

# An Investigation into the Relevance of Flexibility- and Interoperability Requirements for Implementation Processes for Workflow- Management-Applications

## PhD – Thesis

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## 0 Abstract

Flexibility and Interoperability have become important characteristics for organisations and their business processes. The need to control flexible business processes within an organisation's boundaries and between organisations imposes major requirements on a company's process control capabilities.

Workflow Management Systems (WFMS) try to fulfil these requirements by offering respective product features. Evidence suggests that the achievement of flexible business processes and an inter-organisational process control is also influenced by implementation processes for Workflow Management Applications (WFMA).<sup>1</sup> The impact of a WFMA implementation methodology on the fulfilment of these requirements is the research scope of the project.

The thesis provides knowledge in the following areas:

1. Review of the relationship between workflow management and the claim for process flexibility respectively -interoperability.
2. Definition of a research-/evaluation framework for workflow projects. This framework is composed of all relevant research variables that have been identified for the thesis.
3. Empirical survey of relevant workflow-project objectives and their priority in the context of process flexibility and –interoperability.
4. Empirical survey of the objectives' achievement.
5. Empirical survey of methodologies / activities that have been applied within workflow projects.
6. Derivation of the project methodologies' effectiveness in terms of the impact that applied activities had on project objectives.
7. Evaluation of existing workflow life-cycle models in accordance with the research framework.
8. Identification of basic improvements for workflow implementation processes with respect to the achievement of flexible and interoperable business processes.

The first part of the thesis argues the relevance of the subject. Afterwards research variables that constitute the evaluation framework for WFMA implementation processes are stepwise identified and defined. An empirical study then proves the variables' effectiveness for the achievement of process flexibility and –interoperability within the WFMA implementation process. After this the framework is applied to evaluate chosen WFMA implementation methodologies. Identified weaknesses and effective methodological aspects are utilised to develop generic methodological improvements. These improvements are later validated by means of a case study and interviews with workflow experts.

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<sup>1</sup> A WFMA comprises the WFMS and „all WFMS specific data with regard to one or more business processes“. [VER01]

# 1 Introduction

This thesis investigates the relevance of Workflow Management in relation to business process management and control. Business Process Orientation and related management techniques such as Business Process Reengineering (BPR), which became very popular during the 1990s, have a mutual dependency with Information Technology (IT). On the one hand, technical developments matured in the last decade, such as database management and networking infrastructures provide the technical foundation to:

- integrate information of different IT-systems and organisations
- retrieve and provide information in an efficient and user-friendly way.

Such an IT enabled informational integration is seen as a prerequisite for the implementation of business processes.[GON01, OES01, KNO01, DAV01] Equally, the implementation of coherent business processes along entire value chains is only feasible with IT-Systems allowing the definition, execution and control of business tasks under consideration of process induced dependencies.[SCH04] In other words the business process paradigm requires sophisticated IT tools to achieve a computer supported execution of business processes. Workflow Management Systems (WFMS) aim to integrate the different tasks and the supporting IT-applications of a business process to end up with a streamlined flow of work.[HAS01, KIR02] In contrast to conventional IT-systems which support single business tasks, a Workflow-Management-Application (WFMA) aims at the computer-supported execution and coordination of entire business processes.<sup>2</sup>[HEI01, LAW01] Workflow-Management (WFM) is seen as a technology to realise remarkable productivity gains for administrative business areas, i.e. reduced costs and flow times and an increased service quality.[TAG01, ZCH01; BIT01]

The successful operation of a WFMA requires both, a WFMS that meets the specific demands of the business domain (sufficient product properties) and an implementation process for the WFMA that helps to achieve the intended objectives.[SCH03, FRE01] Academics consider the impact of implementation process on the quality of a WFMA as a field for potential research.<sup>3</sup>[HEI01, DEE01, RIN02] The inter-organisational execution of processes by means of integrated WFMA and their flexible adaptation to new process properties have been extensively discussed within the workflow community as crucial requirements on WFMA.[HEI04, RIN01, BAR03] This thesis investigates implementation processes for WFMA particularly with regard to the effects that a WFMA implementation process has on the interoperability and flexibility of the business processes that are to supposed to be controlled by a WFMA.<sup>4</sup>

This chapter introduces the reader to the research purpose of the thesis. The first section, the problem statement, acquaints with workflow related considerations of business process flexibility and inter-company process control that have led to the formulation of this research subject. Both the practical relevance and the research contribution are discussed. In the next section, the questions raised in the thesis are defined and subjects that are out of the thesis's scope are marked off. The research design and the applied research methods are explained in

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<sup>2</sup> Basic definitions for the Workflow, Workflow-Management, Workflow-Management-Application, and Workflow-Management-System are provided in Chapter 2.

<sup>3</sup> E.g. the Workflow Management Research Group announced 2007 that it provides a forum to investigate and discuss best practices in workflow projects.

<sup>4</sup> Implementation process means a life-cycle model for the integration of a given WFMS into an organisation. It does not mean the software development process for a WFMS.

further sections. The last section explains the thesis's structure in terms of chapters and sections.

## **1.1 Problem Statement**

Recent past has shown that business environments have a decreasing stability in many lines of business.[HOC01, RIN01, KIR02] Organisations are under the pressure to keep pace with very specific and regularly changing customer demands, increasing competition, and technological innovations.[BAR02] Products, services, and hence business processes are subject to a continuous change. Agility has become the most important challenge of business process management.[JOS01] For the future, an even increasing change frequency can be assumed.[PER01] A survey of 4000 senior executives revealed that the ability to flexibly adapt companies' organisations to changing environmental conditions is regarded as the most important management challenge until 2010.[ECO01]

Generally one can identify some economic trends that are expected to have an impact on the variability and the integration of (inter-organisational) business processes.[SHA01, ECO01, RIN01]

1. Globalisation, Mergers & Acquisitions, and an increasing number of joint ventures or strategic alliances require the alignment of business processes and the integration of IT-systems that have been separated before.
2. Virtual companies lead to temporary collaborations and loosely coupled business processes of different companies.
3. New business models and marketplaces, promoted by e-commerce and internet-marketplaces found inter-organisational business processes.
4. New legislations imposed by global trade relations come into effect and force companies to adapt their business processes.
5. Companies still strive for optimised business processes and restructured organisational structures.
6. High pressure competition urges companies to innovate service, not just products and therewith promotes business change.
7. Innovation will become global as companies become familiar with decentralised Research & Development on several sites.

