be promoted

To practically implement and sustain a learning organization, three key problems have to be solved (Kraus 2004, p. 37). First, it is important that the individual knowledge and know-how has to be collected despite personnel fluctuation. Knowledge that is only accessible by individuals cannot support the learning of the organization. Second, the adequate use of the knowledge and know-how for the organization has to be assured, since the collection alone does not yield any benefit. Third, the established collection and application processes have to be sustained and stabilized, which requires continuous motivation.

Hammer and Champy have introduced the term Business Process Reengineering (Hammer and Champy 1993; see also Hammer and Champy 1990; Hammer and Champy 2001). Their basic idea was a radical transformation of business processes to achieve a distinct improvement of important performance indicators like, e.g., cost, quality, service, and speed (Hindle 2004). The overall objective is to increase customer satisfaction and company performance in a revolutionary way (Kraus et al. 2004, p. 22). The main topics in Business Process Reengineering are:

- Focus on the business processes critical to success (core processes)
- Alignment of the core processes to the customer (focus customer)
- Use of modern information technologies

The approach of reengineering concepts is rather mechanistic, the human aspect is often not considered. Main objective is the re-orientation of the business, which is accomplished with the four steps positioning, process description, process design, and controlling.

Gabriel (1995) compares Business Process Reengineering and improvements along the dimensions temporal frame, change degree, and change area. He classifies Business Process Reengineering as an approach with a high degree of change, a long timeframe, and affecting areas company-wide. In contrast, improvements are defined as introducing only small changes, having a short timeframe, and affecting only functions. Figure 10 graphically depicts the difference between the discussed approaches.

In general, in the implementation approach the implementation object is known or given. This is in contrast to other change approaches, where often the focus is to create a basic change supportive atmosphere in the company (Zeyer 196, p. 83).

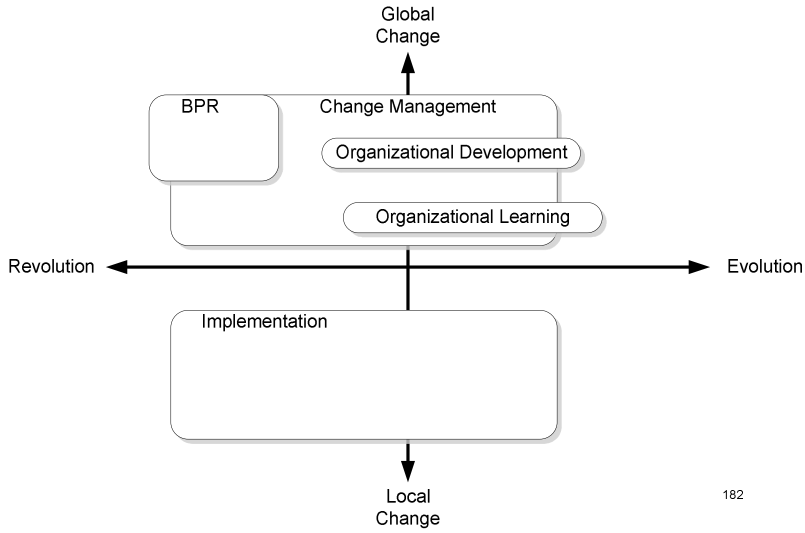

Figure 10: A classification of different approaches for change

According to DIN standard 69901, a project is a special undertaking, which can be seen as singular due to its objectives, due to financial, temporal, personal or other constraints, due to differentiation towards other undertakings, and due to a project specific organization. NASA describes a project as “a defined time- and cost-controlled activity with clearly established objectives and boundary conditions executed to gain knowledge, create a capability, or provide a service” (INCOSE 1998). Since the term project usually implies a defined start and end date, it is only applicable for undertakings that exhibit these characteristics. Examples are the installation of a new software, the planning and execution of an information session, etc. (Greif et al. 2004, p. 27). To describe a continuous undertaking, Greif et al. (2004, p. 28) suggest to use the term change program, although many people imply that programs consist of an extensive set of activities. To describe complex and simple, continuous and limited undertakings, the term change process can be used.

Summary

In literature, the terms “introduction” and “implementation” are often used interchangeably, although they have a slightly different meaning. First, introduction comprises only those activities that **actually change** the context or the concept, whereas implementation also includes the activities supporting the introduction. Second, from a procedural point of view, introduction considers the **execution of the change** in the organization structure, process, etc. In contrast, implementation has a much broader view on the process, already starting with the idea and initiative for change until the control of the change results.

The **implementation object** is equal to the problem-adequate solution that has to be introduced. On the other hand, the **implementation context** represents all affected aspects in the company (Daniel 2001, p. 15). Thus, the implementation object is introduced in the implementation context during the implementation.

Finally, implementation was put into the **context of other change approaches** (e.g. Business Process Reengineering, etc.). Two of the main differentiating factors are that implementation **represents both revolutionary and evolutionary changes** (with a slightly higher emphasis on revolutionary changes), but rather in a **local area**.

1.5 Difference between Strategy, Process, and Method

In this chapter, the terms **strategy, process, and method** are **defined**. This serves on the one hand to delimit these terms, but on the other hand also to show the overlap.

In literature, the terms strategy implementation, method implementation, and process implementation are often used.

Lehner (1996, p. 7) provides three basic definitions for strategy.

(1) Strategy is the determination of integrating long-term objectives of the enterprise
(2) Strategy is (1) and the application of resources as measures to achieve these objectives
(3) Strategy is (2) and the determination of conditions, on which it depends

In management literature the first definition is prevailing, the second definition is partly also used. The military mostly uses the term strategy with regard to the second definition. Lehner (1996, p. 7) uses the third and widest definition for strategy, which includes also implementation in the sense of definition of measures and determination of the conditions for their adoption as part of strategy. Since this view is not relevant here, the second definition is used in this dissertation, which describes strategy as the determination of integrating long-term objectives of the enterprise and the application of resources as measures to achieve these objectives.

The INCOSE SE Terms Glossary defines method as a formal, well-documented approach for accomplishing a task, activity, or process step (INCOSE 1998, p. 145), i.e. the "how" of each task. Methods usually imply a degree of discipline and orderliness. Methods can be performed in an undisciplined fashion, even though good methods, in general, do enhance the structure and efficiency of a task. Etymologically, the noun method stems from the Middle French "methode", coming originally from the Greek "methodos", which is composed of the syllables "meta-" and "hodos" (= way). It means the "right way" of cognition gathering and processing (Merriam-Webster 2004; Bertelsmann Lexikon-Institut 1992). Method is defined as "a procedure or process for attaining an object as (1) a way, technique, or process of or for doing something, or (2) as a body of skills or techniques (Merriam-Webster 2004). Pahl and Beitz (2004, p. 750) define methods as a systematic procedure for the achievement of a certain objective. Similarly, the NASA Software Management Guidebook (1996, p. 96) defines method as a technique or approach that establishes a way of performing activities and arriving at an intended result. This may be supported by procedures and standards. Dobberkau and Rauch-Geelhaar (1999, p. 605) define methods as formalized procedures for the solution of problems.

A process, in contrast, is defined as a series of actions or operations for a given purpose (e.g. Merriam-Webster 2004; NASA 1996, p. 97). According to Martin (1996, p. 54; see also INCOSE 1998, p. 176) a process is a logical sequence of tasks which have to be accomplished to achieve a certain objective. A process defines what has to be done, without saying how the individual task has to be performed. In contrast, a method specifies how the individual activity has to be conducted. It often includes also a specific notation and specifically defines the type of the required inputs and provided outputs.

Another difference between method and process can be found in the temporal aspect. A method on the one hand is a procedure, which is suitable for a specific purpose. It usually has a typical input and output, but does not include a temporal aspect. A temporal aspect is only added at its actual application. A process on the other hand has always a temporal aspect, meaning that usually a start date, end date, and duration can be assigned to the overall process and to each task in the process.

Method implementation always has to be part of a strategy implementation; otherwise it runs the risk of being an undirected activity, which is not integrated with the company's overall objectives. The characteristics of a method that are relevant for its implementation are the activities it consists of, the internal (to other method activities) and external (to other process activities) relations it has, and the responsibilities for the individual method activities. What is not relevant for the implementation is how actually each activity / step is accomplished as well as the temporal aspects of the method, i.e. the duration of the method execution.

Since the present dissertation deals with concept implementation in companies, the relevant characteristics of a new concept to be introduced are its elements (activities), relations, and the responsibilities. From this high-level point of view, there is no difference between method and process. Therefore, the term concept is used throughout the present dissertation, comprising method and process.

Summary

The purpose of chapter 1.5 was to define and delimit the terms strategy, process, and method. For the purpose of the present dissertation, the term **strategy** is defined as the determination of integrating long-term objectives of the enterprise and the application of resources as measures to achieve these objectives.

A **process** is a series of actions or operations for a given purpose. It basically defines the "what" of a task. A **method** is a technique or approach that establishes a way of performing activities and arriving at an intended result. That is, a method describes the **"how"** of a task. A method often specifically defines the type of the required inputs and outputs and has a unique notation. Another differentiation can be found in the **temporal aspect**, since usually a start date, duration, and end date is assigned to a process.

1.6 Synopsis

Section 1 of the present dissertation has shown that due to the increasing pressure on companies to change, the **introduction of new processes** in product development is required. Studies show that the **majority of change projects** fail, often because the introduction procedure is **not carefully planned**. Therefore, the present dissertation provides an approach for determining the **optimal introduction procedure** for a new process.

Change can occur along **several dimensions**. Although successful change has to adopt a **holistic approach**, the present dissertation focuses on the process and team structure, since the introduction of new methods affects primarily these areas. The procedural aspects of change are very important, yet they are not investigated extensively in literature. Thus, the present dissertation specifically examines the **procedural aspects of an introduction**. Change can affect humans on six different levels, but the investigated process changes and introduction of new methods affect only the first two levels through a **changing context** (environment) and **new activities** (attitudes). With regard to the different types of changes, the present dissertation concentrates on the **transitional change**, where the new, target state is known in advance. Since the **transition** between the existing, initial state and the target state is very important, it is in the focus of the present dissertation.

Experiences from the SysTest project have shown that for the success of a new method or process, it is **important how it is introduced** in the company. Additionally, studies show that a **majority of change initiatives fail**, often because the **procedural aspect** of the introduction was not adequately taken into account. Therefore, the objective of the present dissertation is to develop an approach that allows **determining the optimal procedure** for the introduction of a new method or process in a company, while considering all **relevant constraints**.

In literature, the terms “introduction” and “implementation” are often used interchangeably, although they have a slightly different meaning. First, introduction comprises only those activities that **actually change** the context or the concept, whereas implementation includes also the activities supporting the introduction. Second, from a procedural point of view, introduction considers the **execution of the change** in the organization structure, process, etc. In contrast, implementation has a much broader view on the process, already starting with the idea and initiative for change until the control of the change results.

The **implementation object** is equal to the problem-adequate solution that has to be introduced. On the other hand, the **implementation context** represents all affected aspects in the company (Daniel 2001, p. 15). Thus, the implementation object is introduced in the implementation context during the implementation.

Additionally, implementation was put into the **context of other change approaches** (e.g. Business Process Reengineering, etc.). Two of the main differentiating factors are that implementation **represents both revolutionary and evolutionary changes** (with a slightly higher emphasis on revolutionary changes), but rather in a **local area**.

The terms strategy, process, and method were defined and delimited. For the purpose of the present dissertation, the term **strategy** is defined as the determination of integrating long-term objectives of the enterprise and the application of resources as measures to achieve these objectives.

A **process** is a series of actions or operations for a given purpose. It basically defines the “what” of a task. A **method** is a technique or approach that establishes a way of performing activities and arriving at an intended result. That is, a method describes the **“how”** of a task. A method often specifically defines the type of the required inputs and outputs and has a unique notation. Another differentiation can be found in the **temporal aspect**, since usually a start date, duration, and end date is assigned to a process.

In other words, a strategy describes the “when”, a process describes the “what”, and a method the “how”.

2 Process Model of the Implementation

In the previous chapter the difference between implementation and introduction was described. Introduction is only one part in the implementation process, comprising the activities that are actually changing the context. However, introduction can be better understood when it is embedded in the context of the implementation process. To that end, the following chapter presents **phase schemes and procedures** of the implementation process from literature. However, the described phase schemes and procedures only provide a high-level view on the implementation procedure. Thus, their value as orientation guide and for creating transparency can be questioned. Therefore, in chapter 2.2 a **process model of the implementation** is developed, which describes the activities that should be conducted, the products that should be produced by the individual activities in the process (outputs), and the inputs that are used by these activities to produce those outputs. Yet, since the defined implementation process model is generic by nature, for a successful application it has to be adapted to the specific needs of the company and project. To that end, an **approach for tailoring** the defined implementation process model is presented in chapter 2.3.

2.1 Phases and Procedure of the Implementation

Introduction is only an aspect of the implementation process. In general, the term introduction describes the activities that are actually changing the context, i.e. the actual execution of the change. To get a better understanding of introduction, it is embedded in the **context of the implementation process**. Therefore, this chapter presents **phase schemes and procedures** of the implementation process from literature.

Due to their generality, procedures or phase schemes are only applicable in a restricted manner in practice. Yet, they help the user in providing a valuable orientation guide and creating transparency. Zeyer (1996, p. 81) emphasizes that feedback loops existing in reality are not depicted in general in such phase schemes. Feedback loops are necessary, since in the whole process changes in the planning may occur frequently, due to the only restricted detail of planning that is initially possible. However, this problem can be overcome when the phase scheme is considered as a rough pattern, representing the implementation procedure rather on the macro level. On the micro level, consisting of several partial cycles, then detailed activities with feedback relations and also partial projects can be depicted. Moreover, assigning activities to the individual phases can only be considered as recommendation, describing the core activities that should be conducted and completed in the respective phase. Special boundary conditions may make it necessary to proceed to the following phase although individual activities are not completed yet, or even to move activities between phases (Zeyer 1996, p. 82).

Zeyer (1996, p. 82f.) describes an implementation procedure on the macro level. He divides this procedure into three main parts: Initiative, planning and preparation, and introduction (see Figure 11).

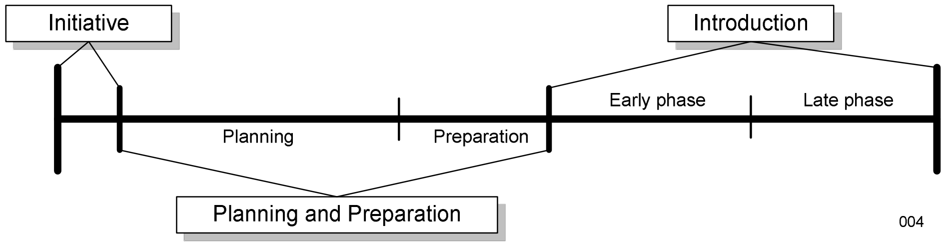

Figure 11: Implementation procedure on the macro level (adopted from Zeyer 1996, p. 82).

The initiative phase has to be executed carefully, since errors there may have a big impact in later phases. Since the implementation object is often known or given, there may be a lack of problem awareness at the employees; in this case, problem awareness has to be created. First, the given implementation concept and the existing implementation context are evaluated. The results are used as basis for deciding if the planned implementation is reasonable. Often the complexity of this issue or lacking information does not allow coming to a rationally funded decision. This underlines the necessity of promoters and initiators at the beginning of the implementation, which are convinced of the implementation benefits. In this phase, already the implementers and promoters are allocated. Areas for the first implementation (pilot areas) may be defined as well, together with the implementation project organization. Pertinent diagnosis and budget constraints help to identify basic procedures (implementation strategies) and objectives on a high level, and to define priorities and degrees of freedom for the implementation work (Zeyer 1996, p. 82f.).

The planning and preparation phase builds on the results of the initiative phase and aims primarily at successively detailing the existing concepts and procedure plans, conducting detailed diagnosis, refining the organizational structure (e.g. teams, implementation areas), and allocating implementers and supporters. Moreover, preparative activities (e.g. qualification) establish the necessary preconditions for the introduction phase. Detailing the concepts has to lead to a better understanding of functional relationships between the concept parts. The detailing of the concepts allows, in combination with the diagnosis of the context, defining appropriate implementation measures. Feasibility considerations have to be part of this analysis. Possible problems have to be taken into account, e.g. through incorporating flexibility in the procedure. During the diagnosis the start context and other constraints have to be identified. The results contribute to the evaluation of the feasibility (go/no go decision) and have to be incorporated in the plans. In this phase above all indirect implementation measures (information, motivation, and qualification) have to take place. Direct implementation activities are mainly constrained to implementer training and possibly pilot projects.

The introduction phase is divided in the early and late phase (see Figure 11). In the early phase the emphasis lies on direct implementation activities, although the indirect implementation measures are still an important part (the focus has shifted there from a preparing to a managing purpose). At the beginning problems have to be taken into account. Therefore, a high speed in the deployment of reactive and proactive activities is valuable. Qualification activities, which have already started in the planning and preparation phase, are still necessary in this phase. With respect to motivation, it is important to plan for small, early, and visible successes. In the late part of the introduction phase, the most important objective is to stabilize the achieved changes through standardization or other appropriate measures, in order to increase the efficiency of the implementation. Furthermore, to increase the overall implementation performance, insights gained from the actual implementation have to be transferred and follow-on projects have to be prepared (Zeyer 1996, p. 85f.).

Lewin (1947) presented a basic model for changes, which is still accepted as valid. It describes mainly the procedure of organizational learning processes. It differentiates between the three phases “unfreeze”, “move”, and “refreeze”.

Behaviors, ways of thinking, systems, etc. get more and more stable the longer they exist and are repeated. To change such a behavior, way of thinking, etc., dedicated measures to “unfreeze” are necessary. A very important part of this “unfreezing” are measures for unlearning, which can be considered as prerequisites for learning. Yet, unlearning does not necessarily precede learning; both can be conducted in parallel as well. Above all for employees that were very engaged and successful in the old system or with the old behavior do have problems with unlearning. Examples for “unfreeze” measures are publication of change necessities, support of communication, or the breaking up of organizational boundaries.

The next phase, after the old behaviors have been “unfreezed”, has the objective to “move” the people and their attitudes. This phase comprises the core activities of change. This includes the cooperative definition of concepts and connected with this the creation of problem awareness at the people affected. Furthermore, the preparation and realization, analysis and steering, and participation are key elements in this phase.

The last phase is “refreeze”, which ensures that the changes are incorporated in the company and no falling-back in old structures occurs. Reasons for a relapse may be inertial forces, a performance onset, or friction in the implementation and uncertainty. “Refreeze” measures are, e.g., repetition of qualification activities, or visualization and standardization of changes (Zeyer 1996, p. 85f.).

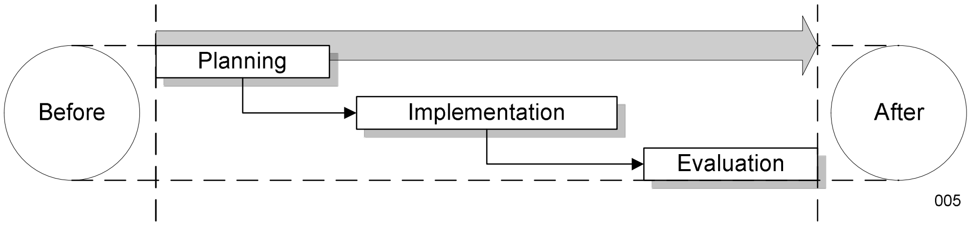

Figure 12: General model of a change process (adopted from Beskow et al. 1999, p. 438).

Beskow et al. (1999) studied several industrial change processes. In their paper, they present the results of an empirical study, which aimed at exploring the process of implementing Quality Function Deployment (QFD) in the product development process, and at identifying aspects that support or hinder the success of the implementation. To that end, they conducted more than twenty interviews in four Swedish companies. Beskow et al. (1999, p. 438; see Figure 12) derived from these interviews a general model of a change or implementation process. This model consists of three basic steps: planning, implementation, and evaluation. Although the authors emphasize key factors for the planning phase (clarified need, a well defined goal, user education, and facilitators), they do not give further information about detailed activities contained in these three phases.

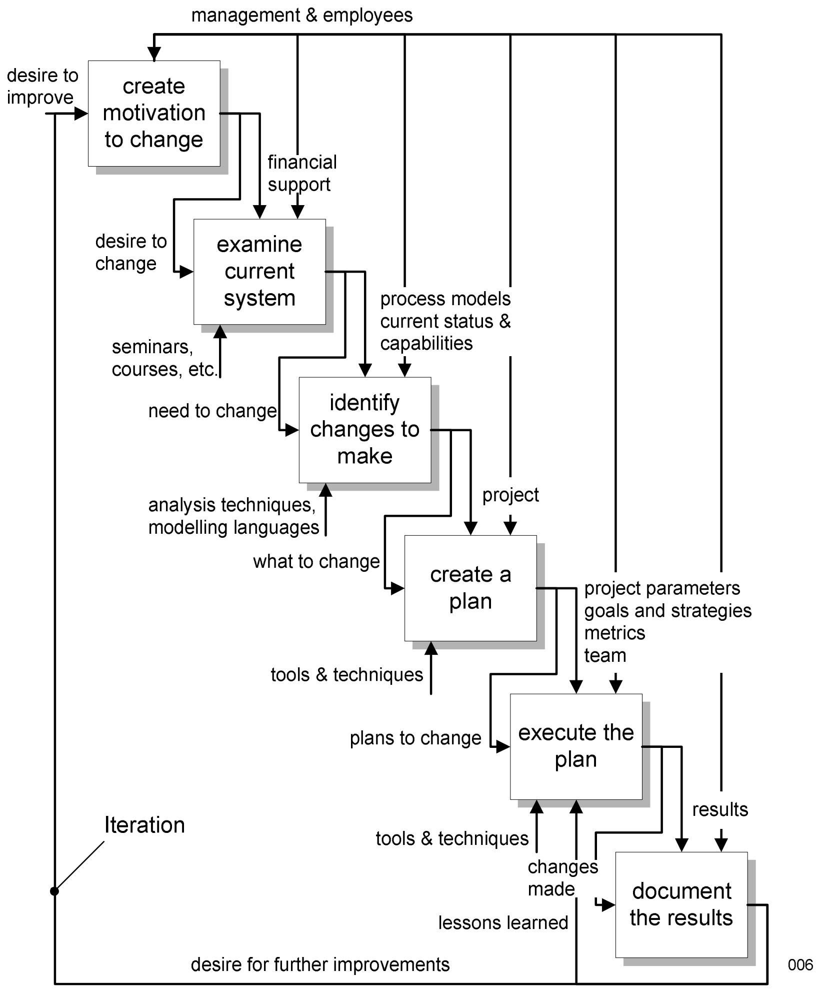

Figure 13: Implementation process for concurrent engineering (adopted from Usher 1996, p. 42).

Usher (1996, p. 42; see Figure 13) provided a more detailed phase scheme of the implementation process for concurrent engineering. He differentiated between six distinct phases and considered as well iterations on different levels. With including the phases “create motivation to change”, “examine current system”, and “identify changes to make” he emphasizes steps that are preceding the actual introduction.

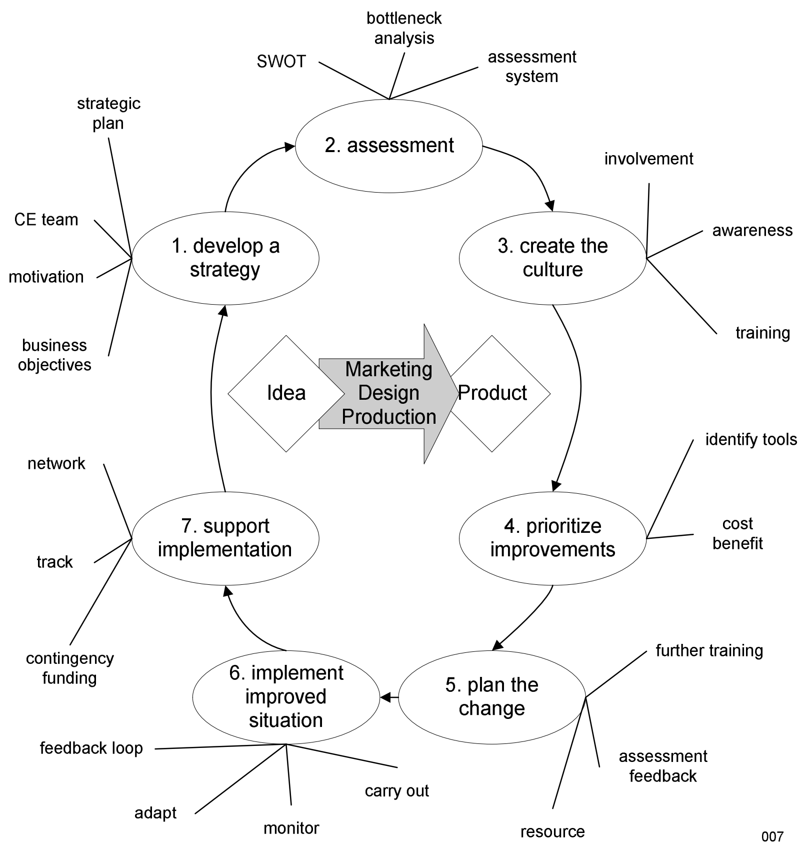

Figure 14: Generic PACE implementation framework (adopted from Driva and Pawar 1997, p. 17).

Driva and Pawar (1997, p. 17) presented a cyclic approach. It can be considered as a more generic framework for the implementation problematic, since the phases (e.g. “create the culture”) are residing on a rather high-level (see Figure 14). The authors claim that this is a holistic approach, which includes all relevant issues of change towards Concurrent Engineering (CE). The framework should be applicable in ordinary companies, without any special conditions (e.g. an extremely motivated project team). The bases of this framework are the steps of Change Management, which were adapted to the specific context of CE and provide a structure for implementation. The model was developed using literature research and experiences of the PACE industrial partners. These experiences were gathered with the help of questionnaires asking for the current situation and identified problem areas in implementing change.

The implementation framework is divided into seven steps (Driva and Pawar 1997, p. 18). The procedure starts with step 1, develop a strategy. At top management level, it has to be identified why the company must change and a top level implementation plan has to be derived. The activities within step 1 are:

- Analyze business objectives: Top management has to derive long and short term objectives
- Define motivation for change: The need for change in the organization has to be assessed and commitment from all concerned has to be obtained
- Appoint a CE team: People committed to the change need to be determined
- Write the strategic plan: A top management strategic plan defining the reasons for change and including all parts of the organization has to be developed

Step 2 is the qualitative and quantitative assessment of the current situation. It includes the activities:

- Perform a SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis: The company targets are defined
- Analyze the core business aspects: Analyze people, technology, processes, and data management
- Perform a bottleneck analysis: Track the workflow and identify the major weaknesses in the company, considering all of the core business aspects
- Assign responsibilities: Assign responsibilities to people from the core team for these initial changes
- Define an assessment system: Define and institutionalize an on-going assessment system

The next step (step 3) aims at creating a change supportive culture in the company. Typical activities include:

- Raise awareness: The reasons for change and the upcoming changes have to be propagated to the people
- Encourage involvement
- Hold initial training sessions
- Arrange a debriefing: Problems should be discussed with top management
- Apply the training: Make sure that people use their newly acquired skills in the job

In step 4, the identified improvement options have to be prioritized:

- Identify suitable tools: Identify the tools supporting the improvement and if they are available in-house or have to be purchased
- Determine the cost-benefit ratio: Prioritize the in step 2 identified weaknesses and determine the cost and value of fixing them

In the following step (step 5) an action plan is developed. The plan should define the responsible and involved people, define the tasks, establish milestones/targets and anticipated interim results, and consider the rate of change, resource allocation, and include a Gantt chart.

The objective of step 6 is to implement the improved situation. Specific activities in this step include carrying out the plan, monitoring deviations, adapting the plans as necessary, and installing a feedback loop.

Finally, step 7 aims at supporting and, above all, sustaining the implementation. Activities in this step may be:

- Get an on-going commitment: Above all top management must continue to support the implementation
- Get contingency funding
- Create a support network: Define communication channels between employees, implementers and top management.

- Track the implementation progress: Measure the values of the implementation and make sure that it does not get sub-optimal
- Continuously train the people: Train new staff and refresh old capabilities

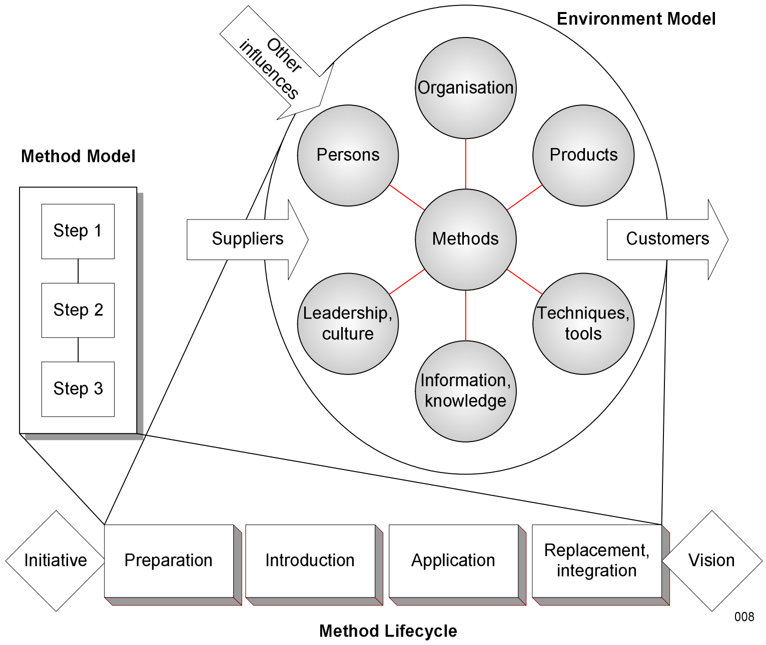

Figure 15: Three models for a holistic method implementation (adopted from Dobberkau and Rauch-Geelhaar 1999, p. 605).

Dobberkau and Rauch-Geelhaar (1999, p. 605) describe a model for the implementation of quality methods in small and medium sized enterprises. They suggest differentiating three models within the overall model, which are: the method model, the environment model, and the method life-cycle (see Figure 15). The method and environment model describe the implementation concept and context, respectively. The central phase scheme for the implementation procedure is the method lifecycle, which describes the stages of a method's lifecycle. Dobberkau and Rauch-Geelhaar (1999, p. 605) emphasize that a configuration of the method and environment are essential prerequisites for a successful method introduction. In an initial step, the company has to define the objectives that the method has to achieve. Moreover, following questions have to be answered during the implementation:

- What is the basic idea of the method?
- When should it be applied?
- How often should it be applied?
- Who should be integrated?
- What benefit is expected?
- What effort is acceptable for this benefit?

Hence, the authors present their model of a method implementation process to support finding answers to those questions.

A very important aspect of the implementation procedure is the adaptation of the method (method model). The best possible fit of the method to the task has to be found, since this later defines the effort and benefit at the method introduction and application. Since a method can be considered as a procedure consisting of individual steps, there are several degrees of freedom with respect to these steps (Dobberkau and Rauch-Geelhaar 1999, p. 606):

§ Type and purpose
§ Sequence
§ Correlation
§ Form
§ Relationship to the method environment

If possible, it should be abstained from individual steps during the implementation and to proceed in a less formalized way. Following characteristics of the step may help in deciding if this step can be disregarded:

§ Effort
§ Benefit
§ Sensibility of a belated addition
§ Necessity for the own company

However, it is not sufficient to leave out individual steps, but each step has to be adapted itself. Following some questions that may guide in forming the steps:

§ How complete has the result of the step to be?
§ How systematically has the procedure to be?
§ Which synergy effects occur with other procedures/methods?
§ Which tools and techniques support this step?
§ Which data and information exists that may be the basis for this step?
§ Which data and information is additionally necessary?

With the environment sub-model, Dobberkau and Rauch-Geelhaar (1999, p. 608) emphasize that the method and the environment have to be adapted to each other. The authors differentiate six company-internal and three company external groups of influencing environmental aspects. The company-internal aspects are the organization, products, tools and techniques, information and knowledge, leadership and culture, and persons. Company-external aspects are suppliers, customers, and other influences, e.g. legislative bodies. Each of these groups contains several elements, from which at least some have to be considered for defining the goals of the method adaptation. However, Dobberkau and Rauch-Geelhaar (1999, p. 606) emphasize that a conscious forming of the environment has to be considered also as valid alternative.

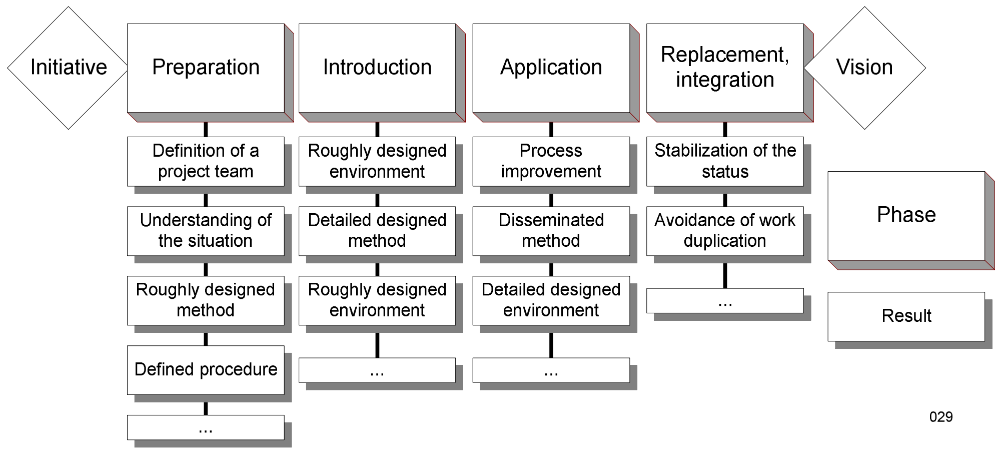

Figure 16: The method lifecycle and intermediate results during the method implementation (adopted from Dobberkau and Rauch-Geelhaar 1999, p. 608).

The third sub-model, the method lifecycle, defines expected results of the implementation (see Figure 16). The method lifecycle contains four phases, which connect the initiative for a method implementation and the vision of the complete and successful method integration. These four phases are the preparation, introduction, application, and replacement and integration.

In the preparation phase, analyses have to clarify (Dobberkau and Rauch-Geelhaar 1999, p. 608):

§ Which are the method objectives?
§ How often the method should be applied?
§ What effort is necessary and acceptable?
§ What degree of acceptance has to be expected?
§ Where are overlaps with other activities?
§ What schedule is realistic?
§ How can the method and the environment be adapted?

The results of this phase should be, among other things, the definition of a project team, an understanding of the situation, a roughly adapted method, and a defined implementation procedure.

The next phase is concerned with the introduction of the method (Dobberkau and Rauch-Geelhaar 1999, p. 608). First experiences in the team may help to adapt the method in a more detailed way. Already in this phase the form of the method application has to migrate from a pilot project to a regular use. Resistance of the involved people has to be expected and measures have to be defined accordingly. Moreover, the environmental aspects have to be roughly adapted as necessary.

The application phase eventually tries to achieve the expected process improvements and to disseminate the method in the company (Dobberkau and Rauch-Geelhaar 1999, p. 608). The environmental aspects are now adapted in a more detailed way. Additionally, the implementation status has to be monitored constantly to detect deviances from the target state.

Finally, in the replacement and integration phase the achieved status has to be stabilized and duplication of work has to be avoided (Dobberkau and Rauch-Geelhaar 1999, p. 610).

Stetter (2000, p. 31ff.) compares different basic models for the method implementation.

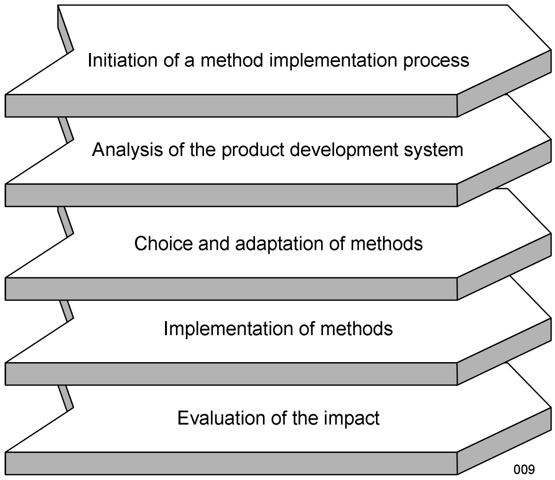

Figure 17: Layers of the implementation process (adopted from Stetter 2000, p. 34).

Stetter (2000, p. 34) propagates a model of the implementation process, which does not consist of phases, but of layers (see Figure 17). This layering takes into account that on a sufficiently low level of detail, the iterative nature of the implementation process becomes obvious. Sequential models do not take into account this phenomenon adequately. Furthermore, he claims that the exact order of executing the steps in the implementation strategy is not crucial, although each step should be performed. Therefore, he distinguishes five layers of the implementation, which classify activities according to their purpose or content. These five layers are:

§ Initiation of a method implementation process
§ Analysis of the product development system
§ Choice and adaptation of methods
§ Implementation of methods
§ Evaluation of the impact

Stetter (2000, p. 35) claims that the implementation procedure may start at any layer, but has to include activities from all layers to ensure the success of the implementation. However, this has to be questioned, since the variety of possible starting points is certainly reduced to a small amount of reasonable starting points. See Figure 17 for a picture of Stetter's method implementation model, showing the five layers and the activities within the layers.

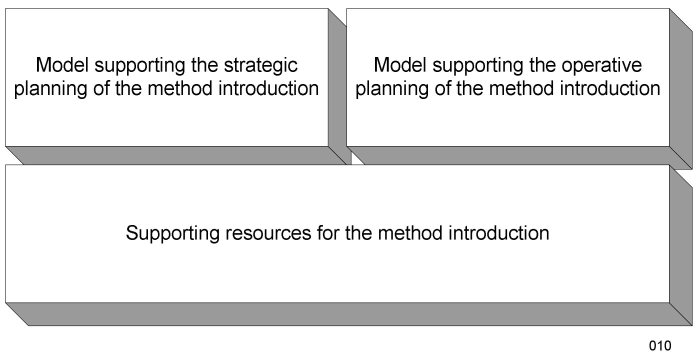

Figure 18: Sub-models of the method introduction model (adopted from Viertlböck 2000, p. 102).

Viertlböck (2000, p. 102) introduces a model that considers the strategic, operative, and resources dimension of the method implementation in different sub-models (see Figure 18).

The resource model describes resources that are necessary and helpful to support the method introduction, thus representing a sub-model for the organizational structure. He sees the method implementation as part of corporate planning. Therefore, he sets the implementation process in relation with company planning. From this point of view, the strategic aspect of his model is part of the strategic company planning, helping to plan the use and introduction of the right methods for the whole company processes (Viertlböck 2000, p. 103). The focus of the operative company planning is the improvement of the company efficiency. Similarly, the operative aspect of the method implementation model considers the efficient introduction of methods in the company (Viertlböck 2000, p. 105).

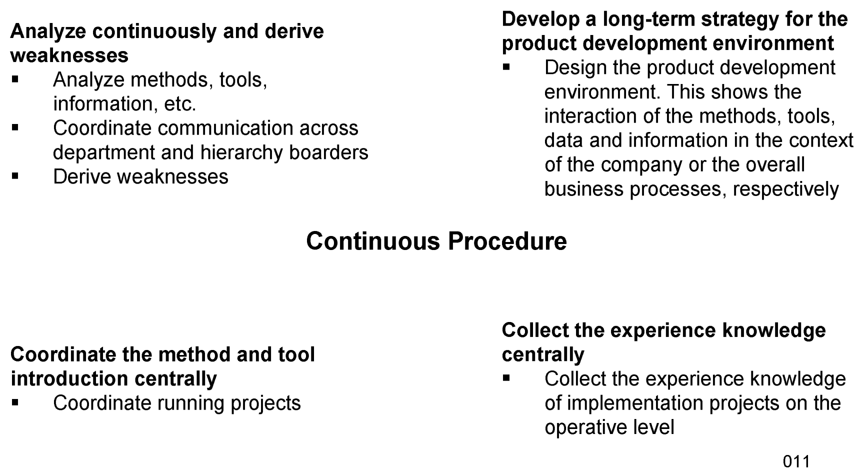

Figure 19: Model supporting the strategic planning of the method introduction (adopted from Viertlböck 2000, p. 106).

In detail, the objectives of the strategic method implementation planning are the analysis of the existing environment (context), the determination of specific improvement measures (which can be realized with the help of the operative sub-model), and the support of the medium- to long-range method planning (see Figure 19). Other aspects are the coordination of running implementation projects and a centralized collection and documentation of lessons learned from implementation projects (Viertlböck 2000, p. 106).

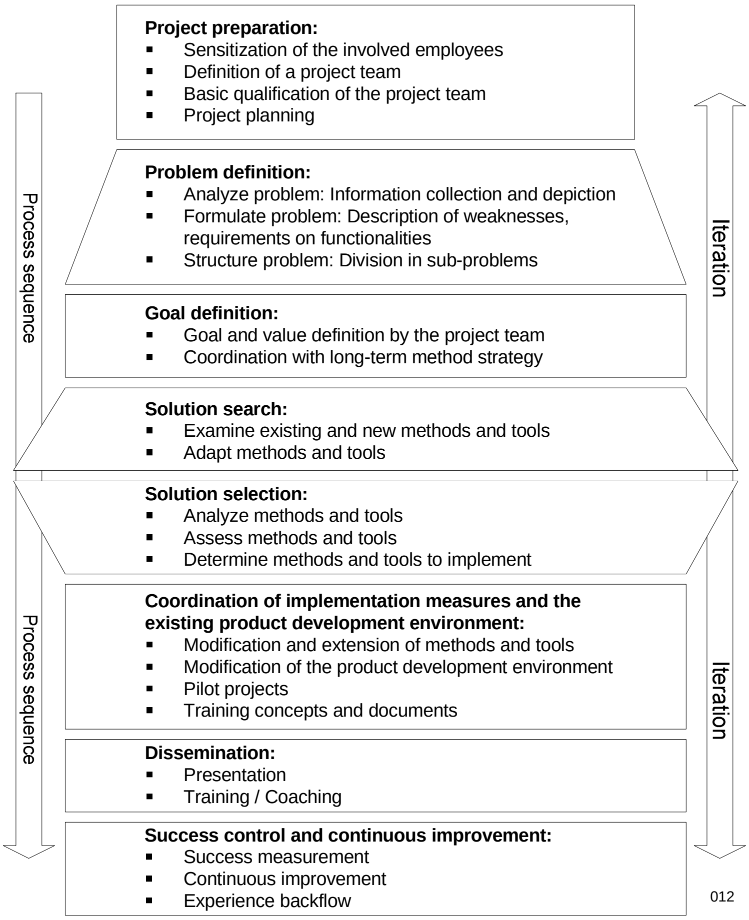

Figure 20: The operative sub-model of the method implementation (adopted from Viertlböck 2000, p. 114).

The operative sub-model provides a structured procedure for the implementation project planning (see Figure 20). Furthermore, it contains methods and tools to support the conduction of the planned activities. A necessary prerequisite for initiating the operative planning is the information about the weaknesses of the current environment from the strategic planning. The objective of this sub-model is to support the medium- to long-range planning of the method introduction projects, based on identified weaknesses and opportunities in terms of methods and tools for the compensation of the weaknesses, coming from the strategic sub-model (Viertlböck 2000, p. 114).

The resource sub-model aims at supporting the implementation projects, which generally cannot be realized alone by employees from the company line structure. Viertlböck (2000, p. 147) emphasizes in this respect employee capacities and provision of tools as the two most important resources that have to be provided to an implementation project.

Viertlböck (2000, p. 149) claims that through the application of the two sub-models for the support of the strategic planning of the method implementation and the supporting resources for the method implementation an implementation-friendly atmosphere can be created in the company This allows to define implementation processes on the basis of the third sub-model, which supports the operative planning of the method implementation, more adequately and successfully.

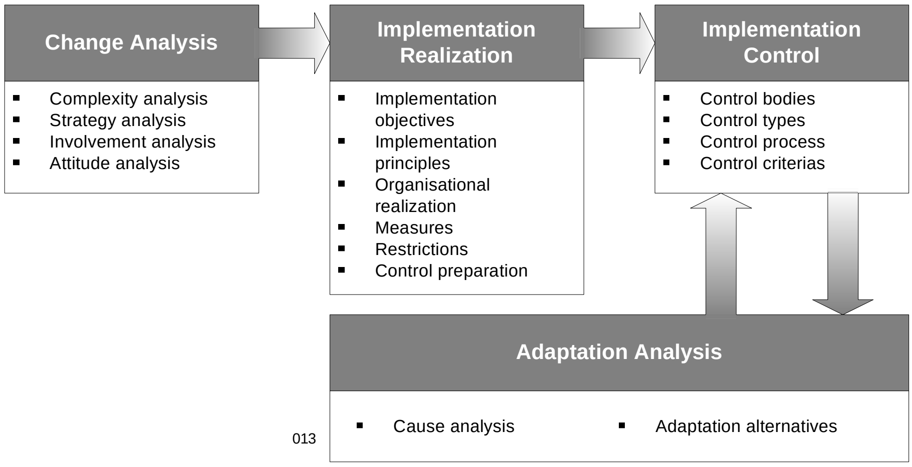

Figure 21: The implementation process according to Tarlatt (adopted from Tarlatt 2001, p. 95).

Tarlatt (2001, p. 95) suggests an implementation process containing three basic phases (see Figure 21). In the first phase, "change analysis", the implementation problem is defined and relevant information is collected. During the "implementation realization" the planning and the actual realization of the implementation is conducted. This is followed by "implementation control", which surveys the success of the implementation project. However, these basics steps are not sufficient for a successful implementation. Insights may be gained from control activities that make it necessary to adapt the chosen implementation strategy. This is adequately mirrored with introducing the step "adaptation analysis". Tarlatt (2001, p. 94) emphasizes that the activities within the steps of the method implementation are not only of administrative nature, as often claimed in literature (see Figure 21). He sees it as very important to include also analysis, in order to ensure the appropriateness of the chosen measures. In his mind, the focus on administrative activities in this respect may be a reason for the high rate of failed implementation projects. In contrast to Usher (1996) and Stetter (2001, p. 34), Tarlatt (2001, p. 95) suggests a directed procedure in the implementation, starting from the change analysis, which provides operational intermediate goals as output. After that, the implementation realization follows, which contains the actual introduction of the implementation object. In this phase, e.g., the implementation principles are defined and the implementation measures are selected. The next phase, the control phase, tries to assess the success of the implementation project. From this assessment, a need for adapting the planning may result, which is further examined during the adaptation analysis. The adaptation analysis then provides the updated plans to the implementation control, which thus can assess the success of the adapted plans.

The models presented above may differ in the terms used, in the proposed partitioning in phases, and in the suggested, low-level activities, but also strong similarities can be seen in the basic steps that have to be conducted. However, most of these phase schemes do only provide a high-level view on the implementation procedure. Although they still provide a valuable orientation guide and create transparency, they still do this only on a rather high-level. Thus, the author of this dissertation doubts the practical benefit of these phase schemes. Furthermore, these models generally neither describe the products that should be produced by the individual activities, nor the inputs that are used by the activities to create those outputs. To sum it up, they do not provide a detailed implementation process model. Process models are already widely used in industry, and more and more also in the area of the product development process, in order to create transparency and consent among the involved people (Fricke et al. 1998). Therefore, a generalized process model is developed in the following chapter, which draws from the phase schemes presented above, literature, and from insights gained in the SysTest project.

Summary

This chapter presented **phase schemes and procedures** of the implementation process from literature, in order to give the reader a better understanding of the relation between introduction and implementation. However, the described phase schemes and procedures provide a **high-level view** on the implementation procedure. Therefore, the author of this dissertation doubts their value as **orientation guide** and for **creating transparency**. A detailed implementation process model will be useful.

2.2 The Implementation Process Model

The phase schemes presented in the previous chapter only provide a **high-level view** on the implementation procedure. Therefore, their value as **orientation guide** and for **creating transparency** can be questioned. Moreover, the presented models do not provide information about the **products** that should be produced in the process by the individual activities, nor do they mention the **inputs** that are used by the activities to create those outputs.

Therefore, in this chapter the **Implementation Process Model** is defined, which describes the activities that should be conducted, the products that should be produced by the individual activities in the process (outputs), and the inputs that are used by these activities to produce those outputs.

Since a process model is defined as a model that describes the decomposition of the overall process into activities and the flow of inputs and outputs for those functions (Buede 2000, p. 438), the phase schemes presented above simply do not provide a detailed implementation process model. Process models are already widely used in industry, and more and more also in the area of the product development processes, in order to create transparency and consent among the involved people. But these advantages are only two among several others, for example (Fricke et al. 1998):

§ **Transparency**

  A process model provides transparency to people, giving them an overview, helping them to understand what their role is, and to see who is doing what and when. This is more important in the case of processes that change very often (e.g., due to reengineering efforts).

§ **Understanding and Learning**

  A transparent process model supports and communicates understanding of complex processes and their interactions and dependencies within the organization. It provides also an excellent learning aid for employees that are new or have changed jobs.

§ **Coordination**

  In the course of the development many process interfaces (flows of information, material, money, etc.) have to be coordinated in content and time. A consistent process model promotes better communication (people talk about the same things) and allows early planning of future interactions.

§ **Better planning and management**

  By enabling transparency and early coordination a modeled process represents a sound basis for detailed planning and easier management of the actual development project.

§ **Documentation and Reusability**

  Process models are a kind of documentation that (or parts of it) can be easily reused as a starting point or "building blocks" in subsequent development projects.

§ **Prerequisites for Audits**

In order to achieve certification (e.g., compliant with the ISO 9000 Series of Standards, esp. ISO 9001) a documented process and evidence that the process is performed as documented are required. A process model that is used (or "lived") by all people involved in the development activity can provide both.

§ **What-if Analyses**

A process model can be used to conduct what-if analyses to determine the effects of process changes. Moreover, process simulation capabilities can be built upon the model.

§ **Basis for Process Assessment and Improvement**

Only if you know what you are doing (which can be described in a process model), you can assess how good you are doing it and use it as a basis for improvement.

§ **Shorter Development Cycles**

One main reason for process modeling is the achievement of shorter development times. Process models are the starting point for process reengineering and optimization activities.

*Therefore, a generalized process model is presented in this chapter. This process model was developed based on the **phase schemes** from the previous chapter, on other **literature** (see, e.g., Greif et al. 2004, p. 141 and 144; Kraus et al. 2004, p. 19; Müller-Stewens and Lechner 2001; Mourier and Smith 2001, p. 30; Rich and Mifflin 1994, p. 114; Davidow 1994, p. 133; Paton and McCalman 2000, p. 80 ff.), and on insights from the **SysTest** project.* Figure 22 *shows the procedure for determining the Implementation Process Model.*

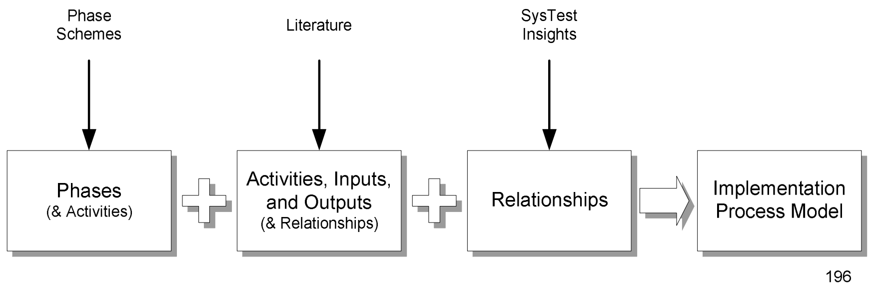

Figure 22: Procedure for determining the Implementation Process Model.

Figure 23 shows from which literature source the activities of the Implementation Process Model were derived. The main contribution of this dissertation with respect to the Implementation Process Model is the combination of the different approaches in literature, so that a full set of implementation activities is derived. Additionally, the relationships between these activities are defined on a very granular level. Thus, a comprehensive process model for the implementation is defined.

Activity ID	Zeyer 1996	Lewin 1947	Beskow et al. 1999	Usher 1996	Driva and Pawar 1997	Dobberkau and Rauch-Geelhaar 1999	Stetter 2000	Viertlböck 2000	Tarlatt 2001
A.1	x	x	x	x	x				x
A.2	x			x	x	x	x	x	
A.3	x	x				x	x	x	
A.4	x	x				x	x	x	
A.5					x	x		x	
A.6		x				x	x		
A.7	x				x				
A.8	x				x				
A.9.		x				x			
A.10	x				x				
A.11	x			x	x	x		x	
A.12			x	x	x	x			
A.13	x				x				
A.14	x			x	x	x			
A.15	x			x	x	x			
A.16	x			x	x	x		x	
A.17	x				x				
A.18	x				x	x			
A.19	x								
A.20	x							x	
A.21				x	x				x
A.22	x					x			
A.23	x								
A.24	x		x						
A.25	x				x				
A.26	x	x		x	x				
A.27	x					x			
A.28	x	x	x		x				
B.1	x	x	x		x				
B.2	x	x		x	x				
B.3	x	x		x			x		x
C.1	x	x				x			
C.2					x		x		x
C.3					x				x
C.4	x			x				x	
C.5					x				x
C.6	x								

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Figure 23: Literature sources of the Implementation Process Model activities.

The implementation process is divided into three sub-phases: Planning, execution, and control. The main objective of the planning phase is to prepare the introduction of a new strategy, method, or process. In the execution phase, the activities to actually introduce the implementation concept in the company are conducted. Finally, in the control phase the concept introduction is monitored and, if necessary adapted, and future implementation projects are prepared. Figure 24 shows the phases schematically.

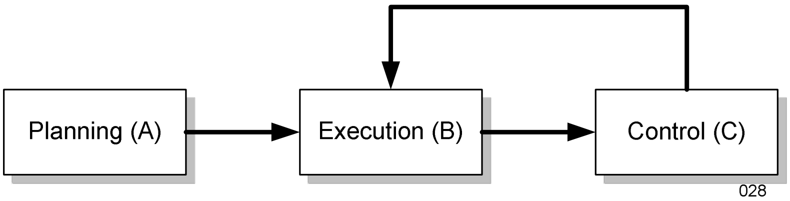

Figure 24: Schematic representation of the implementation process.

For an easier differentiation, the phases are denoted with the characters A (planning), B (execution), and C (control). Please note that the arrows in the figure above realistically depict the information flow between the phases. The planning phase does only provide the execution phase with information, whereas the execution phase does not only provide to, but gets also information from the control phase. All necessary adaptations of the planning are included in phase C. The remaining chapters 3 and 4 of this dissertation discuss the context- and personnel-related activities, which are part of phase B.

Figure 25 shows the Implementation Process Model in a graphical format. In this Figure, only direct relations between activities are depicted. Transitive relations (see, e.g., Igenbergs 2001, p. 31) are omitted, i.e. in the case that activity A has a direct relation with activity C and an indirect relation with activity C via activity B, the direct relation is not shown.

Figure 26, page 45, describes the developed implementation process model in table format. Each row contains one activity of the process. To designate each activity uniquely, an activity ID is assigned to the activity in the first column. The first part of the ID is a character designating the phase, then the activities are numbered consecutively within a phase. The input column (second column) lists all the inputs that are used by the activity. In the third and fourth column a title and description characterize the activity content. Finally, in the fifth column the outputs that the activity produces are enumerated. For easier readability, the inputs that come from other activities within the Implementation Process Model are referenced with an identifier. The identifier structure is: O<Activity ID><Output Number>. For example, if the input is the second (2) output of activity A.3, the identifier is OA.3.1.

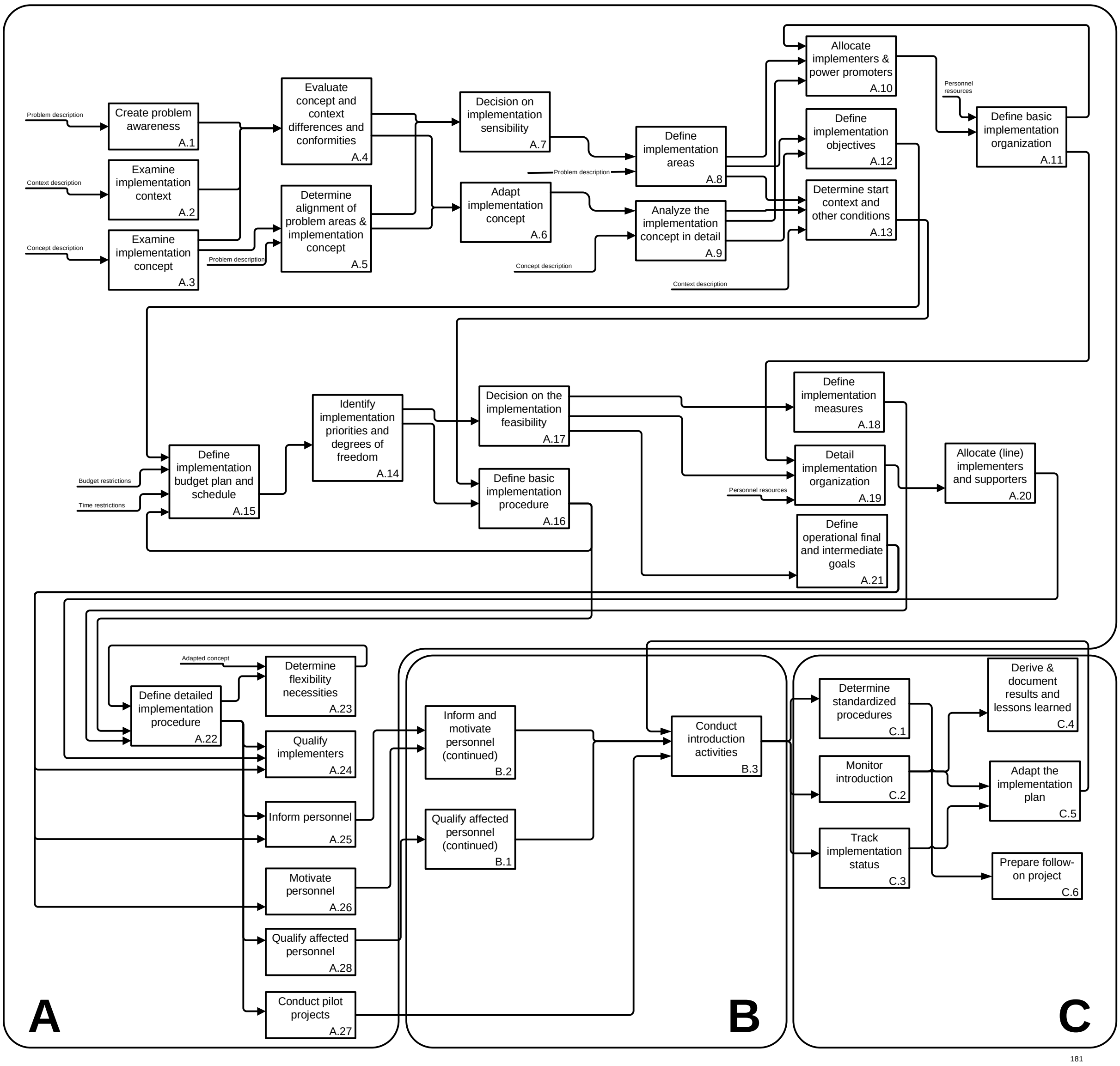

Figure 25: Graphical representation of the Implementation Process Model.

ID	Input	Activity		Output
		Title	Description	
A.1	1. Problem description	Create problem awareness	Create problem awareness among the personnel. This may be necessary if the problems in the company are not apparent or if it is a proactive change. Moreover, examine and describe the problem for the purposes of the implementation.	1. Information material / problem description
A.2	1. Context description	Examine implementation context	Examine all relevant aspects of the context, e.g. existing process activities, personnel capabilities, etc.	1. Context characteristics
A.3	1. Concept description	Examine implementation concept	Examine the proposed concept, e.g. required process activities, personnel capabilities, etc.	1. Concept characteristics
A.4	1. OA.2.1 2. OA.3.1 3. OA.1.1	Evaluate concept and context differences and conformities	Evaluate the differences and conformities between concept and context characteristics.	1. Differences and conformities between concept and context
A.5	1. Problem description 2. OA.3.1	Determine alignment of problem areas and implementation concept	Determine the alignment of the identified problems areas in the company and the chosen implementation concept	1. Problem and concept alignment
A.6	1. OA.5.1 2. OA.4.1	Adapt implementation concept	Adapt the implementation concept according to the necessities of the implementation context and the problem and concept alignment	1. Degree of problem and concept conformity 2. Updated concept structure
A.7	1. OA.4.1 2. OA.5.1	Decision on implementation sensibility	Decide if the implementation of the concept makes sense with respect to the identified problems and the given context of the company	1. Go/no go decision on sensibility
A.8	1. OA.2.1 2. OA.3.1 3. Problem description 4. OA.7.1 5. OA.4.1	Define implementation areas	Define business areas, processes, etc. of the company where the implementation should focus on.	1. Implementation areas
A.9.	1. Concept description 2. OA.3.1 3. OA.6.2	Analyze the implementation concept in detail	Detailed analysis of the content of the implementation concept, which has to lead to an understanding of the functional relationships within the implementation concept.	1. Functional relationships in the concept
A.10	1. OA.9.1 2. OA.8.1 3. OA.11.1	Allocate (project) implementers and power promoters	Define and allocate implementers (at this stage mainly project implementers) and power promoters for the implementation (implementers for doing the operative work and power promoters to support the implementation) Implementers: Personnel doing operative, but also strategic implementation work (e.g. project manager, coordinators, etc.); Project implementers are persons that are concerned only with implementation activities (e.g. coordinators, concept developers, project managers) Promoters: Personnel that is able to support the implementation due to their power, professional competence, or concept knowledge Power promoters: Upper management of implementation initiatives that are able to support the implementation due to their power in the company	1. Resource plan 2. Role allocation
A.11	1. OA.9.1 2. OA.10.1 3. OA.10.2 4. Personnel resources	Define basic implementation organization	Define a basic organizational structure for the implementation project, i.e. project leader(s), type of project organization, etc.	1. Basic implementation organization
A.12	1. OA.9.1 2. OA.8.1	Define implementation objectives	Define the implementation objectives, i.e. concept elements to be introduced, targeted improvements, schedule objectives, etc.	1. Implementation objectives
A.13	1. Context description 2. OA.9.1 3. OA.8.1	Determine start context and other conditions	Determine the start context and other conditions that are relevant for the implementation.	1. Feasibility aspects 2. Implementation conditions

A.14	1. OA.12.1 2. OA.15.1 3. OA.15.2	Identify implementation priorities and degrees of freedom	The implementation priorities define the relative importance of the objectives; the implementation degrees of freedom define where the implementation procedure is flexible, i.e. where alternative ways of performing the implementation are possible	1. Implementation priorities 2. Degrees of freedom for the implementation
A.15	1. Budget restrictions 2. Time restrictions 3. OA.16.1 4. OA.12.1	Define implementation budget plan and schedule	Determine the budget and time that is available for the implementation and develop, based on these constraints, a budget plan and schedule	1. Budget plan 2. Schedule
A.16	1. OA.13.1 2. OA.13.2 3. OA.15.1 4. OA.15.2 5. OA.14.1 6. OA.14.2	Define basic implementation procedure	Define the basic steps of the implementation	1. Basic implementation procedure
A.17	1. OA.13.1 2. OA.15.1 3. OA.15.2 4. OA.12.1 5. OA.14.1 6. OA.14.2	Decision on the implementation feasibility	Decide if the implementation makes sense with respect to the feasibility.	1. Go/no go decision on feasibility
A.18	1. OA.9.1 2. OA.17.1	Define implementation measures	On the basis of the functional relationships in the concept, the necessary implementation measures have to be defined.	1. Necessary implementation measures
A.19	1. OA.11.1 2. Personnel resources 3. OA.17.1	Detail the implementation organization	Detail the structure of the organization for the implementation, i.e. define teams, panels, trainers, etc.	1. Detailed implementation organization
A.20	1. OA.19.1 2. OA.10.1 3. OA.10.2	Allocate (line) implementers and supporters	Define and allocate implementers (at this stage already line implementers) and supporters. Since the power promoters were already defined before, the focus here lies on defining and allocating personnel that can support the implementation due to their professional or concept competence (see also 1.5) Line implementers: Line managers from implementation areas. Since they are usually more affected by the implementation than the project implementers, they are considered separately. Supporters: Personnel that is able to support the implementation due to their professional competence or concept knowledge. The supporters are a sub-group of the promoters. Promoters: Personnel that is able to support the implementation with respect to their power, professional competence, or concept knowledge.	1. Updated resource plan 2. Updated role allocation
A.21	1. OA.12.1 2. OA.17.1	Define operational final goals and intermediate goals	Define operational final goals and intermediate goals for the implementation.	1. Final goals 2. Intermediate goals
A.22	1. OA.16.1 2. OA.23.1 3. OA.18.1	Define detailed implementation procedure	Define the detailed implementation procedure, considering also feasibility aspects.	1. Detailed implementation procedure
A.23	1. OA.22.1 2. Adapted concept	Determine flexibility necessities	Define the necessary flexibilities in the implementation concept and the procedure.	1. Flexibility necessities
A.24	1. OA.22.1 2. OA.21.1 3. OA.18.1	Qualify implementers	Qualify the implementers.	1. Qualification measures

	4. OA.20.1 5. OA.20.2			
A.25	1. OA.22.1 2. OA.21.1 3. OA.18.1	Inform personnel	Inform the affected personnel.	1. Information material
A.26	1. OA.21.1 2. OA.18.1	Motivate personnel	Motivate the affected personnel.	2. Motivation measures
A.27	1. OA.22.1	Conduct pilot projects (optional)	Conduct pilot projects, if this is planned in the implementation procedure	1. Pilot project results 2. Pilot project lessons learned
A.28	2. OA.22.1 3. OA.21.1 4. OA.18.1	Qualify affected personnel	Qualify the affected personnel, i.e. the workers that have to adjust to the new working conditions.	1. Qualification measures
B.1	(1. OA.8.1 2. OA.16.1 3. OA.21.1 4. OA.18.1) 1. OA.28.1	Qualify affected personnel (continued)	Intensify the qualification activities for the affected personnel, i.e. the workers that have to adjust to the new working conditions. Moreover, assess the success of the previous qualification measures and determine where qualification has to be repeated or newly applied.	1. Intensive qualification measures
B.2	1. OA.25.1 2. OA.26.1	Inform and motivate personnel (continued)	Define areas where additional information and motivation measures are necessary. Inform and motivate personnel where necessary.	1. Updated information and motivation measures
B.3	1. OA.22.1 2. OA.27.1 3. OA.27.2 4. OC.5.2 5. OB.1.1 6. OB.2.1	Conduct introduction activities	Conduct activities that actually introduce the implementation concept in the company context	1. Actual working procedures 2. Actual introduction results
C.1	1. OB.3.1	Determine standardized procedures	Stabilize achievements in the introduction of the new concept by standardizing the working procedures or using other measures.	1. Standardized procedures 2. Other stabilization measures
C.2	1. OB.3.2 2. OA.22.1	Monitor the introduction	Monitor the status of the concept introduction and detect deviations from the plans. These deviations have to be documented in the monitoring results. Monitoring considers the budget, schedule, and process, but not the overall objectives of the implementation.	1. Monitoring results
C.3	1. OB.3.2 2. OA.21.1 3. OA.21.2	Track the implementation status	Continuously track the status of the implementation in order to detect a decline in the implementation success on time. Tracking considers the fulfillment of the implementation objectives, but not the fulfillment of the budget, schedule, and process goals.	1. Implementation status report
C.4	1. OC.2.1 3. OB.3.2	Derive and document results and lessons learned	Derive results and lessons learned from the implementation projects and document these.	1. Lessons learned 2. Implementation results
C.5	1. OC.2.1 2. OC.3.1	Adapt the implementation plan	If necessary, adapt the implementation procedure and goals based on the previously detected deviations. This should not adapt the plans to the deviations, but should ensure that the implementation gets back on track and will finally meet the objectives.	2. Updated implementation procedure
C.6	1. OC.1.1 2. OC.1.2	Prepare follow-on projects	Prepare follow-on projects that spread the achievements in new implementation areas or intend to stabilize the achievements in the current implementation area.	1. Plans for follow-on projects

Figure 26: Inputs, activities, and outputs of the implementation process

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Summary

Phase schemes only provide a **high-level view** on the implementation procedure. Therefore, their value as **orientation guide** and for **creating transparency** can be questioned. Thus, in this chapter a **process model of the implementation** was developed, which describes the activities that should be conducted, the products that should be produced by the individual activities in the process (outputs), and the inputs that are used by these activities to produce those outputs. Process models are already widely used in industry. Their advantages are, among others, that they create **transparency**, support **understanding and learning**, and improve the **communication** between the persons in charge. The implementation process can be divided in the three phases **planning, execution, and control**.

2.3 Tailoring of the Implementation Process Model

The implementation process model defined in the previous chapter can only be a generic process model. That is, for a successful application it has to be adapted to the specific needs of the company and project. To that end, an **approach for tailoring** the defined implementation process model is presented in this chapter.

In the process model of the implementation, several groups of activities can be differentiated. The activity groups support the main “functions” of the implementation process and thus can be considered as basic steps of the implementation process. Figure 27 shows these process functions and the assigned activities.

Nr.	Process Function	Assigned Activities
1	Context examination and preparation	A.1, A.2, A.7, A.8, A.13
2	Concept adaptation	A.3, A.4, A.5, A.6, A.9
3	Implementation organization and supportive framework definition	A.10, A.11, A.19, A.20
4	Implementation project definition (goals, procedure, budget, etc.)	A.12, A.14, A.15, A.16, A.17, A.18, A.21, A.22, A.23, A.27
5	Qualification, information, motivation, introduction	A.24, A.25, A.26, A.28, B.1, B.2, B.3
6	Control, feedback, and follow-on preparation	C.1, C.2, C.3, C.4, C.5, C.6

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Figure 27: Implementation process functions and assigned activities.

A first group of activities examines and prepares the context for the concept introduction. The concept adaptation is a second group of activities, where the concept to be implemented is tailored to the needs of the company and project. An implementation organization and a supportive organizational framework is a prerequisite for a successful implementation. The activities supporting this process function are combined in group number three. For the implementation also general project management tasks have to be conducted, e.g. the definition of goals, procedure, budget, etc., which are in group four. Group five contains all activities related to the qualification, information, and motivation of the personnel, as well as introduction activities. Finally, the activities dedicated to the control of the implementation project, providing feedback, or preparing the follow-on projects are combined in group six.

The intention of the Implementation Process Model is to provide a comprehensive view on the activities, inputs, and outputs necessary for the implementation of a new concept in a company. However, the process model certainly cannot be considered as complete; activities may have to be added in special cases. On the other hand, in many implementation projects not the full set of activities, as described in the previous chapter, is necessary. Depending on the general project characteristics, emphasis has to be put on some parts of the implementation process, whereas other parts may be less important or even obsolete. A tailoring approach with a similar structure as that applied in the SysTest project was defined (SysTest Consortium 2005, p. 20).

Tailoring should be performed on two different levels:

(1) Tailoring for each organization – this tailoring is usually performed once for the enterprise, with occasional updates. In addition it can be performed on an organizational level for different business units thus establishing a tailored implementation process for each business unit. In the event of major business organizational changes there might be a need to perform the tailoring again.

(2) Tailoring for specific projects – This tailoring is usually performed at the beginning of each implementation project as part of the project planning. For project tailoring purposes, three groups of tailoring parameters have been defined and an initial set of tailoring heuristics are defined for each parameter.

Before starting the implementation project, first its characteristics should be identified. There are three main groups of characteristics that influence the implementation process.

1. The first group identifies five major project parameters – These parameters are major discriminators between diverse implementation projects and can be used for both organizational and project tailoring.
2. The second group includes three typical programmatic risks that significantly affect the tailoring and planning of implementation projects.
3. The third group includes three concept characteristics affecting the adaptation of the implementation process.

In the following chapter, the characteristics combined in each group are described, including their typical values.

2.3.1 Tailoring Parameters

In this chapter, the **project** and **concept characteristics** as well as the **programmatic risks** influencing the tailoring of the implementation process are described more closely.

Project Characteristics

The following Figure 28 identifies major discriminating characteristics of the implementation task and describes their typical values.

Planning Approach	Incremental
	Synoptic
Implementation Strategy	Evolutionary
	Revolutionary
Transition Strategy	Coupled transition
	Parallel transition
	Context supplement
Concept Scope	Small - few elements and relations
	Large - many elements and relations
Context Scope	Small - few projects / departments
	Large - many projects / departments

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Figure 28: Discriminating parameters of the implementation task and typical values.

With respect to the planning approach, an incremental and a synoptic approach can be differentiated (see, e.g. Schmidt 1997, p. 57; Krüger 1994, p. 211). The incremental approach defines several stages of the implementation and takes into account trial and error processes. The synoptic approach, on the other hand, develops a holistic implementation plan and tries to conclude the implementation in one “stage” (see, e.g., Romanelli and Tushman 1994, p. 1143; Kreikebaum 1989, p. 119; Reiß 1992, p. 60).

The incremental approach allows an easier adaptation of the implementation to boundary conditions that either were not considered in advance or occur only during the implementation. After each stage the status can be evaluated and the further implementation procedure can be adapted accordingly. The advantage of the synoptic approach is that the concept to be implemented does not have to be divided into individual modules, which guarantees an integral concept.

Basically, an evolutionary or revolutionary implementation strategy can be chosen. The implementation strategy and planning approach are closely coupled; often the implementation strategy is considered as paramount to the planning approach (Zeyer 1996, p. 143; Krüger 1994, p.204). Zeyer (1996, p. 143) defines the revolutionary degree as quotient of what he calls “implementation quality” and time required for the overall initiative. Note that here the implementation quality with respect to the implementation activities (and not with respect to the effects) is meant (Zeyer 1996, p. 145), which comprises the degree of concept dissemination in the enterprise, the extent to which the concept parts are introduced, and the operability of the introduced concept elements (Zeyer 1996, p. 137). That is, the shorter the timeframe is in which to introduce a given set of concept elements, or the more concept elements to be introduced in a given timeframe, the more the implementation is on the revolutionary side of the spectrum.

Krüger (1994, p. 204) summarizes the differences of an evolutionary and revolutionary change along several categories, as depicted in Figure 29.

	Revolutionary Change	Evolutionary Change
Basic Idea	Considerable pressure is necessary to overcome barriers to change	An enterprise cannot cope with too much change at once
	Deep and comprehensive change	Change in small steps
	Restricted timeframe	Ongoing learning process
Character	Discontinuous process	Continuous process
Logic	Synoptic approach	Incremental approach
	Clear separation of phases with and without change	Change frequency corresponds to the change capability in the company
Chances	Integral approach	
	Restricted planning possibility	Constant disturbance
Risks	High instability during the change	Restricted dapability for ongoing change

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Figure 29: Differences between revolutionary and evolutionary change (adopted from Krüger 1994, p. 204)

Greif et al. (2004, p. 29) describe revolutionary as episodic and evolutionary as continuous changes. According to Weick and Quinn (1999; cited in Greif et al. 2004, p. 29) episodic changes follow the three phases (unfreeze, change, refreeze) defined by Lewin, whereas for continuous changes a different model[12] has to be applied. However, the author sees Lewin’s three phases also applicable for continuous / evolutionary changes, yet on a smaller scale. On the smallest level, also evolutionary changes show a discontinuous behavior. When it comes to changing an individual activity or relation, again the phases unfreeze, change, and refreeze can be applied.

Generally, three different strategies are possible for the transition between current context elements and new concept elements, illustrated in Figure 30[13].

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[12] Weick and Quinn (1999) developed a concept for self-organizing, continuous changes, which they see as more appropriate for describing continuous / evolutionary changes.

[13] Daniel (2001, p. 165 ff.) mentions four different transition strategies. One of them is the decoupled transition, where a time lag is between the removal of the current context elements and the introduction of the new concept. The advantage of this approach is that it supports de-learning processes. However, its applicability in real-life projects can be doubted. Therefore, it is not considered here.

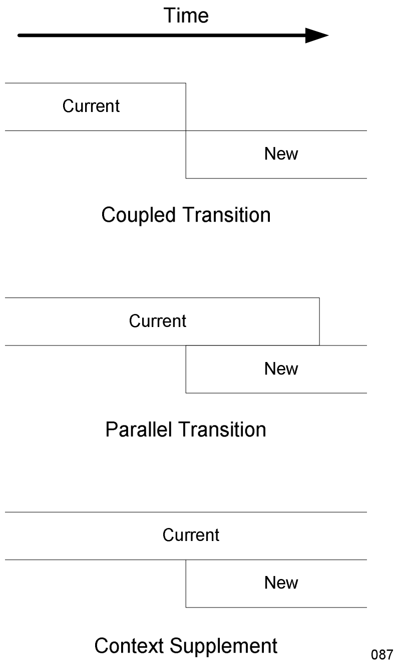

Figure 30: Different strategies for the transition between current and new elements.

At the coupled transition all obsolete current context elements are removed before the new concept elements are introduced. But no time lag is between the removal and the introduction, so that the old and new context is closely coupled. For the parallel transition the obsolete context elements are kept in parallel to the introduced concept elements to ensure a smooth transition. Finally, the new concept can be a supplement and no context elements have to be removed. Certainly, in practice these transition strategies often are combined (different strategies are applied for individual concept elements) and no such clear differentiation can be made, although a certain approach will usually be prevailing.

The concept scope may vary between few elements with a low number of relations and many elements with many relations. Accordingly, the context can consist of few elements and relations or many elements and relations (context scope).

Programmatic Risks

An implementation initiative can exhibit three different programmatic risks, which are schedule risk, budget risk, and quality risk. Figure 31 explains these programmatic risks.

Schedule Risk	The allocated time is too short to implement all relevant elements with required maturity and quality
Budget Risk	The allocated budget is too small to implement all relevant elements with required maturity and quality
Quality Risk	There is a lack of support from the management or the affected people. This may negatively influence the implementation quality

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Figure 31: Programmatic risks of an implementation initiative

Schedule may be too short or budget may be too small to reach the defined maturity and quality goals. Apart from these “hard facts”, problems may come also from a lack of support from management or from the affected personnel. Knippel and Schulz (2004, p. 13) confirm that there is the need of commitment on the management and the operational level. However, different company cultures may shift the focus. In a formal culture formal documentation and management commitment are the key success factors, whereas in an informal culture informal documentation and user acceptance are the key success factors (Knippel and Schulz 2004, p. 12).

Concept Characteristics

Three basic characteristics of the concept to be implemented can be differentiated, which determine the recommended approach for the implementation. These three characteristics are summarized and explained in Figure 32.

Critical	The implementation of the new concept is critical for the achievement of business / process objectives or even for the business success
Complex	The concept to be introduced has many elements and relations. Moreover, much information has to be processed, the processing description is depending on many boundary conditions, and there is a high variability of the input information
Innovative	The concept to be introduced is a very new approach and was previously not or only partly tested

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Figure 32: Concept characteristics that influence the implementation process.

A new concept may be essential for the achievement of the business or process objectives. Depending on the importance of these objectives, the concept to be implemented even may influence the business success. Complexity is another characteristic of the implementation concept. As already mentioned, an object can be complicated due to its number of elements and relations (e.g., number of activities and relations, amount of information to be processed, dependence of processing description on boundary conditions, etc.), which is a prerequisite but not sufficient for complexity. Complexity always has the aspect of variability in the course of time, e.g. the variability of the input information. A new concept may be innovative, which means that it was previously not or only partly tested. This gives rise to the risk of concept failure, which has to be taken into account when planning the implementation project.

In the following chapter, tailoring heuristics for each of the three groups of tailoring parameters are provided.

2.3.2 Tailoring Heuristics

In this chapter, **heuristics for the tailoring** of the implementation process are described. The tailoring heuristics provide guidance **how to adapt the implementation process**, dependent on variations in the tailoring parameters, which were presented in the previous chapter. The tailoring uses the basic steps (**process functions**) of the implementation process, defined in chapter 2.2, as variables in the process structure. That is, variations in the tailoring parameters influence to which extent the basic steps of the implementation process have to be executed.

Project Characteristics

The planning approach for an implementation can vary between incremental and synoptic planning. In case of an incremental planning, less effort can be put on the context examination and preparation and the concept adaptation. Knippel and Schulz (2004, p. 12) emphasize that in a complex business environment it is in general not possible to provide new structures first time right. Planning has to incorporate a stepwise evolution of the new structures, by constantly adapting the reference structures based on application experiences. The incremental approach takes into account trial-and-error processes, that is feedback is very important here. It is planned for corrective actions during the implementation. Therefore, the context preparation and concept adaptation can be less detailed. On the other hand, effort has to be put into planning the increments, but since there is the possibility of corrective actions, the project definition may be less detailed. As mentioned above, feedback and the preparation of follow-on projects is very important, which means that phase three of the implementation process has to be executed carefully.

The synoptic approach, on the other hand, requires a careful planning and execution in all aspects of the implementation project. Here the focus is on a planning that exactly defines the implementation in advance with less emphasis on feedback, i.e. a holistic implementation plan. Therefore, the context and concept should be well known and prepared. Additionally, project management issues need to be considered more intensely, since the time horizon of the planning is longer. With respect to the last group of activities in the implementation process, control activities are very important, to ensure that the implementation is on track. However, both approaches, incremental and synoptic, do not essentially influence the definition of the implementation organization and the extent of qualification, motivation, information, and introduction activities. Figure 33 summarizes the tailoring heuristics for the incremental and synoptic planning approach.

Nr.	Process Function	Planning Approach	
		Incremental	Synoptic
1	Context examination and preparation	È	Ç
2	Concept adaptation	È	Ç
3	Implementation organization and supportive framework definition	–	–
4	Implementation project definition (goals, procedure, budget, etc.)	È	Ç
5	Qualification, information, motivation, introduction	–	–
6	Control, feedback, and follow-on preparation	Ç	Ç

Ç = Higher emphasis 176

– = Not influenced or mainly influenced by other characteristics

È = Lower emphasis

Figure 33: Tailoring heuristics for different planning approaches.

Since the implementation strategy is related to the planning approach, the tailoring heuristics are similar. For the evolutionary implementation, also the context and concept preparation is less important, whereas for a revolutionary implementation the concept and context has to be fully understood and sufficiently prepared. The evolutionary strategy does need an extensive implementation organization, but it has to be institutionalized to ensure continued change. Due to the restricted change scope, motivation is a less important issue. On the other hand, information and qualification are crucial to a continuous improvement. Finally, an assessment of the implementation project is needed to determine future directions.

The revolutionary implementation, on the other hand, needs a formal implementation organization and supportive framework due to the scope of the planned changes. The implementation organization and supportive framework are necessary to achieve and stabilize the changes in the company. Strong motivation may be needed to avoid resistance, but project control and stabilization of the achieved status are also important issues. However, the choice of the implementation strategy does not directly influence the project definition.

Nr.	Process Function	Implementation Strategy	
		Evolutionary	Revolutionary
1	Context examination and preparation	È	Ç
2	Concept adaptation	È	Ç
3	Implementation organization and supportive framework definition	È	Ç
4	Implementation project definition (goals, procedure, budget, etc.)	–	–
5	Qualification, information, motivation, introduction	Ç	Ç
6	Control, feedback, and follow-on preparation	Ç	Ç

Ç = Higher emphasis [177]
– = Not influenced or mainly influenced by other characteristics
È = Lower emphasis

Figure 34: Tailoring heuristics for different implementation strategies.

Mainly three strategies for the transition between the initial and the final implementation state can be differentiated. The coupled transition does not require an intensive context examination and preparation. Since the existing, relevant parts of the context are substituted by the new concept, context and concept do not have to function jointly. This means for the concept that it does not need to be modularized, thus the concept adaptation is also less lavishly. However, the abrupt transition from existing to new structures requires intensive support by an implementation organization and an intensive information, qualification, and motivation. Moreover, the implementation has to be controlled precisely to avoid falling back into old structures, i.e. a stabilization of the new concept. The implementation project definition is not necessarily influenced by the coupled transition.

The parallel transition, on the other hand, requires a detailed examination and preparation of both the context and concept to ensure a smooth transition. For this transition strategy, the emphasis may be less on the control of the implementation, but more on the definition of the implementation project. For example, the introduction procedure has to be carefully defined in order to guarantee the success of the parallel transition. Qualification, information, and motivation have to be executed less extensively, since this stepwise approach causes in general less resistance (see, e.g., Hedberg et al. 1976, p. 60; Imai 1994, p. 112-126; Krüger 1994). The formality of the implementation organization is not influenced by these project characteristics.

Finally, the context supplement requires less effort in almost all areas, because no existing elements have to be removed. Thus, the problems (e.g. resistance) and tasks (e.g. context preparation) associated with the substitution of context elements are not relevant in this case. However, this transition strategy does not decisively influence the type of implementation organization and the elaborateness of the project definition. Figure 35 summarizes the tailoring heuristics for the various transition strategies.

Nr.	Process Function	Transition Strategy		
		Coupled	Parallel	Context Suppl.
1	Context examination and preparation	È	Ç	È
2	Concept adaptation	È	Ç	È
3	Implementation organization and supportive framework definition	Ç	–	–
4	Implementation project definition (goals, procedure, budget, etc.)	–	Ç	–
5	Qualification, information, motivation, introduction	Ç	È	È
6	Control, feedback, and follow-on preparation	Ç	È	È

Ç = Higher emphasis [178]
– = Not influenced or mainly influenced by other characteristics
È = Lower emphasis

Figure 35: Tailoring heuristics for different transition strategies.

In general, the effort in the implementation is proportional to the scope of the concept to be introduced. For a small concept scope the risk of negative effects concerning the introduction (e.g. resistance, incongruities between context and concept, etc.) is lower. Therefore, the context examination and preparation can be less detailed. Moreover, due to the reduced complexity also less emphasis can be put on the control and feedback tasks, and on the implementation project definition. For smaller concepts, a lower number of intermediate goals are sufficient. Since not so much resistance has to be expected, the information and motivation tasks can also be reduced. Finally, the importance of the implementation organization is not necessarily lower for smaller concepts. For example, a small concept that is introduced in many and diverse departments needs in any case a formal and well structured implementation organization.

However, if the concept scope is large more emphasis has to be laid on a formal and well structured implementation organization, even if the concept is only implemented in one department. Accordingly, the other areas have an increased importance as well. The risk of negative effects of the implementation (e.g. resistance) is higher, thus the context examination and preparation has to be executed more carefully. More control and feedback is necessary, which gives also rise to the need of a detailed implementation project definition. Finally, more emphasis has to be put on information and motivation to avoid or at least restrict resistance among the personnel. However, if the concept scope is small or large does not influence the importance of the concept adaptation. Certainly, a small concept causes less work, but its impacts on cost or revenue may be high, thus the adaptation has to be conducted with care. Figure 36 summarizes the tailoring heuristics for different concept scopes.

Nr.	**Process Function**	**Concept Scope**	
		Small	**Large**
1	Context examination and preparation	È	Ç
2	Concept adaptation	–	–
3	Implementation organization and supportive framework definition	–	Ç
4	Implementation project definition (goals, procedure, budget, etc.)	È	Ç
5	Qualification, information, motivation, introduction	È	Ç
6	Control, feedback, and follow-on preparation	È	Ç

Ç = Higher emphasis [179]
– = Not influenced or mainly influenced by other characteristics
È = Lower emphasis

Figure 36: Tailoring heuristics for different concept scopes.

Whether the context scope is small or large influences also the implementation project. A small context scope does not necessarily mean that the context examination and preparation is less important, since on the one hand it is less work, but on the other hand the affected context may be a very important element in the value chain (see, e.g., Murman et al. 2002, p. 184). However, the concept adaptation may be conducted less detailed, because there is a lower risk for the company, since only a small company area is affected in case of a misfit. A small context scope means that less organizational issues have to be handled, thus an informal approach for both the implementation organization and project definition could be applied.

When the implementation is conducted in a large context, the context examination and preparation, as well as the concept adaptation, is more important, since the impact in case of bad preparation or misfit is higher. Moreover, emphasis has to be put on the implementation organization and project definition. In a large context, more organizational issues have to be handled and more coordination is necessary. Thus, a formal approach for the organization and project definition seems to be appropriate. The extent of project functions five (qualification, information, etc.) and six (control, feedback, etc.) are not influenced by the context scope. Figure 37 summarizes the tailoring heuristics for different context scopes.

Nr.	Process Function	Context Scope	
		Small	Large
1	Context examination and preparation	–	Ç
2	Concept adaptation	È	Ç
3	Implementation organization and supportive framework definition	È	Ç
4	Implementation project definition (goals, procedure, budget, etc.)	È	Ç
5	Qualification, information, motivation, introduction	–	–
6	Control, feedback, and follow-on preparation	–	–

Ç = Higher emphasis 180
– = Not influenced or mainly influenced by other characteristics
È = Lower emphasis

Figure 37: Tailoring heuristics for different context scopes.

Programmatic Risks

An implementation project can show risks in three different areas: schedule, cost, and quality. In this chapter, approaches to avoid or mitigate these risks are defined, based on the experiences from the SysTest project (SysTest Consortium 2005, p. 27). These approaches include tailoring heuristics, but also general advices.

To which extent the process functions should be executed is only influenced by the project characteristics. For example, if to a very large and complex project insufficient time and budget is assigned, it does not mean that individual activities may be neglected. However, it does mean that strategies have to be examined to satisfy the project, budget, and schedule characteristics at the same time.

With respect to the schedule risk, the following guidelines can help to mitigate or avoid the risk:

§ Negotiate the scope of the implementation to reduce it
§ Convince the stakeholders to extend the schedule
§ Build consensus about the acceptable quality
§ Move some of the desired functionality into future versions
§ Use an incremental, evolutionary implementation approach (i.e. provide the concept in stages)
§ Adapt a less formal implementation process (e.g. informal reviews, less documentation)
§ Compromise on the quality of some concept parts; implement them with a quality level that is “just enough”, and not more
§ Use a concurrent engineering approach for the implementation project; try to execute as much tasks as possible in parallel (make assumptions for missing information) and use fast iteration cycles
§ Define pilot projects with less intensively prepared context and concept

Concerning the budget risk, approaches similar to those for the schedule risk can be applied:

§ Negotiate the scope of the implementation to reduce it
§ Convince the stakeholders to extend the schedule – this reduces also the budget because tasks can be executed successively, thus fewer assumptions have to be made and fewer iterations / rework occurs

- Build consensus about the acceptable quality
- Adapt a less formal implementation process (e.g. informal reviews, less documentation)
- Start the implementation with a mature concept and a fully prepared context

The quality risk can be controlled by considering the following guidelines:

- Plan for an increased implementation effort (schedule and budget)
- Define the implementation project in detail
- Use external experts for the implementation in general and especially for the concept adaptation
- Use frequent informal and formal technical reviews
- Put emphasis on control and feedback activities

Concept Characteristics

Three concept characteristics that are relevant for the tailoring of the implementation approach can be differentiated. The concept can be critical to the achievement of business or process objectives; it can be complex, i.e. it can consist of many elements and require many information flows; and it can be innovative, i.e. it is a new approach and was previously not or only partly tested.

With respect to critical concepts, the following guidelines can help to tailor the implementation project adequately:

- Examine and prepare the context more detailed
- Perform criticality analysis of the concept and allocate more effort (with respect to adaptation) on critical parts
- Use control and feedback activities intensively to ensure that the implementation project is on track

Figure 38 summarizes the tailoring guidelines for critical concepts:

Nr.	Process Function	Critical Concept
1	Context examination and preparation	Ç
2	Concept adaptation	Ç
3	Implementation organization and supportive framework definition	–
4	Implementation project definition (goals, procedure, budget, etc.)	–
5	Qualification, information, motivation, introduction	–
6	Control, feedback, and follow-on preparation	Ç

Ç = Higher emphasis 198

– = Not influenced or mainly influenced by other characteristics

È = Lower emphasis

Figure 38: Tailoring heuristics for critical concepts.

Complex concepts require a different approach for the implementation. Some heuristics can be applied to mitigate the risk of project failure:

§ Use external experts for the concept adaptation and the implementation project in general
§ Apply an incremental, evolutionary approach for the implementation
§ Define the implementation project in detail, especially the introduction procedure
§ Apply a formal implementation approach (formal reviews, milestone criteria, formal documentation)
§ Put emphasis on control and feedback activities

Figure 39 summarizes the tailoring guidelines for complex concepts:

Nr.	Process Function	Complex Concept
1	Context examination and preparation	–
2	Concept adaptation	–
3	Implementation organization and supportive framework definition	Ç
4	Implementation project definition (goals, procedure, budget, etc.)	Ç
5	Qualification, information, motivation, introduction	–
6	Control, feedback, and follow-on preparation	Ç

Ç = Higher emphasis 199
– = Not influenced or mainly influenced by other characteristics
È = Lower emphasis

Figure 39: Tailoring heuristics for complex concepts.

Finally, when implementing innovative concepts, it has to be ensured and controlled that the concept meets the company needs:

§ Apply an incremental, evolutionary approach for the implementation
§ Put emphasis on the concept adaptation
§ Use pilot projects to verify the concept adaptation and validate the concept benefits
§ Apply feedback activities intensively

Figure 40 summarizes the tailoring guidelines for innovative concepts:

Nr.	Process Function	Innovative Concept
1	Context examination and preparation	–
2	Concept adaptation	Ç
3	Implementation organization and supportive framework definition	–
4	Implementation project definition (goals, procedure, budget, etc.)	Ç
5	Qualification, information, motivation, introduction	–
6	Control, feedback, and follow-on preparation	Ç

Ç = Higher emphasis 200
– = Not influenced or mainly influenced by other characteristics
È = Lower emphasis

Figure 40: Tailoring heuristics for innovative concepts.

With the help of the tailoring guidelines presented above, the Implementation Process Model can be adapted to the project needs. Thus, an implementation process framework can be defined that is cost-effective and achieves the defined objectives. However, this framework only provides information about what has to be done (activities), not how it can be accomplished (procedure).

Moreover, the suggested tailoring is on a rather high level. Individual process aspects have to be further examined. For example, the process tailoring may yield that emphasis has to be put on personnel information, qualification, and motivation. However, still the question remains “how much” information, qualification, or motivation is actually needed, i.e. which strategy is optimal with respect to its cost-effectiveness. Therefore, in the following chapter a simple quantitative model of the personnel-related implementation activities is developed, which allows to determine the optimal strategy for personnel information, qualification, and motivation.

2.3.3 Summary

The implementation process model defined in chapter 2.2 can only be a generic process model. That is, for a successful application it has to be adapted to the specific needs of the company and project.

The implementation process can be divided in the three phases **planning, execution, and control**. Within these phases, several groups of activities can be differentiated. The activity groups support the main “functions” of the implementation process (**process functions**) and thus can be considered as **basic steps** of the implementation process.

Tailoring should be performed on the organizational and the project level. Before starting the implementation project, first its characteristics should be identified. There are three main groups of characteristics that influence the implementation process: **project characteristics**, **programmatic risks**, and **concept characteristics**. The project characteristics can be used for both organizational and project tailoring. In chapter 2.3.1, the **project** and **concept characteristics** as well as the **programmatic risks** influencing the tailoring of the implementation process were described in detail.

In chapter 2.3.2, **heuristics for the tailoring** of the implementation process were described. The tailoring heuristics provide guidance **how to adapt the implementation process**, dependent on variations in the previously defined tailoring parameters. The suggested tailoring approach uses the basic steps (**process functions**) of the implementation process as variables in the process structure. That is, variations in the tailoring parameters influence to which extent the basic steps of the implementation process have to be executed. Thus, the tailoring heuristics define if **higher or lower emphasis** should be put on the corresponding basic process function, or if the basic process function is **not influenced** or mainly influenced by other characteristics.

2.4 Synopsis

Section 2, “Process Model of the Implementation”, presented **phase schemes and procedures** of the implementation process from literature. The described phase schemes and procedures only provide a **high-level view** on the implementation procedure, which makes their value as **orientation guide** and for **creating transparency** questionable (see chapter 2.1).

Therefore, in chapter 2.2 a **process model of the implementation** was developed, which describes the activities that should be conducted, the products that should be produced by the individual activities in the process (outputs), and the inputs that are used by these activities to produce those outputs. Process models are already widely used in industry. Their advantages are, among others, that they create **transparency**, support **understanding and learning**, and improve the **communication** between the persons in charge. The implementation process can be divided in the three phases **planning, execution, and control**. Within these phases, several groups of activities can be differentiated. The activity groups support the main “functions” of the implementation process (**process functions**) and thus can be considered as **basic steps** of the implementation process.

This implementation process model can only be a generic process model. That is, for a successful application it has to be adapted to the specific needs of the company and project.

Tailoring should be performed on the organizational and the project level. Before starting the implementation project, first its characteristics should be identified. There are three main groups of characteristics that influence the implementation process: **project characteristics**, **programmatic risks**, and **concept characteristics**. The project characteristics can be used for both organizational and project tailoring. In chapter 2.3.1, the **project** and **concept characteristics** as well as the **programmatic risks** influencing the tailoring of the implementation process were described in detail.

In chapter 2.3.2, **heuristics for the tailoring** of the implementation process were presented. The tailoring heuristics provide guidance **how to adapt the implementation process**, dependent on variations in the previously defined tailoring parameters. The suggested tailoring approach uses the basic steps (**process functions**) of the implementation process as variables in the process structure. That is, variations in the tailoring parameters influence to which extent the basic steps of the implementation process have to be executed. Thus, the tailoring heuristics define if **higher or lower emphasis** should be put on the corresponding basic process function, or if the basic process function is **not influenced** or mainly influenced by other characteristics.

3 Quantitative Model of Personnel-related Implementation Activities

As mentioned in the previous chapters, the most important **personnel-related implementation activities** are **information**, **motivation**, and **qualification**. Their importance is underlined in literature (see, e.g., Tarlatt 2001, Zeyer 1996, Lehner 1996, Daniel 2001) and several authors describe basic aspects, their application in practice, as well as possible means. The main objective of information as implementation instrument is certainly to allow people for seeing their own work in the bigger context, which in general increases the **work performance**. For qualification, the main goal is to create the necessary **capabilities** within the people, which they need to accomplish the new tasks that are required. Another aspect of information and qualification is to help to avoid or overcome **resistance**. Lack of information and qualification in general leads to fear from the future or may give rise to conflicts, which results in resistance of the people affected against the implementation (Zeyer 1996, p. 295 ff.).

However, although these essential parts of the implementation procedure are widely treated in literature, they are only treated qualitatively. There is no approach that tries to help the practitioner in choosing the **right strategy** for information, motivation, and qualification of the personnel considering the **information, qualification, and motivation level** on the one hand, and the **cost** of these personnel-related implementation activities on the other hand. Moreover, a quantitative approach allows for an optimization of the chosen strategy. If required, the data enables to determine the **information, qualification, and expected motivation level** of the individual and the **distribution homogeneity** of these factors.

Figure 41 summarizes the weaknesses of the current treatment of the implementation aspects information, qualification, and motivation in a company and confronts them with the objectives of the proposed quantitative approach.

Current Weaknesses	Proposed Quantitative Approach
Who receives which information when is based on a subjective decision.	Determine the recipients, the needed information and capabilities, and the date when they need it.
Employees receive information or qualification not focused on their tasks or position in the process. Similarly, motivation measures are not focused on the right target group. This means a waste of resources and may lead to an unnecessary inroad of the employee's capacities.	Derive a prioritized list of topics and capabilities for a single task and position in the process.
There is no trade-off between the breadth or intensity of the personnel-related implementation activities (i.e. the effect of these activities) and the cost of those.	Determine the cost-value-ratio of the personnel-related implementation activities and thus allow an optimization of cost versus effects.
An information, qualification, and expected motivation level cannot be easily assigned to the single employee. Therefore, no statements can be made where additional information, qualification, or motivation needs may exist. Moreover, no view of the distribution of information, qualification, and motivation means can be provided.	Determine the individual information, qualification, and expected motivation level and the respective homogeneity of the measure distribution in the company.

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Figure 41: Confrontation of current weaknesses and proposed quantitative approach for personnel-related implementation activities.

A model is an incomplete representation and an abstraction of reality (see, e.g., Buede 2000, p. 60; Kossiakoff and Sweet 2003, p. 410; Sage and Armstrong 2000, p. 181). It is incomplete or an abstraction, because only those aspects of reality are modeled that, in the eyes of the modeler, are important to answer the “questions” that the modeler wants to ask the model. Buede (2000, p. 60) sees also the question or set of questions that the model reliably can answer as the essence of the model. There are different model classifications. One approach is the distinction between the types of questions that can be answered by the model (Buede 2000, p. 60, Sage and Armstrong 2000, p. 183). The three basic types are descriptive or predictive, normative, and definitive questions. Definitive questions relate to the way how an entity should be defined. In the engineering domain, definitive models describe how the system is being designed, what inputs it requires, which functions it has, which outputs it provides, and which resources it uses. The descriptive model tries to predict answers to questions that may or may not be obtained in the future. Models that predict the behavior of the system are a very common example for descriptive models. Those, usually executable, models try to predict the system behavior in certain situations, which may occur in reality and thus give the possibility to assess the model validity. Normative models support decision making with providing information about how individuals or other entities ought to think about a problem. A value function is an example for a normative model. Value functions try to describe the value of a system in a quantitative manner, thus including subjective aspects. Another approach for classifying models is in terms of their representation "language". Although there is no universal standard classification, a common distinction is between physical, quantitative or mathematical, qualitative, and mental models (Buede 2000, p. 62; Kossiakoff and Sweet 2003, p. 410, Sage and Armstrong 2000, p. 181), which can further be subdivided into sub-categories. Physical models are physical representations of the system, generally reflecting only parts of the physical characteristic of the system under study. Often, physical models are scale models of the real system. Examples for physical models are automotive prototypes, a globe of the Earth showing the continents, or a ball and stick model of the structure of a molecule. Quantitative models describe the system mathematically, thus allowing executing the model in order to derive predictions about the system behavior. Examples include differential equations for fluid dynamics and simulation models. Qualitative models consist of symbols, text, or graphics. They are often used to convey relationships qualitatively and therefore are a valuable means of communication. On the other hand, since they are very abstract, there is the danger of misinterpretation, which has to be reduced by using standardized terminology. The system specification, describing the requirements on a system in textual and graphical format, is an example for a qualitative model. Finally, a mental model is an abstraction of thought. Mental models are necessary in the engineering process, due to the huge complexity of systems and the restricted capacity of humans for parallel problem solving.

Modeling consists of three basic steps (see, e.g., Sage and Armstrong 2000, p. 185; Igenbergs 2004, p. 29). The first step is to define the structure of the system. That is, the system boundary has to be drawn and the elements, that are relevant to the problem under consideration, have to be defined. Moreover, the structural relations between those elements have to be determined. This first step can be considered as a definition phase, where the model requirements are defined and the model specification is identified. This includes also determining the problem definition and the value system. The second step is to determine qualitatively the functional relationships between the identified elements in the model. It is investigated, which are the relevant attributes of the elements in the given problem context. Furthermore, the inputs and outputs of the elements are identified. The functions, which connect inputs, outputs, and attributes, are defined only qualitatively. The third step in the modeling aims at determining the quantitative interrelation between the model elements. This means that the relations that were identified in the second step are now expressed mathematically. Furthermore, the actual value of the attributes and the external inputs in the system are defined. The second and third phase is equal to a development phase. In this model development phase, the model structure and relevant parameters are identified, and possibly the model is verified and validated.

In accordance with the procedure described above, a **model for the personnel-related implementation activities** was developed in the present dissertation. First, the **objectives for this model** were defined. These objectives can be considered as questions, which are not yet fully addressed in literature. To help answering these questions is the objective of the presented model. Second, the **elements** that are relevant for answering those questions were identified, and thus implicitly the system boundary was drawn (see chapter 3.1). Following, in chapter 3.2 the qualitative relations between those elements were examined, which was the basis to finally determine the quantitative relationships between the model elements (chapter 3.3).

To depict the qualitative model, a simplified Entity-Relationship notation was applied, which normally is used for database design. Figure 42 shows this notation. An entity is a real-world object or thing with an independent existence and which is distinguishable from other objects. Entities are, e.g., books, cars, planes, telephones, or an activity in a process. An entity may have one or several attributes, which are the descriptive properties of the entity. For example, the entity “activity” may have the attributes cost and duration. In the figures, rectangles depict entities and ovals depict attributes (see Figure 42). Dotted lines show to which entity an attribute is associated to. An entity may have several attributes, but an attribute is only associated with one entity. The relationships are another important characteristic of an Entity-Relationship diagram. A relationship is an association among two or more entities. For example, “Sepp Meier” is catching a “Football”. In this case, “catching” is the relationship. In the presented model, only two types of qualitative relationships are relevant, expressing equality or dependency. If A is equal to B, this is expressed with a thick double-headed arrow. A thin single-headed arrow indicates dependency, e.g. that B depends on A (see Figure 42).

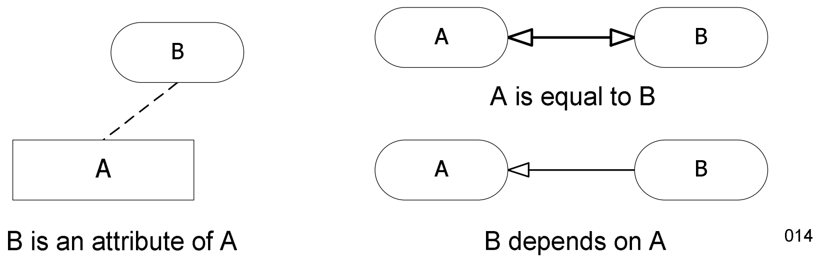

Figure 42: Adapted Entity-Relationship notation for the developed model.

3.1 Model Elements

In this chapter, the **objectives** of the quantitative model are defined, which are not yet addressed in literature. Moreover, the necessary **elements** of the quantitative model are defined, and thus implicitly the system boundary of the quantitative model is drawn

The first step in the modeling procedure is to identify the model elements. Which real-world entities have to be portrayed depends on the questions that should be answered by the model, or the objectives that it has, respectively. The model objectives were already summarized in Figure 41; in Figure 43 these objectives of or questions on the model are confronted with elements, whose interplay has to be examined and determined quantitatively in order to be able to answer those questions.

Proposed Quantitative Approach	Involved Elements
Determine the recipients, the needed information and capabilities, and the date when they need it.	Individual, Information, Qualification, Activity
Derive a prioritized list of topics and capabilities for a single task and position in the process.	Information, Qualification, Activity
Determine the cost-value-ratio of the personnel-related implementation activities and thus allow an optimization of cost versus effects.	Information, Qualification, Motivation, Individual
Determine the individual information, qualification, and expected motivation level and the respective homogeneity of the measure distribution in the company.	Individual, Information, Qualification, Motivation

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Figure 43: Confrontation of model objectives and elements.

Personnel-related implementation activities encompass information, qualification, and motivation, which have to be considered as elements of the model. On the one hand the interrelationship between these three elements is of interest, but since they are applied on the individual, their interplay with the individual is of interest as well. Therefore, the individual has to be considered as another element of the model. The role of the individual in the company is defined through the activity he performs. It depends on the type of the activity, which information, motivation, and qualification measures have to be applied on the individual. For this reason, the activity is included as another element in the model. In summary, the necessary model elements are:

- Individual
- Activity
- Information
- Qualification
- Motivation

With these elements, all relevant aspects of the real-world problem are considered and the model objectives can be fulfilled. To be able to define the qualitative relations between the identified elements, their relevant attributes have to be determined. For the element information an essential characteristic is that some kind of content (topic) is provided to a recipient (see Figure 44). Another relevant aspect is the means with which this information is transported.

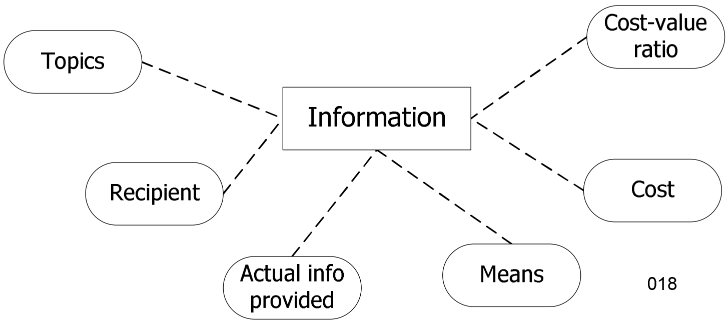

Figure 44: Information – Entity and attributes.

The term “topics” refers to the full set of information that is relevant for an individual or for the whole company with respect to the implementation. Since it may not be possible or affordable to distribute all relevant information to each individual, the extent to which the information is distributed (actual info provided) and the cost associated with this distribution should be considered in the model. The decision, how much to invest in the information of the employees is a trade-off between cost, information provided, and the individual performance. Trying to reduce the cost of the information distribution by not providing relevant information to certain employees may lead to lower working performance due to resistance or lack of context comprehension. Therefore, the decision whom to provide which information is a strategic decision. The effectiveness of the chosen information strategy is expressed by the cost-value ratio.

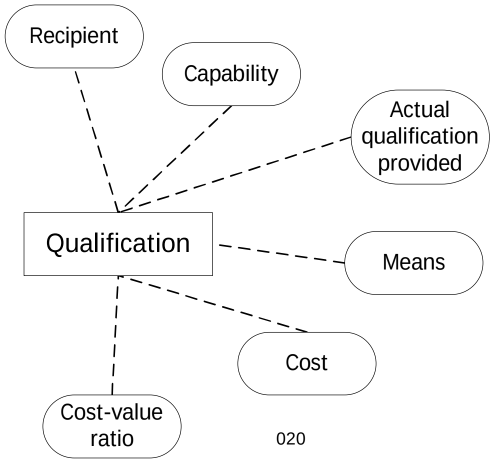

Figure 45: Qualification – Entity and attributes.

Similarly to the topics at information, for qualification the capability (or capabilities) that has to be conveyed to the employees is an essential attribute. Furthermore, also here the capabilities that were actually conveyed to the employees (actual qualification provided) are depending on the chosen qualification strategy, and therefore are an important attribute. All other attributes are equal to those already defined for information, i.e. recipient, means, cost, and cost-value ratio (see Figure 45).

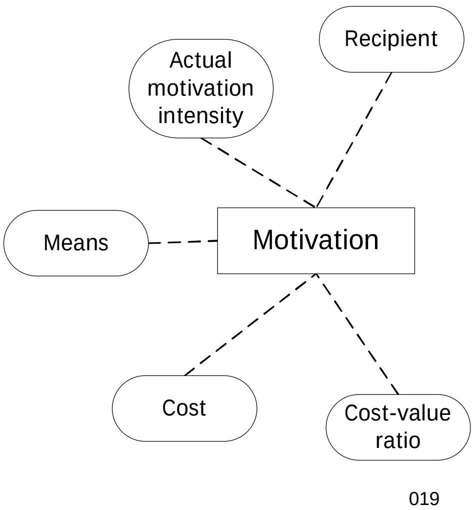

Figure 46: Motivation – Entity and attributes.

For motivation, there is a decisive difference. Motivation is not, as information and qualification, related to any topic or capability (see Figure 46). Therefore, the need for motivation cannot be directly related to an individual's task or position in the company. How it can be determined nonetheless is described later on in the present dissertation. Similarly to the attributes actual information provided and actual qualification provided, the actual motivation intensity describes the extent to which motivational measures are applied. The remaining attributes (recipient, means, cost, and cost-value ratio) are equal to those already defined for information and qualification.

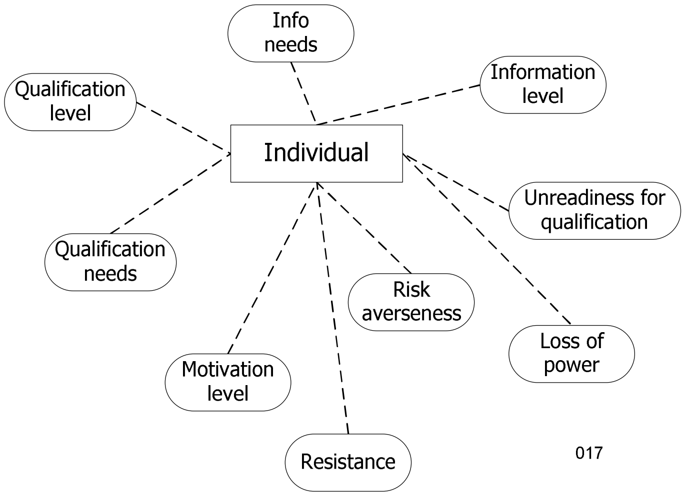

Figure 47: Individual – Entity and attributes.

Qualification, information, and motivation affect the individual. Based on how intense these measures are applied, the individual employee has a certain information, qualification, and motivation level (see Figure 47). Opposite to that, each individual has information and qualification needs, depending on his task and position in the process. For the motivation, the relationships are more complex. There may be several factors that may lead to a resistance of the individual against the implementation. For example, a personal unreadiness for qualification may lead to a lacking success of the qualification measures. Hence, the employee does not acquire the necessary capabilities to perform his (new) task. As a result, the employee has to work on tasks for which he lacks the necessary capabilities. Furthermore, due to a new organizational structure that is implemented, the employee may loose power in the company. As a third aspect, a personal risk averseness of the employee leads to a general rejection of changes in the environment. All three aspects can occur during an implementation and may lead to resistance, thus they are important attributes of the individual. Resistance, on the other hand, can be considered as a measure for the need for motivation of the employee. The higher the resistance is due to one or more of the aspects described above, the more motivation would be required. Thus, the motivation level has to be according to the personal resistance.

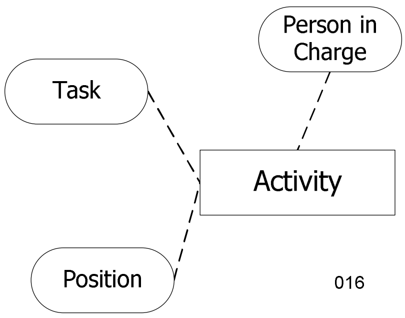

Figure 48: Activity – Entity and attributes.

The information and qualification needs are depending on the task and position of the individual in the process. Therefore, two essential attributes of an activity are the task that has to be performed within an activity and its position in the process structure (→ relations with other activities) and in the organizational structure (→ relations with other persons in charge). Furthermore, through the person in charge for the activity, a relationship between an activity and the individual employee can be established (see Figure 48).

Summary

The **main objectives** of the presented quantitative model of the personnel-related implementation measures are to determine the **cost-value-ratio** of the personnel-related implementation activities and thus allow an optimization of cost versus effects, and to determine the **individual information, qualification, and expected motivation level** and the respective **homogeneity of the measure distribution** in the company.

These objectives can be seen as questions that the proposed model has to answer. In order to be capable to answer these questions, the model has to include the **elements** individual, activity, information, qualification, and motivation. To be able to derive their qualitative relationships, the **element's attributes** were determined in this chapter.

3.2 Qualitative Relationships

Based on the identified elements of the quantitative model from the previous chapter, in this chapter the **qualitative relationships** between the elements of the system are defined.

Figure 49 shows a comprehensive view of the entities with attributes and the existing relationships between them. It is obvious that the resulting structure is rather complex. The main objective for the quantitative model of the personnel-related implementation activities is basically to determine the efficiency of the chosen measures, i.e. to determine the cost-value ratio of the chosen information, qualification, and motivation strategy. For this reason, only the path to determine the cost-value ratios will be explained in the following paragraphs. However, due to the consideration of all relevant aspects on these paths, all relationships between the entities are treated. Moreover, since the other model objectives are milestones on the way to determine the cost-value ratios, they are also treated in the following paragraphs.

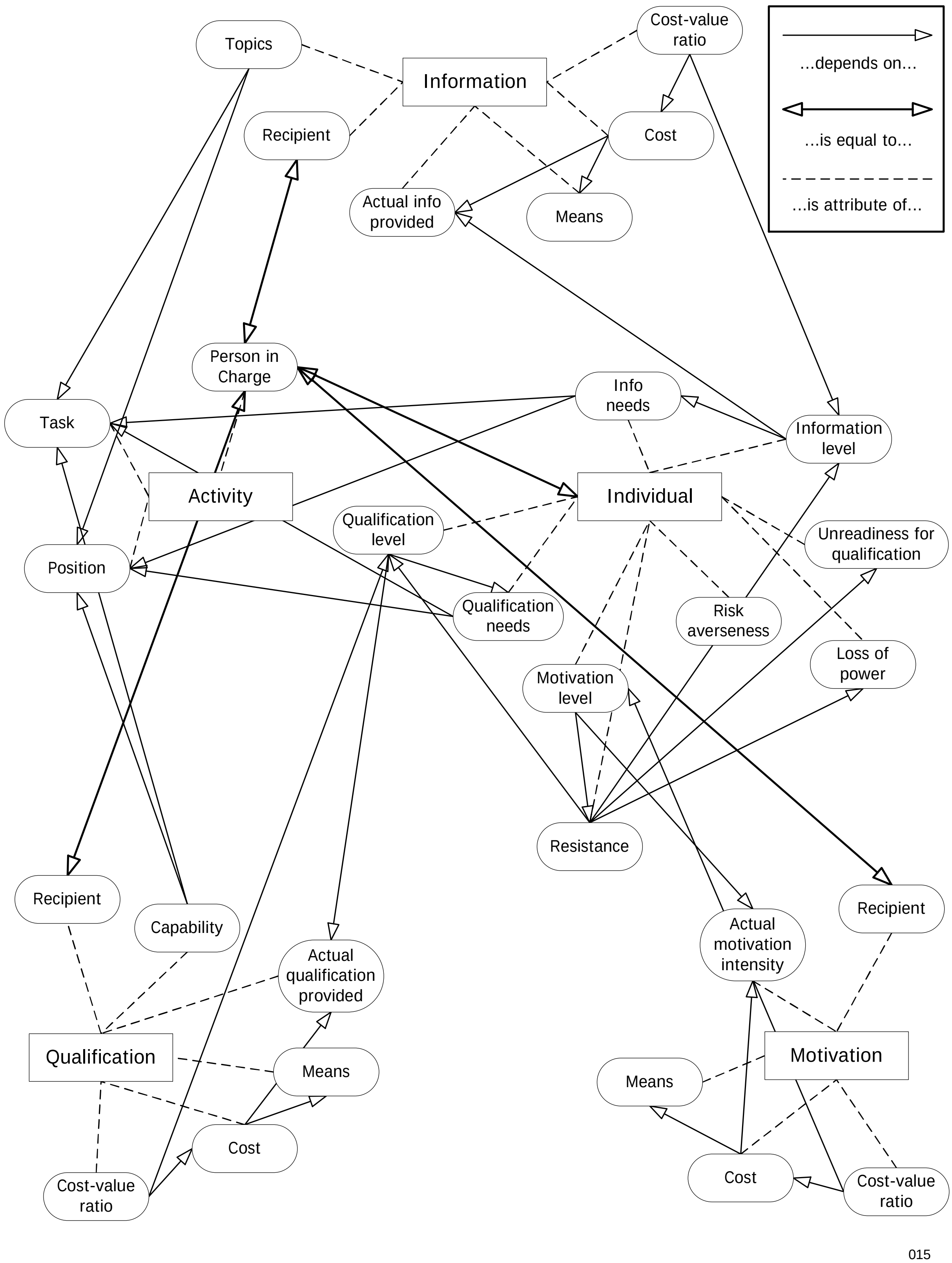

Figure 49: Entity-Relationship diagram for the personnel-related implementation activities.