An accelerated change of business processes and new forms of collaboration emphasise the importance of a WFMA's flexibility and interoperability. Both, flexibility and interoperability have been discussed as software product properties in the context of software quality since the late 1970s.[MCC01] Nowadays, these requirements constitute a shifted focus in the importance of quality criteria for WFMA's. In other words flexibility and interoperability became crucial properties of a WFMA. Workflow technology is often regarded as a technical key asset for flexible business processes and inter-organisational process control.[HEI04, PER01] Yet, academics report that workflow technology has not led to more flexible organisations, but it increased inflexibility instead.[MÜH03, GON01] In fact, academic literature often exclusively considers the claim for interoperability and flexibility as properties that a WFMS product has to secure (See Chapter 3).[RIN01] Nevertheless, a WFMS product that aids flexibility and interoperability is necessary but not sufficient, as it is assumed that the WFMA implementation process also has a considerable effect on the ability to flexibly adapt business processes and to control inter-company processes.[BAR03] Existing life-cycle models often strive for an optimisation of business processes in terms of cost savings and reduced cycle times, but do not sufficiently consider the future need for flexibility and

interoperability.[MÜH03, GAL01, GÖT01] Research in the area of BPR and WFMS has shown that an implementation process has to include specific activities and guidelines that describe how to reach objectives that go beyond a pure technical WFMS implementation.[THI01, BIT01, BEC02] It is not sufficient to merely technically implement any business process according to the technical opportunities of a WFMS. It is rather required to evaluate the flexibility- and interoperability-needs of the business domain first, to assess the possibilities of the considered WFMSs, and to regard the original objectives that are to be reached by implementing the workflows. Workflow technology must not inhibit organisational change and innovative forms of inter-company collaboration. Methodologies have to follow the premise that business needs to rule technology.

## **1.2 Research-Objectives and -Questions**

This thesis investigates the relevance of WFMA implementation processes for the achievement of flexible business processes and an inter-organisational process control.<sup>5</sup> A main assumption is that workflow technology has not necessarily led to more flexible business processes, though it has been perceived as a technological key driver in this field (See section 1.1 ‘Problem Statement’). Substantial research has been carried out in the field of flexible and interoperable WFMS, but minor attention has been paid to the impact that project methodologies will have on the achievement of these objectives. It is also intended to find out how basic improvements of the workflow life-cycle can help to achieve flexibility and interoperability of WFMA. Such improvements are supposed to relieve or even to dominate companies’ environmental uncertainties which impose the need for organisational change (See section 1.1 ‘Problem Statement’). Therefore the thesis assumes process flexibility and interoperability as fundamental requirements for WFMA which are to be accomplished by the implementation process.<sup>6</sup> To sum it up it can be said that the thesis provides knowledge in the following areas:

1. Review of the relationship between workflow management and the claim for process flexibility respectively -interoperability.
2. Definition of a research-/evaluation framework for workflow projects. This framework is composed of all relevant research variables that have been identified for the thesis.
3. Empirical survey of relevant workflow-project objectives and their priority in the context of process flexibility and –interoperability.
4. Empirical survey of the objectives’ achievement.
5. Empirical survey of methodologies / activities that have been applied within workflow projects.
6. Derivation of the project methodologies’ effectiveness in terms of the impact that applied activities had on project objectives.
7. Evaluation of existing workflow life-cycle models in accordance with the research framework.
8. Identification of basic improvements for workflow implementation processes with respect to the achievement of flexible and interoperable business processes.

It is not intended to investigate the reasons why certain objectives are more or less important for workflow projects. An analysis of the reasons that constitute an effective influence of the

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<sup>5</sup> In the following the terms “implementation process”, “implementation approach”, “workflow life-cycle” and “life-cycle model” will be used synonymously.

<sup>6</sup> The research focus has been outlined by means of structured interviews with workflow experts. The outcome of these interviews has become the foundation of the research framework described in chapter 3.

project methodology on the investigated project objective is also not within the research scope.

### **1.3 Research Design**

Business Informatics as a specific discipline of computer science is a real science with a special interest in information systems and informational structures for business and administration. According to Heinrich/Roithmayr the discipline's object of cognition are „information- and communication systems in terms of people/task/technology-systems including methodologies and tools for the construction (analysis, design, implementation and installation) of such systems“. [ROI01] The definition implies an idea of information systems constituted by relationships between people and tasks, people and technology, tasks and technology. Since the object of cognition does not only comprise information systems, but also methodologies and tools for their analysis, design, and implementation, the author founds the thesis's research focus on Roithmayr's definition. In other words the investigation in WFMA implementation approaches contributes to research in the business informatics field of knowledge. It also provides knowledge to the related software engineering discipline which strives for principles, methods and tools applicable to the software development process. [LF01] Research as executed in the thesis with its relationship between new findings and the findings' applicability focuses on practical requirements. One can also argue that the growing market penetration of standardised “of-the-shelf software“ as a counterpart to individually “from scratch” developed software, requires specific implementation processes which again justify research in the field of applied computer sciences. [KIR01] In fact, empirical research in the area of workflow management and standardised business-software proves the following [ALT01][MUM01]:

- The utilisation of those systems has increased over the last decade
- Implementation methodologies became noticeably important for the systems' operational usability<sup>7</sup>

The research objective of the business informatics discipline consists of an explanatory task and a design task/creative task. [HEI02] Discoveries/findings and actions take turns and lead to new findings. Research progress in business informatics needs to be based on practical problems, i.e. it requires an exploration of reality. This thesis fulfils the explanatory research task by investigating WFMA implementation processes. For that purpose, empirical research is of major importance. [HEI03] On the other hand, the thesis fulfils its design task by deriving approaches to an improved implementation of WFMA where any of these proposals must be validated in terms of their practical applicability.

The research process is described in figure 1-1. It applies deductive and inductive methods and therefore fulfils the claim for methodological pluralism. [FRA01] In the first part, expert interviews and a literature survey are used to deduce specific hypotheses. The thesis fulfils basic scientific quality standards as these predictions, which are identified with deductive methods, have been empirically revised. [HEI03] Assumptions for such significant findings have been initially derived from really executed workflow projects and from literature sources. In the second part, where general approaches for improvements of flexibility and interoperability are developed, inductive methods in terms of interviews with workflow experts are supposed to validate the proposed improvements. Validation interviews are

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<sup>7</sup> Implementation means the technical and organisational installation and integration, but not the original development of the WFMS.

inductive in the sense that the proposed improvements are to be universalised in order to assure their applicability to WFMA projects in general.