Figure 50 shows the calculation procedure for determining the cost-value ratio of the information strategy. The arrows show the flow of the calculation, i.e. which result is derived from which sources.

To each activity, a task, a position, and a person in charge can be assigned (see Figure 50). To accomplish the task, certain information may be necessary or beneficial. Furthermore, the existing relations with other activities determine the position of the activity in the process structure.

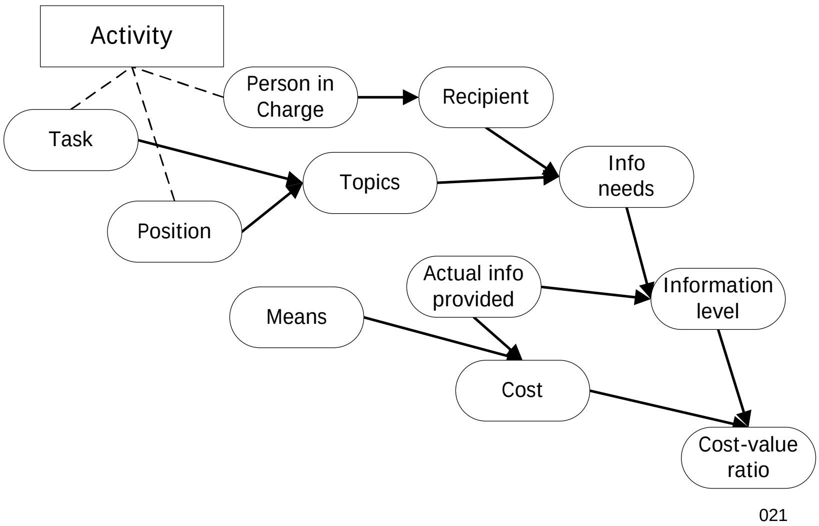

Figure 50: Information – Calculation procedure.

From the point of view of the employee, the activity in general necessitates contact to other people in the company. These contacts are not restricted to the exchange of deliverables, how it is seen, e.g., in constructing the team structure. These contacts may be present also due to organizational bonds, e.g. when the person in charge for the activity is part of a certain department in the company and has contact to colleagues within his department. The activity itself may as well be assigned to a specific department, thus creating the need for the person in charge of this activity to be informed about issues relevant to this department. Each task and position may require knowledge of more than one topic. On the other hand, each topic may be also relevant for several positions and tasks, thus creating an n*m-relationship between topics and tasks/positions. Figure 51 depicts these relationships schematically.

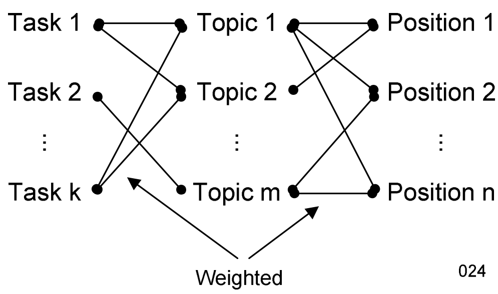

Figure 51: Relationship between information topic and activity task/position.

Introducing a weighting of the relations between information topics and activity tasks/positions allows deriving a prioritized list of topics for each activity, which is one objective of the quantitative model. Moreover, since every activity has a temporal aspect and a person in charge, it can be derived when, which information has to be provided to whom. The person in charge of the activity is equal to the recipient of the information. Together with the set of topics, the information needs of the individual can be determined. However, an information need does not mean that this need is always satisfied. Many constraints (e.g. cost or temporal constraints) may make it necessary to provide a reduced set of information to the employees. This “actual information provided” can be compared to the information needs and in this way an information level derived. The information level is a measure for the degree of information of an employee.

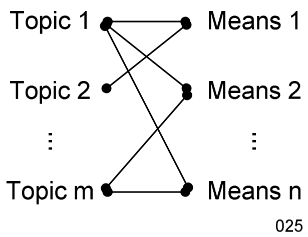

Figure 52: Relationship between information topic and distribution means.

The amount and type of information provided (actual information provided), together with the means used to distribute the information, determines the cost. Similar to the task and position of the activity, the distribution means for the information may be generally mapped to all relevant topics within the considered area (see Figure 52). Finally, by comparing the information level and the cost, the cost-value ratio of the chosen information strategy can be derived.

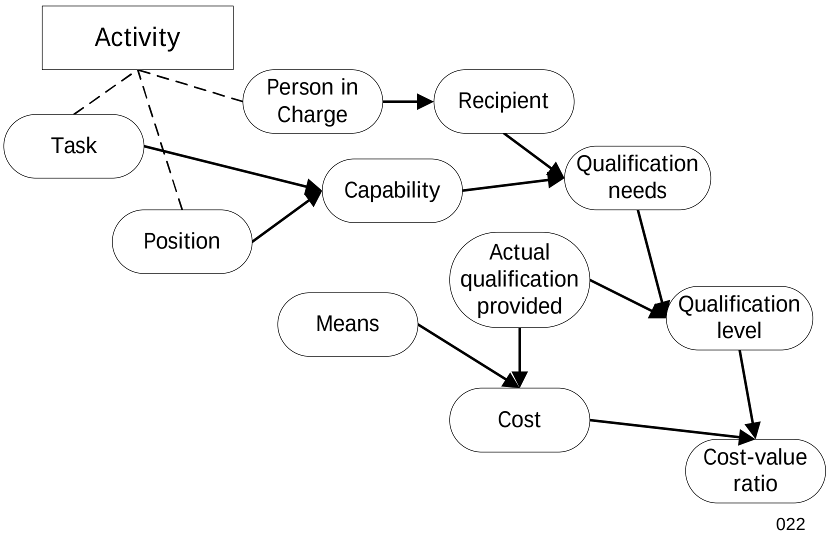

Figure 53: Qualification – Calculation procedure.

The cost-value ratio of the chosen qualification strategy is determined similarly (see Figure 53). Again, the arrows show the flow of the calculation, i.e. which result is derived from which sources.

To each activity, a task, a position, and a person in charge can be assigned. Task and position of the activity require a certain capability or set of capabilities (see Figure 54), which determine, together with the recipient of the qualification, the qualification needs of the individual.

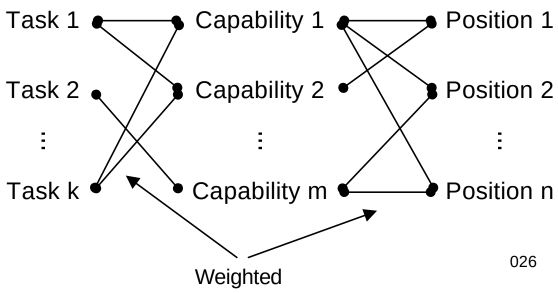

Figure 54: Relationship between required capability and activity task/position.

The actual qualification provided can be used for calculating the qualification level and, based on the qualification means, the qualification cost. Finally, the cost-value ratio for the chosen qualification strategy is the fraction of the achieved qualification level and the qualification cost.

For motivation, the calculation procedure has to be different. Motivation needs are not resulting from an activity, but from the individual disposition to the planned change. Therefore, the starting point has to be the individual and his attributes. The objective of motivation is to overcome resistance and create not only acceptance, but identification (Zeyer 1996, p. 91 and p. 324). Zeyer (1996, p. 324) differentiates between resistance on an action level and conflicts on an interest level. That is, both resistance and conflicts have the same sources, but the term conflict in this case stands for an inner attitude, whereas resistance is used when individuals actively oppose the change process. For defining a quantitative model of motivation, this differentiation is not necessary. Therefore, in the following only the term resistance will be used, meaning both inner resistance (conflicts) and active resistance. There are several factors that may trigger the resistance of individuals (Tarlatt 2001, p. 67):

- Uncertainty about the scope and consequence of the change
- Uncertainty about the own competence for a new task or function
- Uncertainty about the change of the formal and informal relation patterns in the company
- Fear of loss of privileges and status symbols
- Fear of autonomy loss
- Fear of redundancy of the own person due to the change
- Force to take risks exceeding the own risk averseness
- Unreadiness to learn new competencies and behaviors

Compensation can be a stimulus for change, if properly handled (Giblin 1994, p. 417; see also Pennings 1994). But not all of these trigger factors may be compensated by motivation. Also information and qualification measures may contribute to a dilution of the resistance sources. Figure 55 shows the applicable mitigation measures for the different resistance trigger factors.

Trigger Factors for Resistance	Mitigation Measures
Uncertainty about the scope and consequence of the change	Information
Uncertainty about the own competence for a new task or function	Qualification
Uncertainty about the change of the formal and informal relation patterns in the company	Information
Fear of loss of privileges and status symbols	Motivation
Fear of autonomy loss	Information
Fear of redundancy of the own person due to the change	Information
Force to take risks exceeding the own risk averseness	Motivation
Unreadiness to learn new competencies and behaviors	Motivation

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Figure 55: Mitigation measures for resistance trigger factors.

This figure shows that motivation has to focus on the personal unreadiness for qualification, risk averseness, and loss of power (see Figure 56). The unreadiness for qualification and the risk averseness are clearly individual attributes, whereas the loss of power is mainly influenced by decisions beyond the influence of the individual. However, the loss of power during a change process in a company is in general different for each employee and therefore may be considered as individual attribute. As already mentioned, there are trigger factors that are best influenced by information and qualification measures. However, since there may be a lack of information or qualification (see the paragraphs about the information and qualification model), these resistance sources have to be considered indirectly over the individual qualification level and information level. The lower the information or qualification level, the higher the personal resistance has to be expected. The resulting resistance can be compared to the actual motivation intensity and thus the individual motivation level derived. Concurrently, the actual motivation intensity determines, together with the used motivation means, the cost of the motivation. Finally, the relation of the motivation level with cost can be expressed by the cost-value ratio for the chosen motivation strategy.

Figure 56 depicts the calculation procedure for determining the cost-value ratio of the motivation strategy. Again, the arrows show the flow of the calculation, i.e. which result is derived from which sources.

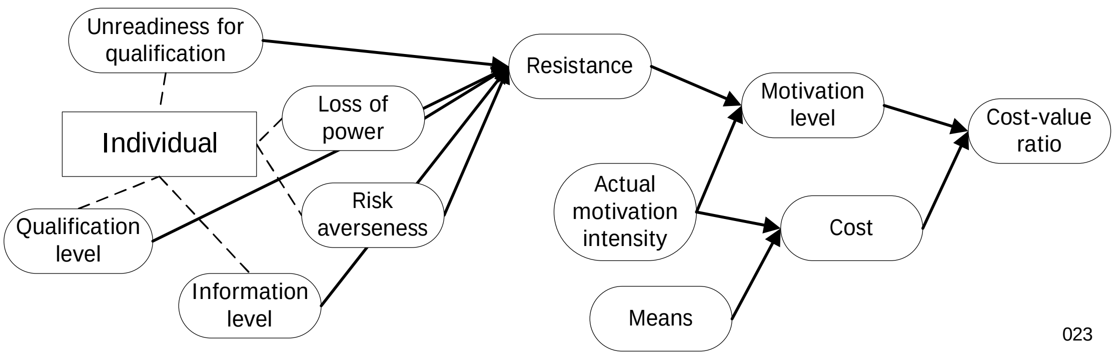

Figure 56: Motivation – Calculation procedure.

Up to this point, the “value” of the different attributes was identified in a qualitative manner. For example, the information needs of the individual are simply derived by mapping the topics (related to an activity) to the person in charge of the activity. The next and final step in the modeling procedure is to define the identified relationships and attributes quantitatively.

Summary

In this chapter the **qualitative interdependencies** between the different model elements and their attributes were defined. Figure 49 shows that these interdependencies are rather complex. The **calculation procedures** for the cost-value ratio of the chosen information, qualification, and motivation strategy have been depicted and explained. The **information topics and capabilities** are core elements in the calculation procedures for the information and qualification strategies. For the motivation strategy **resistance** is the most important element in the calculation procedure. Resistance can be caused by various **triggers**, which can be **compensated** by information, qualification, and motivation. Thus, resistance depends on the **chosen information and qualification level**, and the triggers that can be **directly influenced** by motivation.

3.3 Quantitative Relationships

The third step in the modeling procedure aims at determining the **quantitative relationships** between the model elements. This means that the qualitative relations that were identified in the second step (see chapter 3.2) are now expressed mathematically. The **external inputs** in the system, i.e. (in this case) the information that the user has to provide to the model, are also defined.

The following paragraphs present and explain the **equations** for calculating the cost-value ratio of the chosen **information, qualification, and motivation strategy**. In chapters 3.3.2 and 3.3.5, two simple **examples** illustrate the use of these equations. First, the equations for the area of information activities are described.

3.3.1 Information

Starting point is an activity. Let $\boldsymbol{t}$ be the vector of the tasks and $\boldsymbol{p}$ be the vector of the positions that are associated with the considered activity. Both are binary vectors, having a 1 in those lines which denote the tasks or positions, respectively, that are associated with the considered activity.

Furthermore, R_{TaTo} is the relationship matrix of the tasks and topics, which contains the weighted dependency of a topic from the activity task. For example, if $R_{TaTo,12}$ is 0.8, this means that topic 2 has an importance of 0.8 for task 1. Please note that

$$R_{TaTo,ij} \in [0;1] \qquad \text{Eq. 1}$$

and

$$\sum_{j=0}^{n} R_{TaTo,ij} = 1 \qquad \text{Eq. 2}$$

where n is the number of columns. These equations simply mean that the weightings have to be between 0 and 1, and that the sum of the weightings for one task (row) has to be 1.

Similar to the relationship matrix of the tasks, R_{PoTo} is the relationship matrix of the positions and the topics, which contains the weighted dependency of a topic from the activity position. For example, if $R_{PoTo,31}$ is 0.5, this means that topic 1 has an importance of 0.5 for position 3. Please note that also here

$$R_{PoTo,ij} \in [0;1] \qquad \text{Eq. 3}$$

and

$$\sum_{j=0}^{n} R_{PoTo,ij} = 1 \qquad \text{Eq. 4}$$

Then, the two vectors of topics resulting from the activity tasks ($\boldsymbol{s_{Ta}}$) and from the activity positions ($\boldsymbol{s_{Po}}$), respectively, can be calculated with

$$\mathbf{s}_{Ta} = \mathbf{t}^T \cdot R_{TaTo} \qquad \text{Eq. 5}$$

and

$$\mathbf{s}_{Po} = \mathbf{p}^T \cdot R_{PoTo} \qquad \text{Eq. 6}$$

With introducing a weighting for the dependency of the topics on the activity tasks (w_t) and the activity positions (w_p), the information needs ($\boldsymbol{i_n}$) can be calculated.

$$\mathbf{i}_n = w_t \cdot \mathbf{s}_{Ta} + w_p \cdot \mathbf{s}_{Po} \qquad \text{Eq. 7}$$

Please observe that

$$w_t + w_p \overset{!}{=} 1 \qquad \text{Eq. 8}$$

Let furthermore be $\boldsymbol{i_p}$ the vector of the provided information topics (in contrast to those needed). Similar to the vectors of the tasks and positions, also $\boldsymbol{i_p}$ is a binary vector with entries at those lines (topics) where information is actually provided. Then, the information level $\boldsymbol{i_l}$ can be calculated by:

$$i_l = \mathbf{i}_p^T \cdot \mathbf{i}_n \qquad \text{Eq. 9}$$

To calculate the resulting cost, it is necessary to define a relationship matrix of the topics and distribution means, R_{ToMe}. This is a binary matrix, where an entry in the cell $R_{ToMe,12}$, e.g., means that the information topic 1 is distributed using means 2. With the help of this matrix and the vector of the provided information topics ($\boldsymbol{i_p}$), the vector of the applied information means ($\boldsymbol{m_I}$) can be derived.

$$\mathbf{m}_I = \mathbf{i}_p^T \cdot R_{ToMe} \qquad \text{Eq. 10}$$

Introducing the cost vector of the means, $\boldsymbol{c_M}$, the overall cost of the information provided, c_{OI}, can be calculated by multiplying $\boldsymbol{c_M}$ and the vector of the applied information means, $\boldsymbol{m_I}$.

$$c_{OI} = \mathbf{m}_I^T \cdot \mathbf{c}_M \qquad \text{Eq. 11}$$

Finally, the cost-value ratio of the chosen information strategy is calculated by dividing the information level with the overall cost of the information provided to the individual.

$$r_{CV,I} = \frac{i_l}{c_{OI}} \qquad \text{Eq. 12}$$

3.3.2 Calculation Example for an Information Strategy

Following example shall clarify the calculation procedure presented above. Let us assume that we have an activity, which has a certain task and a certain position in the process. In the overall list of tasks, this task is number 2, and the position is number 3. Thus, the task and position vectors are

$$\mathbf{t} = \begin{pmatrix} 0 \\ 1 \\ 0 \\ 0 \end{pmatrix}; \ \mathbf{p} = \begin{pmatrix} 0 \\ 0 \\ 1 \\ 0 \end{pmatrix} \qquad \text{Eq. 13; Eq. 14}$$

Furthermore, the relationship matrices for the task and position to the topic are assumed for this example as

$$R_{TaTo} = \begin{pmatrix} 0.9 & 0.1 & 0 \\ 0 & 0.2 & 0.8 \\ 0 & 0.5 & 0.5 \\ 0 & 1 & 0 \end{pmatrix}; \ R_{PoTo} = \begin{pmatrix} 0 & 0.9 & 0.1 \\ 0 & 1 & 0 \\ 0.3 & 0.7 & 0 \\ 0 & 0.6 & 0.4 \end{pmatrix} \qquad \text{Eq. 15; Eq. 16}$$

For example, the first line of the relationship matrix between the task and the topic, R_{TaTo}, means that task number 1 (since it is the first line of the matrix) is related to topic 1 (with a weighting of 0.9) and to topic 2 (with a weighting of 0.1). With this information, we can calculate the two vectors of topics resulting from the activity tasks ($\boldsymbol{s}_{Ta}$) and from the activity positions ($\boldsymbol{s}_{Po}$), respectively, with

$$\mathbf{s}_{Ta} = \mathbf{t}^T \cdot R_{TaTo} = \begin{pmatrix} 0 \\ 1 \\ 0 \\ 0 \end{pmatrix}^T \cdot \begin{pmatrix} 0.9 & 0.1 & 0 \\ 0 & 0.2 & 0.8 \\ 0 & 0.5 & 0.5 \\ 0 & 1 & 0 \end{pmatrix} = \begin{pmatrix} 0 \\ 0.2 \\ 0.8 \end{pmatrix} \qquad \text{Eq. 17}$$

and

$$\mathbf{s}_{Po} = \mathbf{p}^T \cdot R_{PoTo} = \begin{pmatrix} 0 \\ 0 \\ 1 \\ 0 \end{pmatrix}^T \cdot \begin{pmatrix} 0 & 0.9 & 0.1 \\ 0 & 1 & 0 \\ 0.3 & 0.7 & 0 \\ 0 & 0.6 & 0.4 \end{pmatrix} = \begin{pmatrix} 0.3 \\ 0.7 \\ 0 \end{pmatrix} \qquad \text{Eq. 18}$$

If we consider the dependency of the topics on the tasks and on the positions as equally important, we can write

$$w_t = w_p = 0.5 \qquad \text{Eq. 19}$$

Then, we can calculate the information needs as

$$\mathbf{i}_n = w_t \cdot \mathbf{s}_{Ta} + w_p \cdot \mathbf{s}_{Po} = 0.5 \cdot \begin{pmatrix} 0 \\ 0.2 \\ 0.8 \end{pmatrix} + 0.5 \cdot \begin{pmatrix} 0.3 \\ 0.7 \\ 0 \end{pmatrix} = \begin{pmatrix} 0.15 \\ 0.45 \\ 0.4 \end{pmatrix} \qquad \text{Eq. 20}$$

Now, we assume that we choose as information strategy to provide only information about topic 2 and 3 (lines 2 and 3 in the information needs vector $\boldsymbol{i}_n$). This gives us for the vector of the provided information topics, $\boldsymbol{i}_p$, the following numbers.

$$\mathbf{i}_p = \begin{pmatrix} 0 \\ 1 \\ 1 \end{pmatrix} \qquad \text{Eq. 21}$$

With this vector, the information level can be calculated as

$$i_l = \mathbf{i}_p^T \cdot \mathbf{i}_n = \begin{pmatrix} 0 \\ 1 \\ 1 \end{pmatrix}^T \cdot \begin{pmatrix} 0.15 \\ 0.45 \\ 0.4 \end{pmatrix} = 0.85 \qquad \text{Eq. 22}$$

The other side of the chosen information strategy is its cost. Therefore, we define the relationship matrix of the topics and distribution means, R_{ToMe}. This is a binary matrix that determines which means is used for distributing which topic.

$$R_{ToMe} = \begin{pmatrix} 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 1 \\ 1 & 0 & 0 & 1 \end{pmatrix} \qquad \text{Eq. 23}$$

With the help of this matrix and the vector of the provided information topics (***i_p***), the vector of the applied information means (***m_I***) can be derived.

$$\mathbf{m}_I = \mathbf{i}_p^T \cdot R_{ToMe} = \begin{pmatrix} 0 \\ 1 \\ 1 \end{pmatrix}^T \cdot \begin{pmatrix} 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 1 \\ 1 & 0 & 0 & 1 \end{pmatrix} = \begin{pmatrix} 1 \\ 0 \\ 1 \\ 2 \end{pmatrix} \qquad \text{Eq. 24}$$

In the next step, the cost of the chosen information strategy is determined. To that end, the cost of the individual information means has to be provided in form of the cost vector of the information means, ***c_M***. In this case, the vector is assumed to be

$$\mathbf{c}_M = \begin{pmatrix} 18 \\ 120 \\ 45 \\ 60 \end{pmatrix} \qquad \text{Eq. 25}$$

The entries in this vector denote the cost of the information means 1 to 4. Now, the overall cost of the information provided, c_{OI}, can be calculated by multiplying ***c_M*** and the vector of the applied information means, ***m_I***.

$$c_{OI} = \mathbf{m}_I^T \cdot \mathbf{c}_M = \begin{pmatrix} 1 \\ 0 \\ 1 \\ 2 \end{pmatrix}^T \cdot \begin{pmatrix} 18 \\ 120 \\ 45 \\ 60 \end{pmatrix} = 1 \cdot 18 + 0 \cdot 120 + 1 \cdot 45 + 2 \cdot 60 = 183€ \qquad \text{Eq. 26}$$

Finally, the cost-value ratio of this information strategy can be determined:

$$r_{CV,I} = \frac{i_l}{c_{OI}} = \frac{0.85}{183} = 4.6 \cdot 10^{-3} \frac{1}{€} \qquad \text{Eq. 27}$$

As an alternative, it may be decided to provide all necessary information to the person in charge of this activity. This means to change the vector of the provided information topics to

$$\mathbf{i}_p = \begin{pmatrix} 1 \\ 1 \\ 1 \end{pmatrix} \qquad \text{Eq. 28}$$

Then, the information level is

$$i_l = \mathbf{i}_p^T \cdot \mathbf{i}_n = \begin{pmatrix}1\\1\\1\end{pmatrix}^T \cdot \begin{pmatrix}0.15\\0.45\\0.4\end{pmatrix} = 1.0 \qquad \text{Eq. 29}$$

Additionally, the vector of the applied information means (***m**$_I$*) will change.

$$\mathbf{m}_I = \mathbf{i}_p^T \cdot R_{ToMe} = \begin{pmatrix}1\\1\\1\end{pmatrix}^T \cdot \begin{pmatrix}0 & 1 & 0 & 0\\0 & 0 & 1 & 1\\1 & 0 & 0 & 1\end{pmatrix} = \begin{pmatrix}1\\1\\1\\2\end{pmatrix} \qquad \text{Eq. 30}$$

Then, with keeping all cost data the same, the cost of the chosen information strategy is

$$c_{OI} = \mathbf{m}_I^T \cdot \mathbf{c}_M = \begin{pmatrix}1\\1\\1\\2\end{pmatrix}^T \cdot \begin{pmatrix}18\\120\\45\\60\end{pmatrix} = 1\cdot 18 + 1\cdot 120 + 1\cdot 45 + 2\cdot 60 = 303€ \qquad \text{Eq. 31}$$

Therefore, the cost-value ratio of the alternative information strategy is:

$$r_{CV,I} = \frac{i_l}{c_{OI}} = \frac{1.0}{303} = 3.3\cdot 10^{-3}\,\frac{1}{€} \qquad \text{Eq. 32}$$

Thus, it can easily be seen that the original information strategy delivers a better cost-value ratio than the alternative information strategy. In the next paragraphs, the calculation procedure for the cost-value ratio of a chosen qualification strategy is described.

3.3.3 Qualification

The calculation of the cost-value ratio of the chosen qualification strategy is similar. Here, the starting point is as well an activity. The vector of the tasks is ***t***, and the vector of the positions is ***p***. Both are binary vectors and are associated with the considered activity.

Furthermore, R_{TaCa} is the relationship matrix of the tasks and capabilities, which contains the weighted dependency of a necessary capability from the activity task. For example, if $R_{TaTo,12}$ is 0.7, this means that capability 2 has an importance of 0.7 for task 1. Please note that

$$R_{TaCa,ij} \in [0;1] \qquad \text{Eq. 33}$$

and

$$\sum_{j=0}^{n} R_{TaCa,ij} = 1 \qquad \text{Eq. 34}$$

where n is the number of columns. These equations simply mean that the weightings have to be between 0 and 1, and that the sum of the weightings for one task (row) has to be 1.

Similar to the relationship matrix of the tasks, R_{PoCa} is defined as the relationship matrix of the positions and the capabilities, which contains the weighted dependency of a necessary capability from the activity position. For example, if $R_{PoCa,31}$ is 0.3, this means that capability 1 has an importance of 0.3 for position 3. Please note that also here

$$R_{PoCa,ij} \in [0;1] \qquad \text{Eq. 35}$$

and

$$\sum_{j=0}^{n} R_{PoCa,ij} = 1 \quad \text{Eq. 36}$$

Then, the two vectors of capabilities resulting from the activity tasks ($\boldsymbol{c_{Ta}}$) and from the activity positions ($\boldsymbol{c_{Po}}$), respectively, can be calculated with the following equation.

$$\mathbf{c}_{Ta} = \mathbf{t}^T \cdot R_{TaCa} \quad \text{Eq. 37}$$

and

$$\mathbf{c}_{Po} = \mathbf{p}^T \cdot R_{PoCa} \quad \text{Eq. 38}$$

With introducing a weighting for the dependency of the capabilities on the activity tasks (w_t) and the activity positions (w_p), the qualification needs ($\boldsymbol{q_n}$) can be calculated.

$$\mathbf{q}_n = w_t \cdot \mathbf{c}_{Ta} + w_p \cdot \mathbf{c}_{Po} \quad \text{Eq. 39}$$

Again, following equation has to be observed.

$$w_t + w_p \stackrel{!}{=} 1 \quad \text{Eq. 40}$$

Let furthermore be $\boldsymbol{q_p}$ the vector of the provided capabilities (via seminars or other means). Similar to the vectors of the tasks and positions, also $\boldsymbol{q_p}$ is a binary vector with entries at those lines (capabilities) where qualification is actually provided. Then, the qualification level q_l can be calculated by:

$$q_l = \mathbf{q}_p^T \cdot \mathbf{q}_n \quad \text{Eq. 41}$$

Furthermore, a relationship matrix of the capabilities and distribution means, R_{CaMe}, is defined. This is a binary matrix, where an entry in the cell $R_{CaMe,32}$, e.g., means that the capability 3 is distributed using means 2. With the help of this matrix and the vector of the provided capabilities ($\boldsymbol{q_p}$), the vector of the applied qualification means ($\boldsymbol{m_Q}$) can be derived.

$$\mathbf{m}_Q = \mathbf{q}_p^T \cdot R_{CaMe} \quad \text{Eq. 42}$$

Introducing the cost vector of the means, $\boldsymbol{c_M}$, the overall cost of the information provided to the individual, c_{OQ}, can be calculated by multiplying $\boldsymbol{c_M}$ and the vector of the applied qualification means, $\boldsymbol{m_Q}$.

$$c_{OQ} = \mathbf{m}_Q^T \cdot \mathbf{c}_M \quad \text{Eq. 43}$$

Finally, the cost-value ratio of the chosen qualification strategy is calculated by dividing the qualification level with the overall cost of the qualification provided.

$$r_{CV,Q} = \frac{q_l}{c_{OQ}} \quad \text{Eq. 44}$$

Since the calculation of the cost-value ratio of the qualification strategy is similar to that of the information strategy, the interested reader may refer to the calculation example for the information strategy.

3.3.4 Motivation

For the calculation of the cost-value ratio of a motivation strategy, the approach is different. In contrast to information and qualification, motivation needs are not associated with an activity, but with the individual employee. Therefore, the individual and his attributes are the starting point for the calculation.

First, the attributes “unreadiness for qualification”, “risk averseness”, and “loss of power” have to be defined. Since it is not possible to objectively measure these attributes, it is suggested to use expert judgment and a qualitative scale. It has proven to be practical to use a five-step scale, ranging from “very low” to “very high” with the intermediate values “low”, “medium”, and “high” (see, e.g., Hoppe et al. 2004). For further calculation, the qualitative expert judgment has to be mapped to a quantitative scale, see Figure 57.

Qualitative Scale	Quantitative Scale
Very high	1.0
High	0.8
Medium	0.6
Low	0.4
Very low	0.2

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Figure 57: Qualitative assessment scale and assigned quantitative measures.

Then, the values for the attributes “unreadiness for qualification” (u_q), “risk averseness” (a_r), and “loss of power” (l_p) can be determined.

$$u_q, l_p, a_r \in \{0.2; 0.4; 0.6; 0.8; 1.0\} \qquad \text{Eq. 45}$$

With using the qualification level q_l and the information level i_l (see calculation for information and qualification cost-value ratio, respectively), the resistance can be derived.

$$r = \frac{1}{4} \cdot \left[\left(1 - q_l \cdot \left(1 - u_q\right)\right) + \left(1 - i_l\right) + l_p + a_r\right] \qquad \text{Eq. 46}$$

Since no difference in the influence of the attributes on the resistance is described in literature, the resistance is calculated as arithmetic mean of the attribute values. To account for the fact that a lower information level and qualification level lead to a higher resistance, the terms *(1-q_l)* and *(1-i_l)* are used in the above equation. Moreover, since the unreadiness for qualification does not directly affect the resistance, but only indirectly over reducing the effect of the qualification measures, it is included as a multiplicative term for the qualification level q_l. Figure 58 depicts the dependency of resistance on the qualification level and the personal unreadiness for qualification.

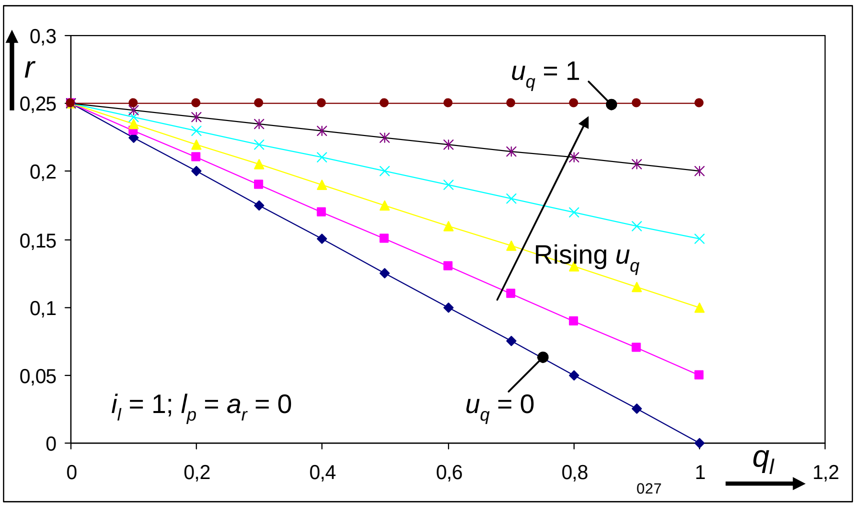

Figure 58: Dependency of resistance on the qualification level and the unreadiness for qualification.

In the next step, the vector of the motivation means, $\boldsymbol{m_M}$, and the vector of the motivation means effects, $\boldsymbol{e_M}$, have to be defined. The vector of the motivation means is a binary vector, with a “1” indicating the applied motivation means. The vector of the motivation means lists the expected effects of the motivation means on the resistance. Since the extent of the effects can only be estimated, it is suggested to apply expert judgment and initially a five-step qualitative scale, ranging from “very low” to “very high”. Also here the qualitative scale has to be transformed to a quantitative scale corresponding to Figure 57. With the help of the defined vectors of the motivation means and the motivation means effects, the motivation intensity, i_M, is calculated.

$$i_M = \mathbf{m}_M^T \cdot \mathbf{e}_M \quad \text{Eq. 47}$$

Thus, the resulting motivation level is

$$m_l = \begin{cases} 1-(r-i_M), \text{for } (r-i_M) \geq 0 \\ 1, \text{for } (r-i_M) < 0 \end{cases} \quad \text{Eq. 48}$$

Basically, the resulting motivation level is derived by subtracting the motivation intensity from the resistance. To determine the cost of the chosen motivation strategy, c_{OM}, the vector of the motivation means, $\boldsymbol{m_M}$, is multiplied with the cost vector of the means, $\boldsymbol{c_M}$.

$$c_{OM} = \mathbf{m}_M^T \cdot \mathbf{c}_M \quad \text{Eq. 49}$$

Finally, the cost-value ratio of the chosen motivation strategy is simply the fraction of the motivation level and the cost of the chosen motivation strategy.

$$r_{CV,M} = \frac{m_l}{c_{OM}} \quad \text{Eq. 50}$$

In contrast to information and qualification, the motivation measures are not able to influence the sources of resistance. These sources, besides the information and qualification level, are on a personal psychological level and therefore cannot be affected by a company strategy. Thus, the motivation measures can only try to compensate the resistance resulting from the individuals’ attitudes. This is reflected by the equation Eq. 48.

3.3.5 Calculation Example for a Motivation Strategy

Let us assume that we have an employee which has a very low unreadiness for qualification and loss of power, but high risk averseness. Furthermore, his or her qualification level is 0.7 and the information level is 0.6.

$$u_q = l_p = 0.2; \quad a_r = 0.8; \quad q_l = 0.7; \quad i_l = 0.6 \quad \text{Eq. 51}$$

Hence, the resistance can be calculated as

$$r = \frac{1}{4} \cdot \left[\left(1 - q_l \cdot (1-u_q)\right) + (1-i_l) + l_p + a_r \right] = \frac{1}{4} \cdot \left[\left(1 - 0.7 \cdot (1-0.2)\right) + (1-0.6) + 0.2 + 0.8 \right] = 0.46 \quad \text{Eq. 52}$$

If we assume that we have the possibility to choose between 4 different motivation means, and we select motivation means number 2 and 4, then the vector of the motivation means, $\boldsymbol{m_M}$, looks the following.

$$\mathbf{m}_M = \begin{pmatrix} 0 \\ 1 \\ 0 \\ 1 \end{pmatrix} \quad \text{Eq. 53}$$

The effects of the various possible motivation means are defined in the vector of the motivation means effects, $\boldsymbol{e_M}$. Figure 59 illustrates the relationship between the qualitative assessment of the motivation means effects and the corresponding expected reduction in the resistance. The following equation shows the resulting vector of the motivation means effects.

Means	Qualitative Assessment	Quantitative Reduction
1	Medium	0.4
2	Low	0.2
3	High	0.6
4	Low	0.2

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Figure 59: Relationship between the qualitative assessment and the expected resistance reduction.

$$\mathbf{e}_M = \begin{pmatrix} 0.4 \\ 0.2 \\ 0.6 \\ 0.2 \end{pmatrix} \qquad \text{Eq. 54}$$

Thus, the motivation intensity, i_M, is

$$i_M = \mathbf{m}_M^T \cdot \mathbf{e}_M = \begin{pmatrix} 0 \\ 1 \\ 0 \\ 1 \end{pmatrix}^T \cdot \begin{pmatrix} 0.4 \\ 0.2 \\ 0.6 \\ 0.2 \end{pmatrix} = 0 \cdot 0.4 + 1 \cdot 0.2 + 0 \cdot 0.6 + 1 \cdot 0.2 = 0.4 \qquad \text{Eq. 55}$$

Since the difference *(r-i_M)* is bigger than zero, the upper line of the following equation has to be used to calculate the motivation level.

$$m_l = \begin{cases} 1-(r-i_M), \text{ for } (r-i_M) \geq 0 \\ 1, \text{ for } (r-i_M) < 0 \end{cases} \qquad \text{Eq. 56}$$

Then, the motivation level is

$$m_l = 1-(r-i_M) = 1-(0.46-0.4) = 0.94 \qquad \text{Eq. 57}$$

The cost vector of the motivation means, $\boldsymbol{c}_M$, defines the cost of the individual motivation means. For this example, it is assumed as

$$\mathbf{c}_M = \begin{pmatrix} 30 \\ 12 \\ 50 \\ 15 \end{pmatrix} \qquad \text{Eq. 58}$$

To determine the cost of the chosen motivation strategy, c_{OM}, the vector of the motivation means, $\boldsymbol{m}_M$, is multiplied with the cost vector of the means, $\boldsymbol{c}_M$.

$$c_{OM} = \mathbf{m}_M^T \cdot \mathbf{c}_M = \begin{pmatrix} 0 \\ 1 \\ 0 \\ 1 \end{pmatrix}^T \cdot \begin{pmatrix} 30 \\ 12 \\ 50 \\ 15 \end{pmatrix} = 0 \cdot 30 + 1 \cdot 12 + 0 \cdot 50 + 1 \cdot 15 = 27€ \qquad \text{Eq. 59}$$

Finally, the cost-value ratio of the chosen motivation strategy is simply the fraction of the motivation level and the cost of the chosen motivation strategy.

$$r_{CV,M} = \frac{m_l}{c_{OM}} = \frac{0.94}{27€} = 3.5 \cdot 10^{-2} \frac{1}{€} \qquad \text{Eq. 60}$$

Alternatively, to apply only the motivation means 3, which means that the cost of the chosen motivation strategy would be

$$c_{OM} = \mathbf{m}_M^T \cdot \mathbf{c}_M = \begin{pmatrix} 0 \\ 0 \\ 1 \\ 0 \end{pmatrix}^T \cdot \begin{pmatrix} 30 \\ 12 \\ 50 \\ 15 \end{pmatrix} = 0 \cdot 30 + 0 \cdot 12 + 1 \cdot 50 + 0 \cdot 15 = 50€ \qquad \text{Eq. 61}$$

However, the motivation intensity also rises.

$$i_M = \mathbf{m}_M^T \cdot \mathbf{e}_M = \begin{pmatrix} 0 \\ 0 \\ 1 \\ 0 \end{pmatrix}^T \cdot \begin{pmatrix} 0.4 \\ 0.2 \\ 0.6 \\ 0.2 \end{pmatrix} = 0 \cdot 0.4 + 0 \cdot 0.2 + 1 \cdot 0.6 + 0 \cdot 0.2 = 0.6 \qquad \text{Eq. 62}$$

With the motivation intensity, the motivation level also rises, but only up to the defined limit.

$$m_l = 1, \text{ since} \left(r - i_M\right) < 0 \qquad \text{Eq. 63}$$

Hence, the cost-value ratio of the alternative motivation strategy is

$$r_{CV,M} = \frac{m_l}{c_{OM}} = \frac{1.0}{50€} = 2.0 \cdot 10^{-2} \frac{1}{€} \qquad \text{Eq. 64}$$

Therefore, the original motivation strategy is better than the alternative motivation strategy with respect to the cost-value ratio.

3.3.6 Summary

Based on the defined qualitative interdependencies, in this chapter, the **necessary equations** for the quantitative model of the personnel-related implementation activities were derived and explained. With the calculation **examples** it has been shown that the proposed quantitative approach can be used to **compare different strategies** for information, qualification, and motivation during the implementation. In Figure 60, the other **objectives** associated with the approach are confronted with calculation results that provide the necessary information.

The **needed information and capabilities** are expressed by the vector of the information needs, $\boldsymbol{i_n}$, and the vector of the qualification needs, $\boldsymbol{q_n}$, respectively. Since these vectors are associated with an activity, the recipient of the information and qualification is equal to the person in charge of the activity, and the due date of the information and qualification is equal to the start date of the activity. A **prioritized list of information topics and capabilities** is provided also by the vector of the information needs, $\boldsymbol{i_n}$, and the vector of the qualification needs, $\boldsymbol{q_n}$, respectively. Through their association with an activity, the task and position in the process, for which the information and qualification is needed, can be derived. On the basis of the calculated **cost-value ratios** of the information strategy, qualification strategy, and motivation strategy, these strategies can be optimized, since all relations are defined quantitatively. Finally, the **individual information level, qualification level, and motivation level** is calculated for each employee, which allows to illustrate the **distribution of information, capabilities and motivation** within the company.

Objectives of the Personnel Strategy Model	Provided Information
Determine the recipients, the needed information and capabilities, and the date when they need it.	(a) Needed information and capabilities are expressed by the vector of the information needs, ***in***, and the vector of the qualification needs, ***qn***, respectively. These vectors are associated with an activity. (b) Recipient is the responsible for the activity. (c) Date is the start date of the activity.
Derive a prioritized list of topics and capabilities for a single task and position in the process.	(a) Prioritized list is provided by the vector of the information needs, ***in***, and vector of the qualification needs, ***qn***, respectively. These vectors are associated with an activity. (b) Task and position is determined by the associated activity.
Determine the cost-value-ratio of the personnel-related implementation activities and thus allow an optimization of cost versus effects.	(a) Cost-value ratios are provided for the information strategy (rCV,I), the qualification strategy (rCV,Q), and the motivation strategy (rCV,M). (b) Optimization is possible, since all relations are defined quantitatively.
Determine the individual information, qualification, and expected motivation level and the respective homogeneity of the measure	(a) The information level (il), qualification level (ql), and motivation level (ml) is calculated. (b) The distribution of the information, qualification, and motivation level within the company can be depicted.

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Figure 60: Comparison of provided information and objectives of the proposed quantitative approach.

Thus, all defined objectives were achieved with the proposed quantitative model of the personnel-related implementation activities.

The presented quantitative model contains **additional degrees of freedom**. For example, the means for distributing information topics could be selected individually for each employee. However, it was chosen to constrict these degrees of freedom for the sake of **model simplicity**. For the same reason, the **model granularity** (e.g., number of attributes considered) and the **model abstraction** (e.g., neglect of stepwise increase of the information means cost) were chosen accordingly.

3.4 Synopsis

Section 3 presented a quantitative model of the personnel-related implementation measures (information, qualification, and motivation). The **main objectives** of the presented quantitative model of the personnel-related implementation measures are to determine the **cost-value-ratio** of the personnel-related implementation activities and thus allow an optimization of cost versus effects, and to determine the **individual information, qualification, and expected motivation level** and the respective **homogeneity of the measure distribution** in the company.

These objectives can be seen as questions that the proposed model has to answer. In order to be capable to answer these questions, the model has to include the **elements** individual, activity, information, qualification, and motivation. To be able to derive their qualitative relationships, the **element's attributes** were determined in chapter 3.1.

In chapter 3.2, the **qualitative interdependencies** between the different model elements and their attributes were defined. Figure 49 shows that these interdependencies are rather complex. The **calculation procedures** for the cost-value ratio of the chosen information, qualification, and motivation strategy have been depicted and explained. The **information topics and capabilities** are core elements in the calculation procedures for the information and qualification strategies. For the motivation strategy **resistance** is the most important element in the calculation procedure. Resistance can be caused by various **triggers**, which can be **compensated** by information, qualification, and motivation. Thus, resistance depends on the **chosen information and qualification level**, and the triggers that can be **directly influenced** by motivation.

Based on the defined qualitative interdependencies, in chapter 3.3 the **necessary equations** for the quantitative model of the personnel-related implementation activities were derived and explained. With the calculation **examples** it has been shown that the proposed quantitative approach can be used to **compare different strategies** for information, qualification, and motivation during the implementation.

The **needed information and capabilities** are expressed by the vector of the information needs, $\boldsymbol{i_n}$, and the vector of the qualification needs, $\boldsymbol{q_n}$, respectively. Since these vectors are associated with an activity, the recipient of the information and qualification is equal to the person in charge of the activity, and the due date of the information and qualification is equal to the start date of the activity. A **prioritized list of information topics and capabilities** is provided also by the vector of the information needs, $\boldsymbol{i_n}$, and the vector of the qualification needs, $\boldsymbol{q_n}$, respectively. Through their association with an activity, the task and position in the process, for which the information and qualification is needed, can be derived. On the basis of the calculated **cost-value ratios** of the information strategy, qualification strategy, and motivation strategy, these strategies can be optimized, since all relations are defined quantitatively. Finally, the **individual information level, qualification level, and motivation level** is calculated for each employee, which allows to illustrate the **distribution of information, capabilities and motivation** within the company.

Thus, all defined objectives were achieved with the proposed quantitative model of the personnel-related implementation activities.

The presented quantitative model contains **additional degrees of freedom**. For example, the means for distributing information topics could be selected individually for each employee. However, it was chosen to constrict these degrees of freedom for the sake of **model simplicity**. For the same reason, the **model granularity** (e.g., number of attributes considered) and the **model abstraction** (e.g., neglect of stepwise increase of the information means cost) were chosen accordingly.

4 Quantitative Model of the Introduction Procedure

Although there is a considerable amount of literature that deals with implementation, in general only qualitative advice is given on how to design the introduction process. To close that gap, this section presents a **quantitative model of the introduction procedure**, the “Introduction Procedure Model”.

In chapter 4.1, the **objectives** of the Introduction Procedure Model are summarized. Since the Introduction Procedure Model can be considered as a **decision process**, it is **structured** accordingly. Chapter 4.2 summarizes the **modeling approach** applied for the Introduction Procedure Model. It is explained how this model can be applied in the case of **distributed implementation initiatives** and how the concepts of **stability**, **modularity**, and **practical rules** support its applicability. The following chapter, 4.3, presents the **objective system** of a concept introduction. To that end, the **introduction axioms and metrics** are defined and arranged in an **assessment system**. Chapter 4.4 shows how the defined introduction metrics are used to **evaluate alternative procedures** for the concept introduction. Finally, the developed Introduction Procedure Model is **applied and verified** in a case study (see chapter 4.5).

4.1 Model Objectives and Structure

In this chapter, the **objectives** of the Introduction Procedure Model are presented. Since a concept introduction can be considered as a **decision process**, the Introduction Procedure Model is **structured** accordingly.

To determine the optimal introduction procedure basically means to determine the optimal sequence of steps for the introduction of the new concept. This is not trivial, since on the one hand, there is generally a large amount of possible introduction procedures, and on the other hand, many aspects are relevant for the evaluation.

Therefore, in this section a quantitative model of the introduction process is presented, which supports the user in finding the optimal introduction procedure, considering the relevant constraints.

The objectives of the Introduction Procedure Model are to:

§ provide an approach to determine the optimal introduction procedure, based on the defined constraints

§ predict the relative effects of the introduction procedure on cost and duration

§ predict the relative effect of the introduction procedure on the quality of the process results, and

§ determine the optimum from the set of alternative introduction procedures.

It is important to note that the objective of the developed Introduction Procedure Model is **not** the **optimization** of the target state. It is assumed that the target state is already fully defined and given. In contrast, the objective of Introduction Procedure Model is to optimize the **procedure** to achieve the target state.

The concept introduction can be considered as a decision process (see Figure 61). At the beginning stands the problem of finding the best way to introduce the new concept. In the next step, the different alternatives for the introduction are modeled. Concurrently, an objective system has to be defined, which determines in which time frame, with which budget, and with which quality the concept introduction has to be conducted. Then the identified alternatives are assessed with the help of the objective system. Finally, on the basis of this assessment a decision can be taken.

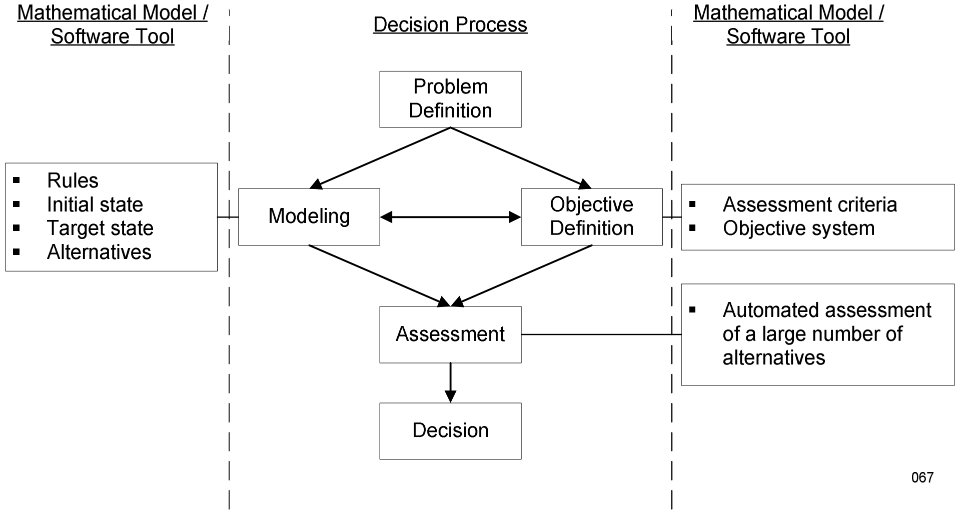

Figure 61: Concept introduction as decision process and supported areas.

It is not the intention of the defined quantitative model and the corresponding tool to substitute this decision process. The goal is rather to support the decision process in selected areas. For modeling, the tool provides the possibility to define the initial state of the process and organization, i.e. before the concept introduction, and the target state, i.e. the process and organization structure after the concept introduction. Furthermore, the user can define practical constraints for the introduction process. These practical constraints set boundaries the different alternative introduction procedures have to adhere to. Finally, the tool allows an automated generation of possible and reasonable alternative concept introduction procedures. For the objective definition, the quantitative model provides already a set of predefined assessment criteria, which can be complemented by the user if necessary. Moreover, the assessment criteria are combined with an objective system for the assessment of the alternative introduction procedures. Finally, the automated assessment in the tool allows the comparison of a large number of alternatives.

This basic structure of the Introduction Procedure Model is also used as chapter structure in this section. First, general information on the introduction process is given, which is a basis to the following development of the quantitative model. In the second chapter of this section, the objective system for comparing the different introduction possibilities is defined. Based on the objective system, the mathematical approach to evaluate different introduction procedures is presented in the following chapter. Finally, the Introduction Procedure Model was applied in a case study at a partner company. The results of this case study are described in chapter 4.5. Figure 62 depicts the chapter structure of this section.

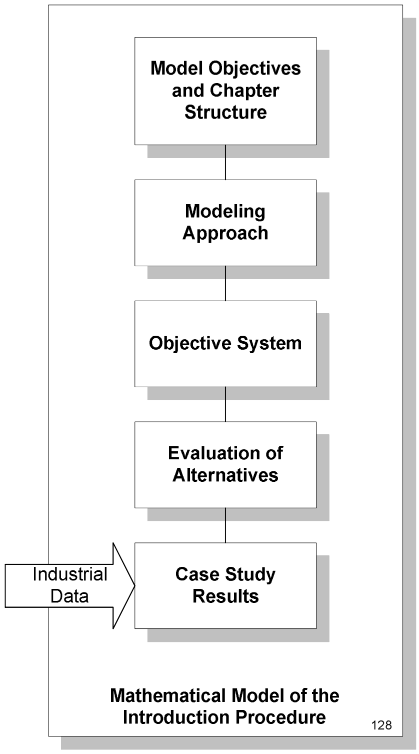

Figure 62: Chapter structure of this section.

Method Definition

The author wants to emphasize that the objective of the developed Introduction Procedure Model is **not** the **optimization** of the target state. The basic assumption of the proposed approach is that the initial state and target state are given. The objective of the Introduction Procedure Model is to optimize the **procedure** to achieve the target state.

The relevant characteristics of a new concept to be introduced are its elements (activities), relations, and the responsibilities. Although these characteristics do not allow a differentiation between method and process, the need to cluster concept elements requires an understanding of the "how", which is a characteristic of a method. Thus, the proposed approach is applicable for both process and method implementation.

The defined approach is **generic**, since it is applicable irrespective of the type of process or method[14] to be introduced.

Summary

The **main objective** of the Introduction Procedure Model is to provide an **approach for determining the optimal introduction procedure**, based on the identified constraints. The concept introduction can be considered as a **decision process**. After the **problem definition**, the different **alternatives** for the introduction are modeled. Concurrently, an **objective system** has to be defined, which is the basis for **assessing** the identified alternatives. Finally, on the basis of the assessment a **decision** can be taken. It is not the intention of the defined quantitative model to **substitute** this decision process, but the Introduction Procedure Model rather **supports** the decision process in selected areas. This basic structure of the Introduction Procedure Model is also used as **chapter structure** in this section.

[14] However, the focus of the present dissertation is the method introduction in the product development process. Therefore, only product development methods are considered.

4.2 Modeling Approach

This chapter summarizes the **modeling approach** applied for the Introduction Procedure Model. It is explained how this model can be applied in the case of **distributed implementation initiatives** and how the concepts of **stability**, **modularity**, and **practical rules** support its applicability.

The implementation of a new concept in a company is generally a complex task. The complexity stems both from the context and the concept. Therefore, strategies are applied to reduce the complexity in the context and the concept area. In the concept area, modularization of the introduction object is a means to determine concept elements (modules) that can be introduced independently (see, e.g., Zeyer 1996, p. 99; Daniel 2001, p. 141 and 157; Tarlatt 122). The introduction context is determined by defining implementation areas, i.e. areas in the company, where the new concept shall be introduced. On the one hand, the implementation areas can be defined with respect to company functions or areas (e.g. departments or business units), which can reach from individual departments to the whole company. On the other hand, the implementation areas can be defined in terms of hierarchy levels; that is, new concepts can be introduced on selected hierarchy levels[15] (see, e.g., Töpfer and Mehdorn 1995, p. 181 f.; Kleb and Svoboda 1994, p. 249; Krüger 1994, p. 211). The interaction of these two approaches for the complexity reduction with the introduction procedure is discussed in the following paragraphs.

The concept introduction is often not restricted to one process area or department. Usually, it comprises several areas or even the whole company. There are two main reasons for defining individual implementation areas (Zeyer 1996, p. 101).

The first is, as mentioned above, the intention to reduce the implementation complexity and thus keep it manageable. To introduce a concept across the whole company requires an extensive management effort and has a high failure risk (Reiß and Höge 1994, p. 33). Therefore, to reduce the risk and the management effort, individual implementation areas are defined, i.e. company areas or departments, in which the concept should be introduced first. However, there is still the possibility to expand the implementation to other company areas in a subsequent step. This approach is a kind of pilot project approach, applied on the macro-level (see also Mourier and Smith 2001, p. 66).

The second reason is that the need for implementing the new concept may be different across the company. The need for implementation has to consider the potential benefit of the concept and the existing competence in the company area (see, e.g., Bartels 1993, p. 206; Grün 1993, p. 100; Daniel 2001, p. 162). If in an individual company area the existing competence in this field is already high, it can be assumed that the implementation failure risk is rather low. If, on the other hand, the potential benefit of the concept in this company area is high, there is a constellation of high return on investment at low risk, which makes the concept introduction in these company areas very attractive.

A matrix with four areas, similar to a portfolio, can be used to determine the company areas where the concept implementation is most promising (Daniel 2001, p. 161, see Figure 63). In this matrix, the dimensions “concept benefit” and “competence” are used to classify the different company areas, which are depicted as circles. Moreover, the size of the circle is related to the expected fulfillment of quality, duration, and cost objectives of the implementation in the corresponding company area.

[15] However, to have the possibility to select a hierarchy level for the introduction is not the normal case. Usually, a concept is focused on one area (e.g. management approaches on management level, design methods on engineering level, etc.).

The company areas in the upper right of the matrix yield a high return on investment at a low risk, and therefore they are candidates for the first phase of the introduction. Concurrently, company areas, which strongly contribute to a fulfillment of the implementation objectives, should be included also in the first implementation phase. Circles in the upper left and lower right corner are company areas, which have either a high competence or expected benefit. They should be included in a second implementation phase. The candidates in the lower left area of the matrix do neither have a high competence, nor provide a high benefit. Therefore, if at all, they should be taken into consideration for a third implementation phase.

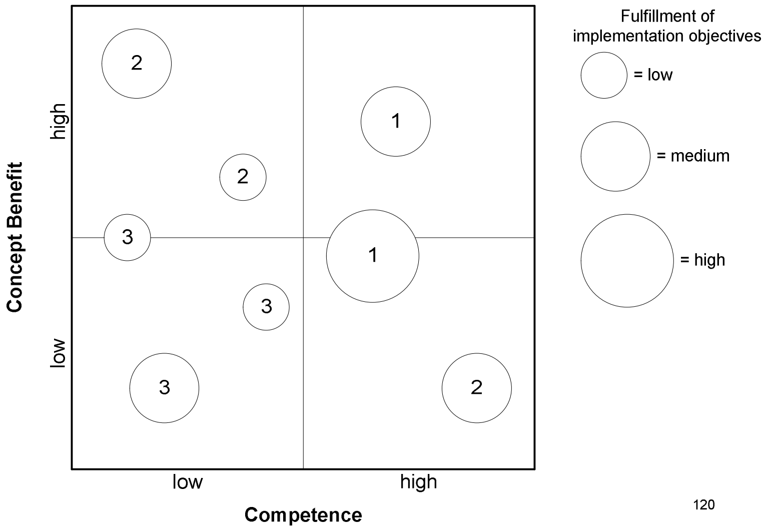

Figure 63: Matrix to determine the implementation areas (adopted from Daniel 2001, p. 162).

Apart from the two main reasons mentioned above, other arguments similar to those for a stepwise introduction of the concept speak for selecting individual company areas for the introduction (Daniel 2001, p. 163). There is on the one hand the possibility that successes in one company area have a positive effect on the acceptance of the people affected. Moreover, restricting the introduction on individual areas potentially leads to faster successes, since the available resources can be concentrated.

Hence, the concept introduction in a company can concurrently be spread over several company areas, as depicted in Figure 64. Although the individual company areas are separated, the respective introduction procedures influence each other. The introduction procedure in one company area goes through different states. For the company area where the concept introduction is conducted first, there may be a high number of intermediate states, since the concept has first to be tested, acceptance among the personnel has to be achieved, etc. However, although the company areas have different process and organization environments, experience from an introduction procedure in one company area may provide important information for another company area (e.g. from company area 1, state 2, to company area 2, state 3). Therefore, a temporal sequence of introduction procedures in different company areas seems to make sense. In effect, this can lead to the omission of individual introduction states in subsequent introduction procedures, since the necessary experience was already made in another department.

However, although there is a link between introduction procedures in different company areas, it only influences the focus of the individual introduction procedure. That is, the objective system will not change, but the importance of the individual introduction objective with respect to the overall objective system changes.