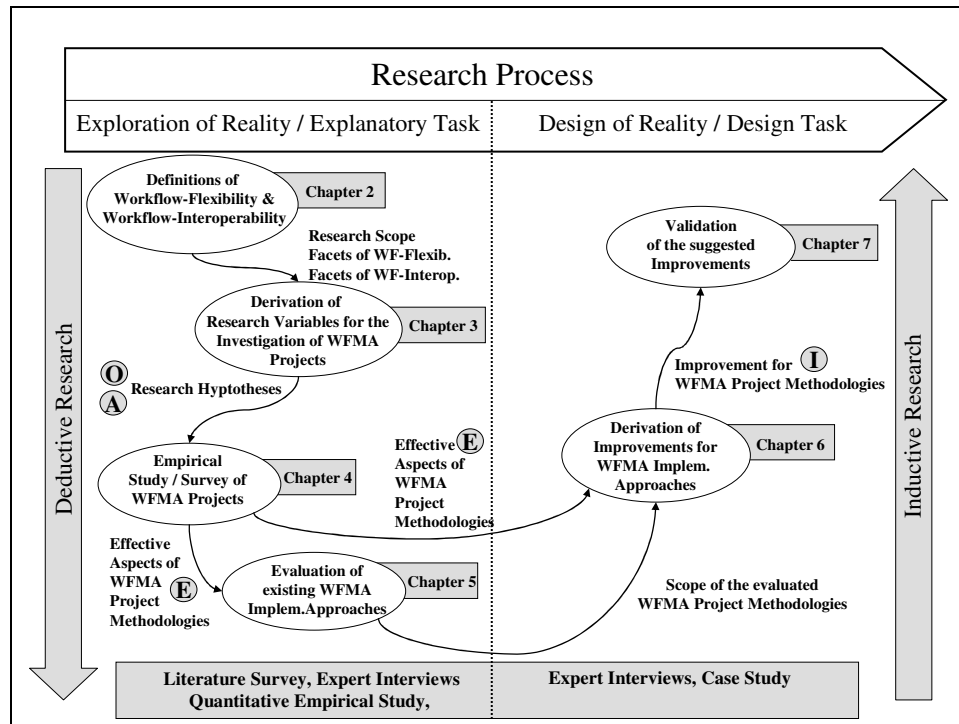


Figure 1-1: Research Process

The thesis considers WFMA implementation processes as socio-technical systems. Therefore, the organisation and improvement of WFMA implementation processes is regarded as an organisational design task with respect to project structures, -activities, -deliverables and the development process itself.[SOM01] This allows the author to base the entire thesis on a reference framework which is derived from organisational theory.[HER03, GRO01] It is intended as a meta-model for the research approach and consists of the following elements:<sup>8</sup>

- **Organisational Objectives of WFMA Projects:** They describe the objectives that are to be reached by executing the project activities and applying the project tools, i.e. they encompass all objectives that a WFMA implementation process has to fulfil in light of this study. Those Objectives are accurately defined by an organisation and cannot be directly changed. A definition of the objectives within the framework allows the measurement of their fulfilment within the empirical study.
- **Project activities and tools for WFMA Projects:** These can be directly influenced by altering the project methodology. Activities and objectives have a connection in so far as project activities have an impact on the objectives' fulfilment. As one can modify the project methodology in order to achieve the project objectives, the thesis regards supposed design options for life-cycle models as parameters. If the empirical survey proves a significant impact of project activities on the fulfilment of project objectives, existing WFMA implementation approaches will be analysed in light of the parameter's fulfilment.
- **General Conditions of WFMA Projects:** They influence the effects that improvements for WFMA implementation methodologies have on the achievement of project objectives. Conditions are the circumstances under which a WFMA implementation project has to be executed. They cannot be influenced.

<sup>8</sup> Herzwurm proposes to found empirical research on frameworks of well-defined research variables.[HER03]

The framework's structure is based on Grochla's view on organisational theory.[GRO01] It is intended as a tool for the analysis and the organisational design of the WFMA implementation process under consideration of the dependencies between relevant project objectives and general project conditions. Assuming that the development and improvement of a software implementation process is also an organisational design task, the consistent definition and application of such a reference framework helps to gain representative and usable results from the research process.

The starting point for the definition of the framework are topical practical issues and well-known problems to do with the implementation of WFMA's under special consideration of process flexibility and inter-organisational interoperability. These are initially discussed in interviews with workflow experts. A major output were project objectives, aspects of the project methodology, and project conditions that are assumed to be relevant for WFMA projects. All thus identified elements of the framework have been validated in light of their relevance for the achievement of flexibility and interoperability. For validation purposes, a literature analysis was executed. Some initially identified elements have been deleted from the framework in the course of the literature analysis. All the rest remained as part of the research framework. Assumed impacts of the project methodology on the achievement of project objectives need to be statistically proven. This is to be done within an empirical study. For that purpose, research hypotheses and a questionnaire were derived from the reference framework. Additionally, an evaluation of published WFMA implementation processes analyses if flexibility and interoperability are appropriately appreciated within available methodologies. Aspects of the project methodology for which a significant effect on project objectives was proven by means of the empirical survey, served as a basis for the definition of improvement measures. As the thesis cannot demonstrate the improvements' effectiveness within a field study, interviews with workflow experts and a case-study with students were carried out to validate the improvement approaches.

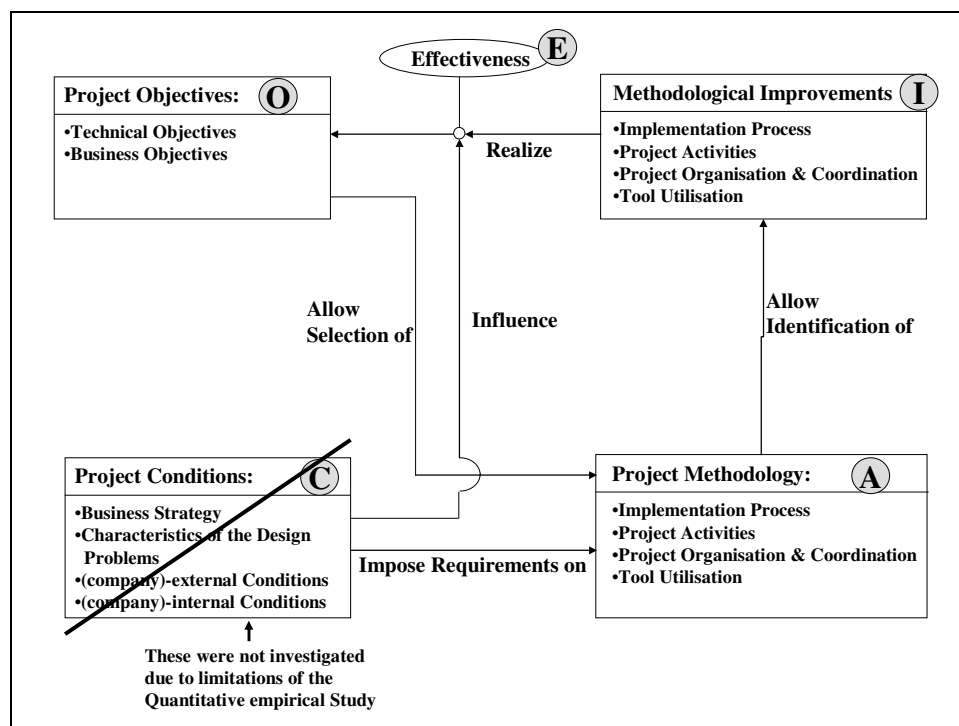
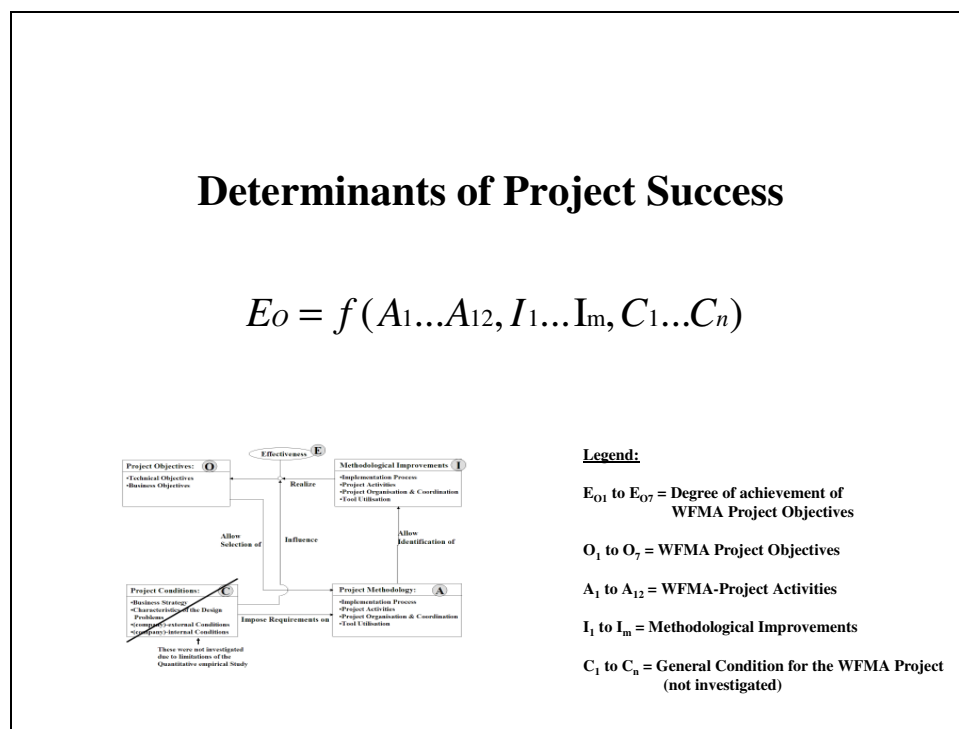