For example, if the concept has already been tested in another company area, an introduction in parallel to the existing process does no longer have a high importance, since the risk associated with the introduction is low. Similarly, if there is a high acceptance among the personnel of the new concept, the introduction procedure does not have to be designed to take into account resistance.

Thus, it can be summarized that in general the implementation of a new concept is conducted concurrently in several company areas. These introduction procedures may influence each other in terms of the information they provide for each other, but usually an introduction procedure in one company area does not depend on the design of the introduction in another company area. Hence, the objective system for the introduction does not change, but the importance of the individual objectives does. The objective importance is reflected in the Introduction Procedure Model by its weighting (see chapter 4.3.3), which has to be adapted for company and project specific purposes. Therefore, the Introduction Procedure Model can be applied to determine the best introduction procedure for an individual company area, based on the defined importance of the introduction objectives, without losing its general validity.

If, however, the introduction procedures in two different company areas are linked in terms of the process or organization system, the two areas can be considered as one integral part in the Introduction Procedure Model.

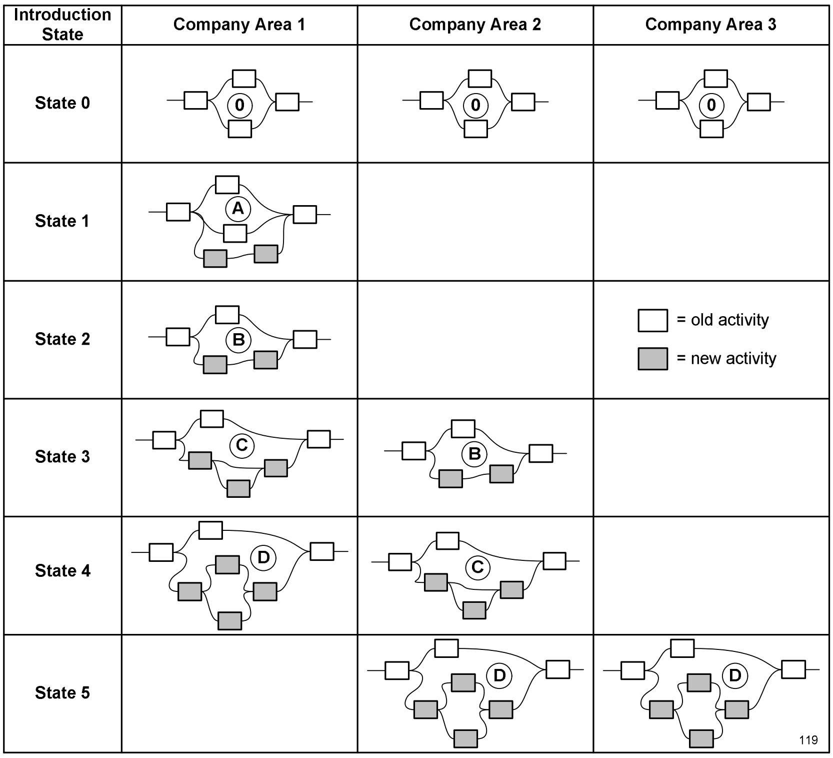

Figure 64: Concept introduction in different company areas / departments.

To appropriately delimit the process system to be considered, first the direct connections of process elements should be taken into account. That is, in a first step only those activities should be included in the process system that have a direct connection to the activities that change, are removed, or are introduced. In a second step, those activities should be included in the process system where change propagation has a considerable effect.

The second approach to reduce the complexity of the introduction is the modularization of the concept. In most cases, concepts have a modular structure, which allows using only selected parts in the beginning, and adding others later in the process. Only if the concept can be divided into at least two modules, the introduction can be stepwise.

Concept modules are integral parts within the concept. They consist of two or more activities with associated relations, which only together produce a reasonable and usable output. For example, individual activities of the new concept may produce information, which can only be processed by other concept activities. Therefore, these activities should be introduced concurrently. To ensure the concept functionality and thus the company operability, the concept modules have to be introduced as a whole in the company.

There are several reasons for the modularization of a concept. First, the modularization supports the understanding of the concept (Daniel 2001, p. 141). Especially if the implementation task is only described vaguely, it is very important to analyze the implementation object and determine its components and their relations.

Second, modularization is necessary if parts of the concept to be introduced already exist in the company (Reiß and Höge 1994, pp. 33-35; Knebel 1994, p. 63). Since more complex new concepts consist of a variety of elements and affect several company areas, it is very probable that there are already competencies in the company for individual concept elements. Thus, these context elements can either be omitted, or they have to be specifically adapted to the company needs.

Moreover, bounded rationality or restricted resources make it necessary to introduce the concept step-wise. To derive a reasonable sequence for the concept introduction, it is necessary to know precisely the concept elements, but also the relations between those elements.

Finally, the company context can also be a reason for the modularization. The business units of larger companies are often geographically spread. Different cultures or legal aspects require an adaptation of the concept that takes these aspects into account. If parts of the concept are introduced in areas with a different cultural or legal background, it is necessary to define the concept modules and their relations to be able to appropriately adapt the individual modules.

The intention of modularization is to define concept parts that have few interrelationships to other concept parts (external relations), but can have a high number of internal relations. These concept parts are called modules. Modular system architectures have advantages in simplicity and reusability (Browning 2001, p. 293). One approach to determine the optimal modularization of a system is the Design Structure Matrix (see, e.g., Browning 2001, p. 292; Baldwin and Clark 2004, p. 11).

After the concept modules and their relations have been determined, their importance should also be defined. Daniel (2001, p. 146) suggests to determine the module importance based on the dimensions of existing competence in this area and potential benefit. Yet this classification is too narrow, since there are more than these factors that influence the module importance. There are two aspects of a module importance: one is the importance of a module for other concept elements, the other is the importance of a module for the company.

A module may serve as catalyst, supporting the introduction and the performance of other concept modules. Transfer effects are generated through the early introduction of catalysts, and the overall performance of the concept introduction can be increased (Reiß and Zeyer 1994, p. 40).

The relation between two modules can be not only supportive, but also enabling. That is, one module can be a prerequisite for another concept element. For example, the implementation of team structures (module 2) requires technical adaptation and organizational restructuring of the company (module 1). However, if the existing structures are sufficient for a transition period, both modules can be introduced independently (Zeyer 1996, p. 131).

The main importance of a module for a company stems from its contribution to the expected concept benefit. If, for example, modules with high and fast monetary effects are introduced in early phases, the timing of implementation measures can generate additional budgets for the method implementation (Kaufman 1971, pp. 48-51; Reiß 1993, p. 554; Reiß 1994, p. 17).

But benefits in other areas (e.g. process duration, quality of the information produced) are also conducive to the introduction acceptance, since the people affected get convinced of the concept advantages. According to Stetter (2000, p. 124), to realize the modules with the fastest and highest benefits first is the main guideline for the development of a gradual introduction approach.

However, the introduction risk is also a factor determining the module importance. In general, modules with a lower success probability should be introduced first, i.e. they should be assigned a higher importance. If these modules do not fail, the overall uncertainty of the introduction project has decreased more than if modules with a higher success probability would have been introduced (Lehner 1996, p. 108).

Finally, the modules can differ in terms of their contribution to the introduction acceptance, duration, or cost goals. There, those modules that contribute more to the fulfillment of these goals are more important.

Thus, it is not sufficient to determine the module importance only based on the existing competence and the potential benefit. Figure 65 provides a checklist with important aspects for determining the module importance. However, this list cannot be considered as complete and has to be adapted also to company-specific constraints.

✓ Contribution to concept benefit

✓ Introduction risk

✓ Prerequisite for other modules

✓ Catalyst for other modules

✓ Company competence in this area

✓ Contribution to introduction acceptance, duration, or cost goals

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Figure 65: Checklist for determining the module importance.

In literature often scaling is described as another approach for reducing the introduction complexity. However, scaling either refers to a scaling of the context or to a scaling of the concept. The scaling of the context is equivalent to determining the introduction areas and is already described above. One aspect of concept scaling is to determine the concept elements are executed, which is equivalent to the described modularization. The other aspect is the extent[16] to which the individual concept elements are executed. The latter aspect has mainly effects on the learning and is considered in the Introduction Procedure Model through the learning curve.

The concept introduction in a company is considered as a sequence of steps until the “target state” is reached (see Figure 66). The target state is the point where the introduction can be considered as complete. Each step comprises one or more changes that are made to the system (process or organization), which lead to temporarily stable system structures, the “intermediate states”. The changes between two intermediate states or an intermediate state and the target state can be collectively denoted as transition of the system.

To evaluate or describe an introduction, where certain intermediate states are mandatory, the Introduction Procedure Model can be applied several times with using the mandatory intermediate states as target states and, in turn, using the target states of the previous run as initial state of the next run.

[16] With respect to quality, exactness, amount of data considered, etc.

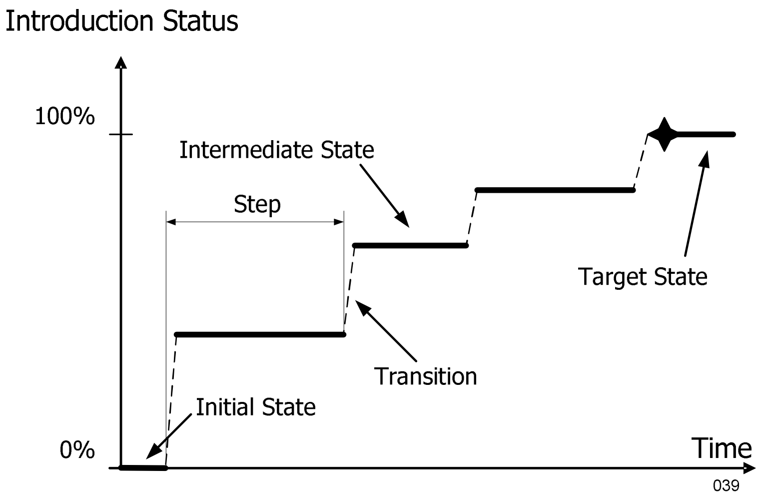

Figure 66: Steps in the concept introduction.

The modeling objective of the Introduction Procedure Model is to determine the alternative introduction procedures, only based on the initial state, the target state, and defined rules for the introduction. The approach in the quantitative model for the generation of possible and reasonable alternative introduction procedures (modeling) will be described using an example. Figure 67 shows the initial and target state of the process system for this example.

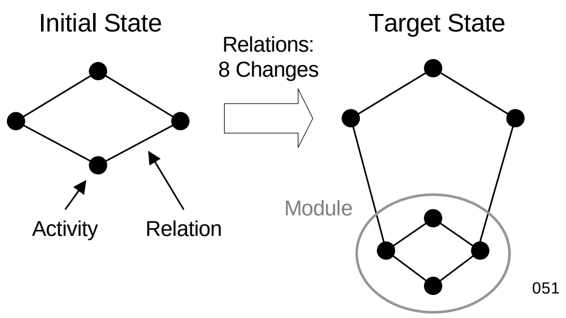

Figure 67: Initial and target state of the modeling example.

The activities are depicted as small knots, whereas the activity relations are shown as lines between the activities. The initial state consists of four activities connected with four relations. In the target state four new activities are introduced and one existing activity is removed, which requires the disintegration of two existing relations and the introduction of six new relations (a total of eight changes).

The objective is to determine the alternative introduction procedures, which is achieved by determining the introduction states and the transitions between these states. Then, the alternative introduction procedures are all possible paths from the initial state to the target state. Figure 68 depicts one possible introduction procedure (dotted line) in a graphical representation of introduction states and transitions.

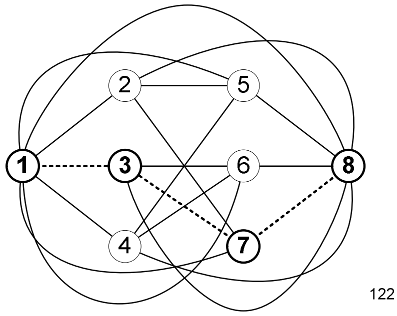

Figure 68: The path of one possible introduction procedure.

First, the set of all theoretically possible introduction states and the transitions between those states are determined. This is a combinatory problem, with n as the number of changes and k the number of changes executed in an individual state. Then, the number of theoretically possible introduction states, N_{ts}, is

$$N_{ts} = \sum_{k=1}^{n} \binom{n}{k} = 2^n - 1 \qquad \text{Eq. 65}$$

The relevant changes for determining the number of states are the introduced or removed relations, since an activity can have one or more inputs and outputs, which means that the introduction of an activity can require one or more changes. Thus, for this simple example the number of theoretically possible introduction states, N_{ts}, amounts to

$$N_{ts} = \sum_{k=1}^{8} \binom{8}{k} = 2^8 - 1 = 255 \qquad \text{Eq. 66}$$

The set of possible alternative introduction procedures contains many intermediate process states, which are not reasonable from an information flow perspective.

This high number already indicates that not all the theoretically possible states make sense. A very simple, yet effective criterion to determine if the modeled introduction state is of practical meaning is its so-called “stability”. Here, the term stability shall describe a state where the information flow in the process is not interrupted. In terms of activities and relations this means that if an activity exists in the process system, it has to have at least one input and one output.

If an activity does not have any input, it does not receive information and thus cannot create reasonable output. On the other hand, if an activity does not have an output, it produces information that is not provided to any other activity. Thus, no dead ends may exist in the process system of the introduction state.

However, there are special activities that can have dead ends. Since the drawing of the system border for the process system cuts off relations with other systems, activities that provide information to or receive information from other systems will lack outputs or inputs respectively. Furthermore, there may be also information sources and sinks in the process that do not rely on any input or output. However, in the Introduction Procedure Model these special activities can be identified on the basis of the defined initial and target state.

Figure 69 depicts three different introduction states from the example above, of which the first and third are not reasonable, since they do not fulfill the stability criterion.

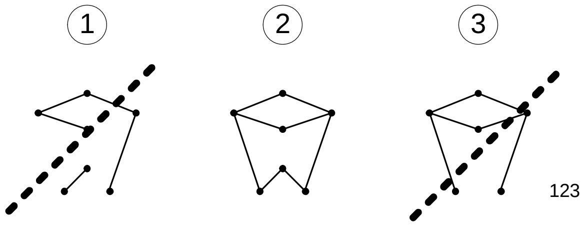

Figure 69: Three possible introduction states.

For the example above, this results in eight different stable states, including the initial and target state (see Figure 70).

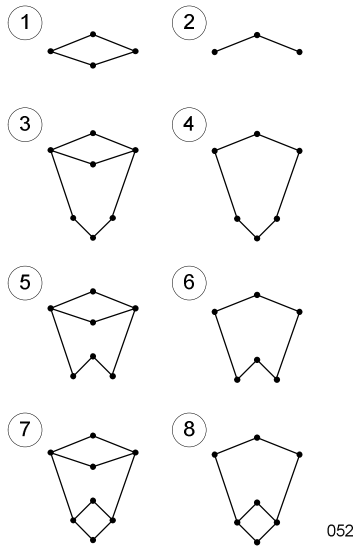

Figure 70: Eight stable states of the example.

In many cases the activities to be introduced form modules that have to be introduced together (see above). Modules are groups of activities which have strong internal relations, e.g. because they mutually depend on information produced by other activities in the module. In the example above, all four new activities form a module; thus the number of stable and modular states is reduced to four (see Figure 71).

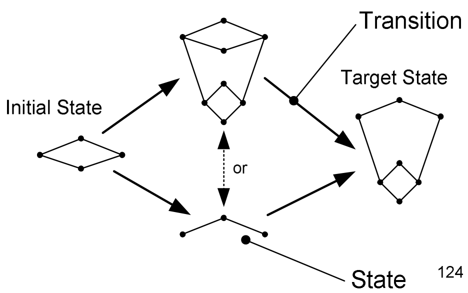

Figure 71: Stable and modular states in the example.

Finally, there may be practical constraints that do not allow following certain introduction procedures. In the example above one intermediate state is considered not reasonable, since the existing activity has already been disintegrated, although the new, corresponding activities have not yet been introduced. Finally, the example above yields one reasonable introduction procedure, which is depicted in Figure 72.

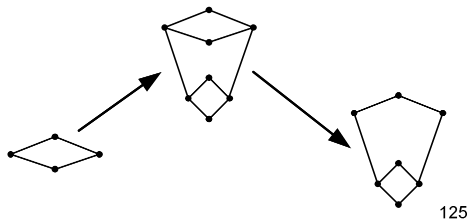

Figure 72: Reasonable introduction procedure for the example.

Figure 73 summarizes the modeling approach in the Introduction Procedure Model to determine the set of reasonable alternative introduction procedures. This set of alternative introduction procedures is evaluated on the basis of the objective system of the introduction. This objective system is described in the following chapter.

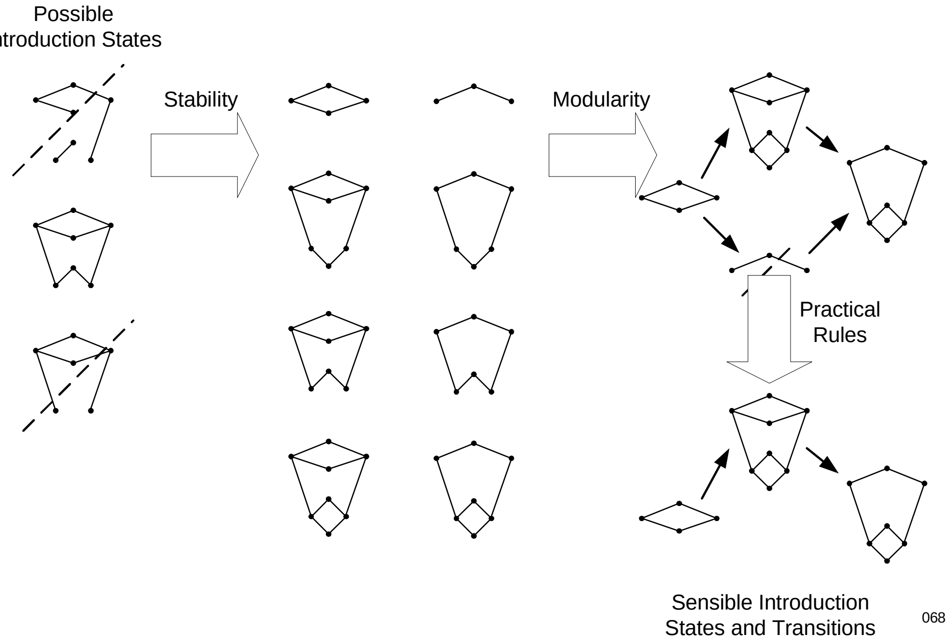

Figure 73: Modeling approach of the Introduction Procedure Model.

Summary

The implementation of a new concept in a company is generally a **complex task**. The complexity stems both from the **context** and the **concept**. Therefore, strategies are applied to reduce the complexity in the context and the concept area. In the concept area, **modularization** of the introduction object is a means to determine concept elements (modules) that can be introduced independently. In the introduction context the complexity is reduced by defining **implementation areas**, i.e. areas in the company, where the new concept shall be introduced.

In general, the implementation of a new concept is conducted **concurrently** in several company areas. These introduction procedures may influence each other in terms of the information they provide for each other, but usually an introduction procedure in one company area does not depend on the design of the introduction in another company area. Hence, the objective system for the introduction does not change, but the **importance of the individual objectives** does, which has to be adapted for company and project specific purposes. Therefore, the Introduction Procedure Model can be applied to determine the best introduction procedure for an individual company area, based on the defined importance of the introduction objectives, without losing its **general validity**.

Concept modules are **integral parts** within the concept. They consist of two or more activities with associated relations, which only together produce a reasonable and usable output. To ensure the concept functionality and thus the company operability, the concept modules have to be introduced as a whole in the company. There are several **reasons for the modularization** of a concept. First, the modularization supports the **understanding** of the concept. Second, modularization is necessary if **parts of the concept** to be introduced already **exist** in the company. Third, **bounded rationality** or **restricted resources** make it necessary to introduce the concept step-wise. Finally, **differences** in various implementation areas require an adaptation of concept parts.

The concept introduction in a company is considered as a **sequence of steps** until the "target state" is reached. The **target state** is the point where the introduction can be considered as complete. Each step comprises one or more **changes** that are made to the system (process or organization), which lead to temporarily stable system structures, the "**intermediate states**". The changes between two intermediate states or an intermediate state and the target state can be collectively denoted as **transition** of the system.

The approach in the quantitative model for the generation of possible and reasonable alternative introduction procedures (**modeling**) was described using an example. The set of possible alternative introduction procedures contains many intermediate process states, which are not reasonable from an **information flow** perspective. A very simple, yet effective criterion to determine if the modeled introduction state is of practical meaning is its so-called "**stability**". Here, the term stability shall describe a state where the information flow in the process is not interrupted. In terms of activities and relations this means that if an activity exists in the process system, it has to have at least one input and one output. In many cases the activities to be introduced form modules that have to be introduced together. Thus, **modularity** is another boundary condition for the modeling. Finally, there may be **practical constraints** that do not allow following certain introduction procedures.

Thus, the applied criterions for the modeling of introduction procedure are:

- Stability
- Modularity
- Practical rules / constraints

4.3 Objective System of an Introduction

This chapter presents the **objective system** of a concept introduction. The objective system consists on the one hand of **introduction objectives** (chapter 4.3.1), which define on a rather high level what a "good" introduction is. On the other hand, the objective system contains **introduction axioms and metrics** (chapter 4.3.2), which define in a very practical way what to do and what to avoid during an introduction. The introduction objectives and the introduction axioms and metrics are combined in an **assessment system** (chapter 4.3.3) for the concept introduction.

4.3.1 Introduction Objectives

This chapter defines the high-level **introduction objectives**, which are the basis for the **top-down definition** of the introduction **objective system**. Together with the introduction axioms and metrics, these form the **assessment system** of the introduction.

To evaluate the performance of a method introduction procedure, the aspects cost, duration, and quality can be applied. Naturally, the method introduction should have low cost and low duration, but at the same time a high quality. While cost and duration can be directly assessed, quality is a complex construct of measures. Introduction quality consists of several aspects, which may be attributed to the quality areas performance sustainment, introduction speed, company operability, introduction acceptance, and concept benefit (see, e.g., Daniel 2001, p. 31 ff.; Nippa 1998, p. 27; Zeyer 1996, p. 136 ff.; Tarlatt , p. 152; Feucht 1996, pp. 75-81; Reiß 1995, p. 278; Grimmeisen 1998, p. 29 f.; Krüger 1999, p. 865).

Performance sustainment comprehends all aspects of the method introduction that may negatively influence the process performance. Process performance here means the quality of the process results, i.e. the process products. Thus, a measure for the process performance is the product quality, the quality of the process products.

The introduction speed describes the pace of the introduction. The faster the method introduction progresses, the sooner the method benefit will be realized. Moreover, resources that are allocated to the method introduction are available again earlier. Similarly, introduction costs tend to decrease with reduced introduction duration.

The company operability is related to the ability of the company to keep the internal processes functional during the introduction. Functional means that the intended process results are achieved and provided to the customer. For the purpose of this objective system, company operability does not include the timeliness and quality of the process results, since these aspects are included in other areas of the objective system: The timeliness of the process results is considered in the introduction duration, whereas the quality of the process results is assessed with the quality aspect performance sustainment.

Another quality area is the acceptance of the introduction procedure from the personnel side. The acceptance of the new method can be decisive for the introduction success. Both acceptance and rejection have a self-reinforcing effect. That is, if the concept is not accepted, it probably is not applied properly and thus the expected benefits do not occur. The absence of the concept benefit will eventually confirm and reinforce the rejection of the new concept.

Finally, also the concept benefit can be found in literature as additional introduction quality area. However, since the concept to be implemented is considered as given, the concept benefit can be neglected when comparing different introduction procedures. Moreover, the concept benefit is indirectly included in this model in the quality area performance sustainment.

All quality aspects may be related to changes in both the process and the organization. Performance reduction, e.g., can be due to a surplus load because new activities are introduced in parallel to existing ones (process) and on the other hand can occur in form of a reduced team performance, resulting from a change in the team composition (organization).

Figure 74 depicts the objective system of the concept introduction.

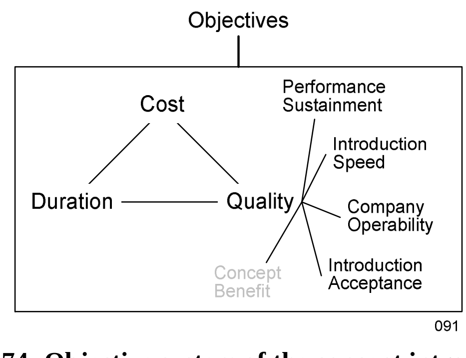

Figure 74: Objective system of the concept introduction.

These introduction objectives are described only qualitatively in literature. That is, there is no approach to quantitatively assess the fulfillment of these objectives.

On the other hand, in literature, many “rules” (axioms) about how to introduce a new concept in a company can be found. These rules are, in contrast to the objectives for a concept introduction, very concrete and describe precisely what to do or what to avoid.

Therefore, axioms that are relevant for the concept introduction were extracted from literature. To be able to quantitatively assess the fulfillment of these axioms, metrics were defined that are connected to each axiom. Finally, to derive a quantitative assessment system, the identified axioms and metrics are attributed to the objectives of the concept introduction.

With this relation between the axioms and the objectives, an assessment system for the concept introduction in a company is established, which can be used to quantitatively evaluate different introduction procedures. Figure 75 illustrates the objective system for the concept introduction schematically.

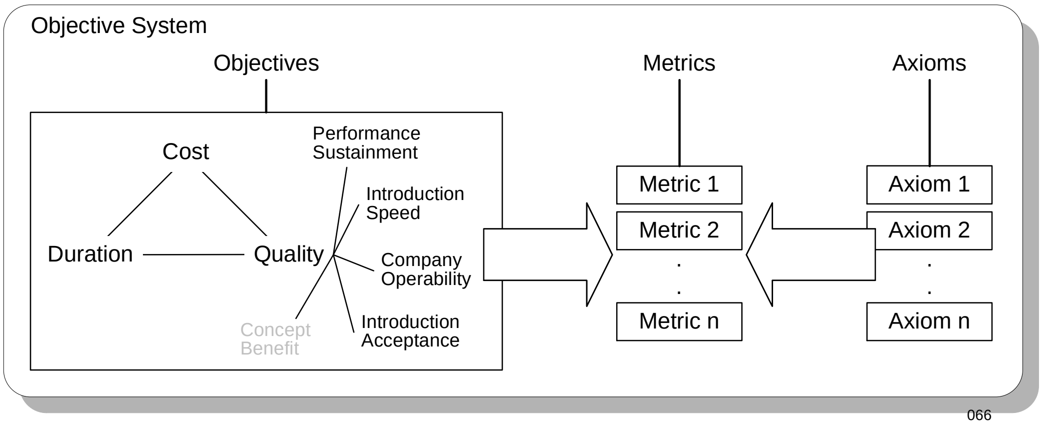

Figure 75: Objective system for the concept introduction.

4.3.2 Introduction Axioms and Metrics

This chapter defines the **introduction axioms and metrics**, which define in a very **practical** way what to do and what to avoid during an introduction. With the defined introduction objectives, the introduction axioms and metrics are combined to an **assessment system** for the introduction.

In literature, many “rules” about how to introduce a new concept in a company can be found. These rules are, in contrast to the objective system for a concept introduction, very concrete and describe precisely what to do or what to avoid.

For example, one rule is that the most important concept elements, i.e. those that are essential for realizing the benefit, should be introduced first. Thus, the employees experience the benefits of the new concept earlier in the introduction process, which supports its acceptance. Moreover, in this way the realistic effects of the new concept can be evaluated earlier, which allows to efficiently adapt the concept to the users’ needs.

Since these rules are self-evident, they are referred to as axioms of the concept introduction[17]. However, usually these axioms are only described qualitatively in literature, which does not allow a comparison of different introduction procedures. Therefore, in the following sections the collected axioms of the concept introduction are described quantitatively with the help of metrics.

[17] Axioms are principles that are expected to be true. They are elementary expressions and therefore do not have to be or cannot be justified within a system.

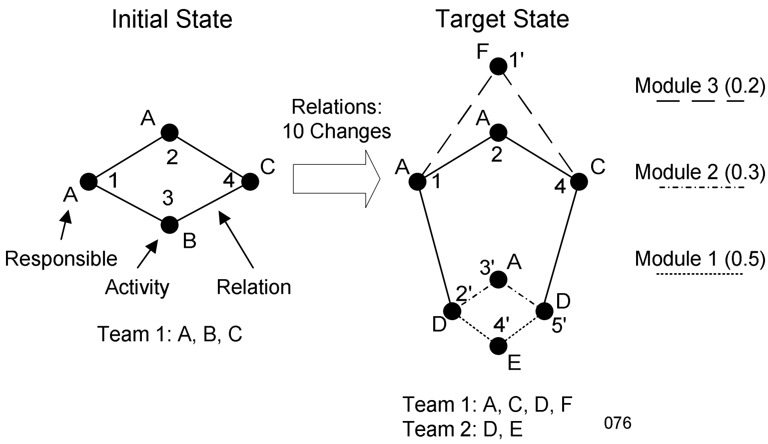

Figure 76: Concept introduction example.

Example

To illustrate the use of the metrics, they are applied to a simple example of a concept introduction. For this example, Figure 76 shows the initial process and organization state in the company before the concept introduction, and the target state after the concept introduction. The activities are depicted as small knots, whereas the activity relations are shown as lines between the activities. In the initial state, the process under consideration consists of only four activities, which are connected by four relations. In the target state, eight activities are connected by ten relations. Each of the activities is denoted with a number; the numbers *1'* to *5'* are assigned to the concept activities.

Beside each knot, the person(s) in charge of the activity is denoted with a capital letter. Below the process view of both the initial and target state, the organization structure of the two states is depicted. For example, in the target state the persons in charge are integrated in two teams, where team 1 consists of the persons in charge A, C, D, and F, whereas team 2 consists of the persons in charge D and E. In the initial state all persons in charge are integrated in one team, which consists of persons in charge A, B, and C.

Moreover, Figure 76 shows also the concept modules and their importance. In this example, the concept to be introduced consists of three modules. Module 1 has the highest importance with an importance factor of *0.5*. Modules 2 and 3 have the importance factor *0.3* and *0.2*, respectively.

To determine the cost of the alternative introduction procedures, the personnel and resource cost of the individual activities have to be known. Figure 77 shows the personnel cost of each person in charge and the resource cost of each activity. Moreover, the overall cost measures derived from the personnel and resource cost are listed in the right column. Each cost value is given in Euro per project. In this way the different introduction procedures can be easily compared over a range of projects.

The overall cost measures summarize the overall resource cost (*TRC*) and personnel cost (*TPC*) of the concept activities, and the overall resource cost (*TCR*) and personnel cost (*TCP*) of the context activities that are removed.

Personnel Cost		Resource Cost		Overall Cost	
Responsible	Cost [€/project]	Activity	Cost [€/project]	Measure	Cost [€/project]
A	24.000	1	0	TRC	1.000
B	30.000	2	0	TPC	81.000
C	24.000	3	2.000	TCR	2.000
D	15.000	4	0	TCP	30.000
E	12.000	1'	0		
F	15.000	2'	0		
		3'	1.000		
		4'	0		
		5'	0		

090

Figure 77: Cost values for the concept introduction example.

Figure 78 illustrates three different introduction procedures for this example. The states of each alternative introduction procedures are arranged in a row. Every state is described by its process structure and its organization structure. The process structure is depicted by its activities (knots) and relations (lines). The organization structure is described by the teams to which the persons in charge are allocated. For example, in intermediate state 1 of procedure III team 1 consists of persons in charge A, B, C, and team 2 consists of persons in charge A, C, D. Certainly, with respect to the organization and process structure, the initial and target states are equal for all introduction procedures.

Since the introduction of the activity relations is a combinatorial problem, theoretically the number of possible states in the introduction procedure is *1024*. However, not all of these possible states are reasonable. To illustrate the application of the metrics, three quite different introduction procedures were chosen.

Introduction procedure I consists of three introduction steps with two intermediate states. This approach has the highest number of introduction steps possible for this example. Thus, it has the slowest progress, but concurrently also a relatively small change scope in each introduction step.

In contrast, introduction procedure II comprises only one introduction step. That is, all concept elements are introduced in one step. Therefore, the introduction progress is very fast in this case. However, on the other hand also the change scope is rather big.

Finally, introduction procedure III is a kind of moderate solution between procedures I and II. Procedure II consists of one intermediate state, thus it splits the concept introduction in two steps. Hence, the introduction progress is lower than with procedure II, but still higher than that of procedure I. Similarly, the change scope for each step is in the middle between those of procedures I and II.

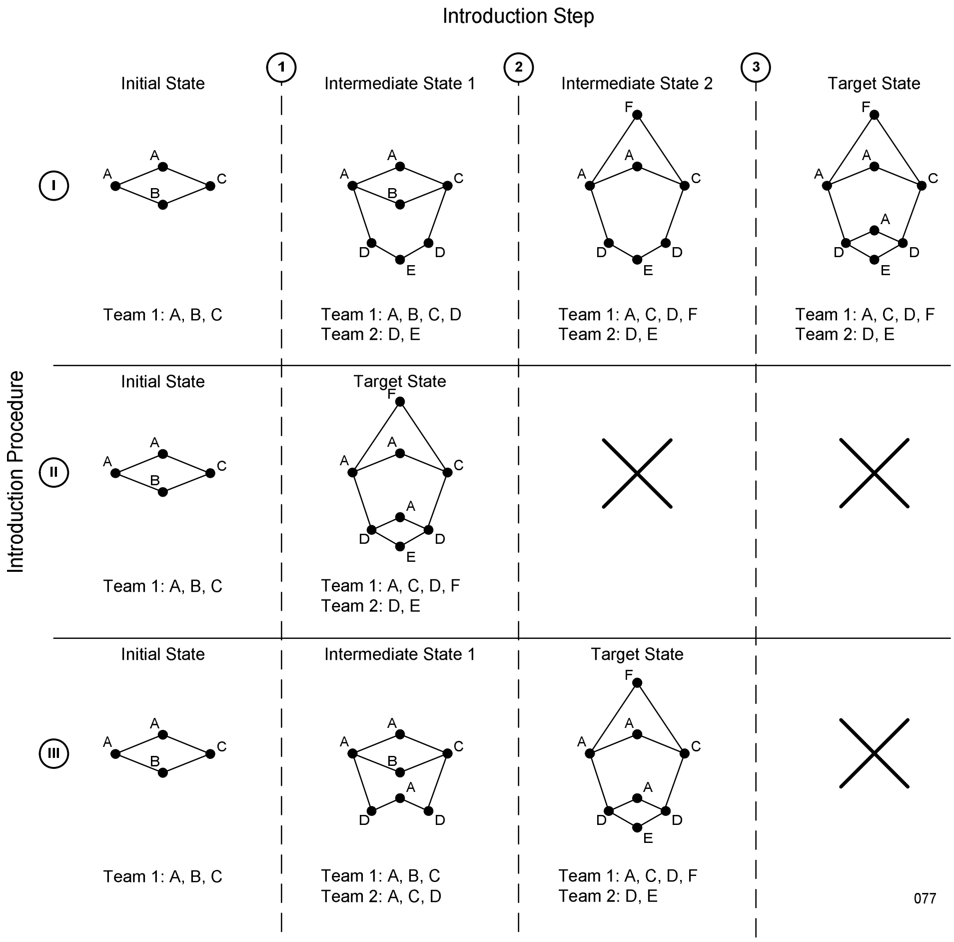

Figure 78: Three different introduction procedures.

In the following sections, the axioms for the concept introduction are described. Moreover, the metrics to quantitatively assess an introduction procedure with respect to the described axioms are presented. These metrics are defined and then illustrated with the help of the example described above.

The introduction procedure is basically a sequence of transitions and states. Starting point is the initial state of the process and organization. Changes to the process and organization system can be considered as a transition from the initial state to the next state. If the introduction is completed with this step, the next step is already the target and final state. Introduction steps therefore consist of a transition and the subsequent state. Figure 79 depicts the structure of the introduction process.

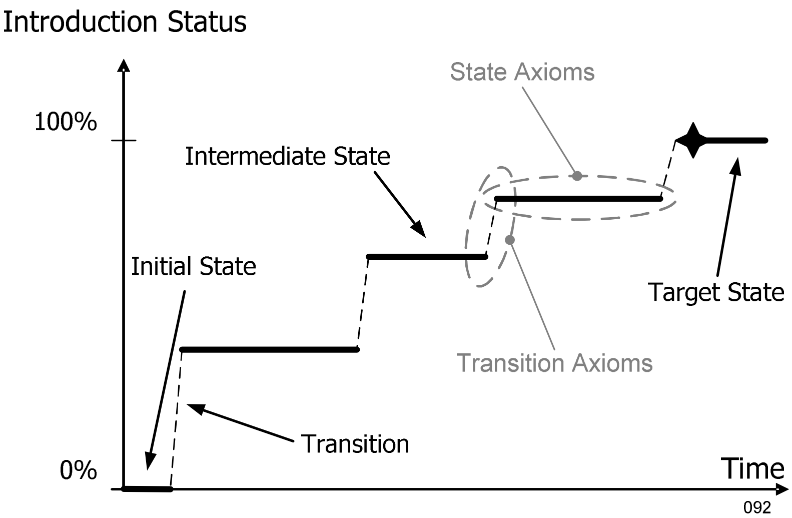

Figure 79: Transitions and states in the introduction process.

This differentiation between transition and state can also be applied for the introduction axioms and metrics. That is, axioms can describe how the transitions should be designed, as well as define what characteristics the intermediate states should have. Therefore, there is a differentiation between state axioms and transition axioms.

State axioms describe the current state of the introduction. They can be evaluated by only considering the current state (n)[18]. Transition axioms describe the transition from the previous state (m) to the current state (n) of the introduction. They can be evaluated by considering the previous state and the current state. Both the transition and state axioms can also depend on general attributes of the introduction, e.g. the number of concept activities. Additionally, the transition axioms may have to be evaluated considering the initial state.

This differentiation is mainly relevant for the quality axioms. The introduction cost is evaluated on the basis of the resource and personnel cost at the states. The costs related to the transition are not considered. Since the concept to be introduced is given, it is assumed that the cost related to the implementation in general (e.g. for information and qualification of the personnel, task forces, implementation boards, etc.) and especially the introduction transition (e.g. investment for new machinery or software, modification cost of buildings, etc.) is equal for all possible introduction procedures.

The introduction duration has two aspects. The first aspect is the duration of the concept introduction with regard to the number of subsequent projects that are necessary to (a) introduce all concept elements, and (b) achieve the expected concept benefit. This number is mainly influenced by the performance reduction due to an introduction step and thus depending on both the transitions and introduction states. The second aspect is the extended duration of the individual projects, due to the changes induced in the process and organization system. This aspect depends also on both the transitions and the introduction states. Therefore, the axioms related to the introduction duration cannot be attributed to state or transition.

The classification in state and transition axioms is helpful for deriving appropriate metrics.

Moreover, the axioms can be classified according to the system type they refer to: process or organization system. Process axioms are related to changes in the process system, whereas organization axioms are related to changes in the organization system. This classification is helpful to connect the objective system and the axioms or metrics, respectively. Since the

[18] Indices: 0 = original state; m = previous state; n = current state; k = index; mn = …between state m and n; m,k = …at state m, for index k.

introduction objectives can be attributed to the process as well as to the organization system, the axiom classification is a first step in attributing the appropriate axioms to the introduction objectives.

The defined metrics are normalized to an interval between *0* and *1*. If the metric value is *1*, the corresponding axiom is fully satisfied, whereas if the metric value is *0*, the evaluated state or transition does not satisfy at all the requirement expressed in the corresponding axiom.

An introduction process can start from diverse initial states, which can differ in terms of size and structure. Size on the one hand refers to the number of activities and relations in the initial state. On the other hand, the structure of an initial state is defined, e.g., by the team composition and the number of teams. Both aspects, the structure and size of the initial state, are relevant for the evaluation of the performance sustainment during the introduction process. It makes a difference if, e.g., *10* new activities are introduced in a process system with *100* existing activities, or in a system with only *10* activities. The change scope induced in the system, and thus also the expected performance reduction, is higher in the latter case. Therefore, this aspect is taken into account in the transition metrics that influences the performance sustainment.

Especially for performance sustainment and introduction acceptance, large change scopes have a superproportional influence compared to small changes. This effect has two reasons.

First, if the changes executed in an individual step are smaller, more steps are necessary to fully introduce the concept in the company. Thus, each subsequent step will introduce the activities and relations in a larger process and organization context. Since the size and structure of the preceding state is considered in the introduction metrics, the assessment tends to yield better values for introductions in several steps compared to a one-step solution.

Second, irrespective of the context size and structure, larger changes create more coordination effort than small changes. The term coordination effort in this case encompasses the effort to realize, coordinate, and stabilize the changes in the process system. The increase in the coordination effort influences mainly the process performance, since the employees are distracted from their original tasks. Thus, this effect is taken into account by calibrating the influence of the metric values on the performance sustainment.

Finally, the sequence of changes is also relevant for the evaluation of the introduction process. In general it is beneficial to introduce smaller concept elements with higher importance at the beginning of the introduction process. In this way, the benefits are realized early, and the change induced in the process and organization system is moderate. The first aspect is taken into account through a separate metric, whereas the second aspect is considered through an adequate representation of the context size and structure in the relevant metrics.

The aim of the present dissertation is to define a model for the concept introduction in a company. Concept introduction in this context comprises the introduction of new activities and relations in a company, as well as the removal of existing activities and relations. Hence, there are two special cases of concept introduction, as it is understood in the present dissertation. First, the concept introduction only consists of introducing new activities and relations, without removing any context elements. Second, the concept introduction only consists of removing existing activities and disintegrating existing relations, without adding any activities and relations. Both situations are included in and thus considered adequately by the presented model.

An important assumption made here is that removing activities and relations does not have any negative influence on the process system. Removing activities and relations (without adding concept elements) basically means that work is reduced, which has rather a positive than a negative effect. Certainly, in some situations psychological aspects may play a role, for example a feeling of worthlessness if responsibilities are withdrawn. However, these aspects in general are restricted to individuals and have only, if at all, a minor influence on the process system. On the other hand, removing activities and relations may have a negative influence on the organization system, if existing structures are changed. This is adequately considered by the organization axioms. For example, the disintegration and creation of team relations are equally considered in the metric Team Change Scope.

Module Importance

The introduction of concept modules realizes the benefit of the new concept in the company. In general, each concept module contributes in a different scope to the expected concept benefit. That is, some modules are more important than others (see chapter 4.2). Therefore, a weighting can be attributed to the individual concept modules, which expresses their importance for and contribution to the realization of the concept benefit. When the more important modules are introduced early in an introduction process, the application of the new concept modules yields higher benefits. Thus, the employees experience the benefits of the new concept earlier in the introduction process, which supports its acceptance. Moreover, in this way the realistic effects of the new concept can be evaluated earlier, which allows to efficiently adapt the concept to the users' needs. Therefore, the most important concept elements should be introduced first.

Axiom Module Importance: *The most important concept modules should be introduced first.*

In some cases individual concept parts may serve as a catalyst for other concept modules. Those catalysts support the introduction and performance of other concept modules, and hence their importance increases. The early introduction of catalysts generates transfer effects, and the overall performance of the concept introduction can be increased (Reiß and Zeyer 1994, p. 40).

For example, team implementation can be divided into three integral concept modules, which are introduced in three steps. In a first step, the first module (containing, e.g. controlling systems, qualification, team formation, etc.) is introduced. Since the technical and structural conditions are considered to be sufficient, the eventually necessary improvements can be introduced only in the second step. However, although the adaptation of the existing payment and working time systems is a prerequisite for the success of the team implementation, because of the required planning and coordination effort, it is only possible to realize it in the third introduction phase (Zeyer 1996, p. 131). This example shows that, when possible, the most important modules should be introduced as early as possible in the introduction process.

Another aspect can be to introduce modules with high and fast monetary effects in early phases. The timing of implementation measures can generate additional funds for the concept implementation (Kaufman 1971, pp. 48-51; Reiß 1993, p. 554; Reiß 1994, p. 17). Similarly, there should be a preference to introduce modules with a lower success probability first. If these modules do not fail, the overall uncertainty of the introduction project has decreased more than if modules with a higher success probability had been introduced (Lehner 1996, p. 108).

When the most important concept modules are introduced first, the employees affected get a realistic insight into the future development system and know more about their role in it at an earlier stage. This involvement helps to avoid resistance, since the employees learn that no disadvantages will arise from the introduction (Stetter 2000, p. 121). Stetter (2000, p. 124) even claims that to realize the modules with the fastest and highest benefits first is the main guideline for the development of a gradual introduction approach.

Figure 80 summarizes the arguments for introducing the most important concept modules first.

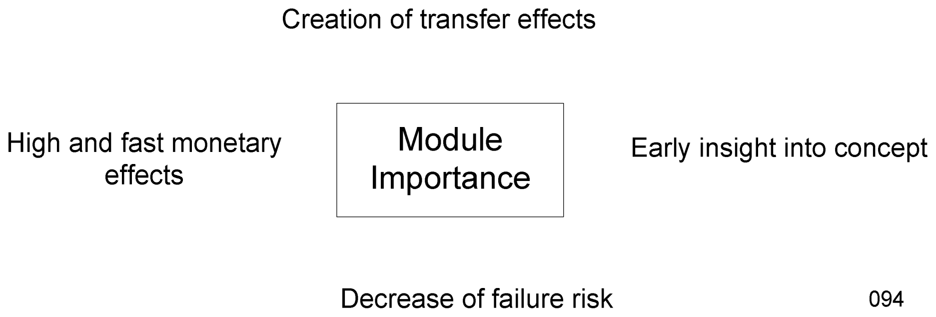

Figure 80: Arguments for the axiom Module Importance.

The metric associated with this axiom has to assess the introduction progress with respect to the importance of the modules introduced. Therefore, the most important measure is the importance of the modules introduced in one step (*MIF*). It is assumed that a factor can be assigned to each module which expresses the importance of the module in terms of financial return, enablers for subsequent introductions, success probability, expected benefit, etc. Since the progress shall be assessed, the importance of the remaining modules to be introduced is calculated by subtracting the importance factor of all the modules introduced up to this step form the overall module importance (*TMI*).

- *MIF* = Importance Factor of Modules Introduced
- *TMI* = Total Module Importance
- *MIA* = Module Introduction Advancement

$$MIA_{mn} = \frac{MIF_{mn}}{TMI - MIF_{0m}} \qquad \text{Eq. 67}$$

Figure 81 depicts the evaluation of the three introduction procedures from the above example on page 99 with the metric Module Introduction Advancement. Introduction procedure II, the one-step approach, shows the fastest progress in terms of module introduction, since all modules are already introduced in the first step. Procedure I starts with the introduction of the most important module, which is also reflected by the metric Module Introduction Advancement. Since in the following step the module with the lower importance factor is realized, the metric value is rather low. Although procedure III starts with the introduction of module 2, which has a low relevance, all remaining modules are realized already in the second step. Therefore, procedure III provides an advantage compared to procedure I in terms of module introduction progress.

In general, the metric Module Introduction Advancement prefers concept introduction procedures with few steps and large introduction scopes. Furthermore, the metric Module Introduction Advancement yields better numbers for large introductions in the early steps. Prerequisite is that the large introduction scopes are connected with a high importance of the introduced elements.

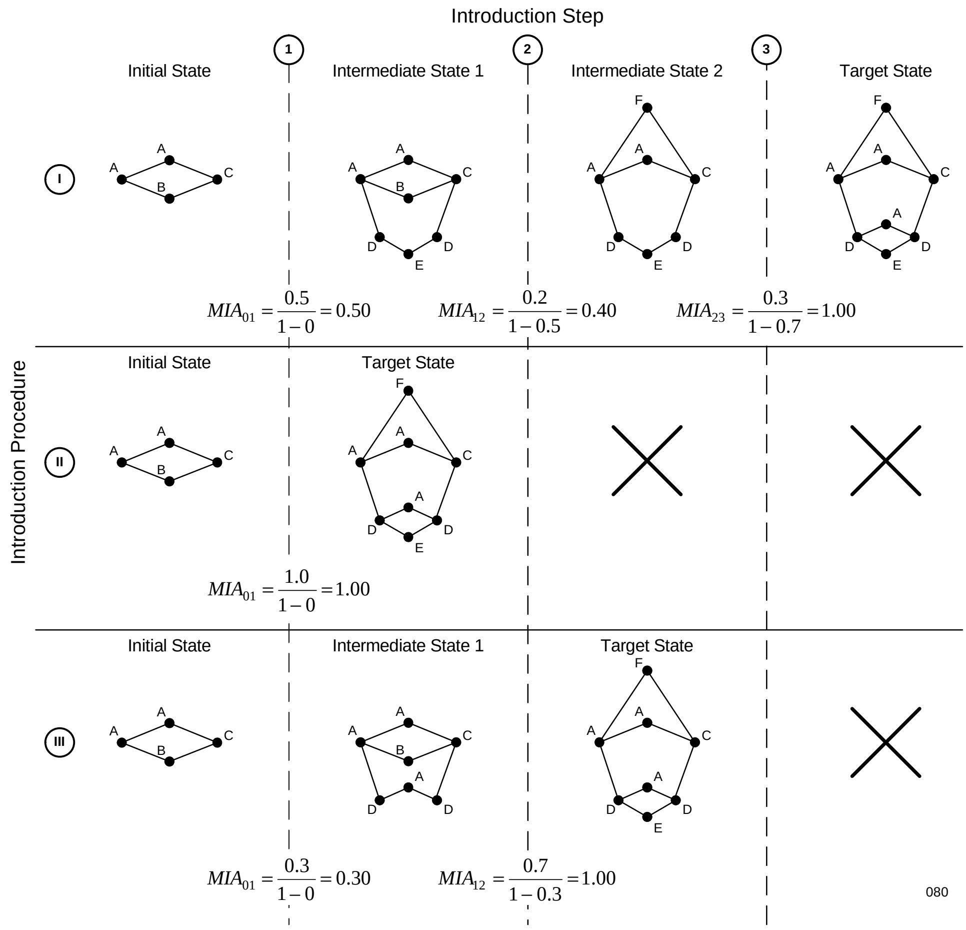

Figure 81: Evaluation of three introduction procedures with the metric Module Introduction Advancement.

Team Change

When a change is induced in the company process system, its organizational system changes as well. If new activities are introduced, new persons in charge may have to be integrated in the existing team structures. On the other hand, if activities are removed, the according team members will be removed from the teams as well. If the extent of the process changes, and thus also the organizational changes, is big enough, it may be beneficial or even necessary to completely restructure the team composition in the respective area. In this way, a new optimal team structure can be found that supports best the information flow between all employees involved. This means that existing teams may have to be disintegrated and new teams may have to be created.

For everybody involved, the change, disintegration, or creation of teams means a changing organizational environment. Within a team, existing relations get lost and new relations have to be created. Moreover, possibly also relations with new teams have to be established.

However, a team change per se would not be anything harmful, if there were no side effects. First, it has to be expected that the team performance declines after the team changes. Second, organizational changes need to be coordinated, which means an additional effort for the people affected. Both aspects lead on the one hand to a decline in the process performance, i.e. a reduced quality of the process results has to be expected. On the other hand, due to the coordination effort and the decline in team performance, acceptance problems may also arise. Therefore, the scope of team changes should be as low as possible.

Axiom Team Change: *The scope of team changes should be as low as possible.*

The coordination efforts occur in three different areas: information, organization / people, and environment.

In the information area, new paths for the information transfer may have to be created. The information transfer within a team is generally different for each team. The team leader or the team members as a group can determine in which way they preferably want to exchange information. This can be, e.g. via e-mail or with printouts in meetings. The coordination effort increases drastically if document servers are used. At least the access rights have to be newly distributed.

Furthermore, new formats may be necessary for the information transfer. This can refer to the way information is transferred, either electronically or in paper format, or to the format of the document itself. In the latter case, it can be necessary to define a new document structure, which allows an easy integration of the document into a higher-level document.

Finally, new information content may be also required. This could be in the form that single sections of a document have to be extended (if the information contained gets more important) or reduced (if the information importance is reduced). But also completely new sections, covering work aspects that were not necessary to be reported before, can be introduced.

Team changes often require changes in the environment. If teams are rearranged, each new team needs to have access to an adequate infrastructure that supports the teamwork. This can be meeting rooms or moderation materials, but also more sophisticated technical infrastructure, like multi-user modeling or document server systems.

Another aspect that has to be considered is to locate the team members near each other. Allen (1977, p. 239; 1997, p. 4) has shown that distance has an impeding effect on technical communication between individuals. He presented the “communication-distance” curve for face-to-face communication in collocated R&D organizations, which shows that technical communication diminishes with distance.

However, Allen (1997, p. 4) uses distance as a substitute for architecture in general. In his paper, he discusses also the influence of office layout, departmental membership, department size, and access to daylight on the decay of communication with distance. Furthermore, he assumes that the communication pattern is independent of the media used (Allen 1997, p. 8).

Sosa et al. (2002, p. 56) support Allen’s view that the distance has a negative effect on the communication frequency across all media (see Figure 82). They suggest that managers should be aware that even if face-to-face communication is substituted by other electronically based communication means, the frequency tends to decrease with distance anyhow. But they also found that this phenomenon could be positively influenced by a high degree of team interdependence, strong organizational bonds, and the use of electronically based communication media (Sosa et al. 2002, p. 55). Thus, co-location of team members is a critical issue.

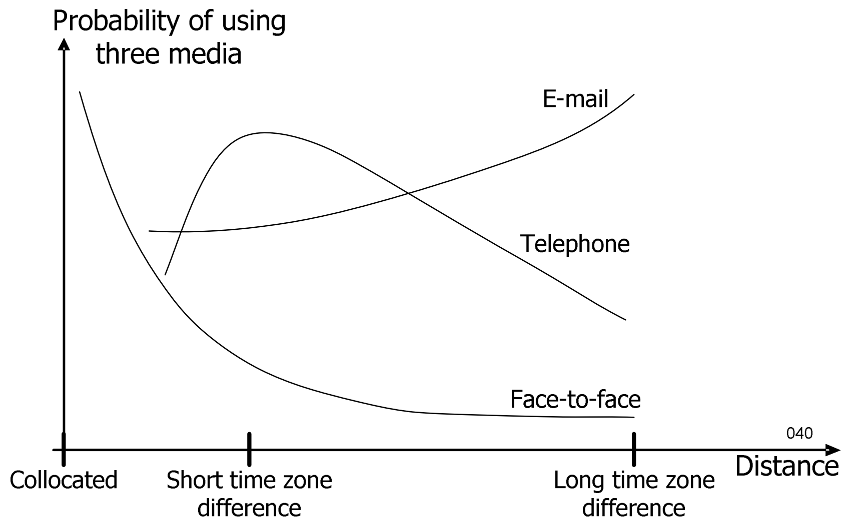

Figure 82: Probability of communication media use depending on distance (adopted from Sosa et al. 2002, p. 48).

Finally, team changes can have an influence on the people and the organizational structure. Depending on the extent of the introduced changes, it can be reasonable to create a new organizational structure, taking better into account the new relations between the employees. On an individual level, former roles in the organization can become obsolete. For example, in new teams also a new team leader has to be assigned. On the other hand, former team leaders of disintegrated teams have to be given a new organizational role. Above all, the latter aspect may lead to resistance among the personnel affected, which has to be especially considered in the introduction.

The preceding paragraphs have shown that team changes can have important effects in the areas of information, environment, and organization / people. These effects have to be accounted for, and adequate compensation measures have to be coordinated. This additional coordination effort leads to a performance reduction in the product development process and negatively influences the quality of the process results.

The second aspect is the decline of team performance after a change in the team structure. Katzenbach and Smith (1993a, p. 118) describe the different forms of "teams". The team classes, with increasing intensity of co-operation, range from working group to pseudo-team, potential team, real team, to high performance team. The team performance, however, does not increase steadily with the intensity of co-ordination, but even declines for the pseudo-team (see Figure 83). That is, the performance of a pseudo-team is even lower than that of a working group.

A pseudo-team, e.g., does not share responsibilities. Its members do not take the risk of conflict, joint work-products, common purpose, and mutual accountability, which is necessary to create a team. Obstacles can make it difficult to move from a potential to a real or high performance team. However, an endless team building process does not help, but the performance has to be the focus (Katzenbach and Smith 1993a, p. 85 f.). To make the way from a working group to a high performance team, an explicit team building process is necessary. The team members need time to learn how to work together, both professionally and personally. Thus, a team will not be fully functional from the start. This means that a decline in the team performance has to be expected when changes in the team structure are induced.

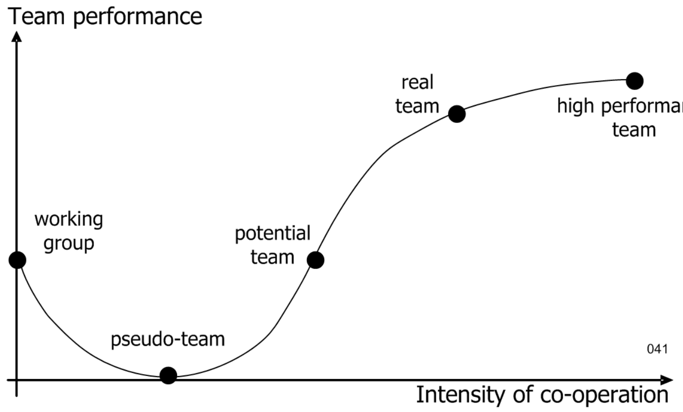

Figure 83: The team performance curve (adopted from Katzenbach and Smith 1993a, p. 84).

To sum it up, the effects of team changes in form of increased coordination effort and reduced team performance suggest avoiding team changes or, if they cannot be avoided, restricting their scope. Both aspects may lead to a decline in the quality of the process results and to resistance among the personnel towards the introduction.

From a general point of view, this is also supported by Viertlböck (2000, p. 94), who warns to make too many changes in a timeframe, which is too short. Zeyer (1996, p. 143; see also Grönlund and Jönsson 1991, p. 201; Ackerman 1997, p. 53) mentions the restricted learning capacity (bounded rationality) of the employees as a determining factor for the extent of changes. He suggests applying temporally graded individual initiatives, since the expansion of the planning horizon requires a high planning and preparation effort as well as an intensive support during the introduction.

In addition, provisional arrangements get more important the bigger the changes are in one step (Zeyer 1996, p. 290). Provisional arrangements are concept constituents with a temporary character. They are intended to assure the functionality during the transition. Although often necessary and beneficial, they require coordination and thus constitute an additional effort.

Schmidt (1997, p. 59) supports the view that the employees should not be overwhelmed by the introduction. It has to be observed that the employees often feel that “small” changes (from the company point of view) are not small at all for them. Thus, the scope of the introduction in general, and especially with respect to team changes, should be considered carefully.

The relations among persons in charge of activities are mainly determined by the information flow between the activities. Despite that, persons in charge that are integrated in one team, although they have no direct relationship based on information exchange, have a relationship on the team basis.

For example, a person in charge who receives and provides information only to one other person has one relation based on the required information flow. On the other hand, this person in charge may be a member of a team with five other persons in charge. Although he provides to and receives information from only one of those five persons in charge, he has to establish and maintain relations with all five team members.

Therefore, for determining the scope of team change, the team relations and not only the relations based on information flow are considered. It can be argued that the information flow relations are more important than the relations that are only based on membership of the same team. This is certainly true, but the presented model does consider the information flow relations to be fixed, that is those relations cannot be disintegrated or “created”. The information flow relations exist if the according information flow exists or has already been introduced, respectively. Thus, assigning a different importance to the information-based and team-based relations would not make a difference for this model. Therefore, the focus here is on the team-based relations in general.

Basic measures to determine the scope of team changes during a transition are the new team-internal relations, the disintegrated team-internal relations, and the new team-external relations between persons in charge of activities. However, there are two different approaches for team building. Both approaches determine the best team structure with respect to the given set of relations between the persons in charge of the process.

Yet, one possibility to determine the best team structure is to make clusters of persons in charge that integrate most of the relations or the most important ones. All other relations that could not be integrated in a cluster of persons in charge, i.e. team, are left outside of the team and thus are team-external relations, which have to be coordinated by the persons in charge affected in direct contact.

The second approach makes clusters of persons in charge and integrates all relations. If it is not possible to include all relations within the individual teams, persons in charge are assigned to more than one team (see, e.g., Yassine and Braha 2003, p. 169). Thus, in effect all relations are integrated within teams and no team-external relations are necessary. In practice, however, often a mixture of the described approaches is applied (see, e.g., Eppinger 2001, p. 157). Wenzel (2002) developed an approach for determining the optimal team structure with respect to "informatoric" dependencies, considering also the cost of the integration.

Since second approach was selected in the present dissertation, the only relevant basic measures for the scope of team changes are the new team-internal relations and the disintegrated team-internal relations.

Figure 84 lists again the arguments for restricting the scope of the team changes.

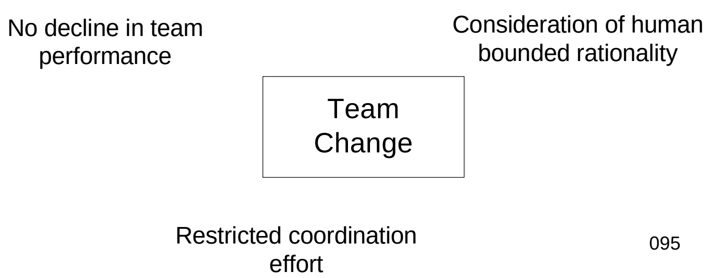

Figure 84: Arguments for the axiom Team Change.

The suggested metric determines the Team Change Scope (*TCS*) depending on the number of new team relations (*NTR*) and the number of disintegrated team relations (*DTR*). For the normalization, both measures are related to the total number of team relations, *TTR*, at state m or n, respectively, and divided by *2*. Finally, this fraction is subtracted from *1* so that the best case yields *1* as metric value.

- § *NTR* = Number of New Team Relations
- § *DTR* = Number of Disintegrated Team Relations
- § *TTR* = Total Number of Team Relations
- § *TCS* = Team Change Scope

$$TCS_{mn} = 1 - \frac{1}{2}\left(\frac{NTR_{mn}}{TTR_n} + \frac{DTR_{mn}}{TTR_m}\right) \qquad \text{Eq. 68}$$

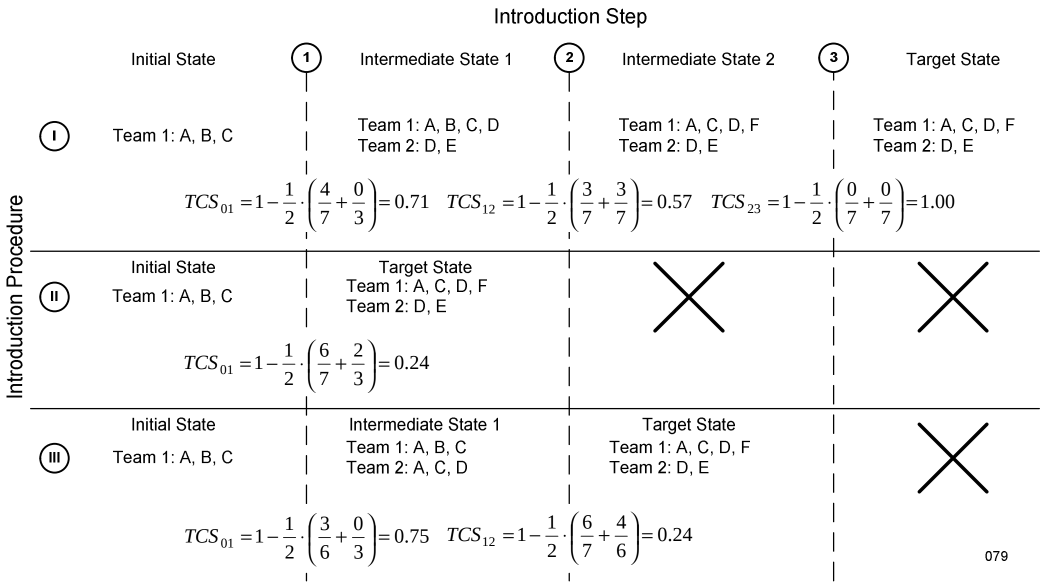

Figure 85: Evaluation of three introduction procedures with the metric Team Change Scope.

Figure 85 shows the evaluation of the three introduction procedures of the example on page 99 with the metric Team Change Scope. The example above shows that procedure II has a low metric value, since all concept elements are introduced in one step and thus also large team changes are necessary. This is also true for the second introduction step of procedure III. In contrast, procedure I induces only moderate changes to the process and organization system. Therefore, the metric Team Change Scope is rather high for this procedure.

The metric value does not depend on the number of introduction steps, or on the scope of the introductions. It is only affected by the scope of the organizational change, which is not directly related to the number of introduction steps or to the change scope.

For the presented metric, only relations that are caused by work-relevant information flows or team membership are considered. However, this does not represent the whole spectrum of communication that occurs in a product development process. Allen (1997, p. 1) describes three different kinds of technical communication (see Figure 86). The first type of technical communication is concerned with work coordination. Since the subsystems or components designed by the engineers have to work together compatibly, the engineers also have to know about each other's design progress. In short, "the right hand has to know what the left is doing". This type of technical communication occurs in almost every type of organization.

Classification	Description
Type 1	Communication to coordinate the work.
Type 2	Communication to maintain staff knowledge of new developments in the area of specialization
Type 3	Communication to promote creativity

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Figure 86: Three types of technical communication (adopted from Allen 1997, p. 1).

In contrast, the second type of technical communication is mainly necessary when the knowledge of the company is highly dynamic. If this knowledge is static, this type of communication is not necessary. If, however, the knowledge is changing considerably in a certain timeframe, it is necessary that the staff be informed. Communication among colleagues plays an important role in this information process.

Additionally, there may be a need for communication to promote creativity. This type three communication is difficult to predict and to manage. However, if there is a need for creativity in the design process, which in most cases is, architecture is an important factor, since it can impede or support this type of communication.

Sosa et al. (2002, p. 49) and Morelli et al. (1995, p. 216) support this classification of technical communication, although labeling it differently.

In the present dissertation, only the first type of technical communication is considered. This means, only the work-related information flows that occur within a team are taken into account. Although this is a simplification, it is assumed not to be harmful for the generality of the approach. The highest effect on team performance, coordination effort, and acceptance has to be expected when relations are changed that are based on a type one technical communication.

Activity Coordination

The introduction of concept activities contributes on the one hand to the expected concept benefit. However, on the other hand there are several reasons that suggest restricting the scope of the activity introduction. For example, the employees are not able to cope with an arbitrary complex introduction. The scope of the introduction has to be adapted to their bounded rationality. Furthermore, larger changes increase the need for provisional arrangements in the introduction, which create effort, but do not contribute to the benefit. Finally, the possibility to test the concept (either locally, i.e. in a restricted company area, or modularly, i.e. only parts are introduced) before fully introducing it opens the possibility to adapt it to the users' needs more specifically and decreases the risk of introduction failure.

Therefore, the scope of the introduction of new activities should be as low as possible.

Axiom Activity Coordination: *The scope of the introduction of new activities should be as low as possible.*

One reason for restricting the number of activities introduced in one step is the bounded rationality of humans (Grönlund and Jönsson 1991, p. 201; Pellegrinelli and Bowman 1994, p. 25; Tarlatt 2001, p. 180; Ackerman 1997, p. 53). There has to be a tradeoff between a synoptic and incremental introduction approach, which takes into account the human bounded rationality, and defines an introduction procedure in several steps, with a realistic scope of the single steps. Ackerman (1997, p. 53) emphasizes that care must be taken not to overload or paralyze the people affected with the complexity and magnitude of the change. Also Kraus et al. (2004, p. 173) describe the optimal introduction speed (and thus scope of activities introduced in one step) as determined by two extremes. One extreme is a very slow introduction, which does not introduce the necessary changes on time; the other extreme is to change too much too fast, which overstrains the employees.

Concept elements that solely have the purpose to ensure the functionality of the process in the transition are denoted as provisional arrangements. Zeyer (1996, p. 290) emphasizes that big introduction steps tend to increase the need for those provisional arrangements. That is, the more activities that are introduced in one step, the higher the probability that provisional concept modules have to be provided. Although those provisional concept modules are reasonable and necessary in some situations, they do not contribute directly to the concept benefit, and should not be used.

Stetter (2000, p. 123) sees the possibility to test the concept as another advantage of a gradual approach for the introduction. An “all-at-once” approach will in general be too risky since the introduced methods and tools cannot be sufficiently tested in their application environment. If the methods and tools are tested under realistic conditions, defects or weaknesses can be found and removed. This means that a negative effect on the process performance can be avoided. Furthermore, a gradual approach provides the possibility to consider the ideas and needs of the users in the next step of the introduction. This makes sure that the concept can be better adapted to the user’s needs, and increases the acceptance of the introduction.

For the acceptance of the introduction, it is beneficial not to conduct too many introduction measures in a short timeframe. Although the changes may seem small from an external point of view, the affected personnel often experiences the changes as enormous (Viertlböck 2000, p. 94; Daniel 2001, p. 149). Moreover, the implementation and stabilization of changes in the company culture or way of thinking cannot be achieved through an “all-at-once” approach.

Another aspect is the complexity of the introduction. The risk of failure is much higher for an “all-at-once” approach compared to a stepwise introduction. The complexity of introducing many activities concurrently often overwhelms the persons in charge of the implementation, therefore the approach to introduce the new concept in one or few steps can only be recommended for simple introductions where the introduction effects are clear (Haberfellner et al. 1999, p. 44). Since an incremental approach uses small introduction steps that often focus on an individual organizational area, the stability of the company is preserved (Tarlatt 2001, p. 179).

Moreover, the introduction of activities and relations creates a coordination effort. The term coordination effort in this case encompasses the effort to realize, coordinate, and stabilize the changes in the process system. The coordination effort occurs due to the introduction of activities and activity relations, which has an effect on three different areas: the information, the process, and the environment / infrastructure.

In the information area, the information content produced by the new activities has to be processed. This ranges from data storage to data interpretation. Storing new data requires an extension of the data structure of the company, or even an adaptation of the information technology. The data has to be provided in its context to allow it to become information. Employees who have to use the data need to interpret it in order to derive information (Schulz 2002, p. 71). This interpretation has to be supported by training or other adequate means to enable the employees to perform this transition process.

Moreover, new paths for the information transfer may have to be created. New activity relations are realized either as a personal contact or in the form of a data flow in the information technology system. If the information exchange is based on personal contact and is not already defined by company procedures, an agreement with respect to, e.g., the format and content of the information, and the frequency of the information transfer must be found. In the case that the activity relations are represented in the information technology system, the format and content of the data is extremely important. It must be ensured that it can be used later in the process, thus data content and format must fit the needs of the target activities.

In the process area, the addition of new activities and relations requires that the employees adapt to new tasks and procedures, and that they use new communication channels. The adaptation is realized through learning, which means an additional effort for the personnel. Since learning is a process, it has to be considered that the products of the new activities do not show the expected quality from the start.

Furthermore, the communication channels that represent the activity relations have to be established, which means that either a negotiation process between the transmitting and the receiving employee takes place, or the implementation of the data flow in the information technology system.

With respect to the environment and infrastructure, new activities may also require new tools, machines, or other infrastructure. The infrastructure has to be provided by the company, but nevertheless the employees have to learn to use it. This creates additional effort for both the company in general and the affected employees.

In summary, the introduction of new activities and activity relations demands additional work from the affected personnel, due to changes in the areas information, process, and environment / infrastructure. This additional effort is described as coordination effort and affects both the process performance or the product quality, respectively, and the introduction acceptance.

The influence of an introduction on the coordination effort is described by two metrics or axioms, respectively. The first metric is the Activity Introduction Scope and the second metric is the Activity Relation Introduction Scope.

Figure 87 summarizes the arguments for restricting the scope of the activity introduction.

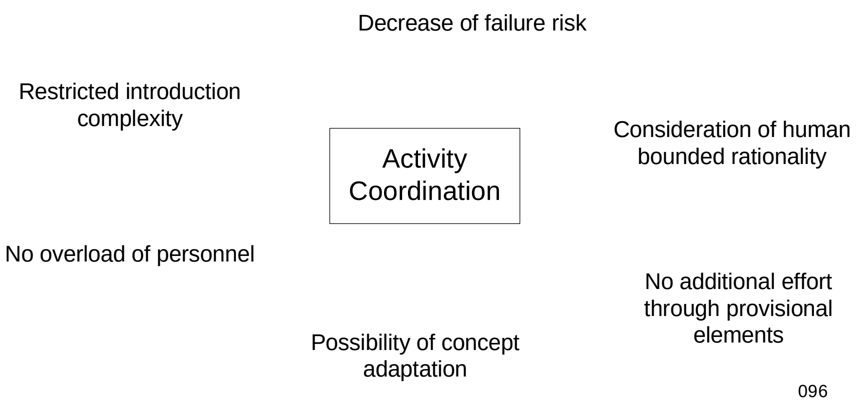

Figure 87: Arguments for the axiom Activity Coordination.

The metric associated with this axiom has to evaluate the scope of the activity introduction in an introduction step. The basic measure for determining this scope is certainly the number of introduced activities (*NAI*). To derive a normalized metric, this measure is divided by the total number of concept activities to be introduced (*TCI*).

However, the number of introduced activities is only one part in defining the scope, since the introduction scope depends also on how many context activities exist. For example, if ten new activities are introduced in a process consisting of one-hundred activities, the activity introduction scope is certainly lower than if the ten new activities are introduced in a process consisting of five activities. Considering the context activities, the different extent of disturbance induced into the process system, depending on the size of this system, is taken into account.

To derive a normalized metric, the number of context activities (*NCN*) at state 0 is divided by the number of context activities at state m. This metric evaluates a “good” transition with a high number, whereas a low metric value indicates that the transition has a bad effect on the process performance.

- *NAI* = Number of Activities Introduced
- *NCN* = Number of Context Activities that are Not Removed
- *TCI* = Total Number of Concept Activity Introductions
- *AIS* = Activity Introduction Scope

$$AIS_{mn} = 1 - \frac{NAI_{mn} \cdot NCN_0}{TCI \cdot NCN_m} \qquad \text{Eq. 69}$$

Figure 88 shows the evaluation of the three introduction procedures of the example on page 99 with the metric Activity Introduction Scope.

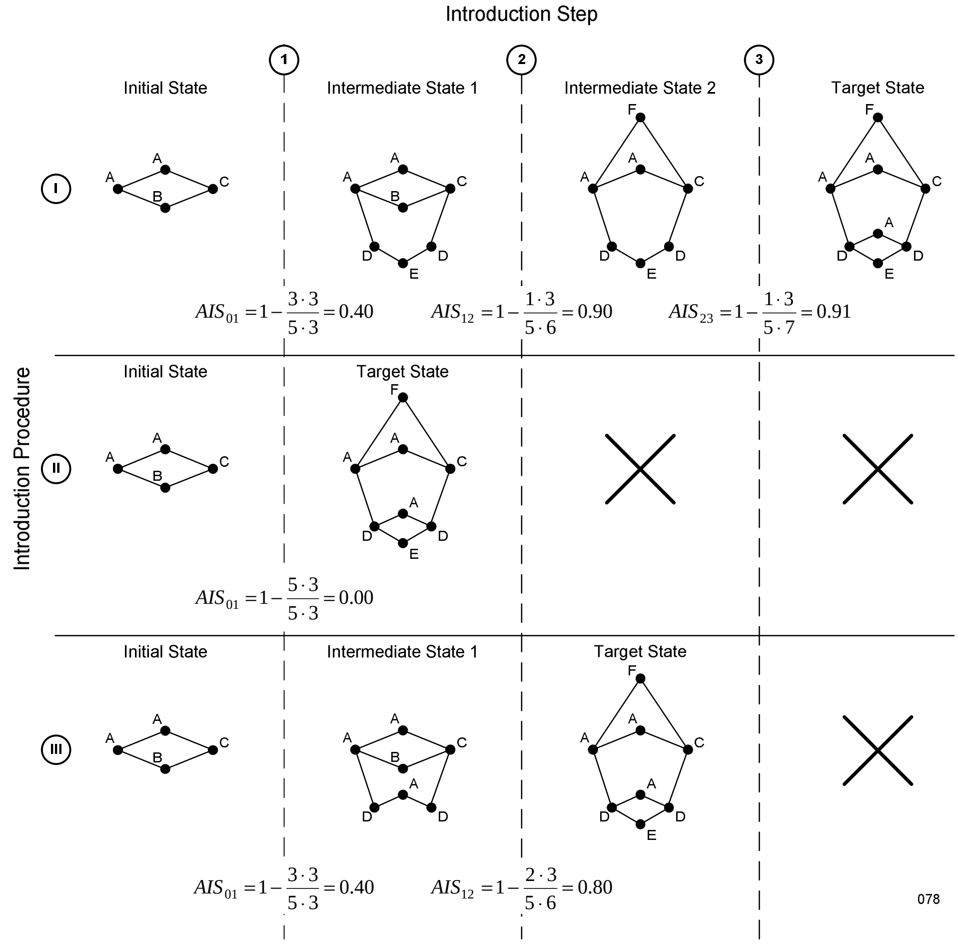

Figure 88: Evaluation of three introduction procedures with the metric Activity Introduction Scope.

The introduction procedure II, the “all-at-once” approach, has the worst metric value. Thus, the introduction procedures I and III are, with respect to the Activity Introduction Scope, clearly preferable compared to the introduction procedure II. For the quality objective Performance Sustainment, the effect of each single introduction step on the product quality is evaluated. Since the metric value has a superproportional effect, the negative impact of procedure I on the product quality will be lower than that of procedure III.

In general, the metric Activity Introduction Scope prefers introduction procedures with small changes and a high number of intermediate states. Furthermore, an introduction late in the introduction process is preferred. If two transitions introduce the same amount of new activities, one earlier and the other later in the introduction process, at the later introduction the number of context activities that are not removed, *NCN*, will be higher and thus the Activity Introduction Scope lower.

Activity Introduction

The faster the concept activities are introduced, the earlier the company will benefit from the concept. Moreover, the affected employees “see” and understand the concept earlier, which contributes to the acceptance. Since the resource allocation to the introduction process is shorter, there will also be a positive effect on the introduction cost. Therefore, the number of introduced activities should be as high as possible.

Axiom Activity Introduction: *The number of introduced activities should be as high as possible.*

Several authors define the introduction speed as an important quality aspect for an introduction (Reiß 1995, p. 278; Grimmeisen 1998, p. 29 f.; Krüger 1999, p. 865; Zeyer 1996, p. 136; Tarlatt 2001, p. 152). In contrast to the axiom Activity Coordination[19], this axiom describes the introduction of a large amount of activities as beneficial. While the axiom Activity Coordination considers the disturbance of the process and organization system, the axiom Activity Introduction relates to the progress achieved with a high introduction speed.

On the one hand, the affected employees get an insight into the concept to be introduced at an early stage. They are able to see and understand the objectives, the process, and the underlying logic earlier and better than if only a small set of the concept elements were introduced (Stetter 2000, p. 121).

Furthermore, in general the overall cost of the concept introduction will be lower if more activities are introduced in one step. If the amount of introduced activities in one step is higher, the number of introduction steps can be reduced. This means that the number of projects with an only partly introduced new concept is lower, and the complete, functional concept is available earlier. Additionally, the concept benefit unfolds earlier in the company, which has reinforcing effects on the acceptance and the quality of the process results.

Another aspect is the allocation of resources. The more steps are used to introduce the new concept in the company, the longer people are concerned with the planning, support, and monitoring of the introduction. These resources are fixed and thus cannot be used in other areas. Therefore, from the point of view of resource allocation a fast introduction should be preferred.

In Figure 89, the arguments for introducing a high number of activities in one introduction step are specified again.

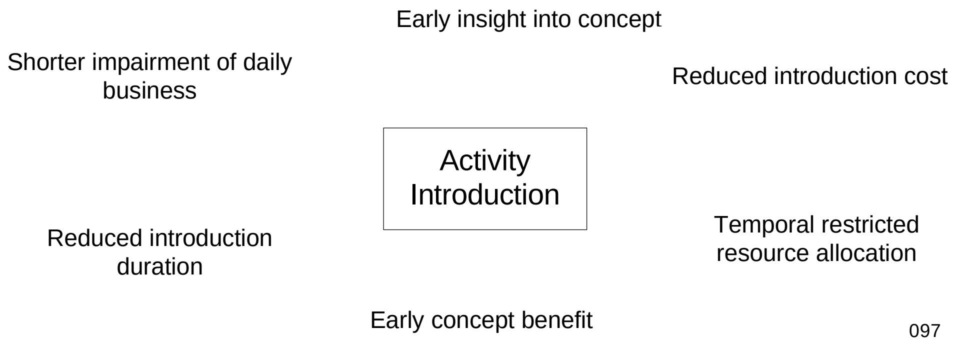

Figure 89: Arguments for the axiom Activity Introduction.

The metric associated with this axiom has to evaluate the progress of the activity introduction. The basic measure for this is the number of activities introduced in the corresponding step

[19] Axiom Activity Coordination states that "the scope of the introduction of new activities should be as low as possible".

(*NAI*). To evaluate the progress and to normalize the metric, this measure is related to the number of activities that still have to be introduced. This number is calculated by subtracting the total number of activities introduced until the previous state m (NAI_{0m}) from the overall number of concept activities that have to be introduced (*CAI*). This metric evaluates a slow progress with a low number, whereas an introduction of all (remaining) activities yields 1 as metric value.

- *NAI* = Number of Activities Introduced
- *CAI* = Number of Concept Activities to be Introduced
- *AIA* = Activity Introduction Advancement

$$AIA_{mn} = \frac{NAI_{mn}}{CAI - NAI_{0m}} \qquad \text{Eq. 70}$$

Figure 90 shows the evaluation of the example presented on page 99 with the metric Activity Introduction Advancement.

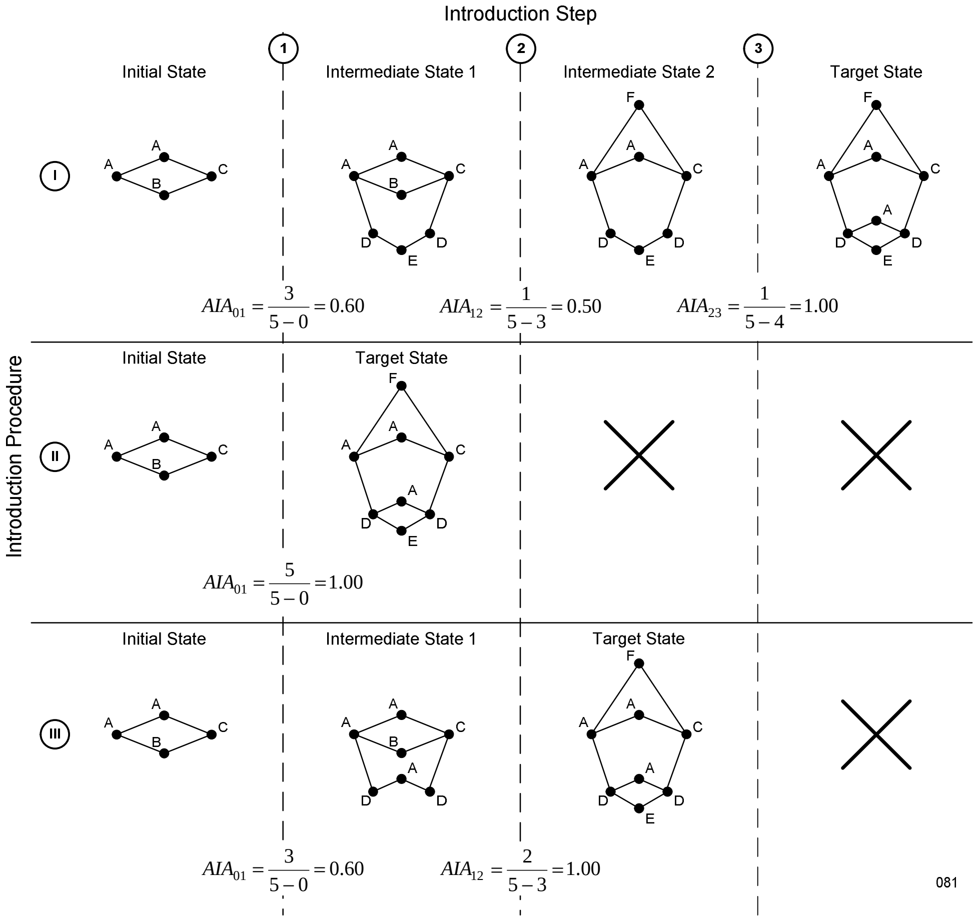

Figure 90: Evaluation of three introduction procedures with the metric Activity Introduction Advancement.

Naturally, for procedure II the metric value for step 1 is *1.0*, since all activities are introduced. In the first introduction step, the introduction procedure I and III have the same metric value, since in both cases three new activities are introduced. However, as procedure I needs two more steps to introduce the remaining activities, the metric yields *0.5* and *1.0*, respectively.

Hence, in terms of introduction progress for the activities, number II is the best procedure, followed by procedure III and I.

The metric Activity Introduction Advancement favors the introduction of a large number of activities, and thus introduction procedures with few steps. Furthermore, to establish activities early in the introduction process results in a higher metric value than a late introduction.

Relation Introduction

The progress in the realization of the new concept not only depends on the number of activities introduced. The concept activities generate new information that is intended to be used in subsequent activities in order to create a benefit for the company. Therefore, it is not sufficient to introduce new activities, but it is essential to connect those activities to preceding or succeeding activities in order to establish an information flow. The introduction progress in general also depends significantly on the progress in the introduction of relations between the activities, which is the basis for the information flow between the activities. With a fast introduction of activity relations, the target state and thus the expected benefit will be achieved earlier. Therefore, the number of activity relations should be as high as possible.

Axiom Relation Introduction: *The number of activity relations should be as high as possible.*

This axiom is contradictory to the axiom Relation Coordination[20], which defines the introduction of a low number of relations as beneficial. The axiom Relation Coordination tries to capture the effect of the relation introduction on the coordination effort in the process system. On the one hand, the additional coordination effort can lead to a decrease in the quality of the process products, on the other hand it can evoke resistance towards the implementation among the personnel. In contrast, the axiom Relation Introduction is related to the introduction speed. Obviously, a high number of introduced relations means a high introduction speed and thus fast progress in the introduction.

In general, the initiators of an implementation prefer an early completion of the implementation (Krüger 1990, p. 281; Daniel 2001, p. 35). The early completion has mainly two advantages. First, the objectives of the implementation, e.g. savings in process cost or time, or improvements in the process results, are achieved earlier. Second, the impairment of the daily business is minimized. Both aspects can lead to cost savings of the concept introduction.

Furthermore, the resource allocation to the concept introduction can be suspended earlier. This releases additional resources in the company and can save overall introduction cost.

Finally, the employees who have to work with the new concept in the future get an insight into its procedure, objectives, and logic at an early stage. This can help to adapt the concept to the company needs already in the first phases of the introduction, which will increase the acceptance and the benefit of the new concept.

Figure 91 summarizes the arguments for introducing a high number of activity relations in an introduction step.

[20] Axiom Relation Coordination states that “the scope of the introduction of new activity relations should be as low as possible”.

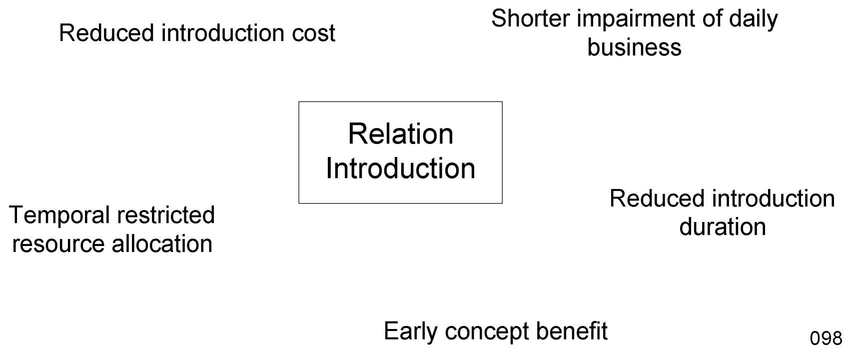

Figure 91: Arguments for the axiom Relation Introduction.

The metric associated with this axiom has to assess the progress of the relation introduction. The basic measure for this is certainly the number of activity relations (NRI_{mn}) introduced in this step. To evaluate the progress and for normalization purposes, this number is related to the activity relations that still have to be introduced. The number of activity relations that still have to be introduced is calculated by subtracting the number of activity relations already introduced (NRI_{0m}) from the total number of concept activity relations (*CRI*). This metric evaluates a slow progress with a low number, whereas an introduction of all (remaining) relations yields *1* as metric value.

- *NRI* = Number of Activity Relations Introduced
- *CRI* = Number of Concept Activity Relations to be Introduced
- *RIA* = Activity Relation Introduction Advancement

$$RIA_{mn} = \frac{NRI_{mn}}{CRI - NRI_{0m}} \qquad \text{Eq. 71}$$

Figure 92 shows the assessment of the three possible introduction procedures from the example described on page 99 with the metric Activity Relation Introduction Advancement.

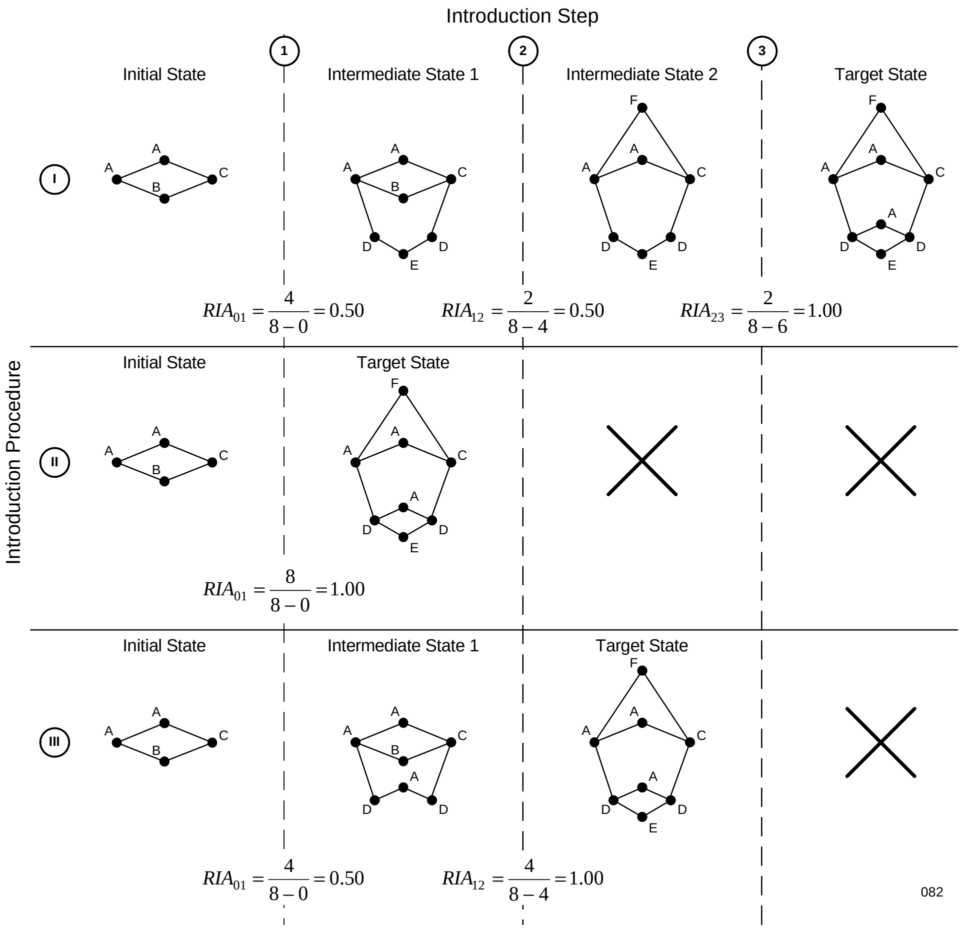

Figure 92: Evaluation of three introduction procedures with metric Activity Relation Introduction Advancement.

Since all concept relations are introduced in the first step, for procedure II the metric yields 1.0. On the other hand, procedure I defines two intermediate states for the introduction of the activity relations, whereas procedure III defines only one. Therefore, during procedure I the metric value increases more slowly. In summary, with respect to this axiom, procedure II yields the best results. Because it has fewer steps, procedure III is evaluated better than procedure I.

Thus, the metric Activity Relation Introduction Advancement prefers introduction procedures with few steps and big changes in terms of relation introductions. Moreover, large changes early in the introduction process have a bigger effect on the metric than late changes.

Relation Coordination

The objective of the introduction of a new concept is basically to create new or better information. On the one hand, this information has to be “used” in the following process activities to yield the expected concept benefit. On the other hand, input from preceding activities is needed to create this new information in general. That is, new information flows are necessary, realized in the form of new relations between activities. However, the exchange of information has to be coordinated. Therefore, the introduction of new relations causes an additional coordination effort, which negatively influences the quality of the process results, and may lead to acceptance problems. Therefore, the scope of the introduction of new activity relations should be as low as possible.

Axiom Relation Coordination: *The scope of the introduction of new activity relations should be as low as possible.*

The advantage of introducing all concept relations in one step can be seen in the reduced introduction duration and (if there are cost components that are time-dependent) in the lower introduction cost. However, this option implies a higher failure risk, thus it can only be recommended for concept introductions with a low complexity (Reiß and Höge 1994, p. 33; Krüger 1990, p. 283; Schmidt 1997, p. 57).

Another effect is that the employees may be swamped with the complexity of the concept introduction. From the company perspective seemingly small changes may be experienced as big changes by the affected employees, since they have to re-learn activities that previously were already routine (Schmidt 1997, p. 59). Along this line, Zeyer (1996, p. 143; see also Grönlund and Jönsson 1991, p. 201; Pellegrinelli and Bowman 1994, p. 25; Ackerman 1997, p. 53) also emphasizes the bounded rationality of humans as a restricting factor for the size of the introduction scope in one step. He considers the increase of planning, preparation, and support effort with the introduction scope to be a restricting factor.

Additionally, large introduction steps tend to require provisional concept modules. Provisional concept modules are only substitutes for the final concept parts, which eventually take their place and provide the expected benefit. Therefore, large introduction steps (with the introduction of a high number of activity relations) which require provisional concept modules should be avoided (Zeyer 1996, p. 290).

Stetter (2000, p. 123) emphasizes the possibility to test new methods and tools when smaller introduction steps are applied. This allows to confirm that the new concept provides the expected benefit, and to adapt it to the users' needs.

Finally, the size of the introduction steps has an important influence on the acceptance of the concept introduction. Small steps, e.g. with only a low number of introduced activity relations, support the acceptance, since the employees are not overstrained and fast successes show the advantages of the concept.

Moreover, the introduction of activity relations creates coordination effort. The sources and the effects of this coordination effort are described in detail for the axiom Activity Coordination.

In Figure 93, the advantages of restricting the scope of the activity relation introduction are summarized.

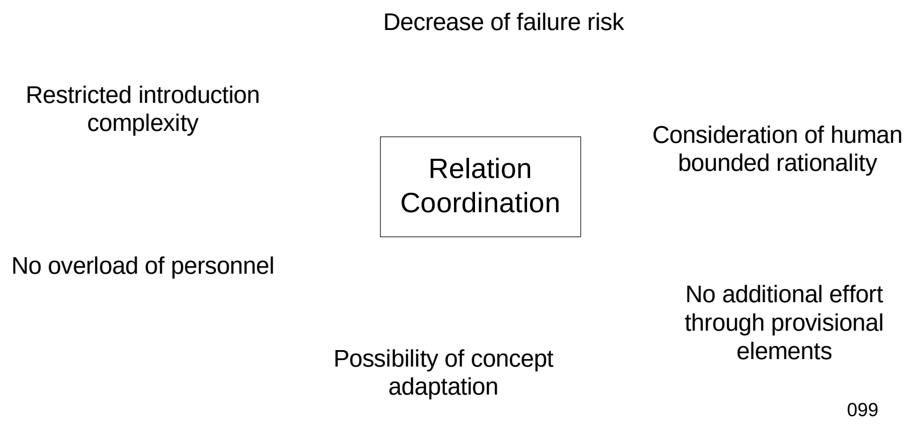

Figure 93: Arguments for the axiom Relation Coordination.

The basic measure for determining the scope of the relation introduction is the number of introduced relations (NAR_{mn}). For normalization purposes, this measure is divided by the total number of activity relations that have to be introduced (*TRI*). Additionally, the number of context relations, which are not removed during the introduction process, at step m (NRN_m) is in the denominator of the metric. In this way, the metric also takes into account the size of the existing process system. Again, for normalization purposes the number of context relations at state 0 that are not removed during the introduction process is multiplied in the counter of the metric. This fraction is subtracted from 1 so that the metric value is 1 in the best case.

- § *NAR* = Number of Activity Relations Introduced
- § *NRN* = Number of Context Activity Relations that are not Removed
- § *TRI* = Total Number of Concept Activity Relations Introductions
- § *RIS* = Activity Relation Introduction Scope

$$RIS_{mn} = 1 - \frac{NAR_{mn} \cdot NRN_0}{TRI \cdot NRN_m} \qquad \text{Eq. 72}$$

Figure 94 depicts the application of the metric Activity Relation Introduction Scope to the example presented on page 99.

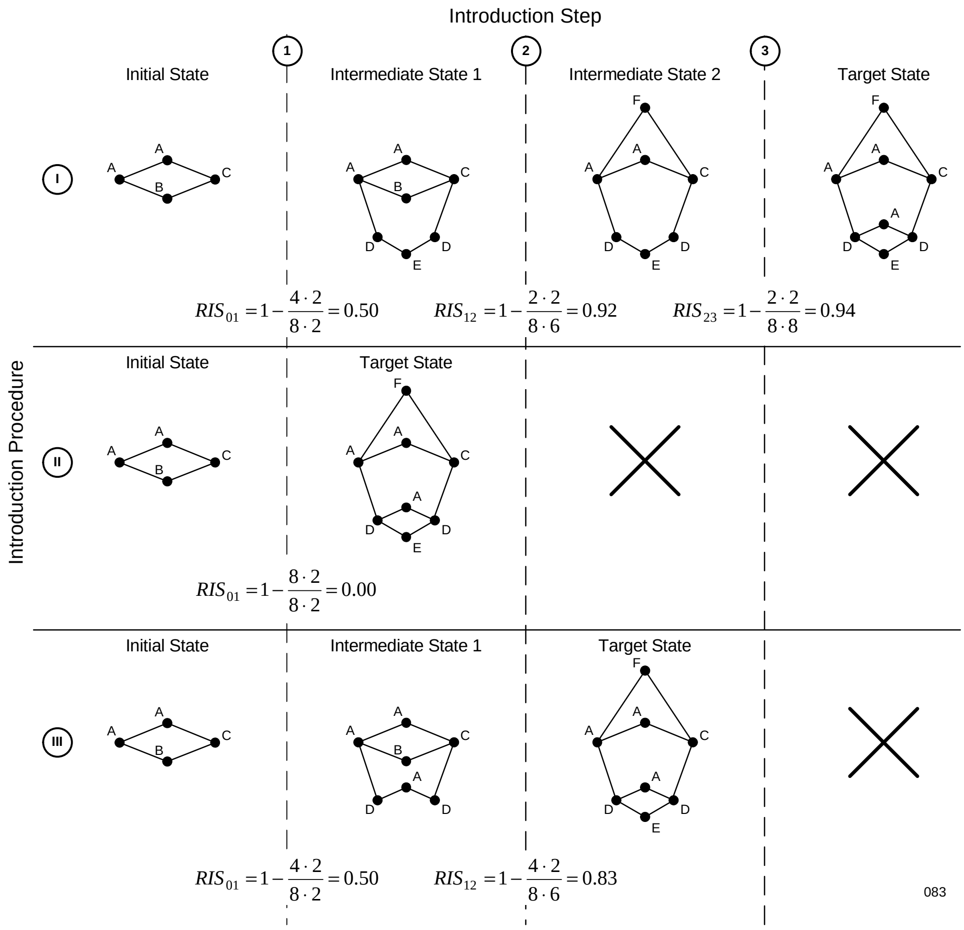

Figure 94: Evaluation of three introduction procedures with the metric Activity Relation Introduction Scope.

The assessment shows that the metric value for step 1 of procedure II is *0*, since all activity relations are introduced in the first step. For procedure I and III the metric values are relatively low at the beginning, and increase with further introduction steps, mainly because the already introduced relations are considered as context relations in the next step and thus increase the denominator of the fraction. Due to the faster introduction, the metric values of procedure III are lower than those of procedure I.

The metric Activity Relation Introduction Scope yields better results for a large number of introduction steps with small changes at each step. If there are introduction steps where a large amount of activity relations is introduced, it is beneficial to position those steps late in the introduction process, since then the number of context relations is higher.

Information Transfer

The involvement of affected employees in any change process is an important factor for success. Involvement certainly contributes to the acceptance of the new concept, but it also supports the learning process and thus helps to achieve the intended performance. Therefore, the people involved in the new concept should be integrated in one team.

Axiom Information Transfer: *The people involved in the new concept should be integrated in one team.*

Here, employees are considered to be involved in the new concept if they provide information to, receive information from, or are responsible for concept activities.

Affected employees have to become involved in the process. In this way acceptance problems can be avoided, but there is also the chance that people independently detect problem areas and find appropriate solutions. If coaching supports this, the “not-invented-here” problematic can be avoided (Viertlböck 2000, p. 94).

But the involvement not only increases the acceptance among the employees, it also enhances the transparency. When people know what they do, better results can be expected. The know-how of the employees can be integrated. Above all it is a possibility to exchange undocumented knowledge. The improved information flow directly between the employees is a prerequisite for fast information flow and thus can improve learning, as well as the reaction to changed situations. The employees get the ability to react independently and competently in an unexpected situation. This enhances the flexibility and stability of the concept introduction (Stetter 2000, p. 121).

Information exchange between employees involved can be in the form of know-how exchange. This exchange is the prerequisite for knowledge, which is the basis for skill. This means that the integration of affected employees has a qualifying component and leads to improved learning. Successful teamwork supports problem-related communication, which tends to improve the problem solving. Moreover, efficient information exchange supports the self-organization of implementation areas. This can reduce the need for organizational measures (see also Doppler and Lauterburg 1994, p. 86f. and 216; Greiner 1982, p. 143).

Involvement through the integration of the people affected in a team is an important factor for performance improvement and learning. Teams have the ability to translate longer-term objectives into definable performance goals. Concurrently, they develop the skills needed to meet those performance goals. That is, learning not only occurs in teams, but endures (Katzenbach and Smith 1993a, p. 5).

Yet, information pathologies can negatively affect the quality and quantity of knowledge production (Scholl 1999, p. 101 ff.). Information pathologies are avoidable failures of distributed information processing. Problems may arise in the production, procurement, transmission, and application of decision-relevant information. Even if the initial message is perfect (i.e. accurate, clear, timely, and relevant), personnel standing between the sender and the intended recipient may translate, condense, or completely block the information. Another aspect of information pathology is the information overload when too many messages are transmitted to the recipient (Wilensky 1967, p. 41). Team structures allow a direct and selected access of all team members to the relevant information and thus help to avoid the described information pathologies. In turn, the quality and quantity of produced knowledge is influenced positively.

Figure 95 lists the arguments for integrating the employees that are involved in the concept introduction in one team.

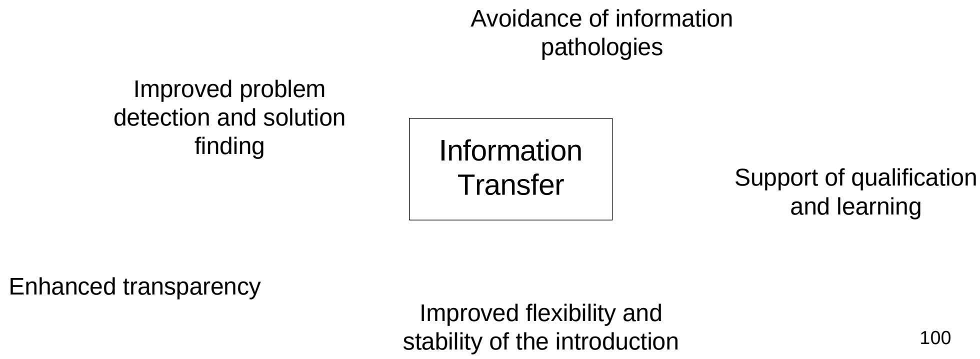

Figure 95: Arguments for the axiom Information Transfer.

The metric Team Integration Factor (TIF_n) can be used to evaluate the axiom Information Transfer. This metric relates the number of people involved in the new concept, and that are integrated in one team (MRI_n), to the total number of people involved in the new concept (PIN_n). If there is more than one team where team members are involved in the new concept, the maximum number of integrated people is used to calculate the metric value. For the best case, i.e. all people involved are integrated in one team, the metric value is one.

§ *PIN* = Number of People Involved in the New Concept
§ *MRI* = Number of People Involved in the New Concept Integrated in One Team
§ *TIF* = Team Integration Factor

$$TIF_n = \frac{MRI_n}{PIN_n} \qquad \text{Eq. 73}$$

Figure 96 depicts the application of the metric Team Integration Factor to the three introduction procedures of the example presented on page 99.

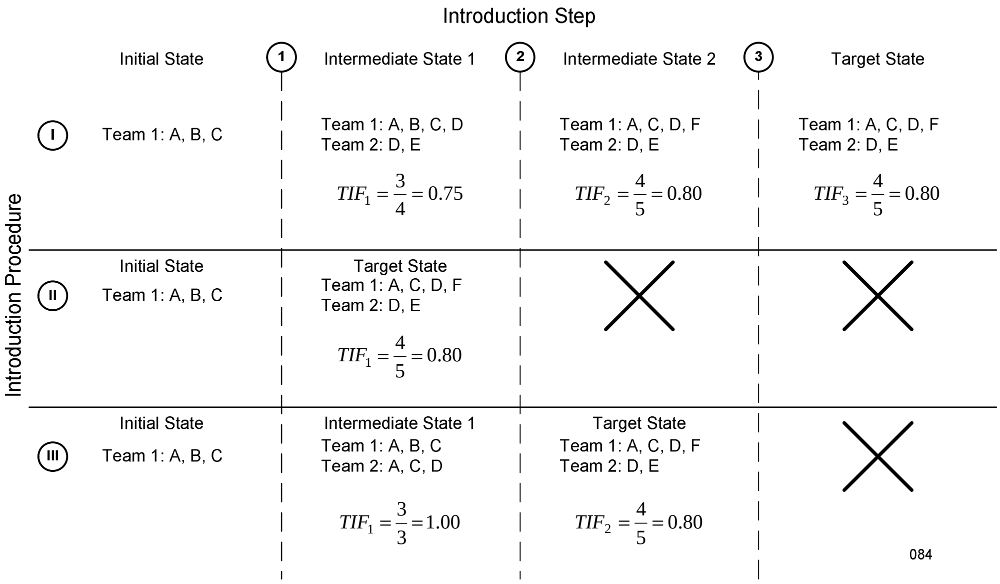

Figure 96: Evaluation of three introduction procedures with the metric Team Integration Factor.

The metric Team Integration Factor evaluates the situation at an introduction state. All procedures have equal metric values for almost all states. The most significant exception is the intermediate state 1 of procedure III, where the Team Integration Factor is calculated to be *1*. At this state, all employees who are involved in the new concept (which are A, C, and D) are integrated in team 2.

This metric is independent of the number of intermediate states or the scope of changes. It only depends on the integration of the employees involved.

Surplus Load

Inevitably, the introduction of a new concept causes additional effort for the company, especially for the people affected. The implementation has to be planned, controlled, but also during the actual introduction extra work has to be performed by the employees.

A new concept often replaces existing procedures in the company. During an introduction, the established procedures may exist in parallel to already introduced concept elements. This is certainly a challenge for resource planning and has to be adequately treated. On the other hand, an extra effort, which cannot be compensated by the allocation of additional resources, occurs as a result of concurrent existence of established and new activity relations. Since the activity relations constitute information flows between activities, the concurrent existence of new and "old" relations means that two different sets of information have to be provided for different recipients. This surplus load that the person in charge of the information providing activity has to perform, on the one hand negatively influences his work quality, on the other hand leads to acceptance problems. Therefore, the surplus load should be as low as possible.

Axiom Surplus Load: *The surplus load induced by the concept introduction should be as low as possible.*

If the surplus load is too large, the employees may be swamped with the complexity of the concept introduction. Seemingly small changes can lead to a big additional effort for individual employees (Schmidt 1997, p. 59), which restricts the time they can spend on their individual tasks. Furthermore, human bounded rationality also leads to a decrease in the work quality if too many tasks have to be completed (see, e.g., Zeyer 1996, p. 143; Grönlund and

Jönsson 1991, p. 201; Pellegrinelli and Bowman 1994, p. 25). Due to the overload, both aspects eventually lead to a lack of acceptance for the concept introduction (Stetter 2000, p. 123).

Figure 97 summarizes the arguments for restricting the scope of the surplus load for the personnel.

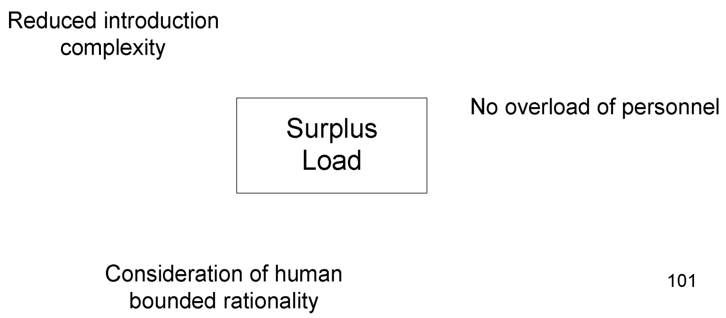

Figure 97: Arguments for the axiom Surplus Load.

The Surplus Load Index is used to evaluate this axiom. This metric determines the extent of co-existence of established and new activity relations. Dividing the number of activity relations that are not yet disintegrated (RND_n) by the total number of activity relations to be disintegrated (*TRD*) is an index for the progress of disintegrating "old" relations. The progress in terms of introducing new activity relations is determined by dividing the number of new activity relations (RDI_n) by the total number of activity relations to be introduced (*TNR*). These two fractions are multiplied with each other to derive a measure for the co-existence of "old" and introduced relations, which is averaged over all relevant activities (*ADN*). This fraction is subtracted from 1 so that the metric value yields 1 in the best case.

- *RND* = Number of Activity Relations Not Disintegrated
- *RDI* = Number of New Activity Relations
- *TRD* = Total Number of Activity Relations to be Disintegrated
- *TNR* = Total Number of New Activity Relations
- *ADN* = Number of Activities with New Activity Relations and Activity Relations to be Disintegrated
- *PEI* = Parallel Execution Index
- *SLI* = Surplus Load Index

$$SLI_n = 1 - PEI_n = 1 - \frac{\sum_{x=1}^{ADN} \left(\frac{RND_{n,x}}{TRD_x} \cdot \frac{RDI_{n,x}}{TNR_x} \right)}{ADN} \qquad \text{Eq. 74}$$

Figure 98 depicts the evaluation of the three introduction procedures of the example described on page 99 with the Surplus Load Index.

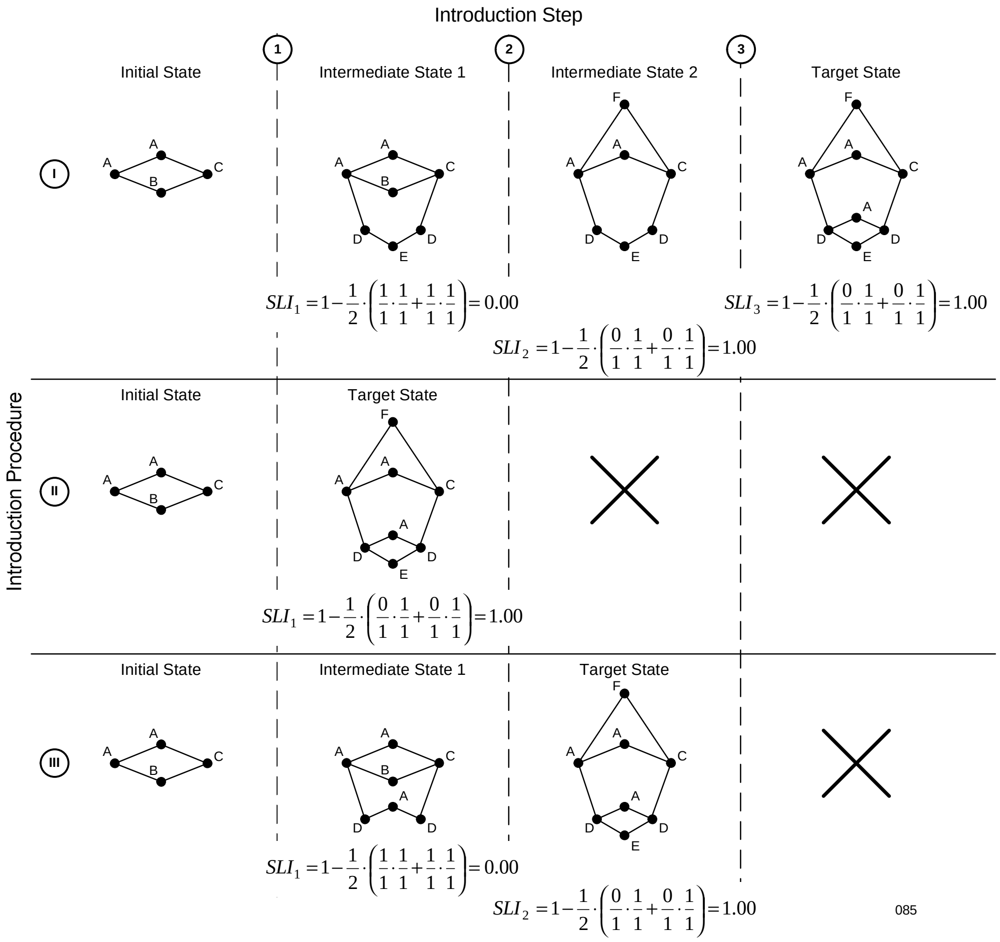

Figure 98: Evaluation of three introduction procedures with the metric Surplus Load Index.

In this simple example a surplus load due to the introduction of new activity relations parallel to existing relations occurs only at intermediate state 1 of procedure I and III. Therefore, in both the first intermediate state of procedure I and III respectively, the metric value is *0*. In these intermediate states a new relation with person in charge D is introduced for the persons in charge A and C, while the relation with person in charge B still exists.

Since this metric is defined for a state axiom, it is independent of the number of intermediate states or the scope of changes. It only depends on the co-existence of old and new relations.

Parallel Introduction

There are three basic approaches for the transition between existing structures to a new concept in a process system (Henn 1999, p. 338; Zeyer 1996, p. 169; Daniel 2001, p. 165 ff.)[21]. The first possibility is a coupled transition, where the introduction of the current solution directly follows the disintegration of the existing solution. At the parallel transition, the current context is kept in parallel to the new concept already introduced for a period of time. Finally, in the context supplement the new concept is introduced in parallel to the existing context, but in contrast to the parallel transition the current context is not disintegrated. Therefore, this approach is in that sense not a transition strategy. Figure 99 shows the three different transition approaches.

[21] Daniel (2001, p. 165 ff.) mentions four different transition strategies. One is decoupled transition, where there is a time lag between the disintegration of the current solution and the introduction of the new solution. The advantage of this approach is that it supports de-learning processes. However, its applicability in real-life situations is at least questionable, therefore it is not considered here.

In a real concept introduction there will always be context elements that are still needed after the concept introduction (context supplement), but probably there will also be a substitution of context elements with concept elements (coupled or parallel transition). Therefore, only the parallel and coupled approaches describe possible transitions between old and new elements.

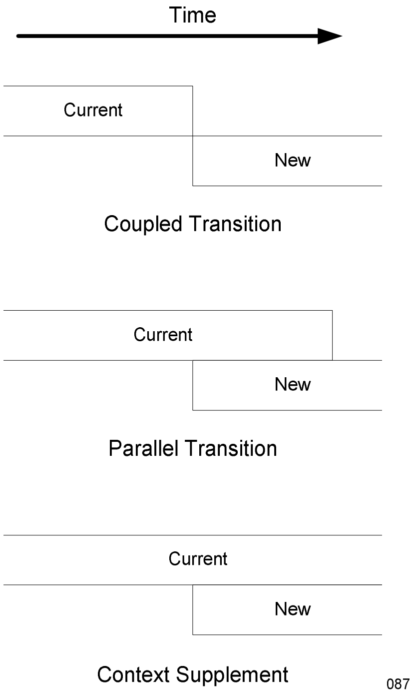

Figure 99: Different possibilities for the transition between current and new elements.

The parallel transition can be considered as a more general form of a pilot project on a micro-level. The main characteristic (or objective) of a pilot project is that it introduces a new approach in a restricted area of the company (macro-level). That is, on a macro-level the current approach co-exists in parallel to the new approach. When this idea of a pilot project is transported to the micro-level, i.e. to the level of a single project, it means that concept elements are introduced while the current approach is still executed. That is, the current approach co-exists in parallel to the new approach, which is defined as a parallel transition.

From the perspective of the introduction quality, a pilot project or parallel transition has several advantages compared to the coupled transition. For example, it reduces the failure risk of the introduction and limits the performance reduction that has to be expected directly after an introduction step. Therefore, new concept activities should be introduced in parallel to existing activities.

Axiom Parallel Introduction: *New concept activities should be introduced in parallel to existing activities.*

There are many publications that emphasize the advantages and necessity of pilot projects (see, e.g., Viertlböck 2000, p. 138; Danner and Reske 1999, p. 234; Stetter 2000, p. 123; Weber et al. 1999, p. 203; Zeyer 1996, p. 103; Lettice et al. 1998, p. 195; Sellgren and Hakelius 1996, p. 7; Daniel 2001, p. 168).

Pilot projects first lead to an increase in the cost and duration of the introduction. On the other hand, the insights gained during the pilot projects can help to reduce the cost and duration of the overall introduction compared to a procedure without pilot projects. However, the primary benefit of pilot projects is that they improve the introduction quality. Whether pilot projects are needed or not mainly depends on the relevant know-how of the people involved (Zeyer 1996, p. 105 f. and p. 153).

Zeyer reports on case studies from the automotive sector, where the opening of new plants was used to introduce Lean Management concepts. The experience from previous pilot projects supported the development of an optimal concept for these new plants (Zeyer 1996, p. 103).

Thus, the introduction of concept elements in parallel to existing structures can serve as a test for the new concept (Stetter 2000, p. 123; Viertlböck 2000, p. 138). This view is also supported by Smith and Reinertsen (1995, p. 278 ff.), which provide guidance for how to initiate, perform, and “clone” pilot projects.