Figure 1-2: Research Framework / Meta Model

Figure 1-2 describes the relationships between the meta-model's elements. Note that methodological improvements do not belong to Grochla's approach; those improvements constitute a pivotal research outcome and were therefore complemented. Project objectives allow the selection of an appropriate methodology, i.e. one has to choose an implementation approach that will probably have the highest contribution to the fulfilment of the project objectives. Project conditions are restrictions that specify unchangeable actual circumstances of a WFMA project. They impose requirements on the project methodology and influence the effectiveness of improvement measures. Project methodologies imply weaknesses and thus opportunities for their improvement. Significant effects of the project methodology on project objectives help to identify potential improvement measures. As it was not feasible to survey all elements of the research framework, project conditions were totally eliminated from the framework.<sup>9</sup> Nevertheless, these elements of the framework are considered as determinants of project success, as they influence the effectiveness of the project methodology or in other words: the degree of achievement of WFMA project objectives. The relationship between these elements of the research framework is indicated in figure 1-3.



**Figure 1-3: Research Framework / Determinants of Project Success**

<sup>9</sup> The pre-test of the survey yielded marginal response (see section 4.1.3). Feedback revealed that the questionnaire was too extensive and not easy to complete. As a result the author decided to simplify the questionnaire by total elimination of the variables for project conditions. The fundamental research variables for project objectives and methodological aspects were kept within the questionnaire.



## 1.4 Research Methods

### 1.4.1 Science and their objectives

Aim and function of science is the acquisition of knowledge.[FRI01] Business informatics is a real science.[HEI03] The discipline's research objective is an explanatory task and a design task.[HEI02] It includes the acquisition of knowledge and knowledge based action which leads to new knowledge. Figure 1-4 shows the interdependency of a research cycle and a problem solving cycle. Both influence each other and establish practice oriented research approaches.

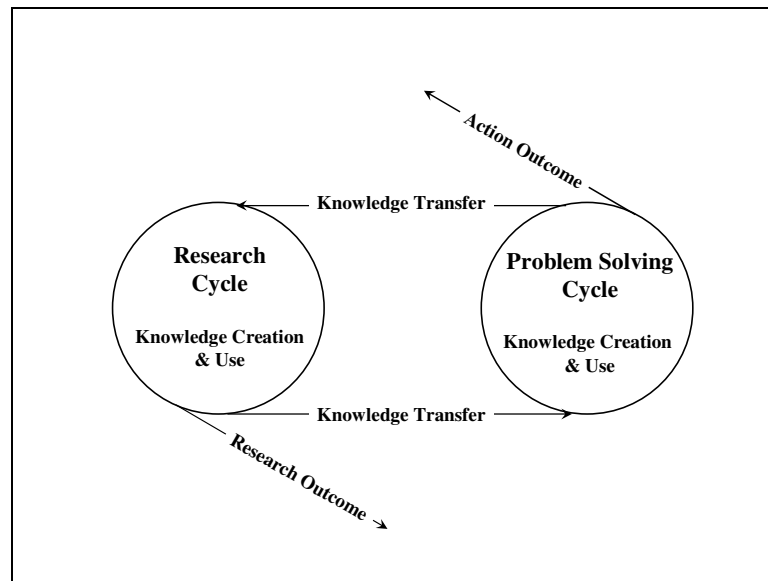


Figure 1-4: Practical Relevance of IS Research – adapted from [MAT01]

The thesis's main object of investigation is the WFMA-implementation process. As the thesis provides insights in the way how WFMA-implementation processes help to achieve process-flexibility and –interoperability, it fulfils its explanatory task. The design task is executed by recommending methodological improvements which are validated by further research steps. Therefore the applied research approach is a combined process of explanatory tasks and design tasks.

The business informatics discipline is rather common in German-speaking areas. It is based on real-, formal- and engineering sciences and utilises constructivist research approaches. Information system research is the English related discipline which is coined behaviouristic.[WIL01]

The constructivistic paradigm of business informatics strives for knowledge acquisition through the design and evaluation of IT-solutions in the form of models, methods and systems.[WIL01] On the other hand, the behaviouristic paradigm analyses the behaviour and impact of information systems on organisations. A general shift away from technological to managerial and organisational issues has been undertaken in information systems research.[MYE01] Both paradigms apply to the thesis' research question (see section 1.2), as the thesis investigates an ideal design for a WFMA implementation methodology (constructivistic) as well as their effectiveness in an organisational context (behavioural).

German researchers criticise that empirical research is not widespread in business informatics though it is judged as an important research approach.[HEI03] Heinrich appraises the quality of business informatics research in German-speaking areas as follows:

- Research quality is generally insufficient
- Commonly accepted criteria for scientific work are unsatisfactorily fulfilled
- Field research is usually applied
- Samples with further **descriptive** data analysis are common
- Research hypotheses are hardly formulated

International comparisons have shown that empirical research in Anglophone countries meets scientific quality requirements to a higher degree than in German-speaking countries.[HEI02]

#### 1.4.2 Research methods: preface

Research methods provide techniques for the investigation of given phenomena. Wilde defines a methodology as an instrument for the acquisition of knowledge.[WIL01] Heinrich goes a step further and argues that research methodologies also evaluate existing knowledge. It comprises a science's methodologies that help to acquire and review knowledge that concerns a given scientific object.[HEI02]

Research methods generally have to avoid the following risks of human perception:

- Selective perception
- Implicit assumptions and conclusions
- Naïve theories and causal fallacies
- Memory- and expectation-effects
- Reference group effects
- Subjective interpretations
- Lacking traceability and transparency
- Limited comparability