Moreover, pilot projects can help to restrict the size of the performance reduction directly after the introduction step (Zeyer 1996, p. 152). Thus, from the perspective of an implementation-related risk management, the application of pilot projects is beneficial, above all when the change is urgent, which reduces the degree of acceptable performance reduction.

Apart from the mitigated performance reduction, a parallel introduction strategy also reduces the failure risk. In the case of inadequacies of the new concept there is still the possibility to go back to the existing procedures (Viertlböck 2000, p. 94; Schmidt 1997, p. 57 f.; Krüger 1994, p. 211). Concurrently, the provision of a fall-back solution is costly, since additional resources have to be allocated. However, the main reason for a parallel introduction of the new concept does not necessarily have to be the reduced risk. It may also be that the new approach functions as a relief for the existing context (Daniel 2001, p. 168).

Pilot projects also preventively help to avoid transformation and acceptance problems. They allow testing the functionality of the new procedures, from which valuable insights can be derived. This increases the success probability of the introduction through an improved introduction quality and acceptance (Daniel 2001, p. 191 f.).

To sum it up, there are several reasons for applying a pilot project (Stetter 2000, p. 123; Viertlböck 2000, p. 138):

- They provide a test of the concept under realistic conditions. Insights with respect to necessary modifications of the concept and the introduction procedure can be gained.
- Positive results from pilot projects attract the interest of other employees and can support the acceptance of the introduction.
- Detailed and seemingly minor aspects of the introduction are often prerequisites for its success. With the help of pilot projects, these aspects can be determined.
- The introduction of new approaches in pilot projects bears only a restricted risk for the company. In the case of failure, the old procedures are still available.
- Pilot projects are a means of training on the job and thus support the qualification of the employees.

In Figure 100, the benefits of the introduction of new in parallel to existing activities and relations are listed once more.

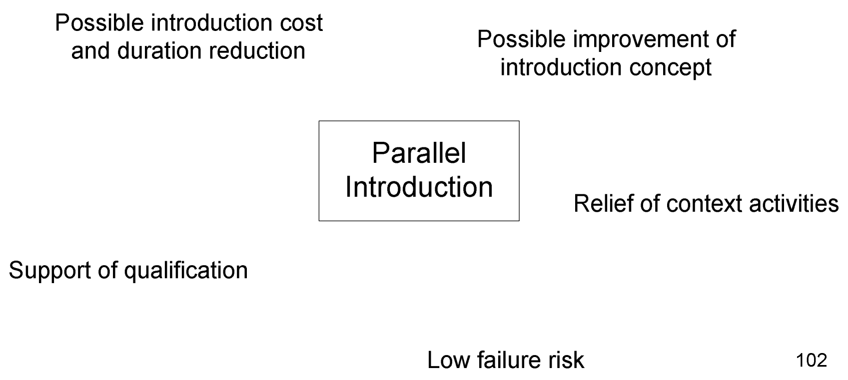

Figure 100: Arguments for the axiom Parallel Introduction.

The metric to assess the parallelism of the introduction strategy is similar to the metric for evaluating the surplus load. Both aspects are directly linked. An introduction of new elements parallel to existing procedures inevitably leads to an increase in work load at least for those employees who have to deal with both the old and new concept.

The Parallel Execution Index is basically calculated by multiplying a figure for the scope of introduced new activity relations with a figure for the scope of existing activity relations that still have to be disintegrated (see axiom Surplus Load, for details). For this metric, 1 means a high degree of parallelism, whereas 0 means a low degree of parallelism.

- *RND* = Number of Activity Relations Not Disintegrated
- *RDI* = Number of New Activity Relations
- *TRD* = Total Number of Activity Relations to be Disintegrated
- *TNR* = Total Number of New Activity Relations
- *ADN* = Number of Activities with New Activity Relations and Activity Relations to be Disintegrated
- *PEI* = Parallel Execution Index

$$PEI_n = \frac{\sum_{x=1}^{ADN} \left(\frac{RND_{n,x}}{TRD_x} \cdot \frac{RDI_{n,x}}{TNR_x} \right)}{ADN} \qquad \text{Eq. 75}$$

Figure 101 depicts the application of the Parallel Execution Index to the three introduction procedures of the example described above on page 99.

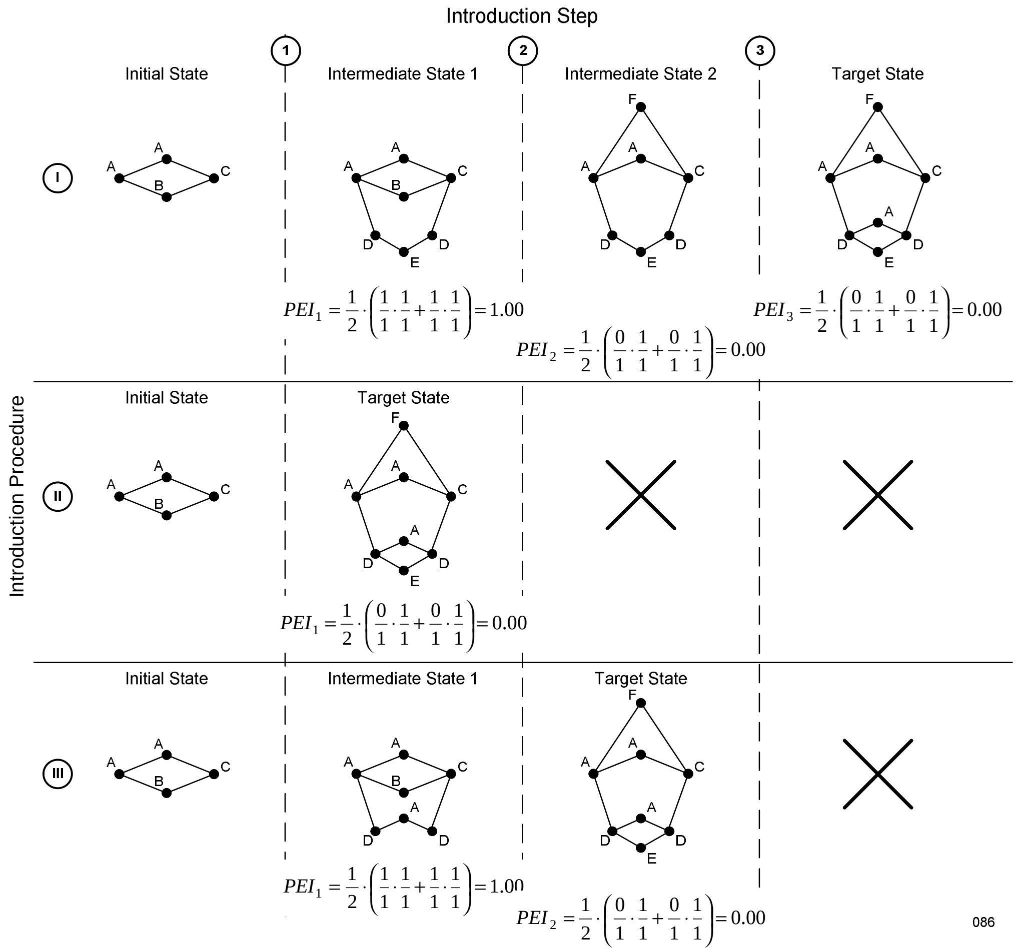

Figure 101: Evaluation of three introduction procedures with the metric Parallel Execution Index.

This example show a parallel execution of concept elements and existing activities in the intermediate state 1 of introduction procedure I as well as III. In this case, the metric value is *1.0*, since the single new activity relation is in parallel to the single activity relation that has to be disintegrated.

Since this metric is defined for a state axiom, it is independent of the number of intermediate states or the scope of changes. It only depends on the co-existence of old and new relations.

Introduction Timeframe

To determine the best introduction procedure, a comparison of the introduction quality, cost, and duration is necessary. In general, the introduction of a new concept in a company contains several projects. In each of the consecutive projects, additional elements of the concept are introduced and / or further context elements are removed. The introduction could be considered completed when the last concept element has been introduced and the last relevant context element has been removed. But since the introduction also has an influence on the quality of the process results, the introduction should only be considered completed when the quality of the process results has reached the target value.

Therefore, the introduction duration depends on the number of projects that have to be conducted until the quality of the process results has finally reached the expected value. The initiators of the concept introduction usually prefer a short introduction duration, since in this way the benefit of the introduction will occur faster. Therefore, the number of projects until the introduction can be considered as completed should be as low as possible.

Axiom Introduction Timeframe: *The number of projects until the introduction completion should be as low as possible.*

In general, the overall cost will be lower if the concept introduction is completed earlier. The more steps are used to introduce the new concept in the company, the longer people are concerned with planning, support, and monitoring of the introduction. These resources are fixed and thus cannot be used in other areas. Therefore, the introduction process in general generates time-dependent cost that will be lower if the introduction duration can be reduced.

Furthermore, reduced introduction duration means that the number of projects with a new concept which has only been introduced partially is lower, and the complete, functional concept is available earlier. Thus, the concept benefit unfolds earlier in the company, which has reinforcing effects on the acceptance and the quality of the process results.

The initiators of a concept introduction in general prefer an early start, an early completion, and a short duration of the introduction process (Daniel 2001, p. 35). The start and completion date determines the timeframe of the introduction. Basically, a short introduction duration minimizes the impairment of the daily business.

In Figure 102, the arguments for restricting the timeframe of the introduction are summarized.

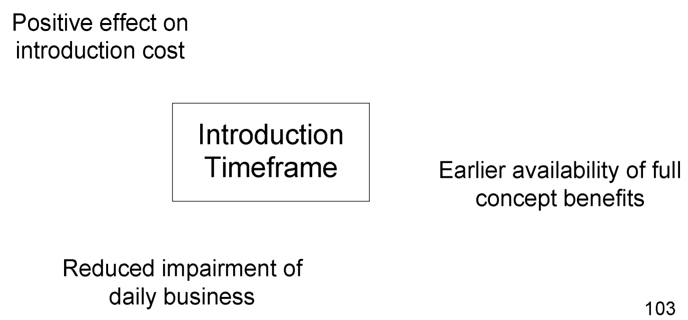

Figure 102: Arguments for the axiom Introduction Timeframe.

The description of this axiom already makes it obvious that the number of projects until the next transition (*PIC*) is the basic measure for its evaluation. To derive a normalized metric, this number is divided by the number of projects for the worst case introduction alternative (*PWC*). The resulting fraction is subtracted from 1 so that a short introduction duration yields a high metric value.

- *PIC* = Number of Projects until the Next Transition
- *PWC* = Number of Projects until the Introduction Completion for the Worst Case Introduction Alternative
- *IDI* = Introduction Duration Index

$$IDI = 1 - \frac{PIC_{0n}}{PWC_{0n}} \qquad \text{Eq. 76}$$

The number of projects necessary to complete the concept introduction cannot be derived directly from the introduction procedure. It depends on the number and sequence of introduction steps, and their influence on the quality of the process results. This influence on the result quality is evaluated by the quality aspect performance sustainment and has to include learning effects. The procedure to determine the number of projects necessary to complete the concept introduction is not trivial and therefore is presented in a separate chapter.

Project Duration

In general, the introduction of a concept is not completed in one project, but it contains several projects. In each of the consecutive projects, additional elements of the concept are introduced and / or further context elements are removed. The introduction cannot be considered completed when the last change is executed, but only when the quality of the process results reaches the target value.

Therefore, the introduction duration depends on the one hand on the number of introduction steps, which determines the number of projects that have to be conducted until the quality of the process results finally reaches the expected value. On the other hand, the introduction duration also depends on the duration of the single project.

Since the objective is only to compare different introduction procedures, it is not necessary to determine the absolute duration of the single projects. It is sufficient to compare the increase of the project duration due to changes in the process and organization system. However, the objective for the overall introduction duration is also valid for the duration of the single project. Therefore, the increase of the project duration due to the concept introduction should be as low as possible.

Axiom Project Duration: *The increase of the project duration due to the concept introduction should be as low as possible.*

The initiators of a concept introduction in general prefer an early start, an early completion, and a short duration of the introduction process (Daniel 2001, p. 35). The start and completion determines the timeframe of the introduction, whereas the objective to have a short duration of the introduction process is related to the increase of the process duration due to the introduction. Therefore, a short introduction duration minimizes the impairment of the daily business.

Competition also demands to restrict the influence of the introduction on the project duration (Frese and von Werder 1994, p. 4; Krogh 1995, p. 141; Zeyer 1996, p. 147). In order to satisfy their customers, companies today need to deliver cost effective products with adequate quality in a timely manner. If the extended project duration makes it impossible to deliver the product on time, the market success of the product can be endangered.

Figure 103 summarizes the arguments for restricting the extent of an increased project duration due to the introduction.

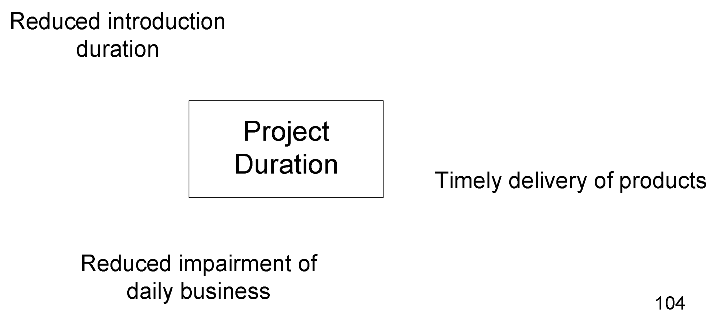

Figure 103: Arguments for the axiom Project Duration.

The increase in the project duration due to a concept introduction stems mainly from three sources. First, changes in the team structures not only lead to a reduction in the team performance, but also require coordinating activities. These coordinating activities include the area from the personal communication pattern (teams need time to find a basis for cooperation; see, e.g., Katzenbach and Smith 1993a, p. 127), and the formal activities (e.g., to grant team database access to new team members). The extent of the team change in an introduction step is captured in the metric Team Change Scope (*TCS*).

Second, the amount of introduced activities and relations influences the project duration. Similarly to the changes in the organization system, changes in the process system also require additional coordination effort. New activities produced information that has to be processed in later activities. New activity relations mean a new path for the information flow, where transmitter and recipient have to negotiate, e.g., the frequency, content, and format of the information. The amount of introduced activities and relations is captured in the metrics Activity Introduction Scope (*AIS*), and Activity Relation Introduction Scope (RIS), respectively.

Third, the surplus load for the employees due to a parallel existence of old and new activity relations decreases the work performance and leads to an increase in the time required for the task completion. The surplus load due to the concept introduction is defined by the metric Surplus Load Index (*SLI*). The Project Duration Index (*PDI*) evaluates the transition from one (intermediate) state to the next in the concept introduction. Since the Surplus Load Index evaluates only an introduction state, the difference between the Surplus Load Index in the state n and state m is used to assess the transition.

All three metrics are added to derive a metric for the project duration. The three summands are weighted according to their importance. These weighting factors have to be adapted specifically to the company where the model is applied. This sum is subtracted from 1 so that the best case, i.e. a low extension of the project duration, yields 1 as metric value.

- *TCS* = Team Change Scope
- *AIS* = Activity Introduction Scope
- *RIS* = Activity Relation Introduction Scope
- *SLI* = Surplus Load Index
- *PDI* = Project Duration Index

$$PDI_{mn} = 1 - \left(0.3 \cdot TCS_{mn} + 0.5 \cdot \left(\frac{AIS_{mn} + RIS_{mn}}{2} \right) + 0.2 \cdot \left(SLI_n - SLI_m \right) \right) \qquad \text{Eq. 77}$$

Figure 104 depicts the evaluation of the three introduction procedures from the example presented on page 99 with the metric Project Duration Index.

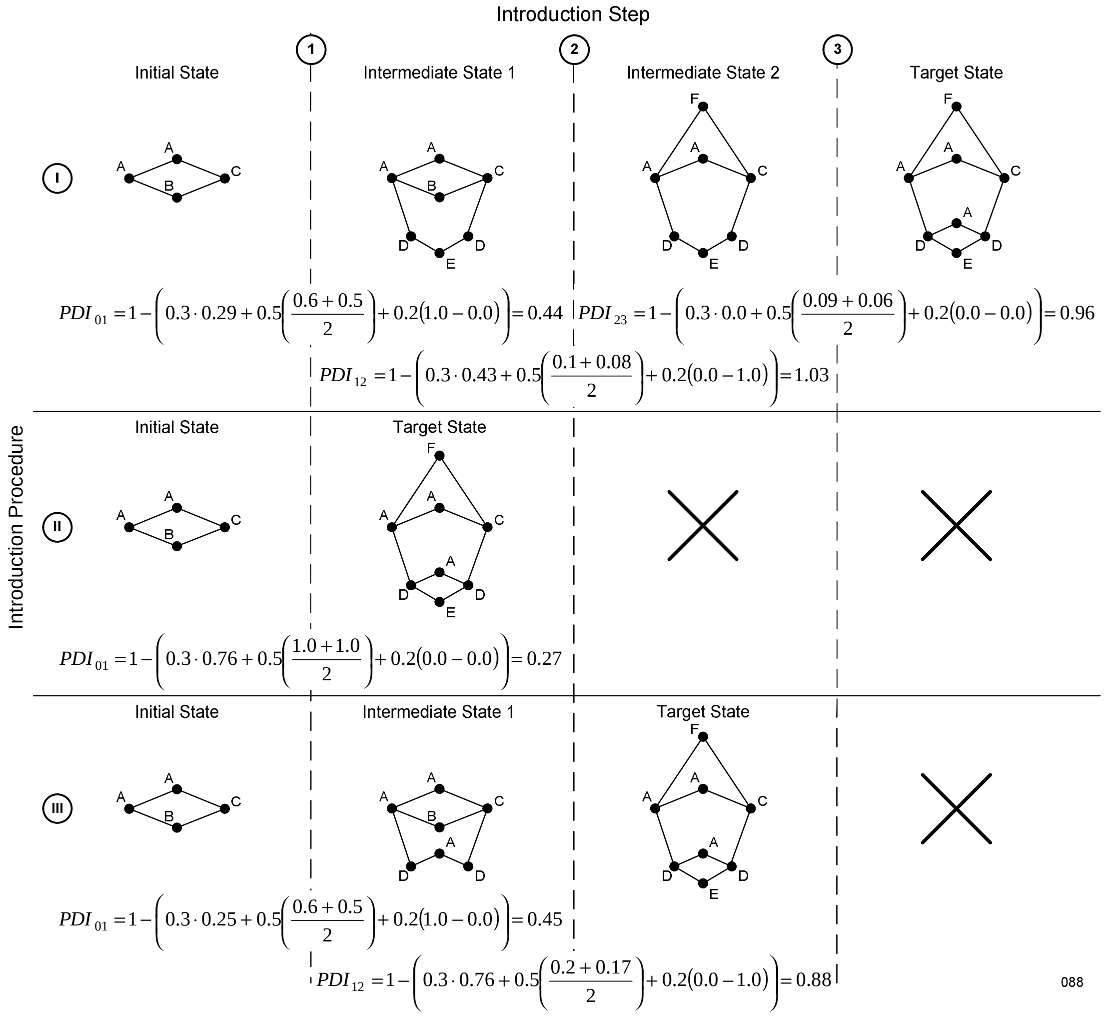

Figure 104: Evaluation of three introduction procedures with the metric Project Duration Index.

This example shows that the value for the metric Project Duration Index decreases with the change scope. For example, the lowest metric value in this example occurs at introduction procedure II, since the largest change occurs here. This metric can also have values larger than one, e.g. in the case of PDI_{12}. Values larger than one may occur when the difference between the Surplus Load Index between state n and m is negative. That is, the surplus load for the employees has reduced due to the introduction step. If the changes in the organization and process system in this introduction step are moderate, the extension of the project duration can be reduced.

The metric Project Duration Index yields better results for a large number of introduction steps with small changes at each step. Since the metric depends on the Activity Introduction Scope and the Activity Relation Introduction Scope, it prefers introduction procedures where large changes are executed late in the introduction process.

Introduction Cost

To comprehensively compare different possible introduction procedures, it is also necessary to consider the cost associated with the alternative introduction paths. Since the objective is only to compare the alternatives, it is not necessary to determine the cost of the concept introduction in absolute numbers. That is, it is not the goal to predict the cost of the concept introduction, which is basically given since the concept elements to be introduced are determined. The goal is rather to compare alternative introduction paths with respect to when the cost occur.

The introduction of a new concept in a company contains several projects. In each of the consecutive projects, additional elements of the concept are introduced and further context elements are removed. The introduction is completed when the changes in the process system are accomplished and the quality of the process results reaches the target value.

Alternative introduction procedures differ with respect to when individual concept elements are introduced and when individual context elements are removed. Since a cost factor can be associated with each concept and context element, the introduction procedures differ also in terms of accumulated cost.

For the company, the cost of the concept introduction, apart from its duration and quality, is an important criterion of the introduction success. Therefore, the cost of the concept introduction should be as low as possible.

Axiom Introduction Cost: *The cost of the concept introduction should be as low as possible.*

Due to its range, it is difficult or even impossible to exactly determine the absolute cost of the concept introduction. For example, if a new software tool is acquired which supports the new concept, but can be used also for other purposes, it is difficult to decide if this software tool should be included in the introduction cost. Therefore, only the relative cost of different introduction alternatives are evaluated.

Since the three overall objectives duration, cost, and quality are closely interlinked, recommendations with respect to a trade-off between these three dimensions can only be derived for the individual case (Zeyer 1996, p. 136). However, a focus on one of those three areas will inevitably have a negative influence on the other areas. Nonetheless, there is a demand for low cost of the introduction (Grimmeisen 1998, p. 55).

To determine the cost of the concept introduction, two different cost types have to be considered: Cost due to expenditures and calculatory cost (Zeyer 1996, p. 139; Daniel 2001, p. 34). The calculatory cost include the personnel cost for implementers or opportunity cost, e.g. due to orders that could not be processed. This cost type is not relevant for the comparison of different introduction strategies.

The cost due to expenditures comprise investment and ongoing cost. Investment cost can be, e.g., the purchase cost for software systems or machinery. Which software or machinery to buy for the introduction is determined by the concept, thus it is fixed for all introduction alternatives. Therefore, investment cost are not considered for comparing the introduction procedures. Ongoing cost are personnel and other resource cost associated with the concept or with investments (e.g. the maintenance cost for a software). Personnel and resources are tied to activities, thus also the ongoing cost are related to activities. However, the concept introduction does not only create additional cost. There can also be cost savings when existing activities are removed from the process system. Then, all related personnel and resource cost can be considered as cost savings due to the concept introduction and thus have to be considered as well.

Since the alternative introduction procedures differ with respect to when activities are introduced or removed, the sum of the realized ongoing cost is also different. Hence, in each step the introduction procedures are compared in terms of ongoing cost for the concept elements already introduced and for the context elements not yet removed.

It makes a difference whether the same ongoing cost are realized early or late in the introduction process. These cost can be considered as investments, which have to be compared on the basis of their net present value. This would include considering the interest rate of the investments. This approach would be more exact and also feasible, since this kind of financial data is in general available in the companies. However, it would require an enormous increase in data collection efforts, which would contradict the nature of this simple yet effective model. Hence, for the purpose of this model a more simplistic approach is used, without considering the net present value of the investments. However, it is possible to expand this aspect if necessary.

To determine the Introduction Cost Index, on the one hand the resource and personnel cost of the introduced concept activities (*RCM* and *PCM*, respectively) have to be determined. On the other hand it is also important to consider the resource (*RCC*) and personnel cost (*PCC*) of the context activities that still have to be disintegrated. The sum of these cost is divided by the sum of the total cost for each cost type (*TRC*, *TPC*, *TCR*, and *TCP*, respectively) in order to derive a normalized metric. This fraction is subtracted from *1* so that the best case yields *1* as metric value. That is, high cost are reflected by a low metric value, whereas low cost are reflected by a high metric value.

§ *RCM* = Resource Cost of the Introduced Concept Activities
§ *PCM* = Personnel Cost of the Introduced Concept Activities
§ *RCC* = Resource Cost of the Context Activities to be Disintegrated
§ *PCC* = Personnel Cost of the Context Activities to be Disintegrated
§ *TRC* = Total Resource Cost of the Concept Activities
§ *TPC* = Total Personnel Cost of the Concept Activities
§ *TCR* = Total Resource Cost of the Context Activities to be Disintegrated
§ *TCP* = Total Personnel Cost of the Context Activities to be Disintegrated
§ *ICI* = Introduction Cost Index

$$ICI_n = 1 - \frac{RCM_n + PCM_n + RCC_n + PCC_n}{TRC + TPC + TCR + TCP} \qquad \text{Eq. 78}$$

Figure 105 shows the application of the metric Introduction Cost Index to the three introduction procedures of the example presented above on page 99.

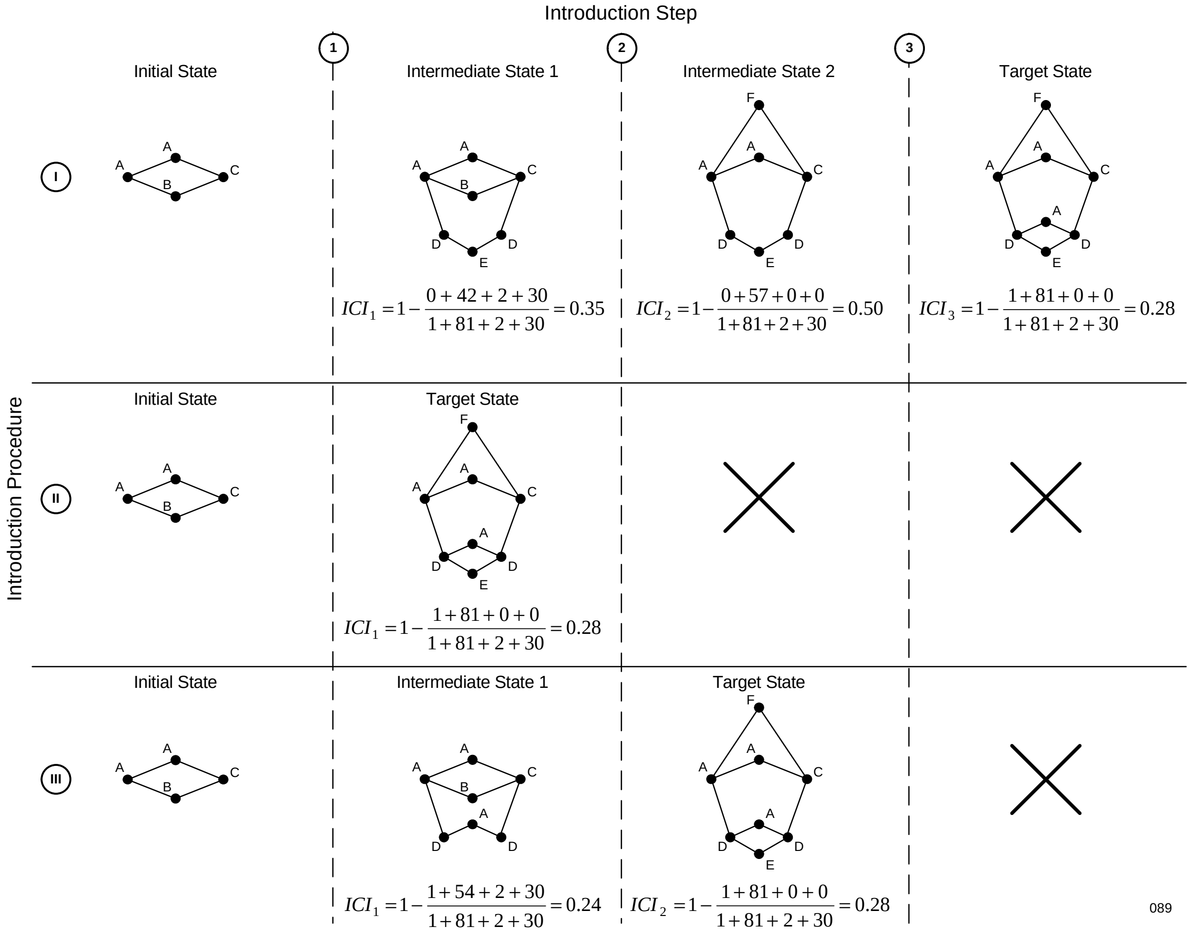

Figure 105: Evaluation of three introduction procedures with the metric Introduction Cost Index.

The example above shows that procedure III has relatively high cost (equal to low metric value) in intermediate state 1. They are higher than the cost of the completely introduced concept. Compared to procedure I, where the cost of the intermediate states 1 and 2 are rather moderate, this is a disadvantage of procedure III.

Since this metric evaluates the cost at each introduction state, it is independent of the number of intermediate states or the scope of changes. It only depends on the cost of the concept and context elements in the relevant state.

Figure 106 summarizes all defined assessment axioms and metrics.

Axiom	Metric Name	Metric
Module Importance	Module Introduction Advancement	$MIA_{mn} = \frac{MIF_{mn}}{TMI - MIF_{0m}}$
Team Change	Team Change Scope	$TCS_{mn} = 1 - \frac{1}{2}\left(\frac{NTR_{mn}}{TTR_n} + \frac{DTR_{mn}}{TTR_m}\right)$
Activity Coordination	Activity Introduction Scope	$AIS_{mn} = 1 - \frac{NAI_{mn} \cdot NCN_0}{TCI \cdot NCN_m}$
Activity Introduction	Activity Introduction Advancement	$AIA_{mn} = \frac{NAI_{mn}}{CAI - NAI_{0m}}$
Relation Introduction	Activity Relation Introduction Advancement	$RIA_{mn} = \frac{NRI_{mn}}{CRI - NRI_{0m}}$
Relation Coordination	Activity Relation Introduction Scope	$RIS_{mn} = 1 - \frac{NAR_{mn} \cdot NRN_0}{TRI \cdot NRN_m}$
Information Transfer	Team Integration Factor	$TIF_n = \frac{MRI_n}{PIN_n}$
Surplus Load	Surplus Load Index	$SLI_n = 1 - PEI_n = 1 - \frac{\sum_{x=1}^{ADN}\left(\frac{RND_{n,x}}{TRD_x} \cdot \frac{RDI_{n,x}}{TNR_x}\right)}{ADN}$
Parallel Introduction	Parallel Execution Index	$PEI_n = \frac{\sum_{x=1}^{ADN}\left(\frac{RND_{n,x}}{TRD_x} \cdot \frac{RDI_{n,x}}{TNR_x}\right)}{ADN}$
Introduction Timeframe	Introduction Duration Index	$IDI = 1 - \frac{PIC_{0n}}{PWC_{0n}}$
Project Duration	Project Duration Index	$PDI_{mn} = 1 - \left(0.3 \cdot TCS_{mn} + 0.5 \cdot \left(\frac{AIS_{mn} + RIS_{mn}}{2}\right) + 0.2 \cdot (SLI_n - SLI_m)\right)$
Introduction Cost	Introduction Cost Index	$ICI_n = 1 - \frac{RCM_n + PCM_n + RCC_n + PCC_n}{TRC + TPC + TCR + TCP}$

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Figure 106: Assessment Axioms and Metrics.

4.3.3 Assessment System

In this chapter, the identified introduction objectives (chapter 4.3.1) and axioms (chapter 4.3.2) are combined to an **assessment system** for the introduction. This assessment system is used for the **evaluation** of alternative introduction procedures.

To derive an assessment system for the evaluation of alternative introduction procedures, the objective system presented above has to be combined with the introduction axioms and thus with the according metrics. Figure 107 summarizes the classification of the introduction axioms with respect to the parts of the introduction procedure and the system type they are related to. With the help of this classification, the objective system and the axioms can be linked.

Axiom	Introduction Procedure Part		System Type	
	State	Transition	Process System	Organization System
Module Importance		X	X	
Team Change		X		X
Activity Coordination		X	X	
Activity Introduction		X	X	
Relation Introduction		X	X	
Relation Coordination		X	X	
Information Transfer	X			X
Surplus Load	X		X	
Parallel Introduction	X		X	
Introduction Timeframe		X	X	
Project Duration	X	X	X	X
Introduction Cost	X		X	

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Figure 107: Classification of introduction axioms.

The introduction quality consists of four relevant aspects: performance sustainment, introduction speed, company operability, and introduction acceptance. To derive an assessment system for the introduction, those quality aspects have to be related to the defined axioms.

In general, the introduction of concept elements leads to a decrease in process performance (see, e.g., Tarlatt 2001, p. 151; Blumenthal and Haspeslagh 1994, p. 105; Reiß 1997, p. 26 ff.; Reiß and Höge 1993, p. 217; Czichos 1990, pp. 419 and 421; Zeyer 1996, p. 150). Whether the objective performance sustainment is achieved is influenced by the way the changes are executed in both the process and organization system. In the process area, the introduction of activities and relations, as well as the surplus load created by the introduction has an effect on the process performance.

If the scope of the activity and relation introduction is low, no provisional concept elements are necessary. Provisional concept elements only lead to additional work, without providing benefits for the company. Furthermore, a low introduction scope opens the possibility to adapt the later introduced concept elements better to the users’ needs, which makes their application easier and yields better results. The restricted introduction complexity also takes into account the human bounded rationality and thus does not lead to an overload of the personnel. The surplus load also contributes to the introduction complexity. If human bounded rationality is taken into account and the personnel is not overloaded, the performance reduction will be moderate.

In the organization system, information transfer and team performance play an important role in sustaining the process performance. Through integrating all employees involved in a team, problem detection and solution finding can be improved. This helps to avoid problems during the introduction or to find solutions faster. In the team, the employees get a clearer overall picture of the introduced concept and thus are able to produce better results. Moreover, the concept introduction gains flexibility and stability. In this way, it can be ensured that relevant information is available for all affected employees. Information pathologies are thus avoided.

Team changes also have an important influence on the process performance. First, they lead to a decrease in team performance, i.e. the quality of the results produced within the team will decline. Second, restructuring a team is always associated with coordination effort, which keeps the employees from performing their original tasks in the process.

Thus, the introduction objective performance sustainment is influenced by the axioms Activity Coordination, Relation Coordination, Surplus Load, Information Transfer, and Team Change. Figure 108 summarizes the assessment system for this introduction objective. On the third and fourth level the metrics and the affiliated axioms are depicted, which are used to evaluate the performance sustainment. The metric values are combined separately for the process and organization system and finally integrated to derive an overall measure for performance sustainment. The numbers on the top of the boxes are the suggested weighting factors for this assessment structure, which were defined through interviews with partner companies in the SysTest project.

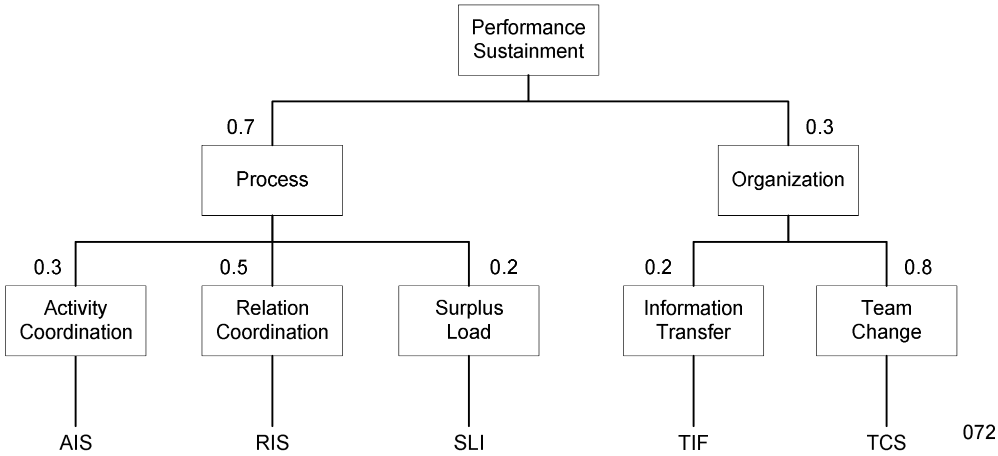

Figure 108: Assessment system for the introduction objective performance sustainment.[22]

Thus, the sum equation of the introduction objective performance sustainment is

$$PS_{mn} = 0.7 \cdot \left(0.3 \cdot AIS_{mn} + 0.5 \cdot RIS_{mn} + 0.2 \cdot \left(SLI_m - SLI_n\right)\right) + 0.3 \cdot \left(0.2 \cdot \left(TIF_m - TIF_n\right) + 0.8 \cdot TCS_{mn}\right)$$

Eq. 79

where n denotes the end state and m the start state of the transition.

Another quality objective of the introduction procedure is the company operability. The focus of the present dissertation is on introductions in the process system. They also implicate changes in the organization system, but those changes do not have the scope and the effects of organizational restructuring. Thus, the changes in the organization system considered in the present dissertation do not influence the company operability. With respect to the process system, the company operability is ensured by the existing context activities. New activities hold the risk of failure. That is, an introduction of new activities parallel to existing ones guarantees the operability of the company. Moreover, the introduction of new activities can be a relief for the context activities. A parallel introduction also provides the possibility to improve the introduction concept, which later reduces the risk of process failure. Thus, the objective company operability is only influenced by the axiom Parallel Introduction. Figure 109 summarizes the assessment system for this introduction objective. The foundation of this assessment system are the metrics and the affiliated axioms. Again, the metric values are combined separately for the process and organization system and finally are integrated to derive an overall measure for company operability. The numbers on the top of the boxes are the suggested weighting factors for this assessment structure.

[22] For a definition of the identified axioms and defined metrics see Figure 114 and Figure 115.

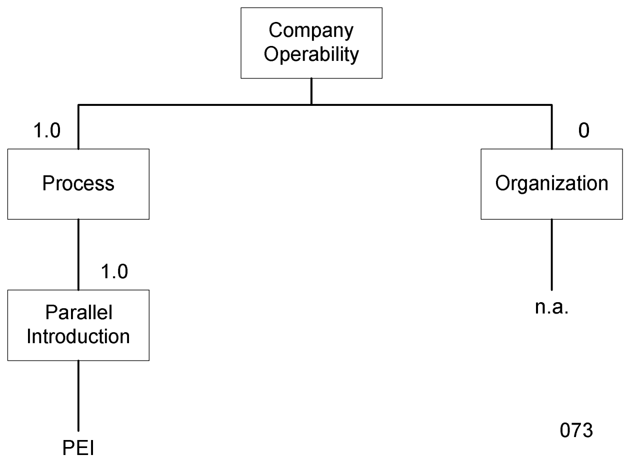

Figure 109: Assessment system for the introduction objective company operability.

Thus, the sum equation of the introduction objective company operability is

$$CO_{mn} = 1.0 \cdot PEI_n \quad \text{Eq. 80}$$

The third quality objective is the introduction speed. Since the focus of the present dissertation is on introductions in the process system, here the introduction speed is also not determined by changes in the organization system. In the process system, the progress with respect to introduced activities and relations defines the introduction speed. The more activities and relations are introduced in one step, the faster the introduction progresses. The high introduction speed leads to a reduced introduction duration and a shorter impairment of the daily business in the company. Thus, the quality objective introduction speed depends on the axioms Activity Introduction and Relation Introduction. Figure 110 summarizes the assessment system for this introduction objective. In this figure, the metrics with the affiliated axioms and the suggested weighting factors are shown.

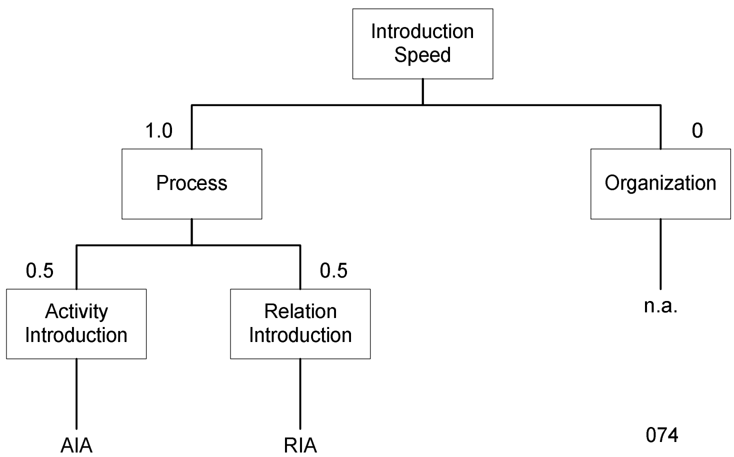

Figure 110: Assessment system for the introduction objective introduction speed.

Thus, the sum equation of the introduction objective introduction speed is

$$IS_{mn} = 0.5 \cdot AIA_{mn} + 0.5 \cdot RIA_{mn} \quad \text{Eq. 81}$$

The last quality objective is introduction acceptance. It depends on many factors whether the personnel reacts with acceptance or resistance towards an implementation. However, since here the focus is on aspects that are determined by the introduction procedure, a relatively small set of influencing parameters can be derived. The introduction acceptance depends on how the changes are executed in both the process and organization system.

From an organizational point of view, team change is an important factor. Team changes imply changes in personal relations between employees. When the social structure is strongly influenced, the affected employees will resist the introduction.

In the process area, above all the coordination effort related to the activity and relation introduction, as well as the surplus load and the module importance influence the introduction acceptance.

If the scope of the activity and relation introduction is low, there is only a small risk that the affected personnel is overloaded physically. Additionally, if bounded rationality is taken into account, the employees will not be overloaded mentally as well. Finally, the restricted introduction complexity supports understanding and thus acceptance of the introduction concept.

Beside the amount of activities and relations introduced, the surplus load due to an introduction of new activities in parallel to existing activities may also lead to a physical and mental overload.

Finally, through introducing the most important modules at the beginning of the introduction procedure, the employees get a better understanding of the concept. Moreover, the concept benefit can be realized earlier, which also supports acceptance.

Thus, the quality objective introduction acceptance depends on the axioms Activity Coordination, Relation Coordination, Module Importance, Surplus Load, and Team Change. Figure 111 shows the applied metrics and axioms, together with the suggested weighting factors.

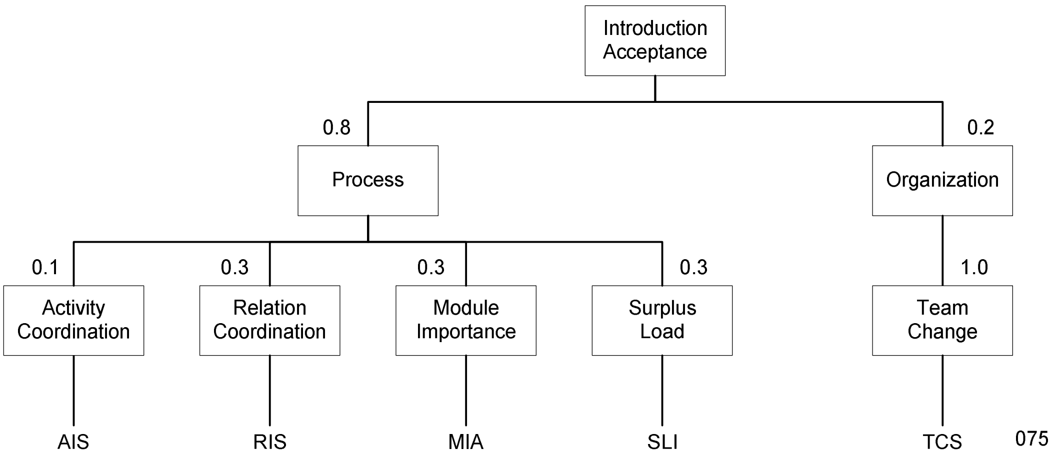

Figure 111: Assessment system for the quality objective introduction acceptance.

Thus, the sum equation of the introduction objective introduction acceptance is

$$IA = 0.8 \cdot \left(0.1 \cdot AIS_{mn} + 0.3 \cdot RIS_{mn} + 0.3 \cdot MIA_{mn} + 0.3 \cdot \left(SLI_m - SLI_n\right)\right) + 0.2 \cdot TCS_{\mathrm{mn}} \qquad \text{Eq. 82}$$

The introduction duration, depends mainly on two aspects. First, on the number of projects needed to complete the introduction process, and second on the extension of the individual project duration. The metrics Introduction Time and Project Duration can be combined to an overall measure for the introduction duration, as depicted in Figure 112. In this Figure, the suggested weighting factors are also shown.

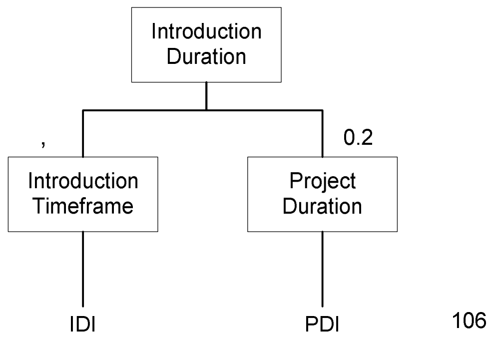

Figure 112: Assessment system for the objective introduction duration.

Thus, the sum equation of the introduction objective introduction duration is

$$ID_{mn} = 0.8 \cdot IDI_{mn} + 0.2 \cdot PDI_{mn} \qquad \text{Eq. 83}$$

On the other hand, the results for the axioms Introduction Time and Project Duration already provide valuable information. Therefore, for the evaluation of alternative introduction procedures, the metric values of those axioms are used directly.

Since only one metric is defined for the introduction cost, the assessment system for this metric is rather simple (see Figure 113).

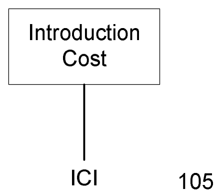

Figure 113: Assessment system for the objective introduction cost.

Thus, the sum equation of the introduction objective introduction cost is

$$IC_{mn} = 1.0 \cdot ICI_{n} \qquad \text{Eq. 84}$$

In the section Evaluation Approach in chapter 4.4, it is described how to derive a single evaluation measure (*EM*) for the introduction.

4.3.4 Summary

To evaluate the performance of a concept introduction procedure, the aspects **cost, duration, and quality** can be applied. Introduction quality consists of **several aspects**, which may be attributed to the quality areas **performance sustainment, introduction speed, company operability, introduction acceptance, and concept benefit** (chapter 4.3.1).

These introduction objectives are described only qualitatively in literature On the other hand, in literature many “rules” (**axioms**) about how to introduce a new concept in a company can be found. Therefore, axioms that are relevant for the concept introduction were extracted from literature. To be able to quantitatively assess the fulfillment of these axioms, **metrics** were defined and connected to each axiom. Figure 114 summarizes the identified axioms and their descriptions. To illustrate the use of the metrics, they were applied to a simple **example** of a concept introduction (chapter 4.3.2).

Axiom Title	Axiom Description
Module Importance	The most important concept modules should be introduced first
Team Change	The scope of team changes should be as low as possible
Activity Coordination	The scope of the introduction of new activities should be as low as possible
Activity Introduction	The number of introduced activities should be as high as possible
Relation Introduction	The number of activity relations should be as high as possible
Relation Coordination	The scope of the introduction of new activity relations should be as low as possible
Information Transfer	The people involved in the new concept should be integrated in one team
Surplus Load	The surplus load induced by the method introduction should be as low as possible
Parallel Introduction	New concept activities should be introduced in parallel to existing activities
Introduction Timeframe	The number of projects until the introduction completion should be as low as possible
Project Duration	The increase of the project duration due to the method introduction should be as low as possible
Introduction Cost	The cost of the method introduction should be as low as possible

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Figure 114: The introduction axioms with descriptions.

Figure 115 shows the identified axioms and the corresponding metrics with names and equations.

Finally, to derive a **quantitative assessment system**, the identified axioms and metrics are attributed to the objectives of the concept introduction. With this relation between the axioms and the objectives, an assessment system for the concept introduction in a company is established, which can be used to quantitatively evaluate different introduction procedures (chapter 4.3.3).

Axiom	Metric Name	Metric
Module Importance	Module Introduction Advancement	$MIA_{mn} = \frac{MIF_{mn}}{TMI - MIF_{0m}}$
Team Change	Team Change Scope	$TCS_{mn} = 1 - \frac{1}{2}\left(\frac{NTR_{mn}}{TTR_n} + \frac{DTR_{mn}}{TTR_m}\right)$
Activity Coordination	Activity Introduction Scope	$AIS_{mn} = 1 - \frac{NAI_{mn} \cdot NCN_0}{TCI \cdot NCN_m}$
Activity Introduction	Activity Introduction Advancement	$AIA_{mn} = \frac{NAI_{mn}}{CAI - NAI_{0m}}$
Relation Introduction	Activity Relation Introduction Advancement	$RIA_{mn} = \frac{NRI_{mn}}{CRI - NRI_{0m}}$
Relation Coordination	Activity Relation Introduction Scope	$RIS_{mn} = 1 - \frac{NAR_{mn} \cdot NRN_0}{TRI \cdot NRN_m}$
Information Transfer	Team Integration Factor	$TIF_n = \frac{MRI_n}{PIN_n}$
Surplus Load	Surplus Load Index	$SLI_n = 1 - PEI_n = 1 - \frac{\sum_{x=1}^{ADN}\left(\frac{RND_{n,x}}{TRD_x} \cdot \frac{RDI_{n,x}}{TNR_x}\right)}{ADN}$
Parallel Introduction	Parallel Execution Index	$PEI_n = \frac{\sum_{x=1}^{ADN}\left(\frac{RND_{n,x}}{TRD_x} \cdot \frac{RDI_{n,x}}{TNR_x}\right)}{ADN}$
Introduction Timeframe	Introduction Duration Index	$IDI = 1 - \frac{PIC_{0n}}{PWC_{0n}}$
Project Duration	Project Duration Index	$PDI_{mn} = 1 - \left(0.3 \cdot TCS_{mn} + 0.5 \cdot \left(\frac{AIS_{mn} + RIS_{mn}}{2}\right) + 0.2 \cdot (SLI_n - SLI_m)\right)$
Introduction Cost	Introduction Cost Index	$ICI_n = 1 - \frac{RCM_n + PCM_n + RCC_n + PCC_n}{TRC + TPC + TCR + TCP}$

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Figure 115: The introduction axioms with metrics.

4.4 Evaluation of Alternatives

This chapter shows how the defined introduction metrics are used to **evaluate alternative procedures** for the concept introduction. The **assessment system** described above integrates the defined metrics. However, these metrics are only designed for the assessment of an individual state or transition in the introduction procedure. To be able to evaluate a **complete introduction procedure**, the assessment system has to be applied to all introduction states and transitions.

Furthermore, most of the metrics only define the scope of influence of the introduction alternatives on the higher level assessment criteria. That is, the results derived do not provide absolute values for the assessment criteria. For some assessment criteria this is neither reasonable nor probably possible. For example, to measure the introduction acceptance in absolute values would be too complicated for this simple model. Moreover, the question would still be in which unit to measure acceptance. On the other hand, for the assessment criteria introduction duration, introduction cost, and performance sustainment, it would be interesting and valuable for the user to know the absolute values. For the introduction cost, the relevant metric is already based on absolute values. With respect to duration, the most interesting measure is the number of projects needed to complete the concept introduction. However, this measure cannot be determined directly from the structure of the introduction procedure, but has to be derived. Similarly, the defined metrics do not provide an absolute number for the expected performance reduction during the introduction of concept elements.

Yet, to know the performance reduction due to the introduction would be a valuable piece of information. On the one hand, the decrease in the quality of the process results can already be taken into account before the start of the introduction. On the other hand, if it is known in advance that this effect has to be expected and is normal, the acceptance from the side of the affected employees will be higher.

Therefore, this chapter presents the approach for evaluating alternative introduction procedures, based on the defined assessment system.

The criteria cost, duration, and quality are on the highest level of the objective system for concept introductions. Since especially introduction quality, but also introduction duration are composed of several criteria, the application of these high level objectives as evaluation criteria would lack transparency for the user. Therefore, it is suggested to use the criteria on the second level of the assessment system. The resulting evaluation criteria are summarized in Figure 116.

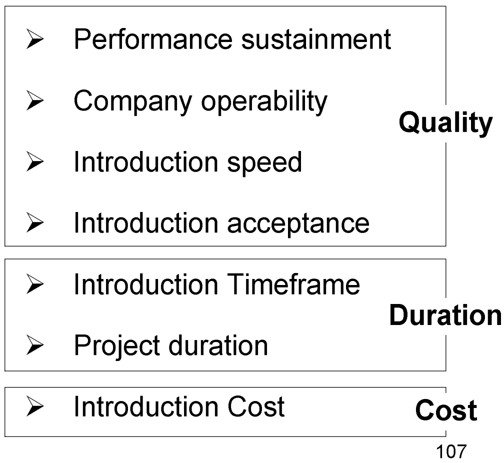

Figure 116: Evaluation criteria for introduction procedures.

The first step is to calculate the performance sustainment, since information from this criterion is needed to calculate the succeeding measures.

Performance Sustainment

The intention of the criterion performance sustainment is to have a measure for the change in the quality of the process results (result quality) due to the concept introduction. Therefore, this criterion is only a vehicle to determine the behavior of the result quality along the introduction procedure.

Figure 117 depicts the result quality along time for an introduction example in two steps. Due to the first introduction step, the result quality declines. Afterwards, learning effects and increased acceptance of the concept will lead to an increase of the result quality. In general, the improvement has the form of an S-curve (s-shaped, grey lines), but since learning occurs in projects, the improvement will have a discontinuous effect from project to project (horizontal, bold lines). The improvement may exceed the original result quality (100%) due to realized concept benefits (in this figure 110%). At a certain point in time, the next introduction step is executed, and this behavior is repeated. Eventually, when all concept elements have been introduced and everything works well, the result quality will reach the expected concept benefit (in this figure 115%).

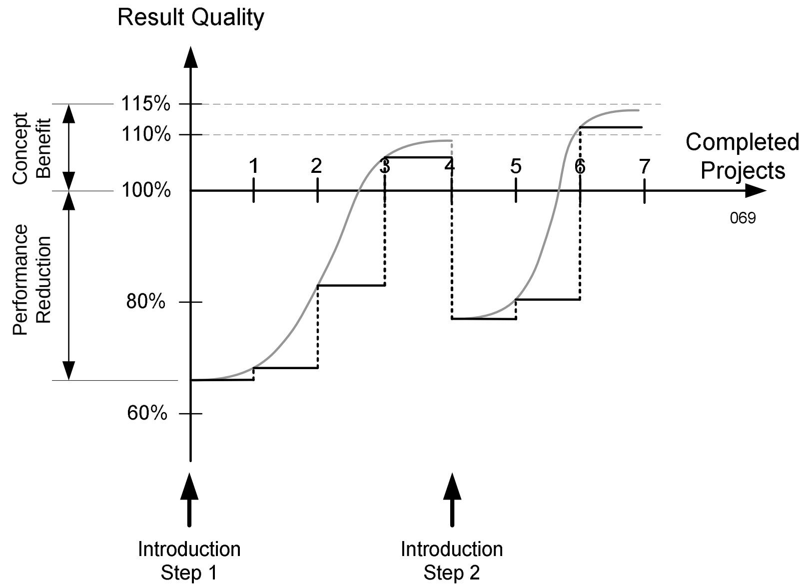

Figure 117: Result quality depending on the introduction procedure[23].

The expected benefit after each introduction step is determined by the introduced concept elements. The overall benefit resulting from the application of the new concept has to be determined already during its evaluation. The expected benefit is certainly one of the most important criteria for deciding if the concept introduction makes sense or if the disadvantages outweigh the advantages.

To determine the benefit of introducing individual elements of the concept may be more difficult. In some cases a Delphi approach can help to quantitatively determine the module benefit. If the individual modules independently provide benefits, the module benefits can be derived quite exactly. For example, a new concept consists of several modules, where each independently leads, apart from other benefits, to a reduction in process duration, the benefit in terms of process duration due to an introduction step is simply the sum of the module benefits introduced in this step.

However, if the modules are strongly interdependent, it is difficult to assess the benefit due to individual modules. In this case, the idea of the module importance can provide a means to derive it from the overall concept benefit. Depending on the module importance, the concept benefit can be assigned to the individual modules. Figure 118 shows an example, where the benefit of a module is derived on the basis of its importance. The concept consists of three modules, α, β, and γ. The overall expected concept benefit is a process duration reduction of 13%. In a first step, the module importance is determined on the basis of the criteria defined in chapter 4.2. In the second step, the module benefit is derived from the importance and overall benefit.

[23] Literature indicates that also the acceptance is depending on the introduction procedure. The author of the present dissertation proposes to consider the integral of the sigmoid curve describing the introduction procedure as measure of the introduction acceptance. The higher the performance reduction is and the longer the result quality recuperation takes, the more negatively influenced the introduction acceptance will be. Low introduction acceptance, e.g. due to a lack of communication, has thus a reinforcing effect.

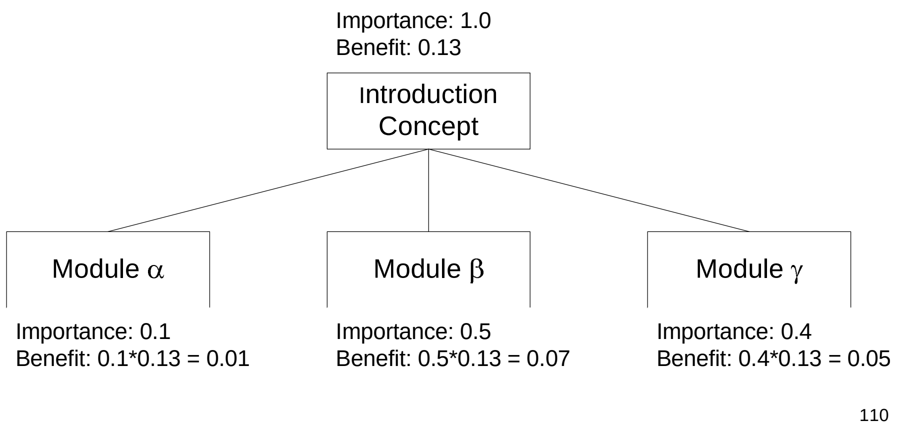

Figure 118: Module benefit based on importance.

If this simplified approach is not accurate enough, there is still the possibility to determine the expected benefit from an introduction step with the help of logical relations between concept modules and benefit. That is, in general the overall concept benefit may be decomposed in "lower level" benefits, which depend on the introduction of modules in a certain combination or even sequence.

Figure 119 shows an example for a concept introduction, where the expected benefit in terms of process duration reduction from an introduction step depends on the combination of introduced modules. The concept consists of three modules, α, β, and γ. Two alternative introduction procedures are defined, both with two introduction steps. The concept benefit B_1, an improvement of 8%, can be achieved when both the modules β and γ are introduced. The full concept benefit, which equals an improvement of 13%, can only be achieved when all three modules are introduced. Depending on these logical relations, introduction procedure II yields a benefit of 8% in state 1, whereas introduction procedure I does not achieve a benefit at this intermediate state.

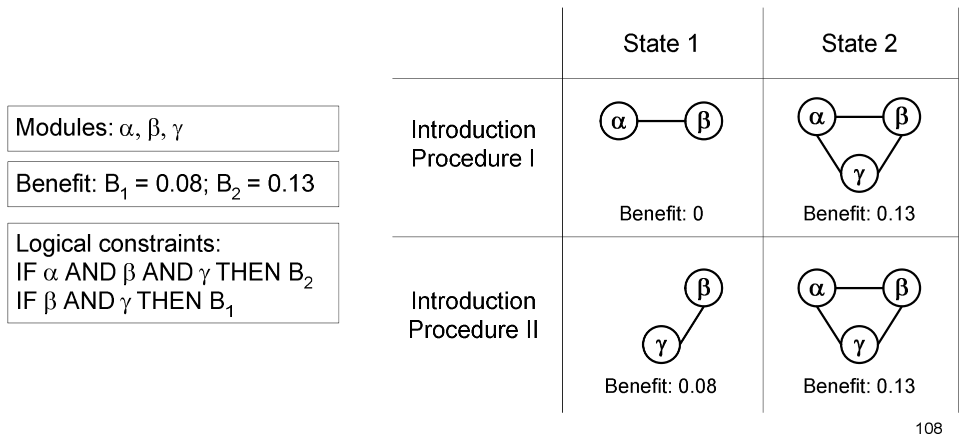

Figure 119: Concept benefit depending on logical relations.