An important claim on research methods is the truth or correctness of its conclusions.[BOR01] This means evidence needs to be consistent and has to comply with reality. Research methods have to fulfil the following requirements to avoid above mentioned problem fields: [FAB01]

- Logical and revisable theories
- Accurately defined terminology
- Clear operationalisation
- Value neutrality
- Rule-governed data acquisition
- Rule-governed data analysis
- Rule-governed data interpretation
- General repeatability

BOR summarises quality factors for research methods as follows [BOR01]:

- Intersubjectivity / intersubjective understandability
- Reliability / repeated execution must yield the same conclusions

- Validity (as proven in chapter 7)
- Precise terms and definitions (as defined in chapter 2 & 3)
- Universability (as proven in chapter 4)
- Relevance (as described in chapter 1 & 2)

The claim for research methods that are based on logic and mathematics depends on researchers' preferences for certain research paradigms. A general demand is that science and research processes are value-free.[BOL01]

To conclude, it can be summarised that research methods are communicable systems of rules (as mentioned above), that actors utilise as goal oriented action plans.[WIL01] These are intersubjective definitions for the understanding of rules and its terms and definitions. Their compliance or non-compliance is prescribed by the normative and prescriptive character of the rules.

Research processes are generally structured as follows:

<b>Coarse Research Process [WIL01]</b>	<b>Detailed research process [BOR01]</b>	<b>Applied Research Methods</b>	<b>Utilisation in the thesis</b>
Research Design	Exploration phase	Desk research & subjective argumentative research	chapter 1 & 2
	Theoretical phase	Structured Literature Survey	chapter 2
	Planning phase	Qualitative Interviews & Structured Literature Survey	chapter 3
Operationalisation Investigation	Investigation phase	Empirical Survey	chapter 4
Analysis	Analysis phase		chapter 4
	Data interpretation phase	Statistical analysis methods & Structured Literature Survey	chapter 4 & 5
	Exploitation phase	Case Study Qualitative Interviews	chapter 5 & 6 & 7

**Table 1-1: Research Methods & Research Process**

Table 1-1 also shows the utilisation of research methods in each phase of the research process. It also assigns them to the thesis's chapters.

### 1.4.3 Types of research methods

The design of the research process and selection of adequate research methods depends on the specific research questions. Appropriate research methods need to be carefully chosen and carefully applied to achieve accurate results. Generally research methods can be distinguished in two categories: [MYE01]

1. **Qualitative research methods** were developed in the social sciences to enable researchers to study social and cultural phenomena, e.g. action research, case study

research, interview approaches. It involves the use of qualitative data, such as interviews, documents, and participant observation data.

2. **Quantitative research methods** were originally developed in the natural sciences to study natural phenomena, e.g. survey methods, laboratory experiments, formal methods, and numerical methods.

Galliers splits research approaches into scientific and interpretive methods. Scientific approaches have their origin in scientific tradition. They are characterised by repeatability and reductionism. They assume that observations of a phenomenon can be made objectively. An application of scientific in a social environment has been questioned.[GAL02]

A further distinction of research methods is provided by Orlikowski & Baroudi. They classify research methods as follows: [BOL01]

1. **Positivist research** „treats the organisational world as objective, essentially the same as the natural world“.[BOL01] It is based on the assumption that reality is objectively given and may be described using measurable properties which are independent of the observer and their instruments. Relevant characteristics are:

- Unity of the scientific method
- Search for causal relationships
- Belief in empiricism
- Foundation of science is based on logic and mathematics

These definitions apply to the sense of quantitative research where numbers come to represent values and levels of theoretical constructs and concepts and where the interpretation of the numbers is viewed as strong scientific evidence of how a phenomenon works.[STR02] Respectively positivist research is often characterised as follows:

- “evidence of formal propositions”
- “quantifiable measure of variables”
- “hypothesis testing”
- “drawing of inferences about a phenomenon to increase predictive understanding”

2. **Interpretivist research** “treats human organisations as fundamentally different, based on subjective meaning and interpretation“.[BOL01] The perspective is subjectivist in nature, as opposed to the objectivist view of positivism. It is based on the assumption that only through the subjective interpretation and intervention in reality can reality be fully understood. The aim is to produce an understanding of the context of the information system, and the process whereby the information system influences and is influenced by the context. Relevant characteristics are:

- Increase understanding of the phenomenon within cultural and contextual situations
- Phenomenon of interest was examined in its natural setting and from the perspective of the participants.
- Researchers did not impose their outsider’s a priori understanding of the situation

The difference between positivist and interpretivist epistemologies is not the same as the difference between qualitative and quantitative research, as positivist-qualitative and interpretivist-quantitative research approaches are also applied in sciences.

According to Heinrich business informatics comprises two different research directions. [HEI02]:

1. **Theoretical research:** is used for the development of theories and for the design of methodologies that are derived from theories. Respective research objectives which aim at a redesign or improvement of methodologies are within the thesis's scope.
2. **Empirical research:** is used for the verification of theories and the designed methodologies. Empirical research is also part of the thesis for the above mentioned purpose (see chapter 4).

**Deductive research** is implemented by empirical research methods. They rely on deductively gained hypotheses and aim to falsify them by means of aggregated samples in reality.[HEI02]

**Inductive research** obtains theoretical evidence on the basis of findings for individual cases that are subject to generalisation. This applies to the research methods used for validation purposes in chapter 7 which aim to validate improvements for WF-implementation methodologies. In this sense the thesis comprises deductive and inductive research methods (see research design, section 1.3).

#### 1.4.4 Selection of a research method

„Researchers, no matter their field, are faced with the problem of selecting an appropriate approach before conducting a study.”[BOL01] Myers states that “all research (whether quantitative or qualitative) is based on some underlying assumptions about what constitutes „valid“ research and which research methods are appropriate. In order to conduct research, it is therefore important to know the underlying epistemology which guides the research.”[MYE01]

The selection of a research method does not only depend on the research objective and the objective of investigation, but also on boundary conditions, e.g. available time and funds.[HEI02]

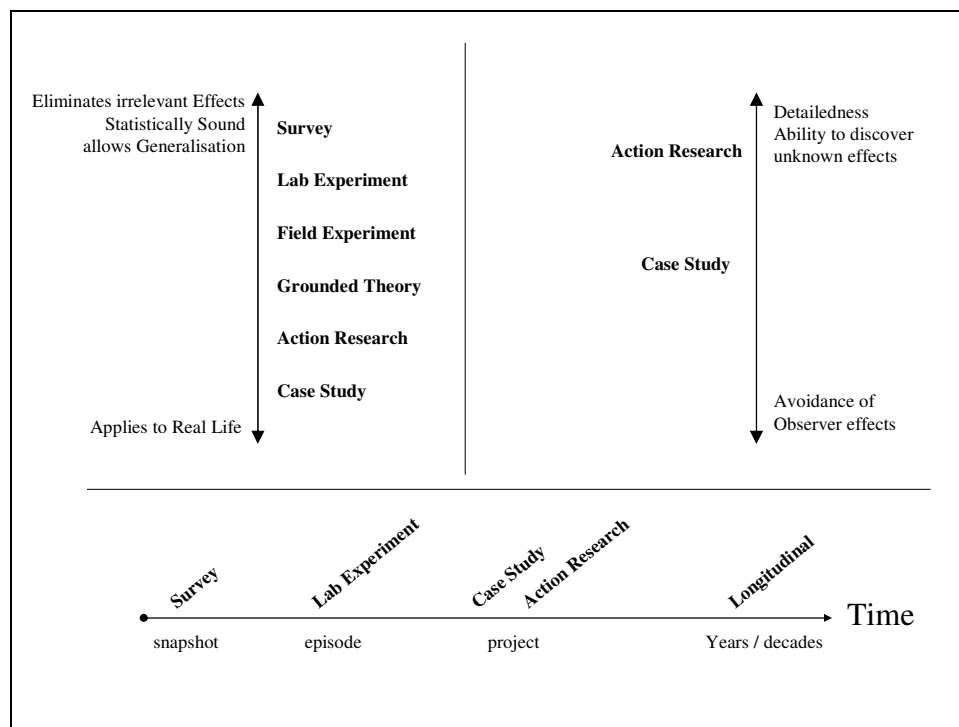
The chosen approach (methods) must support a process of intervention in a particular context to achieve the desired outcome.[DOB01] There is generally no ideal research methodology. Each has both strengths and shortcomings”.[COC01] The choice of method or approach must be “appropriate to the nature of the object under study and the purpose and expectation of the study”.[DOB01]

For instance, as the thesis aims to investigate a broad spectrum of variables, an empirical survey and further statistical analysis methods were applied. This conforms to the nature of deductive research (see chapter 4). As the thesis also investigates the applicability of life-cycle improvements from the perspective of affected users and their context, case studies and interviews are also applied. In this sense research methodologies were applied in a goal oriented way and with utilisation of their respective advantages.

### 1.4.5 Justification of a combined utilisation of research methods

As described earlier an ideal research method does not exist, as each individual approach has its own strengths and weaknesses. A combined application of different research methods may help to compensate each others weaknesses. This was also attempted for the thesis's underlying research process. It is intended to gain increasing confidence in the research results with any further research step that is based on a different research methodology and which yields research results that do not contradict results of an earlier research step.

Figure 1-5 illustrates the general differences between research methods.



**Figure 1-5: Research Methods and their Oppositions – adapted from [COC01]**

Cockburn has investigated possibilities for the combination of research methods and states that “the challenge is to find practical ways to combine qualitatively different research approaches” [COC01]

A combined application of research methods is permitted in Information Systems research. Will argues that Information Systems Science (in Germany: Business Informatics) is based on method pluralistic approaches to gain knowledge.[WIL01] Although most researchers do either quantitative or qualitative research work, some researchers have suggested combining one or more research methods in the one study.[MYE01] For instance, Cockburn recommends to incorporate and balance multiple approaches.[COC01] He points to the possibility of improved practice but also mentions that a drawback is that such research may need long time periods.

#### 1.4.6 Reasons for the utilisation of selected research methods

The thesis combines research methods because utilisation of different methodologies' advantages is expected to gain an optimum research process (see section 1.4.5). The applied methodologies can be described as follows:

##### **Desk research and subjective argumentative research:** [WIL01]

- is a way of creative research based primarily on opinion and speculation
- useful in building a theory that can subsequently be tested
- places greater emphasis on the role / perspective of the researcher. [COC01]

##### **Qualitative interview:**

- Is a qualitative empirical cross-section-analysis[WIL01]

##### **Survey:**

- Is a quantitative empirical cross-section-analysis[WIL01]
- Is actually a data collection process, but not a complete methodology[WIL01]
- Methodological character is provided by combination with further quantitative statistical analysis procedures[WIL01]
- Results for samples allow conclusions with regard to the population to be drawn
- time-stamped samples from which inferences are made[COC01]
- Propagation: 7.3% of all scientific articles in Information Systems research journals between 2000 and 2004 were based on empirical surveys [BOL01]

Table 1-2 describes how interviews and the empirical survey were carried out in the research process:

	<b>Empirical Survey</b>	<b>Validation of Research Results</b>
	<b>Questionnaire Approach</b>	<b>Interview Approach</b>
Data Collection Technique	Oral Survey / Written Survey	Oral Survey
Degree of Standardisation	Totally Standardised	Partially Standardised / Focused
Mode of Contact	Telephonic Email	Direct
Time Range	Eight Months	Four Weeks
Number of surveyed Persons	Seventy Nine	Eight (three interviews)
Surveyed Persons	Project Managers, Consultants, Users	Consultants
Number of „Interviewers“	Four	One
Duration per Survey	Fifteen Minutes	Approx. one hour
Documentation	Questionnaire	Written notes
Mode of Analysis	Qunatitative / Statistical	Qualitative Content Analysis

**Table 1-2: Properties of Data Collection Techniques**

##### **Case study:**

- investigation of complex phenomena in their natural context [WIL01]
- descriptive reports of projects / episodes [COC01]
- special approach of qualitative-empirical methodologies [WIL01]

- not applicable to wide cross-section-analysis, but investigation of a few single attributes [WIL01]
- can be behaviouristic as well as constructivistic [WIL01]
- can be positivist or interpretive depending upon the underlying philosophical assumptions of the researcher [MYE01]
- objective is to objectively investigate hypotheses [WIL01]
- Propagation: 11.6% of all scientific articles in Information Systems research journals between 2000 and 2004 were based on case studies [BOL01]
- Applicability to Information Systems research: “clearly, the case study research method is particularly well-suited to IS research, since the object of our discipline is the study of information systems in organisations, and interest has shifted to organisational rather than technical issues”. [MYE01]
- the thesis applies case study research in a constructive way to gain insights in the applicability of WFMA implementation methodologies

According to Wilde the applied research methodologies can be categorised in a framework as illustrated in figure 1.6.

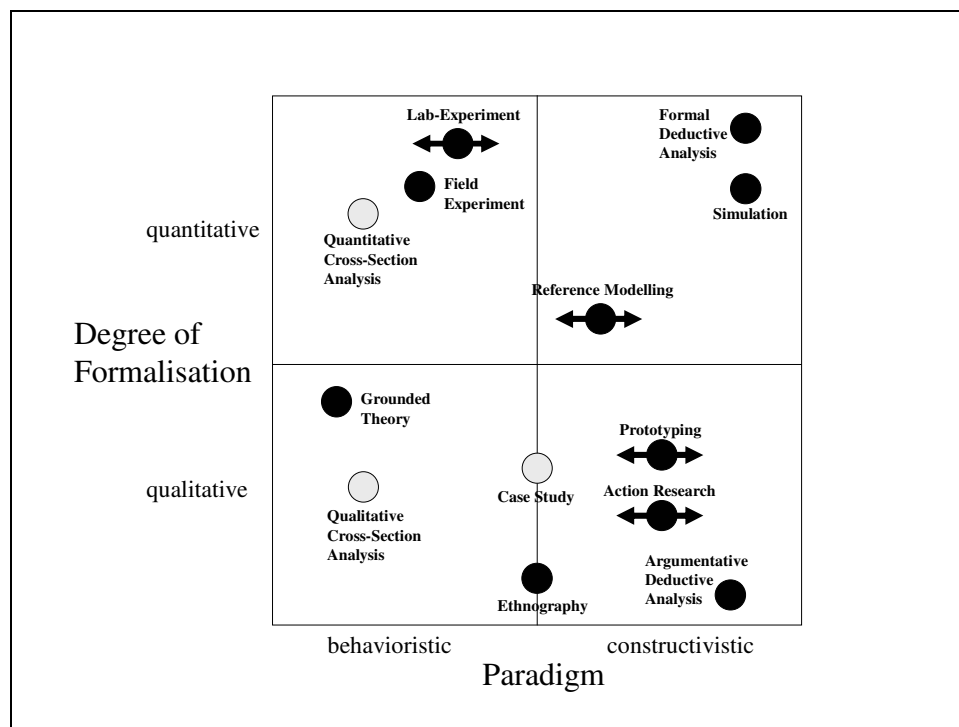


Figure 1-6: Classification of Methods – adapted from [WIL01]