The benefit resulting from an introduction step can be determined as described. It is however more important but also more complicated to determine the scope of the quality decline due to an introduction. In chapter 4.3.3, the assessment hierarchy was defined, and thus already the metrics necessary to determine the performance sustainment. However, the bridge between the metric values and the influence on the result quality is still missing. Therefore, the first step is to define the combination of the metrics in order to derive a measure for the performance sustainment. The second step then is to adequately map the value for the objective performance sustainment to a result quality reduction.

In the assessment hierarchy for the performance sustainment defined above, two classes of metrics are present: State and transition metrics. The state metrics assess the process and organization structure at an intermediate state, whereas the transition metrics assess the transfer from one state to the next.

In general, the influence on the result quality of the process depends on the scope of changes executed in an introduction step. That is, to determine the quality effect the previous and current state of the introduction procedure have to be considered. This is already included in the transition metrics, but not in the state metrics. Hence, to calculate performance sustainment, the difference between the state metrics in the previous and the current state is used. The equations below show how the state metrics Team Integration Factor and the Surplus Load Index for the transition (SLI_{mn} and TIF_{mn}) are calculated.

$$SLI_{mn} = SLI_m - SLI_n \qquad \text{Eq. 85}$$

$$TIF_{mn} = TIF_m - TIF_n \qquad \text{Eq. 86}$$

Based on the assessment hierarchy defined in the previous chapter, now the relevant metrics could be combined to derive a measure for the introduction objective performance sustainment, and then this measure could be mapped to a result quality reduction. Yet this procedure would not adequately take into account the effect of the individual aspect on the result quality, since there is a non-linear correlation. Therefore, each individual metric is evaluated with a function to derive its effect on the quality of the process result. This function is defined as the correlation function, since it correlates the metric values with a decrease in the result quality (delta result quality).

The characteristics of this correlation function are governed by the characteristics of the relation between the metric value and quality decline. In the following paragraph, the necessary assumptions to derive a correlation function are made. Assumptions are made for the best and worst case, and for the slope of the correlation function. Here, worst case means that the corresponding axiom is not fulfilled at all, whereas best case means that the corresponding axiom is fully satisfied.

First, for the worst case, i.e. a metric value equal to 0, it is assumed that the result quality reaches a certain value, which is denoted as $\Delta RQ_{WC, M}$. The second assumption is that for the best case, i.e. a metric value equal to 1, the result quality will not change. Thus, the delta result quality for the best case, $\Delta RQ_{BC, M}$, is equal to 0. The third assumption is that in general the influence on the result quality increases disproportionally with the change scope. That is the delta result quality increases faster than the metric value. Despite that, the fourth assumption is that for high metric values, small variations in the metric value have only a less than proportional effect on the result quality. In practice this means that there is not much difference in terms of influence on the result quality between small changes. For example, if 1.0% or 1.2% of a process system is changed, this does not make a decisive difference. Finally, the same is assumed for high metric values, i.e. large change scopes, that small variations in the metric values do only have a less than proportional effect on the result quality. For example, if 88.0% or 88.2% of a process system are changed does not make a big difference.

In summary, these assumptions are boundary conditions, which yield an S-curve as correlation function. Figure 120 shows the general form of the correlation function with the numbers of the assumptions assigned to the curve areas which they define.

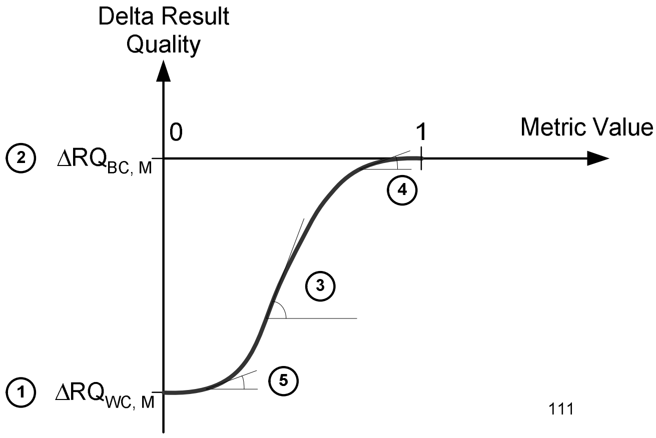

Figure 120: Correlation function for an individual metric value.

There is no proof in literature for the assumptions described above. However, this concept of the correlation function and its shape were verified in interviews with industrial partners. Nevertheless, these assumptions are made without loss of generality for the presented Introduction Procedure Model. If further research was to show a different behavior of the correlation function, it can be adjusted without harm to the basic approach in the Introduction Procedure Model.

The slope of the correlation function for low, medium, and high metric values are company specific and thus have to be defined by the user. Yet conservative assumptions for this aspect do not decisively change the behavior of the correlation function and thus the results.

In contrast, the value for the delta result quality in the worst case has a much stronger influence on the results and therefore it is more important. To determine this value for each metric seems to be too complicated for the user, since it is difficult to assess. Therefore an approach is suggested that makes use of the assessment system previously defined.

In general, the experience from the SysTest project has shown that it is easier for the user to determine the worst possible value on a high level for the case that every aspect that influences this value is as negative as possible. Therefore, for this model it is suggested to first determine the delta result quality in the case that all influencing metric values are equal to 0. In practice, this would mean that the change scope in the process and organization area is as high as possible. Specifically, this means for the different axioms in the assessment system of the performance sustainment:

- Activity Coordination: All concept activities are introduced in one step
- Relation Coordination: All concept activity relations are introduced in one step
- Surplus Load: All new activities and relations are introduced parallel to the existing process system
- Information Transfer: All people involved in the new concept are in separate teams
- Team Performance: All of the existing team relations are disintegrated; all team relations after the concept introduction are new

The determined overall value for the delta result quality, ΔRQ_{WC}, can now be attributed to the individual metrics via the weightings in the assessment system defined above. That is, each metric is assigned a share on the delta result quality equal to its weight in the assessment system. With the suggested weightings of the assessment system, this yields the relations between the overall delta result quality, ΔRQ_{WC}, and the delta result quality for the individual metrics, $\Delta RQ_{WC,\,i}$, which are depicted in Figure 121.

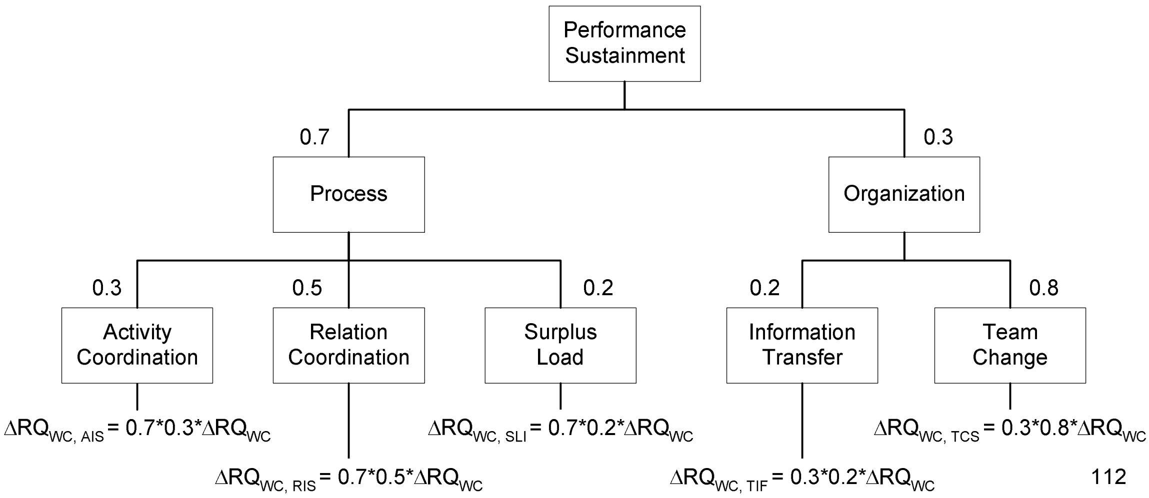

Figure 121: Calculation approach of the worst case delta result quality for the metrics.

For example, if the overall delta result quality ΔRQ_{WC} is 20%, then the delta result quality for the metric Activity Introduction Scope $\Delta RQ_{WC, AIS}$ is 0.7 (i.e. the weighting of the process factors) times 0.3 (the weighting of the axiom Activity Coordination within the process factors) times 20%:

$$\Delta RQ_{WC,AIS} = 0.7 \cdot 0.3 \cdot \Delta RQ_{WC} = 0.7 \cdot 0.3 \cdot 20\% = 4.2\% \qquad \text{Eq. 87}$$

This means that the reduction in the result quality due to increased activity coordination is assumed to be 4.2%.

With this information, the result quality after an introduction step can be determined. After this introduction step, the result quality increases again to the value determined by the benefit provided by the introduced concept elements.

Another aspect that has to be determined is the point in time when the next introduction step should be executed: the transition point. Without loss of generality, it is assumed that the best transition point is when the slope of the sigmoid function is below a certain value. When the slope of the sigmoid function is small, the executed projects do not yield an improvement rate as high as projects that are executed at a time when the sigmoid function has a large slope. Figure 122 illustrates this behavior.

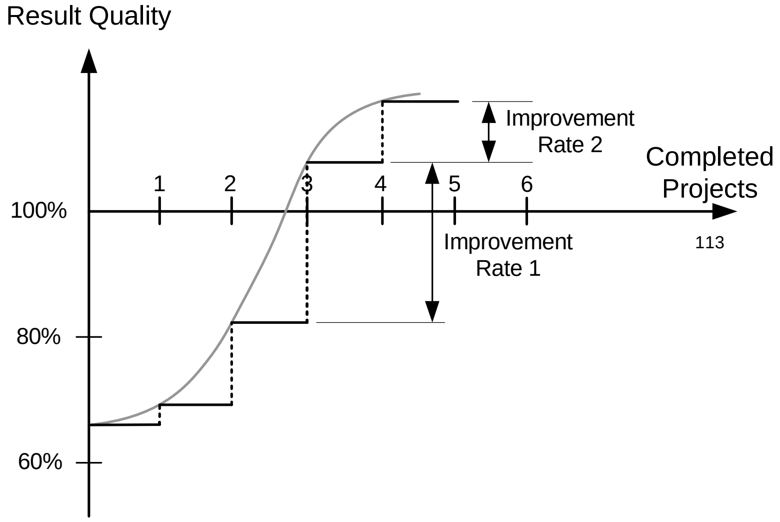

Figure 122: Improvement rates at different positions of the sigmoid curve.

Therefore, a slope is defined where the transition to the next introduction step should be executed. The correct definition of this optimal point for initiating the next introduction step has to be further investigated in future research. Without loss of generality, the optimal for initiating the next introduction step was defined as the point with a slope of 0.01.

For the next introduction step, the same procedure to determine the influence on the result quality as described above is repeated.

With this evaluation procedure for the performance sustainment, first the trend of the result quality and second the number of projects needed to complete the introduction is determined (see Figure 123). From the first aspect the average of the result quality until introduction completion is derived, which is applied as measure for the performance sustainment. The number of projects needed to complete the introduction is used to calculate the metric Introduction Duration Index.

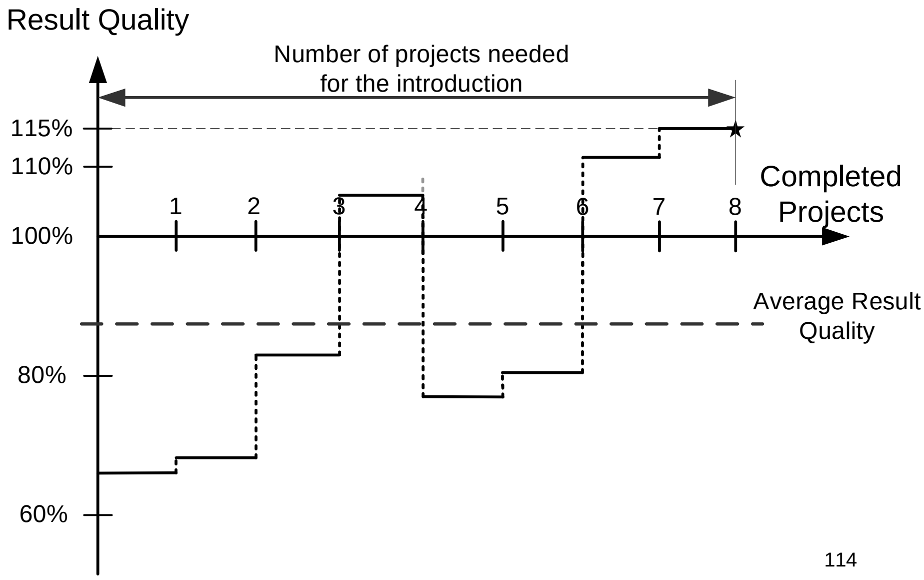

Figure 123: Two measures derived from predicting the result quality.

It is not reasonable to use the average of the result quality for comparing different introduction approaches, since small quality losses over a large number of projects are worse than a medium quality loss in, e.g., only one project. Therefore, the difference between the actual Result Quality and the maximum result quality (representing the quality loss) is accumulated over all projects. This term is then subtracted from one to be consistent with the definition ("higher is better") of all other Introduction Objectives. The actual quality loss is the inverse of the Result Quality. Thus, the equation for the Accumulated Result Quality, RQ_{Acc} is:

$$RQ_{Acc} = 1 - \left(np \cdot (1 + CB) - \sum_p RQ_p \right) \qquad \text{Eq. 88}$$

In this equation, np is the number of projects in the introduction procedure, CB the Concept Benefit, and RQ_p the Result Quality of project p.

Project Duration

The introduction duration is mainly composed of two elements: The project duration and the number of projects needed to accomplish the introduction. The number of projects has already been derived from the analysis of the result quality, whereas the behavior of the project duration over time has not yet been determined.

The Project Duration Index describes the scope of the prolongation of an individual project due to an introduction step. Yet it does not consider time effects, which lead to a recuperation of the project duration, so that it eventually reaches again its original value[24]. This recuperation mainly stems from learning effects that allow people to do their tasks faster with the same quality.

There are several functions that describe the learning success of humans (Zangwill and Kantor 1998, p. 917); one of these is the exponential learning curve.

$$T = (Min - Max) \cdot e^{(-l \cdot x)} + Max \qquad \text{Eq. 89}$$

This equation describes the exponential learning curve mathematically, where T is the time, x is the "quantity produced"[25], Min is the time for the quantity 1, Max is the optimum performance level, and l is the learning parameter.

Since we are interested in the influence of learning effects on the project duration, T is substituted by the Project Duration Index at time x. Then, Min is the Project Duration Index directly after the introduction, and x is the number of completed projects after the introduction. The parameter Max defines the value which the exponential function approaches, in this case a Project Duration Index equal to 1. The learning parameter l has to be defined individually for each company. This yields the following equation.

$$PDI_{n,x} = (PDI_n - 1.0) \cdot e^{(-l \cdot x)} + 1.0 \qquad \text{Eq. 90}$$

Figure 124 depicts the qualitative behavior of the Project Duration Index (PDI) over time, based on the equation defined above. For each subsequent introduction step, a new decline of

[24] This implies that no further introduction steps are conducted and that the concept itself does not lead to a reduction in project duration.

[25] The variable x is defined as the "quantity produced" since the concept of the learning curve originally stems from the production area.

the Project Duration Index has to be expected. The average Project Duration Index is used to compare the alternative introduction procedures.

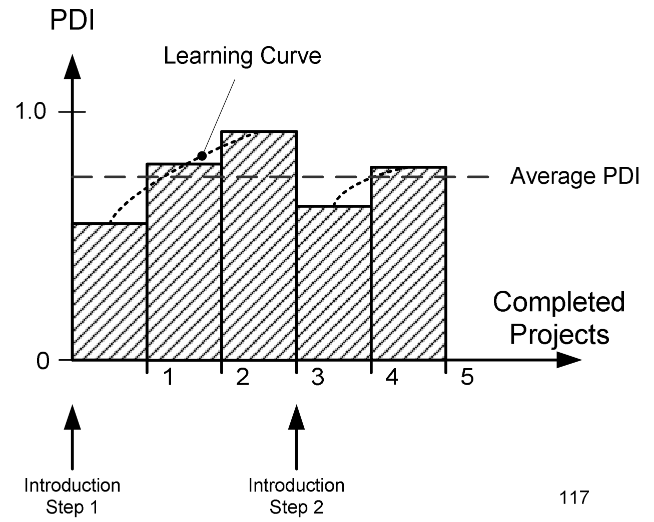

Figure 124: Influence of learning on the Project Duration Index.

Other Introduction Objectives

In contrast to the evaluation of the performance sustainment and the project duration described above, the other introduction objectives are easier to evaluate, since the applied metrics can be directly combined to an overall measure for the introduction objective. In consequence, the values for the introduction objectives do only change at the introduction steps. This behavior of the introduction objective values is shown as an example for the introduction speed in Figure 125. For all introduction objectives the average value over all completed projects is used as evaluation measure.

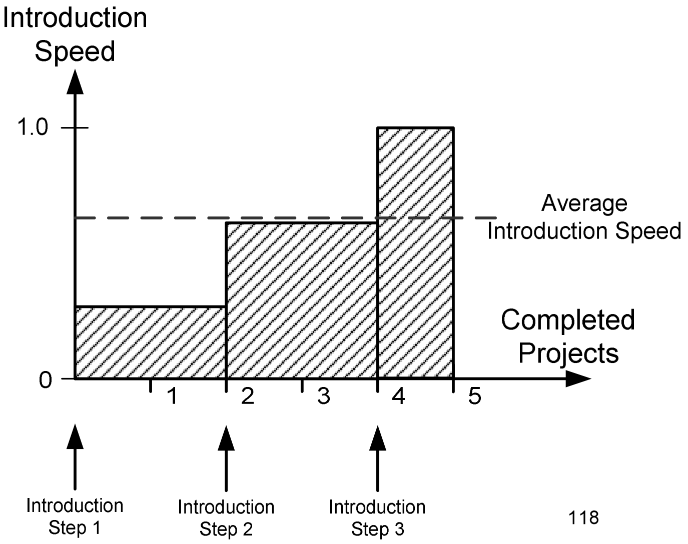

Figure 125: Temporal behavior of the introduction speed.

Hence, seven parameters are used for the evaluation of the alternative introduction procedures, which are:

- Performance sustainment

- Introduction speed
- Company operability
- Introduction acceptance
- Project duration
- Introduction Timeframe
- Introduction cost

In the following chapter, the application of the Introduction Procedure Model in a case study is described.

Evaluation Approach

This chapter describes how the described assessment system and approach can be implemented in a tool. To that end, the input values necessary for the calculation, the model variables, and the algorithm in form of pseudocode are defined.

The input values necessary for determining the optimal introduction procedure are described in Figure **126**.

Input Data	Description
R_i	Initial process state with the activities contained and the relations between these activities
R_e	Target process state with the activities contained and the relations between these activities
Resp	Responsible persons for the activities
M_{xnor}	Modules of the relations to be removed and modules of the relations to be introduced
mif	Module importance (vector of the importance factors)
DQ_{wc}	Quality reduction in the worst case
pc	Personnel costs (vector of the costs per person)
rc	Resource cost (vector of the costs per activity)
CB	Concept benefit
$\boldsymbol{w}_{XY}$	Weightings of the State and Transition Metrics for calculating the Introduction Objectives (vector of the weightings per Introduction Objective)
cfw	Weightings of the Introduction Objectives for calculating the Evaluation Measure (vector of the weightings)

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Figure 126: Input values for determining the optimal introduction procedure.

The model variables that are used in calculating the optimal introduction procedure are listed in Figure 127.

Variable	Description
DQ_{wcax}	Quality reduction in the worst case
S_{all}	Reasonable introduction states
T	Transitions between the determined reasonable introduction states
C_i	Optimal team structure at the initial state
C_e	Optimal team structure at the target state
C_k	Optimal team structure at state k
$SMIF_k$	Overall benefit of the introduced modules
$S_{1,t}$	Source state of the transition t
$S_{2,t}$	Target state of the transition t
TME_t	Value of the transition metric TME (placeholder) for transition t
IO_n	Value of the Introduction Objective IO (placeholder) for state n
$DQ_{ax,k}$	Quality reduction due to the introduction of new elements at state k
np_n	Number of projects that are performed in state n
$q_{n,p}$	Quality with which each project p in state n is performed
$RQ_{med,n}$	Medium value for the Result Quality for state n
$IO_{med,n}$	Medium values for the Introduction Objective IO (placeholder)
np_{0m}	Number of projects until the current transition
cfw_{IO}	Weighting of the introduction objective IO (placeholder)
D_{0n}	Distance of state n from the initial state, state 0
D_{0T}	Distance of the target state, state T, from the initial state, state 0
EM	Evaluation Measure

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Figure 127: Model variables for determining the optimal introduction procedure.

In the following paragraphs, the algorithm for determining the optimal introduction procedure is described.

1. Determine the quality reduction in the worst case, DQ_{wcax}, for each Introduction Axiom
   This is done by multiplying the weightings of the axioms represented in the Introduction Objective Performance Sustainment, $\boldsymbol{w_{PS}}$, and the overall quality reduction in the worst case, DQ_{wc}

2. Determine the reasonable introduction states S_{all} using the criteria stability, modularity, and practical constraints, based on the initial and target process state, R_i and R_e,
   (1) Stability: The stability requires that each activity has at least one input and one output, despite of defined start and end activities (can be derived from the initial and target state)
   (2) Modularity: The relations to be introduced or removed are treated as modules, as defined by the matrix M_{xnor}
   (3) Practical constraints: Practical constraints defining a certain introduction state as not valid are considered. Rules that describe these practical constraints are previously defined by the user
   For example, a rule may be that module 3 must not be removed before module 5 is introduced.

3. Find all transitions T between the determined reasonable introduction states S_{all}
   The transitions are determined through searching for states from which, with removing or adding activities in a valid manner, the state under consideration can be reached

4. Determine the optimal team structure at the initial state C_i
   The optimal team structure is determined through clustering of teams, using the clustering algorithm described in (DSMWeb 2006)

5. Determine the optimal team structure at the target state C_e
The optimal team structure is determined through clustering of teams, using the clustering algorithm described in (DSMWeb 2006)

6. For each state k repeat

6.1 Find the optimal team structure at state k, C_k, considering the initial and target state team structure, C_i and C_e
The optimal team structure for an individual state is defined as the team structure closest to C_e **and** C_i

6.2 Evaluate state k with the defined metrics
(1) The calculated metrics are: TIF (Team Integration Factor), SLI (Surplus Load Index), PEI (Parallel Execution Index), ICI (Introduction Cost Index), and IDI (Introduction Duration Index)
(2) The ICI is calculated based on the responsible persons for the activities, *Resp*, and the personnel and resource costs, ***pc*** and ***rc***

6.3 Calculate the overall benefit of the introduced modules at state k, $SMIF_k$
$SMIF_k$ is calculated based on the defined concept benefit CB and the module importance factors, ***mif***

7. For each transition t repeat

7.1 Determine the source state of the transition t, $S_{1,t}$

7.2 Determine the target state of the transition t, $S_{2,t}$

7.3 Calculate the transition metrics for transition t, TME_t
The Transition Metrics are: MIA (Module Introduction Advancement), TCS (Team Change Scope), AIS (Activity Introduction Scope), AIA (Activity Introduction Advancement), RIA (Activity Relation Introduction Advancement), and RIS (Activity Relation Introduction Scope), PDI (Project Duration Index)

7.4 Calculate the values of the Introduction Objectives for $S_{2,t}$, IO_n
That is, Performance Sustainment, Introduction Speed, Company Operability, Introduction Acceptance, Introduction Duration, and Introduction Cost.
The Introduction Objectives are calculated using the weightings of the State and Transition Metrics

7.5 Determine the quality reduction due to the introduction of new elements (activities and / or relations) at state k, $DQ_{ax,k}$

8. For each state m repeat

8.1 For each transition g from state m repeat

8.1.1 Determine the "distance" of the next state (state n) from the initial state (state 0), using the transition g

8.1.1.1 Determine the number of projects that are performed in state n, np_n
The sigmoid function is used to determine the number of projects to be performed until the next introduction step is initiated

8.1.1.2 Determine the quality with which each project p in state n is performed, $q_{n,p}$
(1) use the quality reduction calculated in step 7.4 as initial quality value
(2) calculate the quality increase due to the improvement curve for this introduction step

8.1.1.3 Determine the medium value for the Result Quality for state n, $RQ_{med,n}$

$$RQ_{med,n} = \left(np_n \cdot (1 + CB) - \sum_p q_{n,p} \right) \div (CB + DQ_{wc})$$

(1) Please note that the quality at the projects is subtracted from the maximum achievable quality (100% + Concept Benefit). In this way a higher number is worse, reflecting the notion of cost of the transition.
(2) The resulting value is divided by the sum of the Concept Benefit and Delta Quality in worst case for normalization purposes

8.1.1.4 Determine the medium values of the Introduction Objectives, $IO_{med,n}$, for state n

$$IO_{med,n} = \left(\left(IO_{med,m} \cdot np_{0m}\right) + \left(\left(1 - IO_n\right) \cdot np_n\right)\right) \div \left(np_{0m} + np_n\right)$$

(1) The Introduction Objectives are: Performance Sustainment, Company Operability, Introduction Speed, Introduction Acceptance, Introduction Duration, and Introduction Cost
(2) Please note that IO_n is subtracted from one to get the "cost" of the transition. In this case a higher value is worse

8.1.1.5 Calculate the "distance" of state n from the initial state, state 0, D_{0n}

$$D_{0n} = \sum_{IO} cfw_{IO} \cdot IO_{med,n}$$

This is done by multiplying the medium values of the Introduction Objectives, $IO_{med,n}$, with the weighting of the introduction objectives, cfw_{IO}

8.1.2 If D_{0n} calculated in this step is lower than the distance of state n from the initial state calculated in a previous step, then set this distance D_{0n} to the distance of state n

9. Determine the optimal introduction procedure
The optimal introduction procedure is the list of optimal predecessors (states) from the target state to the initial state

10. Determine the Evaluation Measure EM
The evaluation measure is equal to the distance D_{0T} of the target state to the initial state

To find the optimal introduction procedure is a shortest path problem, which was solved using the Dijkstra algorithm (see e.g. Morris 2005, Wikipedia 2006).

Summary

This chapter presented the approach for **evaluating alternative introduction procedures**, based on the defined assessment system. The criteria cost, duration, and quality are on the **highest level** of the objective system for concept introductions. Since especially introduction quality, but also introduction duration are composed of **several criteria**, the application of these high level objectives as evaluation criteria would lack **transparency** for the user. Therefore, it is suggested to use the criteria on the **second level** of the assessment system.

The first step is to calculate the **performance sustainment**, since information from this criterion is needed to calculate the succeeding measures. The intention of the criterion performance sustainment is to have a measure for the **change in the quality** of the process results (**result quality**) due to the concept introduction. Therefore, this criterion is only a **vehicle** to determine the behavior of the result quality along the introduction procedure.

The **introduction duration** is mainly composed of two elements: The **project duration** and the **number of projects** needed to accomplish the introduction. The number of projects can be derived from the analysis of the result quality, whereas the behavior of the project duration over time is depending also on learning effects.

In contrast to the evaluation of the performance sustainment and the project duration, the other introduction objectives are easier to evaluate, since the applied metrics can be **directly combined** to an overall measure for the introduction objective.

In the last chapter, the evaluation approach was described trough defining the **input values**, **model variables**, and the **algorithm** for determining the optimal introduction procedure.

4.5 Verification of the Introduction Procedure Model

The Introduction Procedure Model developed in the previous section was **verified** in a case study[26], conducted after the end of the SysTest project in cooperation with Tetra Pak Carton Ambient. In chapter 4.5.1, the case study is **described**. In the then following chapter 4.5.2, the **applied introduction procedure** is **evaluated** and **important insights**, as well as data for **calibrating** the Introduction Procedure Model, are derived. Finally, the Introduction Procedure Model is used to determine the **optimal introduction procedure**, which is explained and discussed in chapter 4.5.3.

Tetra Pak Carton Ambient is part of the Tetra Pak Group, which is a system developer in the liquid food packaging industry. The term system in this industry includes packaging lines, filling machines, downstream equipment, and the package, which is the main product. Companies in the food packaging industry work in a business-to-business condition: The packages are produced at the customer's premises using internally developed equipment, machinery and materials. Products can therefore be subdivided into two main typologies: machinery (processing systems, filling machines, optional equipment and kits, downstream equipment) and package (packaging materials, opening systems, sales and distribution solutions).

The case study deals with the joint development of a liquid food package and the according machinery in one development process. This development process is enhanced by a new methodology[27], which promises to improve the knowledge about the product, i.e. about the package, the machinery, and their interaction.

4.5.1 Case Study Description

The **case study** at Tetra Pak Carton Ambient was a methodology introduction in a development process. This chapter describes both aspects: the **development process** and the **methodology introduction**.

The production and filling of packages is a typical industrial transformation process in the liquid food industry environment. Semi-manufactured goods (e.g. the packaging material) are the input to a generic transformation process, which is affected by external noises, and the output is a finished product. The case study in the present dissertation deals with one type of development process at Tetra Pak Carton Ambient: The joint development of a liquid food package and the according machinery.

The objective of this generic type of development process is to define a new package solution which is different from previously produced packages in terms of geometry, material, or other characteristics. That is, not only the package itself has to be developed, but also the machinery handling the package has to be adapted to the new package characteristics. Therefore, this project may be a new development with respect to the package, but is a product update with respect to the machinery.

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[26] The results of the case study can be seen as a verification, because they show that the Introduction Procedure Model was „done right“, i.e. that it satisfies its requirements. However, in the framework of this dissertation it is not possible to validate the Introduction Procedure Model, i.e. to show that the „right thing was done“. This would require to set up an introduction project based on the results of the Introduction Procedure Model, measure the actual characteristics of the introduction (acceptance, speed, performance reduction, etc.) and to compare these values with the predicted data.

[27] A methodology is a body of methods, rules, and postulates employed by a discipline, a particular procedure or set of procedures that enable a systematic plan of inquiry or accomplishment to be followed toward a defined objective, or a way, a technique, or a process of or a process for doing something. The new approach to be introduced is denoted as methodology, because it consists of several methods that together accomplish the intended task.

In Tetra Pak Carton Ambient (TPCA), the product lifecycle is divided into the phases Product Definition, Concept Development, Prototype Development, Product Qualification, Product Launch & Production, Product Upgrade and Maintenance, and Product Disposal. In the case study process, the phases Product Definition, Concept Development, Prototype Development, and Product Qualification are covered.

In the first phase (Product Definition), the goal is to define the requirements on the package. During the Concept Development phase, the packaging material is defined and the relevant characteristics assessed. The Prototype Development produces package prototypes that are used as inputs for the development of the machinery. Still in this phase, prototype package and machinery are "integrated" and tested together. Finally, in the Product Qualification the actual machinery and packaging material is validated together in a realistic environment.

The liquid food packaging system industry relies on milestones that are connected to verification and validation activities. The control activities are limited to the package specification and filling of the package with the processed liquid food. Currently, the verification and validation activities are mainly a kind of "defect counting", where the type of defect and the amount of defective packages is determined. Yet, this approach does not allow inferences on the causes of the defect, since simply the knowledge about the correlation between cause and effect is lacking.

Therefore, a new methodology shall be introduced that provides this information. The objective of the new methodology is to determine the correlated effects of raw materials, transformation process, and intrinsic variability of noises on the geometrical dimensions, defectiveness of the appearance, and tare weight of the container.

In particular, the introduction of the new methodology is expected to have advantages in two areas. First, to introduce measurement versus defect counting means a transfer from qualitative to quantitative methodologies. This will generally increase the knowledge about the product. Second, the process is documented, which yields comparable parameter values (e.g. packaging material dimensions) that can be used in other projects, allowing to assess the similarity of different projects via these parameter values. In summary, the knowledge about the project is increased. This knowledge is the basis for project control, i.e. with the help of this data variations in the product characteristics can be determined and assessed and adequate measures can be taken. It is expected that this will reduce the number of defect packages produced by the machinery, which is usually measured by the metric defect packages per hour.

Figure 128 shows the as-is state of the development process (initial state). The process activities are depicted as boxes, which are connected by arrows symbolizing the information flow. The activity name is in the upper part of the boxes. For confidentiality reasons, the activity names are changed for this case study. In the lower part, an acronym for the activity responsible and the activity number is shown. The dashed arrows are information flows that become obsolete through the introduction of the new methodology, and thus are removed during the introduction process.

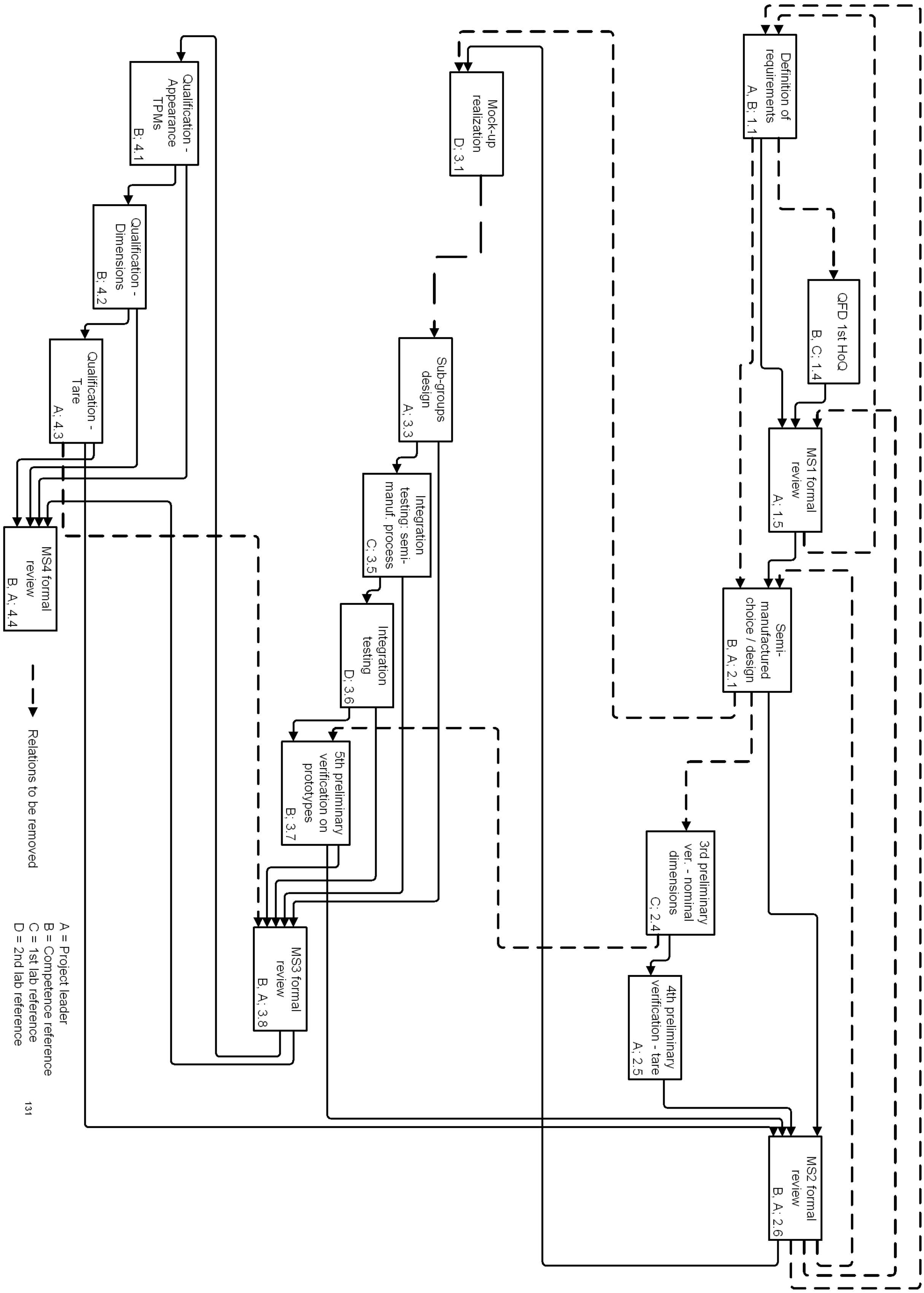

Figure 128: Initial state of the process at TPCA.

As mentioned, the purpose of the methodology introduction in this case study is to enhance the knowledge about the product (package and machinery) and thus be able to determine cause and effect relations. This general objective has different characteristics in the various phases. The objective in Product Definition is to “learn” if the requirements are suitable and feasible. Therefore, the new verification activity “preliminary feasibility” is introduced (see Figure 129). With introducing the activity “second preliminary verification” in the Concept Development phase, the effects of the variation in the packaging material shall be assessed. This variation can be e.g. in the width of the packaging material. In the Prototype Development the effects of variations in the machine on the resulting product are evaluated. This is supported by the new activity “first mock-up measures – reverse engineering”. In general, the objective of reverse engineering is to analyze a device with the intention to derive its underlying structure. In the context of the case study, the package mock-up is reverse-engineered in order to derive the necessary characteristics of the machinery and packaging material.

In the last phase, the classic approach of defect counting with samples is applied. However, with the information gathered in the previous phases it is possible to relate the detected defects to variations in the package and machinery characteristics.

With introducing the activities, existing information flows become obsolete and new information flows have to be created. Therefore, existing relations have to be removed and new relations have to be introduced. The new relations that have to be introduced are depicted with dotted and dashed lines in Figure 129. The meaning of the different colors and line styles is discussed in the following chapter.

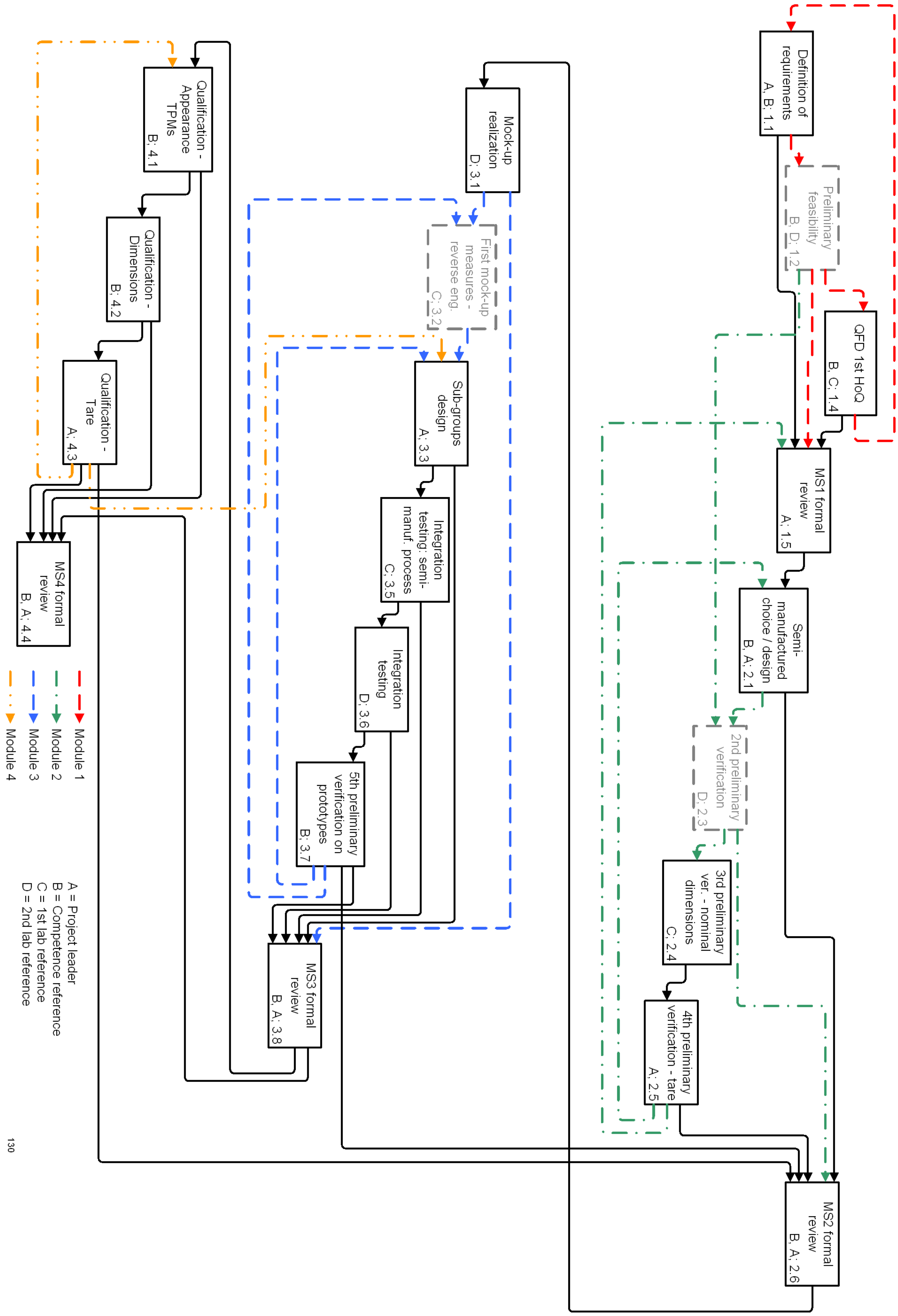

Figure 129: Target state of the process at TPCA.

For the new methodology, three new activities have to be introduced (boxes with grey and dotted borders in Figure 129). The number of new relations to be introduced is 17, while eleven relations have to be disintegrated.

The engineers at Tetra Pak Carton Ambient decided to introduce all new activities and relations in one step, i.e. in one project. This project is currently conducted at TPCA and has reached activity 3.5, “integration testing: semi-manufactured process”. In the following chapter, the characteristics of the applied one-step approach are derived and this introduction procedure is evaluated.

4.5.2 Evaluating the Applied Introduction Approach

In this chapter, the **introduction approach** actually applied at Tetra Pak Carton Ambient is **evaluated** based on the defined **Introduction Procedure Model**. To verify the Introduction Procedure Model, it was implemented in MATLAB. This tool was used to determine the optimal introduction procedure in the case study.

To introduce the new methodology, a total of three changes at the activities and 27 changes (introduction and disintegration) at the relations have to be executed. This yields more than 134 million theoretically possible intermediate states. The engineers at Tetra Pak Carton Ambient decided to introduce the new methodology in one step, which means that all activities and relations are introduced in the first project. The characteristics of this introduction approach were determined through an interview and, based on this data, the introduction approach was evaluated. The evaluation results are presented in this chapter.

As previously mentioned, the main benefit expected from the introduction of the new methodology is a reduction in the defect packages per production hour. Currently, an average of less than 14 defect packages per hour is produced. With the help of the quantitative assessment of product properties, it is assumed that the number of defect packages per hour will decline to less than ten, which means a reduction of *28.6%*. However, this calculation is based on the assumption of an ideal behavior of the system development process. In reality, imperfections occur that, in effect, restrict the achievable improvement in the number of product defects. For example, the new methodology may be applied in a wrong way by the employees or the determined data may be not fully correct. Hence, carefully estimated the number of defect packages produced per hour will improve by *15%*, and not, as theoretically possible, by more than *28%*. Also if only this reduced benefit is achieved, the concept introduction is still a success, since the benefit still outweighs the investment.

On the other hand, a decline in the result quality has to be expected during the introduction process. To calibrate the Introduction Procedure Model, the reduction in the result quality for the worst case introduction has to be determined. In this case study, the result quality is defined as the amount of knowledge about the product. Since the knowledge about the product will not be reduced due to any introduction, this parameter will not cause a decline in the result quality. However, there are other factors that have to be taken into account for the result quality, which in this case are influenced by the introduction. For example, the result quality depends not only on the *effectiveness* of the development process, but also on the *efficiency*. Thus, aspects like investment cost and time effort related to the introduction have to be taken into account. In this example, new testing machines have to be acquired, which increases the cost of the development. Concurrently, the introduction of the new methodology requires training of the personnel, which is an additional cost, but also time effort for the employees. Both aspects have to be combined for determining the worst case result quality, which was estimated to be *18%*. From this worst case result quality, the maximum number of projects until the introduction completion was calculated as *14*.

During the interview with the expert from Tetra Pak Carton Ambient, also the relative importance of the introduction objectives was determined. Since it is not possible to objectively measure these attributes, it is suggested to use expert judgment and a qualitative scale. It has proven to be practical to use a five-step Lickert-scale (see, e.g., Hoppe et al. 2004):

- Very high
- High
- Medium
- Low
- Very low

In a next step, numbers were assigned to the qualitative importance levels, in order to be able to derive a quantitative measure for the importance of the introduction objectives. Figure 130 shows the qualitative importance levels and the assigned quantitative values.

Importance	
Qualitative	**Quantitative**
Very low	1
Low	2
Medium	4
High	7
Very high	11

[140]

Figure 130: Qualitative levels and quantitative data for the introduction objective importance.

In the following Figure 131, the results of the interview are summarized. For each introduction objective, its qualitative importance was determined. Based on the sum of the assigned quantitative values, the importance measures were normalized.

Introduction Objective	Importance		
	Qualitative	**Quantitative**	**Normalized**
Performance Sustainment	Very high	11	0.33
Introduction Speed	Very low	1	0.03
Company Operability	Very high	11	0.33
Introduction Acceptance	Very low	1	0.03
Introduction Duration	High	7	0.21
Introduction Cost	Low	2	0.07
	Sum:	33	1.00

[141]

Figure 131: Normalized importance factors for the introduction objectives.

The Performance Sustainment and the Company Operability are the most important introduction objectives. The interviewee saw it as crucial to achieve the expected concept benefit, restrict the performance reduction (Performance Sustainment) and at the same time reduce the risk for the operability of the development process (Company Operability). Additionally, the introduction duration was assessed to be of high importance. Compared to these three objectives, all other introduction objectives are of relatively low importance.

The benefit of the new methods will not take effect immediately after their introduction. The persons in charge have to understand and learn the new tasks. This cannot be achieved in one project, but lasts several projects, depending on the individual learning curve of the affected people. Moreover, the acceptance of the new methods influences as well the pace of the improvement. Both aspects lead to the known S-shaped improvement in the result quality (see, e.g., Zeyer 1996, p. 150). The slope of the S-curve depends on the individual learning capacity and the acceptance. The engineers at Tetra Pak Carton Ambient expect that the full benefit of the new methodology will be achieved within four projects from the beginning of the introduction. The number of projects needed to achieve the full benefit, together with the expected benefit, the worst case result quality, and the fact that TPCA applied a one-step approach allows determining the slope of the S-curve at the inflection point, based on the Figure 120 in chapter 4.4. Specifically for this project at TPCA, the slope of the S-curve at the inflection point is *0.17*.

The methodology to be introduced consists of three new activities, each introduced in a different phase of the development process. Since each of these activities contributes independently to the goal of the methodology, they can also be introduced independently. However, the introduction of the three new activities and the 27 relations is not independent of each other. The activity relations symbolize the information flows between the activities and thus are an important basis for the “functionality” of the activities. In order to provide the expected output, the activities have to receive all necessary information. Moreover, to benefit from the new activities, their produced information has to be provided to other activities, where it is needed. Hence, the new relations can be grouped in modules, where each module has to be introduced as a whole, but can be introduced independently from other modules.

In general, to think about introducing an activity as simply inserting the activity in the process lacks one important aspect of the activity: its relations to other activities. A new activity cannot be seen as introduced as long as it does not have at least one input and one output relation. Moreover, as discussed in the paragraph above, an activity may need certain activity relations (which may be also relations between two other activities) to provide the full functionality. Therefore, it is more appropriate to think of modules in terms of relations to be introduced than with respect to the activities. In this example, the relations to be introduced can be grouped into four modules. Modules 1 to 3 include the information flows related to the three new activities, whereas module 4 includes two new feedback relations, which are not directly related to one of the new activities. In Figure 132, the relations forming the modules are depicted in different colors and line styles.

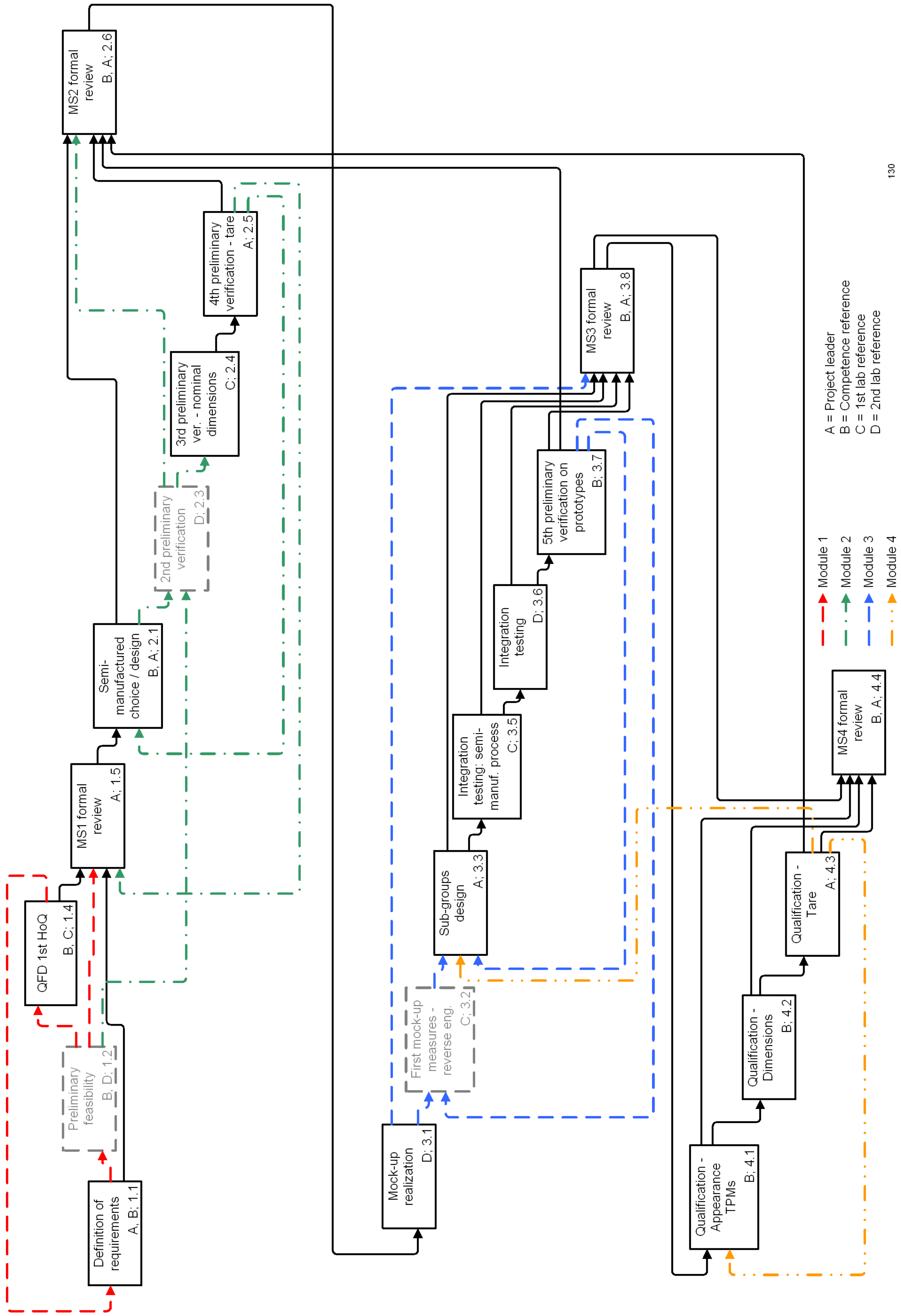

Figure 132: Modules of the new methodology.

Figure 133 lists the activity relations contained in the different modules. The relations are defined by its source and destination activity and therefore are denoted by combining the ID’s of the source and destination activity.

	Module 1	**Module 2**	**Module 3**	**Module 4**
Activity Relations	1.1-1.2	1.2-2.3	3.1-3.2	4.3-3.3
	1.2-1.4	2.1-2.3	3.1-3.8	4.3-4.1
	1.2-1.5	2.3-2.4	3.2-3.3	
	1.4-1.1	2.3-2.6	3.7-3.2	
		2.5-1.5	3.7-3.3	
		2.5-2.1		

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Figure 133: Activity relations in the modules of the new methodology.

Similar to the new relations that are introduced, also the relations that have to be removed can be combined to groups. The existing relations depend on each other in the sense that the structure of the relations to or from one activity follows a certain logic. If one of these relations is removed, other relations can loose their justification, which suggests removing also these relations. Additionally, the existing relations possibly become obsolete through the introduction of new activities or relations. Since the new relations are introduced as modules, that is as groups of relations which together provide new and improved information, all existing relations that contribute to the “old” information production are obsolete and can be removed integrally. In this case study, four modules of existing information flows can be defined, which are related to the four modules of the new information flows (see Figure 134).

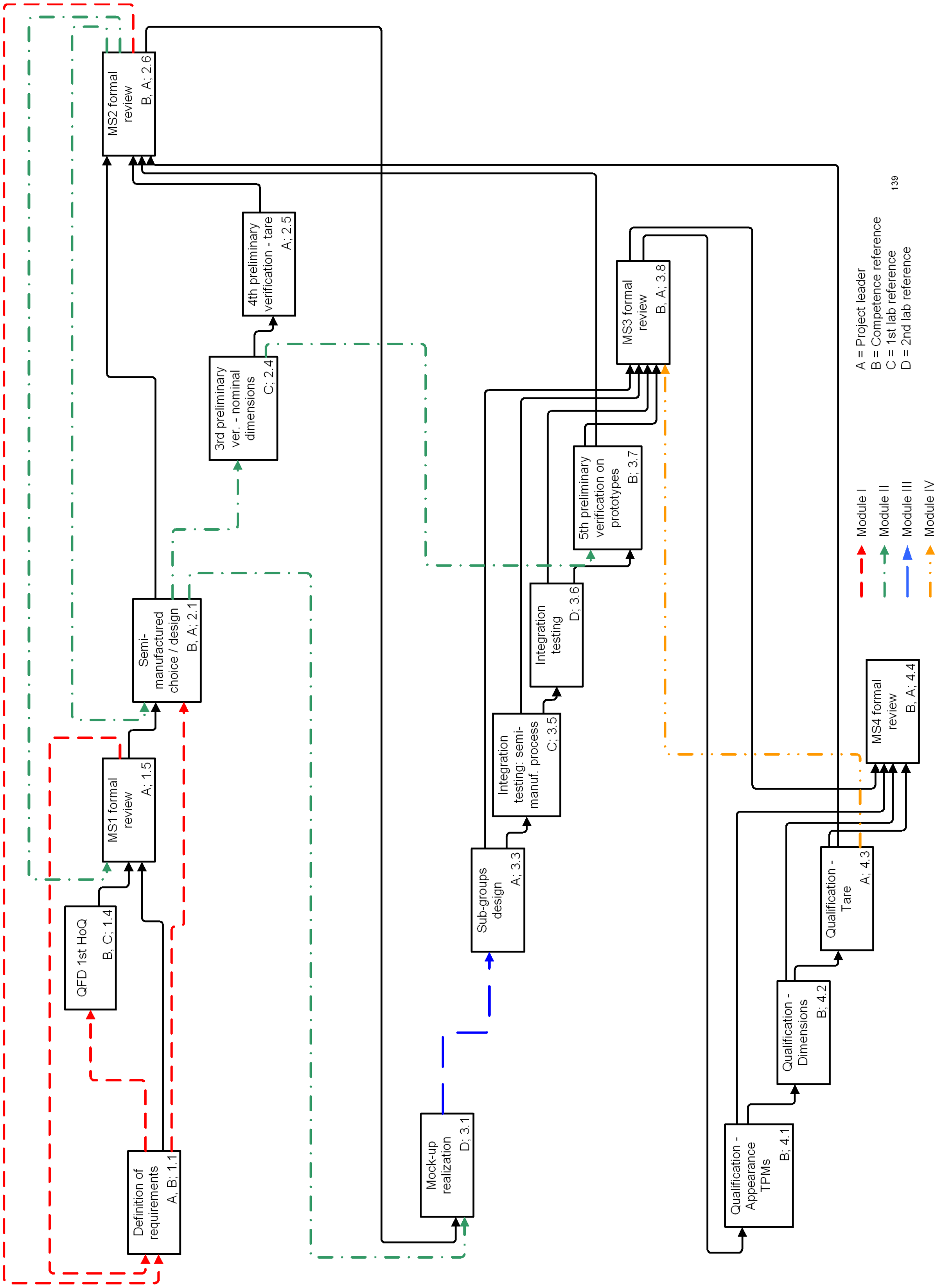

Figure 134: Modules of the relations to be removed.

Modules of existing and new relations that belong together are depicted with the same color and line style in Figure 132 and Figure 134, which is also expressed by a similar numbering scheme. However, for a better differentiation the modules of the existing relations have a roman numbering. Figure 135 lists the activity relations contained in the modules. The relations are defined by its source and destination activity and therefore are denoted by combining the ID's of the source and destination activity.

	Module I	Module II	Module III	Module IV
Act. Relations	1.1-1.4	2.1-2.4	3.1-3.3	4.3-3.8
	1.1-2.1	2.1-3.1		
	1.5-1.1	2.4-3.7		
	2.6-1.1	2.6-1.5		
		2.6-2.1		

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Figure 135: Activity relations in the modules of the existing relations.

With the help of the modularization it is possible to allocate the expected benefit to single entities of the new methodology. To determine the importance of the individual module, again a qualitative approach was applied. The interviewee could choose the qualitative level of importance of each module ranging from very low to very high. To each qualitative level a number from 0.2 (very low) to 1.0 (very high) is assigned, which finally is normalized. The modules of the existing relations are not considered, since they do not contribute to the benefit of the new methodology. Figure 136 shows the resulting quantitative module importance.

Module	Importance		
	Qualitative	Quantitative	Normalized
Module 1	Low	0.4	0.2
Module 2	Medium	0.6	0.3
Module 3	High	0.8	0.4
Module 4	Very low	0.2	0.1
	Sum:	2.0	1.0

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Figure 136: Quantitative importance of the concept modules.

In general, each activity in a process has a person in charge that is responsible for the timely delivery and quality of the activity results. In this simplified example of the TPCA development project there are only four different persons or groups of persons in charge of the individual activities (see, e.g., Figure 134):

- Project leader (A)
- Competence reference (B)
- 1st lab reference (C)
- 2nd lab reference (D)

Although the project leader is responsible for the overall success of the project, he is also in charge of some individual activities. Tetra Pak Carton Ambient clusters the company core competencies, related to the food packaging industry, in special departments. If needed, these competence departments provide resources to the single projects, which is denoted here as competence reference. To successfully conduct this type of development project, the support of two different laboratories within TPCA is necessary. Therefore, these are denoted as "1st lab reference" and "2nd lab reference".

Through introducing a new concept, the cost of a development project may change. In this example, three new activities are introduced, but no existing activity becomes obsolete, which means additional cost due to needed resources (persons and material). But also in case that the resource cost after the concept introduction is the same as before the concept introduction, alternative introduction procedures can have different cost structures in terms of cost of existing activities that have to be removed and cost of new activities. Consider the example that in an introduction procedure many "old" activities are kept in parallel to new activities. Then, the cost of this introduction procedure is rather high compared to other procedures, since the resource cost of the old and new activities add. For this case study, Figure 137 shows the personnel cost of the persons in charge[28].