### Reasons for the application of desk research and subjective argumentative research

- It was applied in the initial step of the research process for the creation of new ideas and insights. The objective was to build an initial theory that can be investigated in further research steps.
- Cockburn argues that it is an unstructured approach of subjective nature with a likelihood of biased interpretations.[COC01]. To compensate these drawbacks further research steps with qualitative interviews and a structured literature survey are carried out.



### **Reasons for the application of qualitative Interviews**

- Bolan and Mende argue that a scientific method may not be regarded as value free as the researchers' frame of reference plays an active part in the way in which scientific knowledge is obtained.[BOL01] For that reason qualitative interviews in combination with a literature survey were carried out to identify and validate research variables and hypotheses.
- Scientists also argue that pure positivist research has become traditional.[BOL01] A combination with qualitative approaches considers the fact that human subjects are not governed by laws in a physical sense, they are considered too 'free' to be used to construct general laws of behaviour.
- Straub argues that design researchers are increasingly using quantitative positivist research, to validate their models.[STR02] At the heart of the positivist mind frame is the concept of deduction (see research design, Section 1.3)
- A further reason for the execution of qualitative interviews is the verification of the research results' external validity, as described by Faber.[FAB01]

### **Reasons for the application of a quantitative survey:**

- Empirical research in the form of a survey is applied to gain a clear picture of practices, procedures, situations. A major objective of the research is to reveal best practice approaches for WFMA projects.
- As it is possible to collect data for more variables than would be possible using an experimental based method, the survey is the ideal methodology to investigate several aspects of WFMA projects. A comprehensive questionnaire design allows investigation of a greater number of research variables and a more appropriate description of real world situations.
- Statistical analysis procedures and hypotheses testing allowed a more appropriate generalisation.[COC01] The methodology provides normologically deductive explanations for an independent variable's impact on depending variables.[FAB01]
- Heinrich declares that empirical research plays a minor role in business informatics, which is improper for the discipline's universe of discourse.[HEI02] He argues that reality of business informatics is often not accessible for researchers. Researchers are not familiar with empirical research methods and the execution of surveys leads to very time-consuming research processes. Often required resources are not available. In spite of these obstacles a survey was carried out to gain experience with those research methodologies.
- Empirical surveys are criticised as they cannot ask about variables not yet recognised. Interviews and literature studies were carried out prior to the survey to identify and validate all relevant research variables.
- An often mentioned weakness of empirical surveys is the possible bias of researchers that leads to a focus on a specific aspect of the phenomenon. Interviews and a literature study were carried out to avoid the risk of a biased selection of research variables and hypotheses.
- Faber mentions that survey outcome must be rechecked against behaviour on live projects.[FAB01] For that reason derived life-cycle improvement for WFMA projects are validated in further case studies and interviews with WF-experts.
- A drawback of surveys is that it provides little insights into processes behind the phenomenon, e.g. it is not possible to obtain reasons for the gained results.

### **Reasons for the application of a Case Study:**

- As case studies allow investigation of a contemporary phenomenon within its real-life context, case studies are used to validate the applicability and effectiveness of life-cycle improvements for WFMA-projects.[BOL01;MYE01]

- Case studies are recommended for situations where the boundaries between a phenomenon and its context are not clearly evident.[BOL01]
- Multiple case research is possible, which is used to validate research results by means of case study group and a control group. It is used to investigate differences in the effectiveness of different WFMA-project approaches.
- Cockburn states that case study research is helpful to detect, develop, and refine frames of reference.[COC01] It captures the local situation in greater detail than is possible with surveys.
- It is criticised for lack of control of variables. For that reason the thesis bases the case study on a clear framework of research variables that are relevant for investigation. These are the same that were relevant for the earlier executed survey and the interviews.
- Application of a clear framework of research variables also helps to avoid further often mentioned weaknesses of case study research, namely the possibility of:
  - different interpretations by different people
  - unintentional biases and omissions in the description

## **1.5 Thesis Structure**

Chapter 1, the introductory chapter, argues the relevance of the subject. It also raises the research questions and justifies the research approach that has been applied to the thesis.

Chapter 2 surveys the academic literature to clarify basic concepts with relevance for the thesis. The first sections introduce basic terms and definitions in the field of workflow- and business-process-management. Further sections provide a more detailed view on the pivotal aspects of the thesis, namely flexibility and interoperability as elementary properties of a WFMA. Each of them is described by means of seven facets. Issues or facets that are not relevant for the thesis are marked off. In this sense chapter 2 is a specification of the research scope. The defined facets of workflow-flexibility and –interoperability have been further used within the interviews which have led to the identification of the research variables (see chapter 3).

The third chapter establishes all relevant research variables that are the basis for the research hypotheses and the empirical study. These research variables are divided into workflow project objectives and aspects of the project methodology for which an impact on the project objectives is assumed. All research variables have first been gathered within structured interviews that were carried out with workflow experts. The research scope and the thesis's view on flexibility and interoperability are explained by means of the earlier defined facets (see chapter 2). For that reason, only project objectives that refer to the facets of flexibility and interoperability were selected. Investigated aspects of the project methodology should have an impact on the earlier identified project objectives. Interview partners were asked to only mention those methodological aspects for which such an impact can be assumed. Relevant outcome of these interviews is summarised and used as a basis for a detailed literature analysis in order to validate the relevance of the surveyed variables in light of available literature sources. All research variables constitute a framework from which research hypotheses are to be derived in a further step. A basic demand for the research framework was that its variables must have implications with process-/workflow-flexibility and –interoperability.

Chapter 4 is the key element of the research project. It summarises the results of the empirical study that has been executed with European companies. The conducted study adopts the research variables of chapter 3 and derives hypotheses for which statistically significant

outcome has been measured. It surveys the experiences that have been made within workflow projects and it draws conclusions concerning the strengths and weaknesses of the applied implementation methodologies. Detailed findings concerning the methodologies' effectiveness with regard to the achievement of relevant project objectives are a major contribution to knowledge. Detailed statistical results of the empirical study can be found in Appendix A, as only extracted results are provided within the main part of the thesis.