Person in Charge	Acronym	Personnel Cost [EUR/project]
Project leader	A	100%
Competence reference	B	100%
1st lab reference	C	100%
2nd lab reference	D	88%

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Figure 137: Personnel cost of the persons in charge of the activities.

The personnel cost and the material cost together yield the overall cost of the new activities, which are listed in Figure 138.

Activity ID	P. in charge	Material Cost [EUR/project]	Personnel Cost [EUR/project]	Overall Cost [EUR/project]
1,2	B, D	3%	97%	100%
2,3	D	3%	45%	48%
3,2	C	5%	52%	56%

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Figure 138: Overall cost of the new activities.

In this case study, the personnel in charge are not exclusively working on the project activities, but are involved in several, concurrent projects. This means that the organizational structure cannot be mapped to or derived from the considered process system. That is, the optimal team structure before and after the concept introduction depends not only on the relations defined by the considered process system, and hence cannot be determined with the available information. Moreover, the low number of persons in charge does not require any team structure, since it is no problem to integrate all of them in one team. Therefore, the organizational aspects, team structure and information transfer, are not considered in this case study.

Based on the above defined and derived data, the Introduction Procedure Model can be used to evaluate the one-step introduction approach applied by the engineers at TPCA. Figure 139 describes the states of the introduction procedure based on the modules in a binary format. Each column represents a previously defined module, whereas each row is a different state in the introduction procedure. In this case, obviously there are only two states relevant: the initial state and the target state. The entries indicate if a module, indicated by the column, exists (1) or does not exist (0) in the introduction state indicated by the row.

[28] The real cost data cannot be shown for confidentiality reasons. Therefore, this and the following cost data is shown as percentage of a reference cost. In order to avoid that any time information can be derived from the cost data, the reference cost used for Figure 137 and Figure 138 is different.

	Module 1	Module 2	Module 3	Module 4	Module I	Module II	Module III	Module IV
Initial State	0	0	0	0	1	1	1	1
Target State	1	1	1	1	0	0	0	0

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Figure 139: Allocation of modules and states for the one-step introduction approach.

Figure 139 shows that in one single step all new modules (i.e. activities and relations) are introduced and concurrently all obsolete modules (i.e. relations) are disintegrated. Evaluating this approach with the Introduction Procedure Model yields values for the assessment metrics, which are shown in Figure 140. Please note that all metrics are normalized to 1 and that high metric values are positive.

	Initial State (0)	Transition 01	Target State (1)
Team Integration Factor (TIF)	1.00	n.a.	1.00
Surplus Load Index (SLI)	1.00	n.a.	1.00
Parallel Execution Index (PEI)	0.00	n.a.	0.00
Introduction Cost Index (ICI)	1.00	n.a.	0.00
Total Module Importance (TMI)	n.a.	1.00	n.a.
Team Change Scope (TCS)	n.a.	1.00	n.a.
Activity Introduction Scope (AIS)	n.a.	0.00	n.a.
Activity Introduction Advancement (AIA)	n.a.	1.00	n.a.
Activity Relation Introduction Advancement (RIA)	n.a.	1.00	n.a.
Activity Relation Introduction Scope (RIS)	n.a.	0.00	n.a.
Introduction Duration Index (IDI)	0.00	n.a.	0.71
Project Duration Index (PDI)	n.a.	0.70	n.a.

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Figure 140: Metric values for the one-step approach.

Because, as mentioned above, the team structure is not considered in this case study, the metrics Team Integration Factor and Team Change Scope are not relevant. The Surplus Load Index is *1.00* , since in both states concept relations do not exist in parallel to relations that have to be disintegrated. For the same reason, the Parallel Execution Index is *0.00*. At the initial state, the Introduction Cost Index is *1.00*, because at this stage no new activities have been introduced yet, thus no personnel and material cost accrue. Since no existing activities have to be removed, no savings in personnel and material cost can be expected from the methodology introduction. At the target state, all new activities have already been introduced and their full resource costs accrue. Therefore, the Introduction Cost Index is *0.00*.

At the transition from the initial state (index 0) to the target state (index 1), all concept activities and relations, i.e. all modules, are introduced. Hence, the Total Module Importance is *1.00*. Since all activities and relations are introduced in one step, the Activity Introduction Scope and Activity Relation Introduction Scope are evaluated negatively (*0.00*). In contrast, the Activity Introduction Advancement and Activity Relation Introduction Advancement, which describe the introduction progress, yield *1.00*. Since the number of projects in the worst case is *14*, and the number of introduction projects in this step is *4*, the Introduction Duration Index is *0.71*. A value of *0.70* was calculated for the Project Duration Index, which is a combination of other metrics.

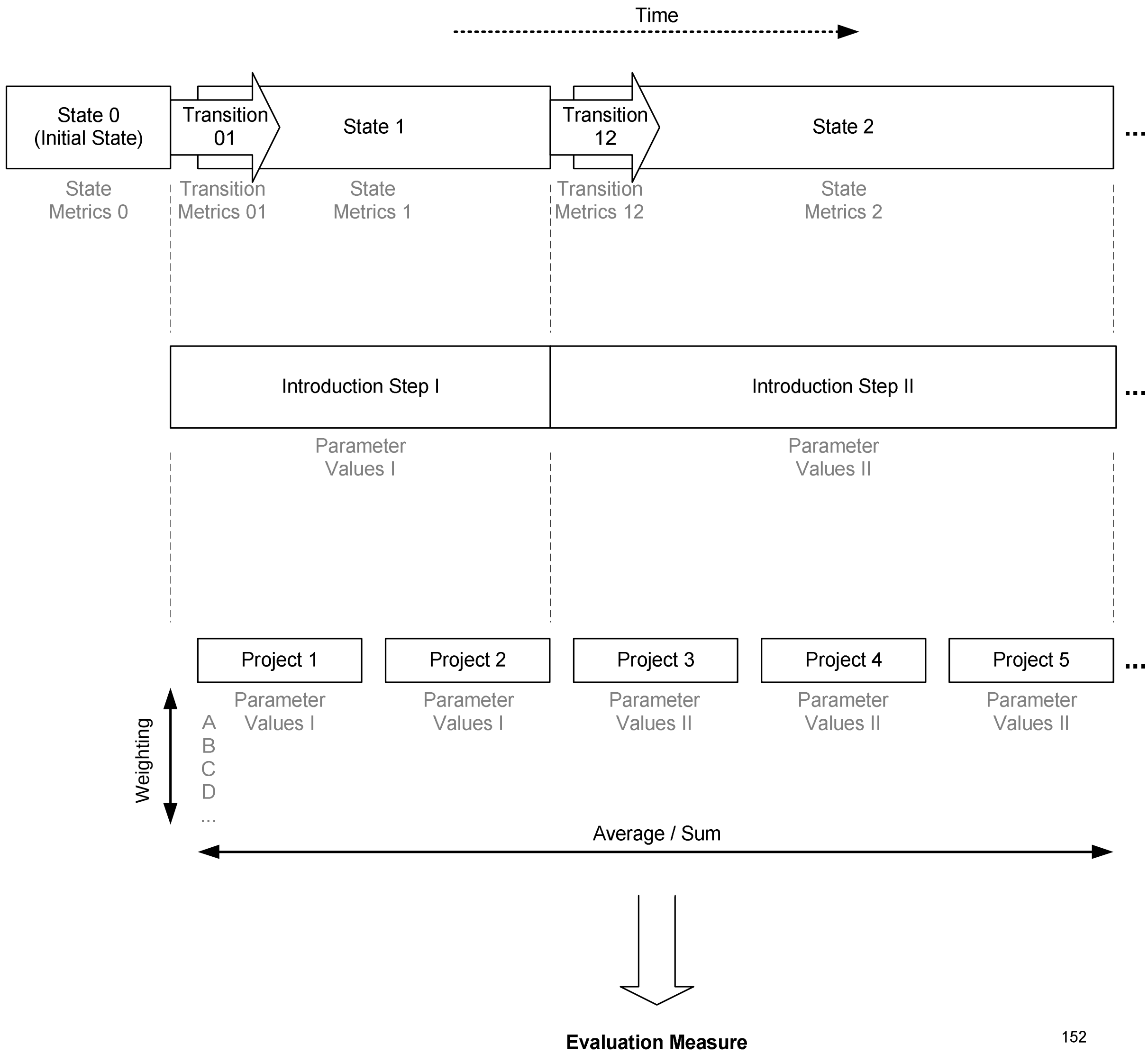

Figure 141: Procedure for determining the overall evaluation measure.

In the next evaluation step, the transition and state metrics are combined to parameter values for each introduction step, using the assessment structure defined in the previous section. The parameter values are assigned to the single projects, which are executed during the corresponding introduction step. To derive an overall evaluation measure, the average or sum (depending on the parameter) of each parameter over the projects is determined. The final evaluation measure is the weighted sum of these averages / sums (see Figure 141). Since the applied approach consists of only one introduction step, the parameter values at all four projects are equal. Figure 142 shows the values for the introduction objectives at all four affected projects. These values were calculated using the equations defined in chapter 4.3.3. Please note that also the parameter values are normalized and that higher numbers are positive.

	Project 1	Project 2	Project 3	Project 4
Performance Sustainment	0.24	0.24	0.24	0.24
Introduction Speed	1.00	1.00	1.00	1.00
Company Operability	0.00	0.00	0.00	0.00
Introduction Acceptance	0.44	0.44	0.44	0.44
Introduction Duration	0.71	0.71	0.71	0.71
Introduction Cost	0.00	0.00	0.00	0.00

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Figure 142: Parameter values of the one-step introduction.

For example, the Performance Sustainment is calculated with the following equation.

$$PS_{mn} = 0.7 \cdot \left(0.3 \cdot AIS_{mn} + 0.5 \cdot RIS_{mn} + 0.2 \cdot \left(SLI_m - SLI_n\right)\right) + 0.3 \cdot \left(0.2 \cdot \left(TIF_m - TIF_n\right) + 0.8 \cdot TCS_{mn}\right)$$

Eq. 91

Using the metric values from Figure 140, the equation yields:

$$PS_{01} = 0.7 \cdot \left(0.3 \cdot 0.00 + 0.5 \cdot 0.00 + 0.2 \cdot \left(1.00 - 1.00\right)\right) + 0.3 \cdot \left(0.2 \cdot \left(1.00 - 1.00\right) + 0.8 \cdot 1.00\right) = 0.24$$

Eq. 92

Please see chapter 4.3.3 for the other relevant equations.

The Introduction Speed is equal to *1.00*, since all necessary changes are executed in the first step. For the same reason, the measure Company Operability is *0.00*; the existing information flows are disintegrated and not kept in parallel to the new information flows, which is a rather risky approach. The Introduction Acceptance has a moderate value (*0.44*), because first the number of introduced activities and relations is moderate and second the introduction does not have any effects on the organization system. The values for the Introduction Duration are, as expected, relatively high (*0.71*), since the introduction in one step has the shortest possible duration of all alternatives. Finally, the value for the parameter Introduction Cost is *0.00*, because all costs accrue in this introduction step.

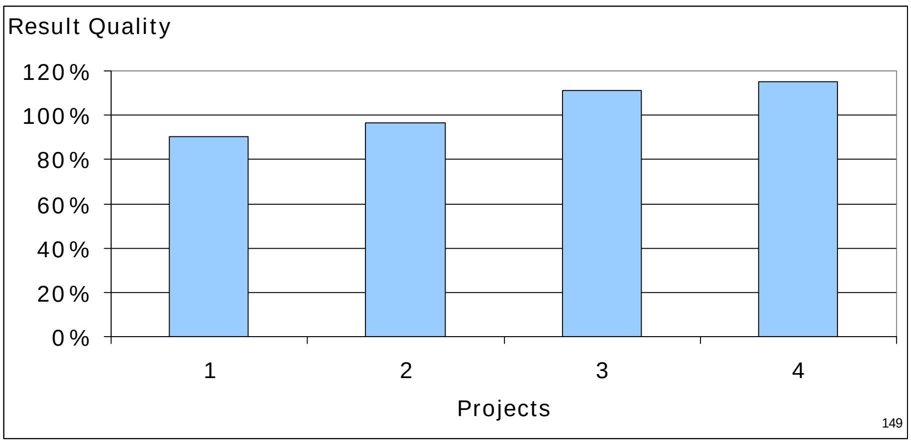

Figure 143: Result quality trend for the one-step introduction.

Due to the big changes induced in the process system, the value for the parameter Performance Sustainment is very low (*0.24*). Based on the calibration values and the determined quality improvement at TPCA, the effect on the quality of the project results can be predicted (see section Performance Sustainment in chapter 4.4). Figure 143 shows the behavior of the result quality in the course of time for the one-step introduction approach. This figure shows that in the first project the quality falls under the initial value of *100%*, down to *90%*, and then increases until it reaches the expected benefit of *115%*. Figure 144 lists the result quality values for the individual projects.

	Project 1	Project 2	Project 3	Project 4	Average
Result Quality	90%	96%	111%	115%	103%

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Figure 144: Result quality values for the projects and average.

To determine the Evaluation Measure, the difference of the actual Result Quality to the maximum result quality (*115%*) is accumulated over all projects and subtracted from one, which yields the accumulated Result Quality, RQ_{Acc} (see section Performance Sustainment in chapter 4.4):

$$RQ_{Acc} = 1 - \left(4 \cdot 1.15 - (0.90 + 0.96 + 1.11 + 1.15)\right) = 0.53 \qquad \text{Eq. 93}$$

For all other Introduction Objectives, the average over all projects is calculated. The result of this step in the calculation are shown in the column "Av. / Sum" in Figure 145. Next, the calculated average / sum is subtracted from *1* (see column "Inverse") and multiplied with the assigned weighting (see Figure 131). The results are shown in the column "Result". The Evaluation Measure, the sum of these results, is *0.63* for the one-step introduction procedure (see Figure 145). The inverse of the average / sum of the Introduction Objectives is used, since it expresses the "cost" of applying this introduction procedure and is used for determining the shortest "path" from the initial to the target state. In this way, a lower number indicates a better introduction procedure.

	Project 1	Project 2	Project 3	Project 4	Av. / Sum	Inverse	Weighting	Result
Result Quality	0.90	0.96	1.11	1.15	0.53	0.47	0.33	0.16
Introduction Speed	1.00	1.00	1.00	1.00	1.00	0.00	0.03	0.00
Company Operability	0.00	0.00	0.00	0.00	0.00	1.00	0.33	0.33
Introduction Acceptance	0.44	0.44	0.44	0.44	0.44	0.56	0.03	0.02
Introduction Duration	0.71	0.71	0.71	0.71	0.71	0.29	0.21	0.06
Introduction Cost	0.00	0.00	0.00	0.00	0.00	1.00	0.07	0.07
					Evaluation Measure (sum):			0.63

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Figure 145: Calculated Evaluation Measure for the one-step introduction.

In the following chapter, the best introduction approach is determined with the help of the Introduction Procedure Model. This suggested introduction approach is then compared to the one-step introduction actually applied at TPCA.

4.5.3 Determining the Best Introduction Alternative

In this chapter, the **Introduction Procedure Model** is used to find the b**est introduction alternative** for the methodology introduction at Tetra Pak Carton Ambient.

The Introduction Procedure Model cannot only be used for evaluating an introduction procedure, but it allows also determining the best introduction procedure for given boundary conditions. In this chapter, the proposed best introduction alternative is described and compared to the applied one-step approach.

The introduction procedure model was used to determine the best introduction procedure for the given introduction problem in the case study. The input and calibration data for this selection process is equal to that applied for the one-step approach; specifically, the process and organization data, as well as the module structure and weighting factors are the same.

First, the Introduction Procedure Model derives all possible alternative introduction procedures. To that end, it determines all reasonable intermediate states and the possible transitions between these intermediate states. Second, the intermediate states and transitions are evaluated using the defined assessment system. Finally, through applying a shortest path algorithm the best "path" through this network of intermediate states is found.

For this example, *84* states were found (including the initial, target, and *82* intermediate states), which are connected by *7056* transitions. From this set of intermediate states and transitions, the best introduction procedure is chosen, which is depicted in Figure 146. It shows the introduction states in a binary format: Each column represents a previously defined module, whereas each row is a different state in the introduction procedure. Please note that modules 1 to 4 are modules of the new methodology and modules I to VI are modules of the existing relations.

	Module 1	Module 2	Module 3	Module 4	Module I	Module II	Module III	Module IV
Initial State	0	0	0	0	1	1	1	1
Interm. State 1	0	0	1	0	1	1	1	1
Interm. State 2	1	1	1	0	1	1	1	1
Interm. State 3	1	1	1	1	1	1	1	1
Interm. State 4	1	1	1	1	1	1	0	1
Target State	1	1	1	1	0	0	0	0

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Figure 146: Allocation of modules and states for the best introduction procedure.

Figure 146 shows that the suggested procedure consists of five introduction steps. In the first introduction step, only the new module 3 is introduced (intermediate state 1). In the second step, modules 1 and 2 follow (intermediate state 2). Finally, module 4 occurs in intermediate state 3. That is, this suggested approach progresses slower than the applied introduction procedure, which introduces all new modules in the first step. Moreover, in the suggested introduction alternative it is not started to remove the existing relations until the fourth introduction step (intermediate state 4). At this step, only module III of the existing relations is deleted. Finally, in the fifth and last introduction step, modules I, II, and IV of the existing relations are removed.

This introduction procedure is also evaluated with the defined assessment system, which yields metric values for the intermediate states and the transitions. The corresponding state metric values are depicted in Figure 147. Please note that all metrics are normalized to one and that high metric values are positive.

	Initial State (0)	Interm. State 1	Interm. State 2	Interm. State 3	Interm. State 4	Target State (4)
Team Integration Factor (TIF)	1.00	1.00	1.00	1.00	1.00	1.00
Surplus Load Index (SLI)	1.00	0.67	0.12	0.00	0.14	1.00
Parallel Execution Index (PEI)	0.00	0.33	0.88	1.00	0.86	0.00
Introduction Cost Index (ICI)	1.00	0.72	0.00	0.00	0.00	0.00
Introduction Duration Index (IDI)	0.00	0.93	0.86	0.93	0.93	0.93

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Figure 147: State metric values for the suggested introduction procedure.

Since the persons in charge work on several projects concurrently, and their low number does allow integrating all of them in one team, the organizational aspect is not considered in this case study. For calculation purposes, it is assumed that the persons in charge are all integrated in one team, which does not change during the introduction procedure. Hence, the metric

Team Integration Factor is not relevant in this case study. The Surplus Load Index decreases in the first steps of the introduction, since this approach proposes to keep the existing information paths in parallel to the new information paths, which means additional work for the employees. On the other hand, this parallelism of existing and new information paths causes the Parallel Execution Index to increase in the early introduction steps. When, beginning from intermediate state 4, the “old” relations are removed, the Surplus Load Index increases and the Parallel Execution Index decreases again. Finally, the Introduction Cost Index decreases stepwise from *1.00* at the initial state to *0.00* in the intermediate state 3, because in the first two introduction steps only parts of the new methodology are introduced, which also causes only part of the resource cost. Since the Intermediate State 2 is valid for two projects, the Introduction Duration Index is *0.86*. All other intermediate states are only valid for one project, therefore there the Introduction Duration Index is *0.93*.

The metric values for the transitions between the intermediate states are shown in Figure 148. The index indicates from which state to which state the transition leads. For example, transition 12 means that this transition is between state 1 and state 2.

	Transition 01	Transition 12	Transition 23	Transition 34	Transition 45
Total Module Importance (TMI)	0.40	0.83	1.00	1.00	1.00
Team Change Scope (TCS)	1.00	1.00	1.00	1.00	1.00
Activity Introduction Scope (AIS)	0.67	0.37	1.00	1.00	1.00
Activity Introduction Advancement (AIA)	0.33	1.00	1.00	1.00	1.00
Activity Relation Introduction Advancement (RIA)	0.29	0.83	1.00	1.00	1.00
Activity Relation Introduction Scope (RIS)	0.71	0.51	0.93	1.00	1.00
Project Duration Index (PDI)	0.42	0.59	0.24	0.17	0.03

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Figure 148: Transition metric values for the suggested introduction procedure.

The metric Total Module Importance expresses the combined importance of all modules already introduced and those introduced during the transition. Figure 148 shows that the full module importance (*1.00*) is not achieved until the transition 23, because the new modules are introduced in two steps. Since the organizational aspects are not considered in this case study, the Team Change Scope is not relevant here. The Activity Introduction Scope describes the change extent with respect to introduced activities. Transition 01 and 12 show that in the first two steps the change scope is relatively high, since all new activities are introduced. Since in the later steps no new activities are introduced, the Activity Introduction Scope there is *1.00*. The Activity Relation Introduction Scope shows the same behavior, since it describes the change scope as well, but in terms of relations. In transition 23, module 4 is introduced, which does not contain an activity, but only relations. Therefore, the Activity Introduction Scope is *1.00*, while the Activity Relation Introduction Scope is only *0.93*. The Activity Introduction Advancement and the Activity Relation Introduction Advancement are measures for the progress of the introduction. In the first transition these metrics have low values, because only one module is introduced, which contains only few relations and one new activity. After transition 12, all activities are introduced, whereas the last relations are introduced in transition 23. Hence, AIA reaches its maximum value *1.00* already at the transition 12, RIA only at the transition 23. The Project Duration Index varies for the different transitions, since it is a combination of other metrics.

In the next step of the assessment, the metrics are combined to derive the parameter values. For the suggested introduction procedure, the resulting parameter values are shown in Figure 149.

For example, the Introduction Speed is calculated with the following equation.

$$IS_{mn} = 0.5 \cdot AIA_{mn} + 0.5 \cdot RIA_{mn} \qquad \text{Eq. 94}$$

Using the transition metric values from Figure 148, the equation yields:

$$IS_{01} = 0.5 \cdot 0.33 + 0.5 \cdot 0.29 = 0.31 \qquad \text{Eq. 95}$$

Please see chapter 4.3.3 for the other relevant equations.

	Project 1	Project 2	Project 3	Project 4	Project 5	Project 6
Performance Sustainment	0.67	0.57	0.57	0.79	0.78	0.68
Introduction Speed	0.31	0.92	0.92	1.00	1.00	1.00
Company Operability	0.33	0.88	0.88	1.00	0.86	0.00
Introduction Acceptance	0.60	0.68	0.68	0.77	0.73	0.55
Introduction Duration	0.83	0.80	0.80	0.80	0.79	0.78
Introduction Cost	0.72	0.00	0.00	0.00	0.00	0.00

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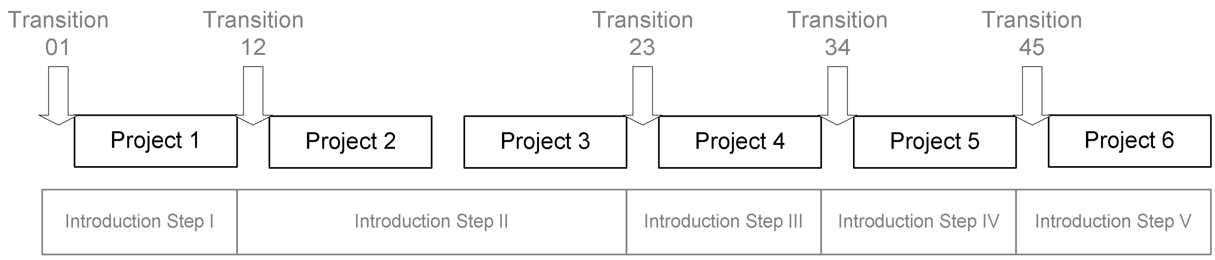
Figure 149: Parameter values of the suggested introduction procedure.

The parameter values are calculated for each introduction step, but each introduction step may comprise several projects (see Figure 141). The evaluation measure is determined by calculating the average or the sum (depending on the parameter) of the parameter values over the projects. Hence, it is relevant for how many projects a parameter result is valid. This is reflected in Figure 149, where the parameter values are assigned to the projects. A total of six projects are necessary to perform the suggested five introduction steps. The number of projects at each introduction step depends on the improvement of the result quality. When the improvement from a project to the next is below a certain value, the next transition should be conducted (see the previous section for details). For the suggested introduction procedure, Figure 150 shows the assignment of the projects to the introduction steps and the points of transitions.



159

Figure 150: Projects and introduction steps of the suggested introduction procedure.

In the following paragraphs, the parameter values for the suggested introduction procedure are compared to those for the one-step approach. To that end, the parameter values for both approaches are depicted together in one graphic with the projects as x-axis. Note that the applied procedure comprises only four projects.

Since the changes in the process system along the suggested introduction procedure are moderate, the parameter Performance Sustainment has a relatively high value. Figure 149 shows that the second introduction step (projects 2 and 3) has a lower parameter value than the first introduction step (project 1), because more activities and relations are introduced, and the surplus load for the employees is higher. In the following introduction steps, only moderate changes are performed and the “old” relations are removed, which increases the parameter Performance Sustainment. These values allow a prediction of the result quality trend, which is depicted in Figure 151.

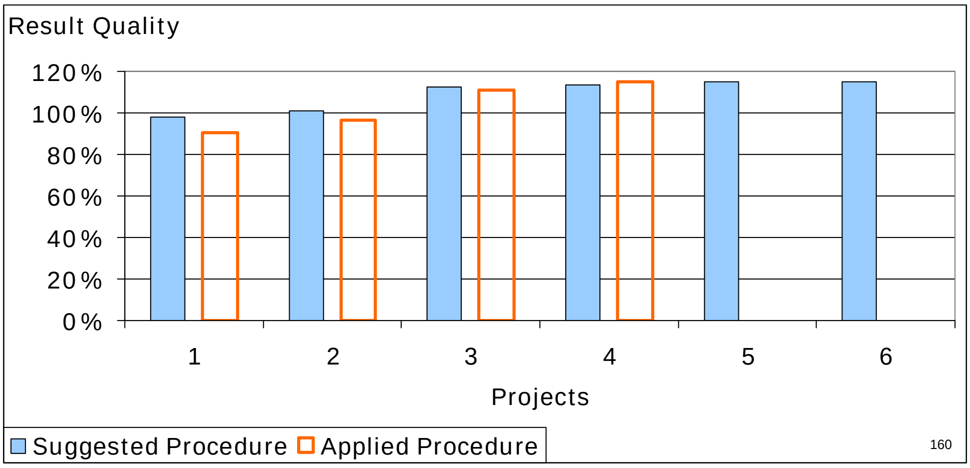


Figure 151: Result Quality trend of the suggested and applied introduction procedure.

The full, blue bars show the values for the suggested procedure, whereas the hollow, orange bars show the quality values of the applied procedure. It can be seen that the applied procedure reaches the maximum result quality earlier, but experiences a larger quality reduction in the beginning (project 1). To compare the two approaches with respect to the quality behavior, the predicted quality for each project is subtracted from the maximum possible quality (*115%* in this example). The difference of the actual Result Quality to the maximum result quality (*115%*) is accumulated over all projects and subtracted from one, which yields the accumulated Result Quality, RQ_{Acc} (see section Performance Sustainment in chapter 4.4):

$$RQ_{Acc} = 1 - (6 \cdot 1.15 - (0.98 + 1.01 + 1.12 + 1.13 + 1.15 + 1.15)) = 0.65 \qquad \text{Eq. 96}$$

Thus, the "inverse quality loss" for the suggested procedure is *0.65*, compared to *0.53* for the applied introduction procedure. Therefore, the suggested procedure is beneficial with respect to the result quality[29]. Figure 152 lists the result quality values for the individual projects.

	Project 1	Project 2	Project 3	Project 4	Project 5	Project 6	Average
Result Quality	98%	101%	112%	113%	115%	115%	103%

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Figure 152: Result quality values for the projects and average.

The comparison of the Introduction Speed, shown in Figure 153, gives a different picture. There, the applied one-step introduction is better, because all concept elements are introduced in the first step. This yields an average value of *1.00* for the Introduction Speed, whereas the suggested procedure has only an average value of *0.86*.

[29] The Result Quality is defined as „higher is better", to be consistent with the definition of all other Introduction Objectives. The actual quality loss is the inverse of the Result Quality, which is *0.35* for the suggested procedure and *0.47* for the applied introduction procedure.

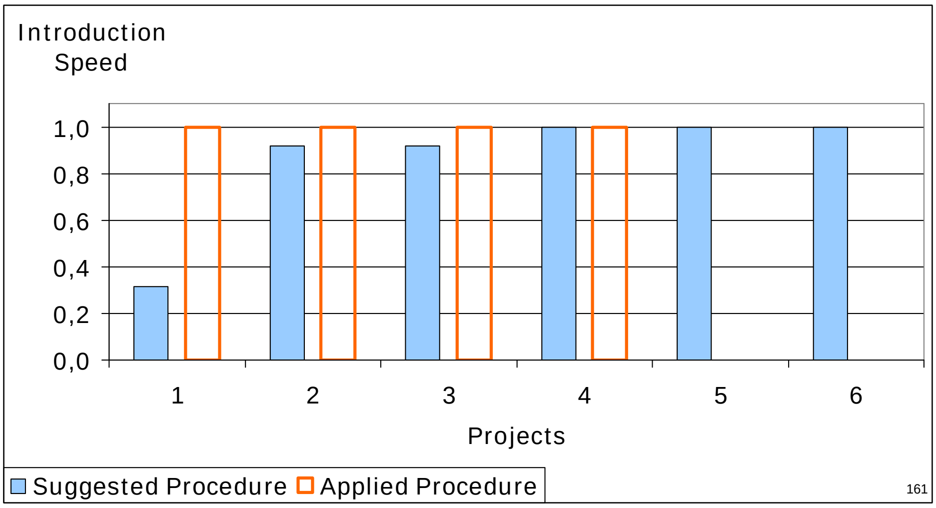

Figure 153: Introduction Speed of the suggested and applied introduction procedure.

The suggested introduction approach does ensure a concurrent existence of “old” and new information flows, which has advantages for the Company Operability (see Figure 154). The value for this parameter rises until all concept elements are introduced and then declines until all obsolete context elements are removed. The average Company Operability for the suggested procedure is *0.66*. In contrast, the Company Operability for the applied procedure is *0.00* throughout all projects, since the existing relations are not kept in parallel to the new concept elements.

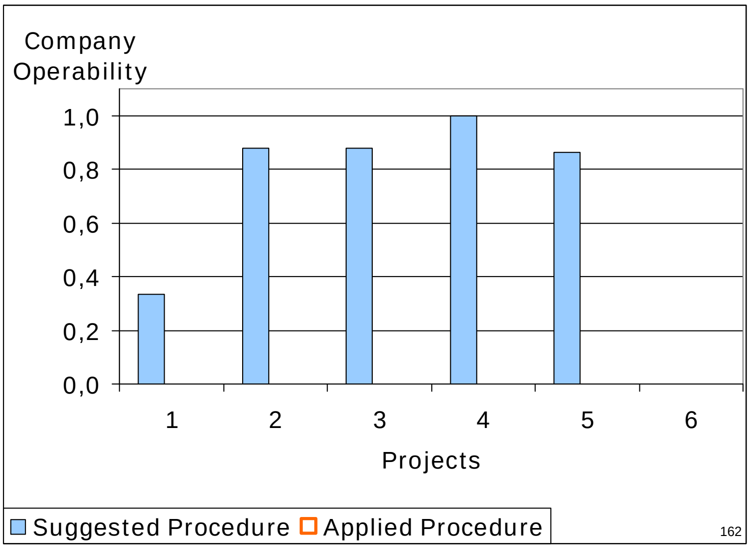

Figure 154: Company Operability of the suggested and applied introduction procedure.

The Introduction Acceptance depends on the change scope, the surplus load, and the benefit of the introduced concept.

Although the applied introduction procedure provides a lower surplus load and introduces all concept elements at the first step, the higher scope of the activities and relations introduced yields a lower Introduction Acceptance value for the applied introduction procedure compared to the suggested procedure (see Figure 155). This behavior is shown throughout the introduction procedure. The average Introduction Acceptance is *0.67* for the suggested, and *0.44* for the applied introduction procedure. That is, the applied introduction procedure has a clear advantage with respect to this parameter.

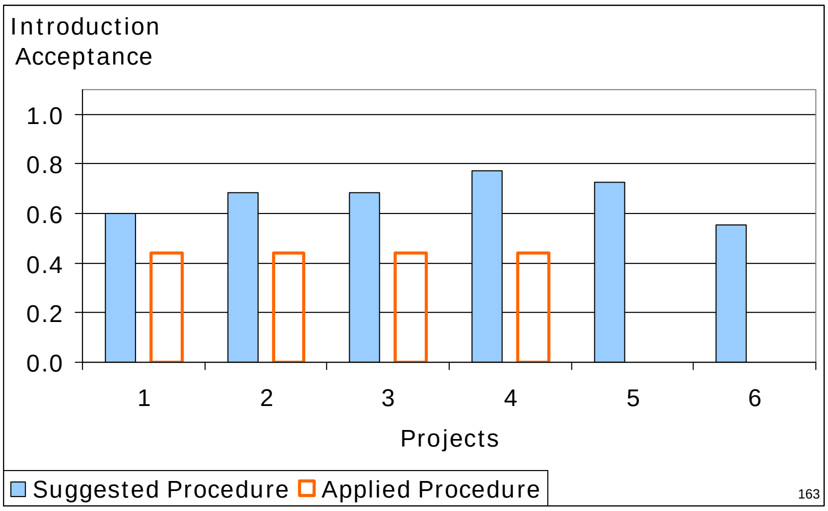

Figure 155: Introduction Acceptance of the suggested and applied introduction procedure.

The comparison of the Introduction Cost is quite simple (see Figure 156). Only the suggested introduction procedure provides a staged deployment of the three, resource-cost causing activities. Therefore, in project one this parameter has a value of *0.72*, whereas at all other projects the Introduction Cost value is *0.00*. In contrast, the Introduction Cost for the one-step approach is *0.00* throughout all projects. Hence, the suggested approach provides a benefit with respect to the accrued cost.

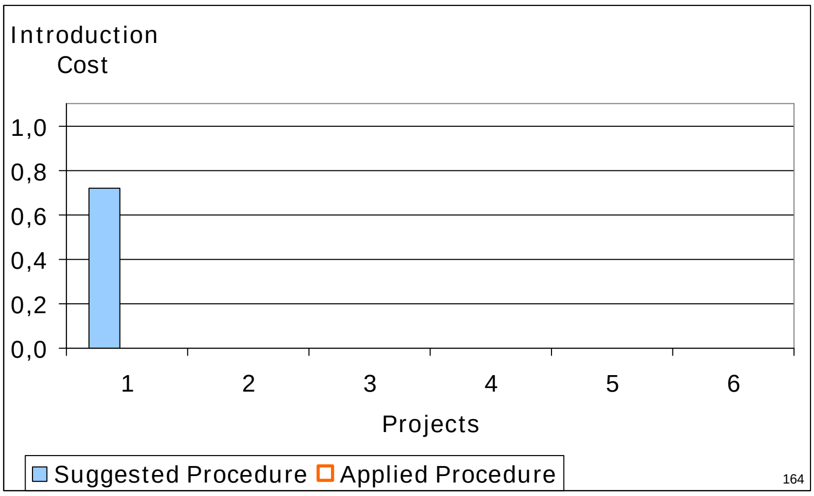

Figure 156: Introduction Cost of the suggested and applied introduction procedure.

The parameter Introduction Duration is composed of the number of projects needed to finalize the introduction process and the extended duration of the single projects due to changes induced in the process and organization system. In terms of extended project duration, the suggested introduction procedure has clear advantages, since the change scope at each step is lower. But concurrently it takes more projects to finalize the introduction process, which is on the other hand a disadvantage. The combination of these two aspects, the parameter Introduction Duration, is shown in Figure 157. For the suggested introduction procedure the average Introduction Duration is equal to *0.80*, whereas for the applied approach it is *0.71*, which indicates a slight advantage of the applied approach in terms of Introduction Duration.

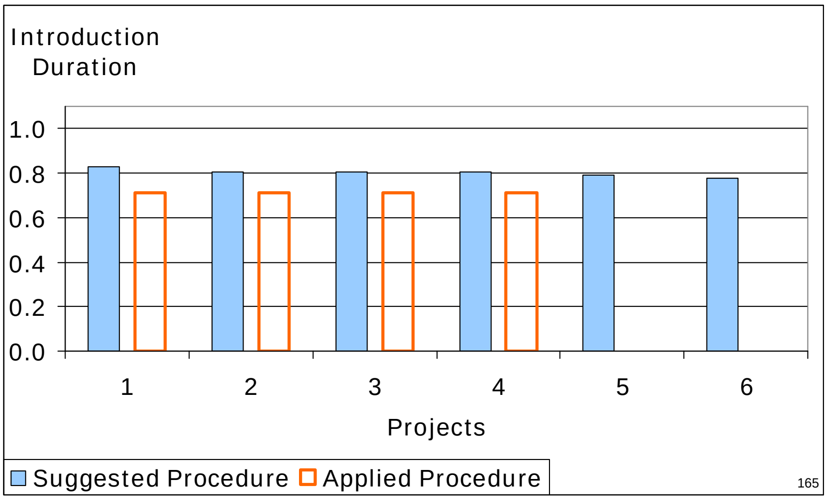

Figure 157: Introduction Duration of the suggested and applied introduction procedure.

To determine the Evaluation Measure, the average / sum of the Introduction Objectives is calculated, corresponding to the calculation for the applied introduction procedure. The results are shown in Figure 158. The Evaluation Measure, the sum of these results, is *0.35* for the suggested introduction procedure.

	Project 1	Project 2	Project 3	Project 4	Project 5	Project 6	Av. / Sum	Inverse	Weighting	Result
Result Quality	0.98	1.01	1.12	1.13	1.15	1.15	0.65	0.35	0.33	0.12
Introduction Speed	0.31	0.92	0.92	1.00	1.00	1.00	0.86	0.14	0.03	0.00
Company Operability	0.33	0.88	0.88	1.00	0.86	0.00	0.66	0.34	0.33	0.11
Introduction Acceptance	0.60	0.68	0.68	0.77	0.73	0.55	0.67	0.33	0.03	0.01
Introduction Duration	0.83	0.80	0.80	0.80	0.79	0.78	0.80	0.20	0.21	0.04
Introduction Cost	0.72	0.00	0.00	0.00	0.00	0.00	0.12	0.88	0.07	0.06
							Evaluation Measure (sum):			0.35

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Figure 158: Calculated Evaluation Measure for the suggested introduction procedure.

As shown in the previous section, the evaluation measure for the applied introduction procedure is *0.63*. Since this measure expresses the "cost" of using an introduction procedure, the suggested approach is better than the applied introduction procedure.

To sum up, the applied introduction procedure has advantages with respect to the duration of the introduction and its progress. On the other hand, the suggested introduction procedure in summary provides a better result quality, company operability, acceptance of the introduction, and cost of the introduction.

4.5.4 Summary

Tetra Pak Carton Ambient is part of the Tetra Pak Group, which is a **system developer** in the liquid food packaging industry. The case study (see chapter 4.5.1) deals with the joint development of a liquid food package and the according machinery in one development process. This development process is enhanced by a new methodology, which promises to improve the **knowledge about the product**, i.e. about the package, the machinery, and their interaction. The objective of the new methodology is to determine the **correlated effects** of raw materials, transformation process, and intrinsic variability of noises on the geometrical dimensions, defectiveness of the appearance, and tare weight of the container. The main benefit expected from the introduction of the new methodology is a **reduction in the defect packages per production hour**.

The engineers at Tetra Pak Carton Ambient decided to introduce the new methodology in **one step**, which means that all activities and relations are introduced in the first project. The characteristics of this introduction approach were determined through an interview and, based on this data, the introduction approach was **evaluated**. The evaluation results were presented in chapter 4.5.2.

The Introduction Procedure Model cannot only be used for evaluating an introduction procedure, but it allows also determining the **best introduction procedure** for given boundary conditions. In chapter 4.5.3, the proposed best introduction alternative, which consists of **five introduction steps**, was described and compared to the applied one-step approach.

The weighted sum of all parameter values yields the **evaluation measure**. The suggested introduction procedure yields a better evaluation measure than the applied introduction procedure. The **applied introduction procedure** has advantages with respect to the duration of the introduction and its progress. On the other hand, the **suggested introduction procedure** in summary provides a better result quality, company operability, acceptance of the introduction, and cost of the introduction.

4.6 Synopsis

Section 4 presented a quantitative model of the introduction procedure, the Introduction Procedure Model. In chapter 4.1, the model objectives and model structure are defined. The **main objective** of the Introduction Procedure Model is to provide an **approach for determining the optimal introduction procedure**, based on the identified constraints. The concept introduction can be considered as a **decision process**. After the **problem definition**, the different **alternatives** for the introduction are modeled. Concurrently, an **objective system** has to be defined, which is the basis for **assessing** the identified alternatives. Finally, on the basis of the assessment a **decision** can be taken. It is not the intention of the defined quantitative model to **substitute** this decision process, but the Introduction Procedure Model rather **supports** the decision process in selected areas. This basic structure of the Introduction Procedure Model is also used as **chapter structure** in this section 4.

In chapter 4.2, the modeling approach is described. The implementation of a new concept in a company is generally a **complex task**. The complexity stems both from the **context** and the **concept**. Therefore, strategies are applied to reduce the complexity in the context and the concept area. In the concept area, **modularization** of the introduction object is a means to determine concept elements (modules) that can be introduced independently. In the introduction context the complexity is reduced by defining **implementation areas**, i.e. areas in the company, where the new concept shall be introduced.

In general, the implementation of a new concept is conducted **concurrently** in several company areas. These introduction procedures may influence each other in terms of the information they provide for each other, but usually an introduction procedure in one company area does not depend on the design of the introduction in another company area. Hence, the objective system for the introduction does not change, but the **importance of the individual objectives** does, which has to be adapted for company and project specific purposes. Therefore, the Introduction Procedure Model can be applied to determine the best introduction procedure for an individual company area, based on the defined importance of the introduction objectives, without losing its **general validity**.

Concept modules are **integral parts** within the concept. They consist of two or more activities with associated relations, which only together produce a reasonable and usable output. To ensure the concept functionality and thus the company operability, the concept modules have to be introduced as a whole in the company. There are several **reasons for the**

modularization of a concept. First, the modularization supports the **understanding** of the concept. Second, modularization is necessary if **parts of the concept** to be introduced already **exist** in the company. Third, **bounded rationality** or **restricted resources** make it necessary to introduce the concept step-wise. Finally, **differences** in various implementation areas require an adaptation of concept parts.

The concept introduction in a company is considered as a **sequence of steps** until the target state is reached. The **target state** is the point where the introduction can be considered as complete. Each step comprises one or more **changes** that are made to the system (process or organization), which lead to temporarily stable system structures, the "**intermediate states**". The changes between two intermediate states or an intermediate state and the target state can be collectively denoted as **transition** of the system.

The approach in the quantitative model for the generation of possible and reasonable alternative introduction procedures (**modeling**) was described using an example. The set of possible alternative introduction procedures contains many intermediate process states, which are not reasonable from an **information flow** perspective. A very simple, yet effective criterion to determine if the modeled introduction state is of practical meaning is its so-called "**stability**". Here, the term stability shall describe a state where the information flow in the process is not interrupted. In terms of activities and relations this means that if an activity exists in the process system, it has to have at least one input and one output. In many cases the activities to be introduced form modules that have to be introduced together. Thus, **modularity** is another boundary condition for the modeling. Finally, there may be **practical constraints** that do not allow following certain introduction procedures.

In chapter 4.3, the objective system of an introduction is defined. To evaluate the performance of a concept introduction procedure, the aspects **cost, duration, and quality** can be applied. Introduction quality consists of **several aspects**, which may be attributed to the quality areas **performance sustainment, introduction speed, company operability, introduction acceptance, and concept benefit** (chapter 4.3.1).

These introduction objectives are described only qualitatively in literature On the other hand, in literature many "rules" (**axioms**) about how to introduce a new concept in a company can be found Therefore, axioms that are relevant for the concept introduction were extracted from literature. To be able to quantitatively assess the fulfillment of these axioms, **metrics** were defined and connected to each axiom. To illustrate the use of the metrics, they were applied to a simple **example** of a concept introduction (chapter 4.3.2).

Finally, to derive a **quantitative assessment system**, the identified axioms and metrics are attributed to the objectives of the concept introduction. With this relation between the axioms and the objectives, an assessment system for the concept introduction in a company is established, which can be used to quantitatively evaluate different introduction procedures (chapter 4.3.3).

Chapter 4.4 presented the approach for **evaluating alternative introduction procedures**, based on the defined assessment system. The criteria cost, duration, and quality are on the **highest level** of the objective system for concept introductions. Since especially introduction quality, but also introduction duration are composed of **several criteria**, the application of these high level objectives as evaluation criteria would lack **transparency** for the user. Therefore, it is suggested to use the criteria on the **second level** of the assessment system.

The first step is to calculate the **performance sustainment**, since information from this criterion is needed to calculate the succeeding measures. The intention of the criterion performance sustainment is to have a measure for the **change in the quality** of the process results (**result quality**) due to the concept introduction. Therefore, this criterion is only a **vehicle** to determine the behavior of the result quality along the introduction procedure.

The **introduction duration** is mainly composed of two elements: The **project duration** and the **number of projects** needed to accomplish the introduction. The number of projects can be derived from the analysis of the result quality, whereas the behavior of the project duration over time is depending also on learning effects.

In contrast to the evaluation of the performance sustainment and the project duration, the other introduction objectives are easier to evaluate, since the applied metrics can be **directly combined** to an overall measure for the introduction objective.

In chapter 4.5, the verification of the Introduction Procedure Model with a case study at Tetra Pak Carton Ambient is described. Tetra Pak Carton Ambient is part of the Tetra Pak Group, which is a **system developer** in the liquid food packaging industry. The case study (see chapter 4.5.1) deals with the joint development of a liquid food package and the according machinery in one development process. This development process is enhanced by a new methodology, which promises to improve the **knowledge about the product**, i.e. about the package, the machinery, and their interaction. The objective of the new methodology is to determine the **correlated effects** of raw materials, transformation process, and intrinsic variability of noises on the geometrical dimensions, defectiveness of the appearance, and tare weight of the container. The main benefit expected from the introduction of the new methodology is a **reduction in the defect packages per production hour**.

The engineers at Tetra Pak Carton Ambient decided to introduce the new methodology in **one step**, which means that all activities and relations are introduced in the first project. The characteristics of this introduction approach were determined through an interview and, based on this data, the introduction approach was **evaluated**. The evaluation results were presented in chapter 4.5.2.

The Introduction Procedure Model cannot only be used for evaluating an introduction procedure, but it allows also determining the **best introduction procedure** for given boundary conditions. In chapter 4.5.3, the proposed best introduction alternative, which consists of **five introduction steps**, was described and compared to the applied one-step approach.

The weighted sum of all parameter values yields the **evaluation measure**. The suggested introduction procedure yields a better evaluation measure than the applied introduction procedure. The **applied introduction procedure** has advantages with respect to the duration of the introduction and its progress. On the other hand, the **suggested introduction procedure** in summary provides a better result quality, company operability, acceptance of the introduction, and cost of the introduction.

5 Summary and Outlook

Although there is a considerable amount of literature in the area of concept implementation, it lacks an approach for determining what should be done (and when should it be done) to *introduce* the concept. Thus, the objective of the present dissertation is to provide an approach for defining the optimal introduction procedure for a new concept, while considering all relevant boundary conditions.

Since the boundary conditions and the systems to be considered (strategy, people, process, and organization) have complex relationships, a formal approach is necessary. This formal approach is the Introduction Procedure Model, which enables the user to optimize the transition from the current process state (initial state), i.e. before the concept introduction, to the intended process state (target state), i.e. after the concept introduction.

Section 1 of the present dissertation has shown that there are several **sources for the increasing pressure** on companies to change, among them the increased product and product development complexity, which requires the **introduction of new approaches** in product development to be able to **master this complexity**. However, studies show that a **majority of change projects fail** to reach the expected benefits. These studies also show that for a successful introduction of new approaches, the implementation and specifically the **introduction has to be carefully planned**. Yet, despite its importance there is no approach that allows determining the **optimal introduction procedure** for a new approach with respect to time, cost, and quality. This **methodological gap** shall be filled by this dissertation.

The main result of the present dissertation is a **quantitative model of the concept introduction** procedure. This Introduction Procedure Model helps to determine the **optimal concept introduction procedure** while considering **relevant constraints**, which are included in the assessment system. The assessment system allows the user to predict the **relative effects** of the introduction procedure on the implementation cost and duration, and on the product quality. Since the **quantitative model was implemented in a software**, it provides the user with the possibility to define and evaluate a large number of possible introduction procedures.

In literature, the terms “introduction” and “implementation” are often used interchangeably, although they have a slightly different meaning. First, introduction comprises only those activities that **actually change** the context or the concept, whereas implementation includes also the activities supporting the introduction. Second, from a procedural point of view, introduction considers the **execution of the change** in the organization structure, process, etc. In contrast, implementation has a much broader view on the process, already starting with the idea and initiative for change until the control of the change results.

Implementation as change approach was put into the **context of other change approaches** (e.g. Business Process Reengineering, etc.). Two of the main differentiating factors are that implementation **represents both revolutionary and evolutionary changes** (with a slightly higher emphasis on revolutionary changes), but rather in a **local area**.

Section 2 presented **phase schemes and procedures** of the implementation process from literature. The described phase schemes and procedures only provide a **high-level view** on the implementation procedure, which makes their value as **orientation guide** and for **creating transparency** questionable. Therefore, a **process model of the implementation** was developed, which describes the activities that should be conducted, the products that should be produced by the individual activities in the process (outputs), and the inputs that are used by these activities to produce those outputs.

The implementation process can be divided in the three phases **planning, execution, and control**. Within these phases, several groups of activities can be differentiated. The activity groups support the main “functions” of the implementation process (**process functions**) and thus can be considered as **basic steps** of the implementation process.

Tailoring of the Implementation Process Model should be performed on the organizational and the project level. There are three main groups of characteristics that influence the implementation process: **project characteristics**, **programmatic risks**, and **concept characteristics**. The developed tailoring heuristics provide guidance **how to adapt the implementation process**, dependent on variations in the previously defined tailoring parameters. The suggested tailoring approach uses the basic steps (**process functions**) of the implementation process as variables in the process structure. That is, variations in the tailoring parameters influence to which extent the basic steps of the implementation process have to be executed. Thus, the tailoring heuristics define if **higher or lower emphasis** should be put on the corresponding basic process function, or if the basic process function is **not influenced** or mainly influenced by other characteristics.

Section 3 presented a quantitative model of the personnel-related implementation measures (information, qualification, and motivation). The **main objectives** of this model are to determine the **cost-value-ratio** of the personnel-related implementation activities and thus allow an optimization of cost versus effects, and to determine the **individual information, qualification, and expected motivation level** and the respective **homogeneity of the measure distribution** in the company. With the calculation **examples** it has been shown that the proposed quantitative approach can be used to **compare different strategies** for information, qualification, and motivation during the implementation.

Section 4 presented a quantitative model of the introduction procedure, the Introduction Procedure Model. The **main objective** of the Introduction Procedure Model is to provide an **approach for determining the optimal introduction procedure**, based on the identified constraints. The concept introduction can be considered as a **decision process**. It is not the intention of the defined quantitative model to **substitute** this decision process, but it rather **supports** the decision process in selected areas.

The concept introduction in a company is considered as a **sequence of steps** until the “target state” is reached. The **target state** is the point where the introduction can be considered as complete. Each step comprises one or more **changes** that are made to the system (process or organization), which lead to temporarily stable system structures, the “**intermediate states**”. The changes between two intermediate states or an intermediate state and the target state can be seen as **transition** of the system.

The approach in the quantitative model for the generation of possible and reasonable alternative introduction procedures (**modeling**) was described using an example. The set of possible alternative introduction procedures contains many intermediate process states, which are not reasonable from an **information flow** perspective. A very simple, yet effective criterion to determine if the modeled introduction state is of practical meaning is its so-called “**stability**”. Here, the term stability shall describe a state where the information flow in the process is not interrupted. In terms of activities and relations this means that if an activity exists in the process system, it has to have at least one input and one output. In many cases the activities to be introduced form modules that have to be introduced together. Thus, **modularity** is another boundary condition for the modeling. Finally, there may be **practical constraints** that do not allow following certain introduction procedures.

To evaluate the performance of a concept introduction procedure, the aspects **cost, duration, and quality** can be applied. Introduction quality consists of **several aspects**, which may be attributed to the quality areas **performance sustainment, introduction speed, company operability, introduction acceptance, and concept benefit**.

These introduction objectives are described only qualitatively in literature On the other hand, in literature many “rules” (**axioms**) about how to introduce a new concept in a company can be found Therefore, axioms that are relevant for the concept introduction were extracted from literature and quantified with **metrics**. To derive a **quantitative assessment system**, the identified axioms and metrics were attributed to the objectives of the concept introduction. With this relation between the axioms and the objectives, an assessment system for the concept introduction in a company was established, which can be used to quantitatively evaluate different introduction procedures.

The approach for **evaluating alternative introduction procedures** is based on the defined assessment system. The criteria cost, duration, and quality are on the **highest level** of the objective system for concept introductions. Since especially introduction quality, but also introduction duration are composed of **several criteria**, the application of these high level objectives as evaluation criteria would lack **transparency** for the user. Therefore, it is suggested to use the **second level** criteria of the assessment system.

The verification of the Introduction Procedure Model with a case study at Tetra Pak Carton Ambient is described. The case study deals with the joint development of a liquid food package and the according machinery in one development process. This development process is enhanced by a new methodology, which promises to improve the **knowledge about the product**, i.e. about the package, the machinery, and their interaction. The objective of the new methodology is to determine the **correlated effects** of raw materials, transformation process, and intrinsic variability of noises on the geometrical dimensions, defectiveness of the appearance, and tare weight of the container. The main benefit expected from the introduction of the new methodology is a **reduction in the defect packages per production hour**.

The engineers at Tetra Pak Carton Ambient decided to introduce the new methodology in **one step**, which means that all activities and relations are introduced in the first project. The characteristics of this introduction approach were determined through an interview and, based on this data, the introduction approach was **evaluated**.

The Introduction Procedure Model cannot only be used for evaluating an introduction procedure, but it allows also determining the **best introduction procedure** for given boundary conditions. The proposed best introduction alternative, which consists of **five introduction steps**, was described and compared to the applied one-step approach. The **applied introduction procedure** has advantages with respect to the duration of the introduction and its progress. On the other hand, the **suggested introduction procedure** in summary provides a better result quality, company operability, acceptance of the introduction, and cost of the introduction.

It is important to note that the objective of the developed Introduction Procedure Model is **not** the **optimization** of the target state. It is assumed that the target state is already fully defined and given. In contrast, the objective of Introduction Procedure Model is to optimize the **procedure** to achieve the target state.

A model is always a simplification of reality. It has to be, otherwise the representation of the investigated problem would be too complex. On the other hand, an oversimplification negatively influences the validity of the model. Thus, the art is to balance between a necessary and beneficial simplification and a harmful oversimplification.

All three presented models, the process model of the implementation, the quantitative model of the personnel-related implementation measures, and the Introduction Procedure Model, strongly simplify the reality. This certainly negatively influences their validity, yet it supports their applicability. The present dissertation is the first attempt to (quantitatively) model these aspects. Therefore, further research can and should try to refine the models, in order to increase their validity, without restricting their applicability.

Specifically, the negative effects of change on the process performance (result quality) and the succeeding recuperation should be investigated in more detail. In many literature sources the decrease of process performance after a change is mentioned, only few describe reasons for this decrease, but none explain its mechanics and correlations. If this is understood more properly, valuable insights can be gained how to design the introduction procedure in order to restrict the decrease in the process performance. Similarly, the succeeding recuperation after a decline in the process performance is not yet fully understood. This recuperation stems certainly from more than only learning effects, e.g. from an increase in the acceptance or other psychological effects. But also the self-organizing capability of an organization can contribute to the increase in the process performance. However, the factors that contribute to the increase are partly not known or not satisfactorily examined. Moreover, the learning curve, well described in the production area, is not yet transferred to the area of product development. Which are the influencing factors on the learning speed (e.g. acceptance, expected benefit) and thus on the slope of the learning curve has still to be investigated.

In the current economical environment, change seems to be the only constant. It gets more and more common that change initiatives quickly follow one after another. However, a change initiative is not finished when the last change is introduced. It requires time to stabilize a new culture, habit, or even process. Therefore, it is important that new introduction steps are made at the right time. In the Introduction Procedure Model, the next introduction step is initiated at a predefined point, depending on the slope of the result improvement curve. This assumption should be tested in studies.

The three presented models were developed independently from each other, since they cover areas that can be treated separately. However, all three aspects, the implementation process, personnel-related implementation activities, and introduction procedure, are interrelated and thus also the models should be connected. Further research is necessary to establish this connection. Moreover, the introduction concept is assumed to be given (at least for one introduction step) and independent of the introduction procedure. That is, the influence of the introduction procedure on the concept adaptation is not modeled. In other words, the focus of the present dissertation is the actual introduction, together with other, individual elements of implementation. In future work, the focus should be broader, encompassing all aspects of implementation and correlating them.

With respect to the defined objective system, only five aspects were considered: performance sustainment, introduction acceptance, company operability, introduction speed, and concept benefit. However, there are possibly more dimensions that have to be considered, e.g. company internal political aspects. Yet, these are company specific, very difficult to model, and thus cannot be considered in the objective system of a generic model. But, to enable modeling these factors (at least partly), the possibility of considering practical constraints was included. Furthermore, more aspects are probably relevant (e.g. psychological aspects), which are not accounted for in the defined axioms, due to a trade off between completeness (validity) and simplicity of the objective system.

For the Introduction Procedure Model, the emphasis was put on changes (introductions) in the process system and the corresponding team changes. Changes in other subsystems of product development were not in the scope of the present dissertation.

Changes in the goal system can be, e.g., new business objectives, which primarily change the culture of the company. Business objectives are directives, which try to orient the activities in the company towards a common goal. For changes in the goal system psychological aspects are most important, because changes in the culture take a long time and are very hard to achieve.

In most cases, changes in the object system take the form of changing the physical structure of the product. This can include make-or-buy decisions, which have the target, e.g., to reduce the complexity of the product or increase its reliability. An important aspect of changes in the object system is change propagation, because changes in one part of the product usually affect also other parts of the product.

Organization restructuring is an example for changes in the agent system. Its objective is, e.g., to reduce the number of hierarchy levels in the organization. This can be an important step in achieving a lean enterprise. Most important for changes in the agent system are psychological aspects, since the loss of power, position, or influence as well as cultural differences can create resistance.

In the information system, the introduction of new or change of existing information technologies (new software and/or hardware) is the common type of change. New software needs new data interfaces, but may also require new activities and create new relations between people. The latter aspect is considered in the present dissertation, whereas the introduction of new data interfaces is a very specific informatics problem.

The examples above show that changes in the goal, object, and agent system have to consider psychological and propagation conditions, in contrast to changes in the process system. Therefore, the application of the Introduction Procedure Model is restricted to changes in the process system (including the accompanying organizational changes) and the information system.

However, from the author’s point of view, the presented Introduction Procedure Model is a simple, but effective method for the planning of an introduction procedure. Although a trade off had to be made between model simplicity and validity, partly because there is a lack of data in this area, the model results are valuable and can help to improve the introduction procedure significantly. Moreover, experience from the SysTest project has shown that even the process of modeling creates valuable insights, which is often underestimated in industry.

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