Thereafter, chapter 5 evaluates implementation methodologies for workflow projects by means of their scope. The intention of this evaluation is to find out if process-/workflow-flexibility and -interoperability are appreciated objectives or quality aspects within the scope of available methodologies. The findings draw conclusions concerning the room for methodological improvements. This analysis is based on a literature study.

Chapter 6 refers to the outcome of the empirical study and the findings gained from the literature survey which evaluated methodologies for WFMA implementation projects. It provides approaches to an improvement of implementation processes in order to achieve better flexibility and interoperability of the implemented WFMA.

Validations of the proposed improvements have been carried out by means of structured interviews with workflow experts and a case study with students of the University of Lüneburg. These are documented in chapter 7. The proposals are not intended to be applied as a complete life-cycle model, but as improvements that may be adopted by still existing implementation approaches. Thus they do not constitute a holistic implementation methodology.

All conclusions, findings and experiences made within research process are summarised in chapter 8. This chapter also provides an outlook on further research in this field.

## 2 Basic Terms and Definitions

This chapter introduces essential terms which are applied throughout the thesis. Definitions incorporate necessary explanations of the conjunction with flexibility and interoperability as the main aspects of investigation. Each section briefly addresses the relevance of these aspects. The last two sections provide a more comprehensive view on flexibility and interoperability as major requirements for workflow management.

### 2.1 Business Process & Workflow

A few years ago researchers noted that the term business process was not uniformly defined.[VOS01] It was clear that a process may be understood in terms of the execution of several functions while considering a definite flow of work. In this sense, each structured task or function can be regarded as a process and vice versa. This dualism constitutes a recursive structure according to which a process consists of sub-processes which again establish processes on a subordinate level.[KNO01] In the meantime many definitions have been provided and a more clear perception of what a process is composed of was established. Childe, for instance, has not explicitly mentioned the cross functional execution of tasks which is an essential characteristic, but he points at coherent tasks to be performed in light of a set objective. He defines a process as “... *a set of logically related tasks performed to achieve a desired business outcome.*”[CHI01] In 1993 Davenport provided a definition to which a process is “... *a specific ordering of work activities across time and place, with a beginning, an end, and clearly identified inputs and outputs: a structure of action: a structure for action.*”[DAV01] Davenport’s definition notes the possibility that a process’s activities might be spatially distributed, which again may be regarded as a concomitant of inter-organisational process execution. However, the definition neither imposes any requirements for flexible process execution, nor does it take a company’s customers into account. The latter aspect was well put by James Martin who considers a process as a “*value stream*” which is “*a set of end-to-end activities which collectively create value for customer*”. In fact, the customer focus is a key concept in business process management. Even if some definitions are confined to internal clients and disregard external customers, it is common sense that business processes are supposed to join an organization’s activities with the requirements of its customers.[COO01] Other authors emphasize information technology and strategic aspects. For instance, Österle stresses the necessity of IT applications to execute business processes. His process-oriented systems development approach regards a process as a link between a company’s strategy and information systems development.[OES01]

#### Interoperability

Interoperability did not always appear in early definitions, e.g. Gaitandes reduced processes to a company-internal view on tasks.[KIR02] However, the foundation of business processes as a concept for an inter-organisational execution of coherent tasks was early founded by Porter who established the notion of the value-chain, which incorporated all up- and downstream stages of value creation.[KIR02] More recent approaches explicitly imply an inter-company process execution, e.g. Ferst & Sinz stress that “... *a process oriented cooperation...*” concerns “... *internal and inter-organisational units*”. Also Davenport and Short stated that business processes cross organizational boundaries.[BEC02]

#### Flexibility

Flexibility is often mentioned as a crucial requirement of business processes in order to respond to a changing environment more rapidly. Practitioners even appreciate process-innovations as important as product-innovations.[CIS01] Nevertheless, flexibility does not

occur as a constituting element within definitions for business processes. It is rather understood as a wanted characteristic of a process-oriented organisation. Thereby, it is assumed that the alignment of activity-flows and organizational structures according to business-processes allows more dynamic changes.

The thesis regards a business process by means of the following aspects<sup>10</sup>:

- **Activities:** Logically coherent set of activities
- **Activity Flow/Succession:** Coherence of activities is definable and controllable
- **Intra-&Inter-organisational Scope:** Independence of functional or object-related organizational units or organizational boundaries
- **Performance:** Value performance between organizational units (implies internal and external clients)
- **Measurability:** Value performance is measurable
- **Resources:** Performers are incorporated (persons and/or information technology)

Business processes have been categorised in many ways.[DAV01, BEC02, OES01] Earl perceives four types of processes, that vary from each other with regard to their structuredness and the value chain target.[EAR01] These are illustrated in figure 2-1.

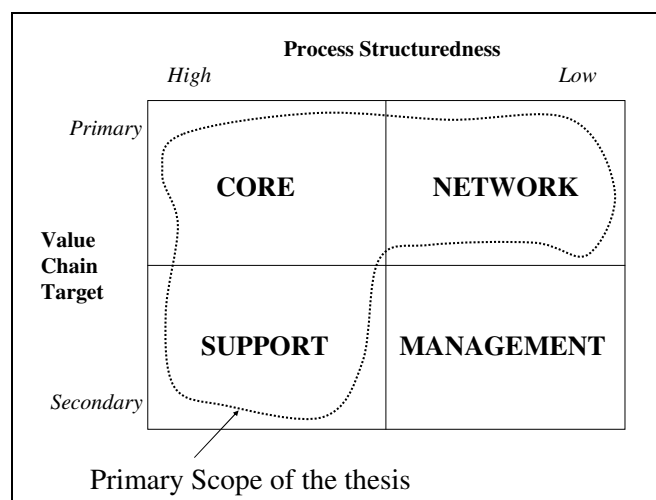


Figure 2-1: Typology of Business Processes – adapted from [EAR01]

According to Earl, core processes are essential to business functioning. They are directly related to external customers and are of strategic importance since they represent the primary activities of the value chain. By contrast, support processes serve internal customers, hence they do not directly contribute to the value chain target (e.g. administrative tasks). Business network processes go beyond the company's boundaries; they integrate suppliers and other partners. Management processes concern the planning, organising and controlling of an organisation's resources. The thesis assumes that highly structured office processes are typical candidates for workflow management. **Therefore, mainly core- and support-processes are within the scope. But also business network processes are within the research focus due to the imposed requirements on an inter-organisational process control.**

<sup>10</sup> In the following the terms „Business Process“ and „Process“ are used synonymously.

The terms “workflow” and “process” is sometimes used synonymously.[DIC01] Becker states that a workflow denotes a rather controlled and formalised process.[BEC02] Some authors simply describe a workflow as an automated business process, hence a process’s technical equivalence.[SHA01, STO01] In fact, the purpose for the specification of workflows is the automation or computer-supported execution of business processes.[BEC02] Yet, business processes do not necessarily rely on computer support, but might have a fully or partially technical representation.[LEY01] The Workflow Management Coalition (WFMC) defines a workflow as “... *the automation of a business process in whole or part, during which documents, information or tasks are passed from one participant to another according to a set or procedural rules.*”[STO01] The thesis adopts this definition and considers a workflow also under the aspect of computer-support.

A workflow combines a process’s tasks to a flow of activities. It defines responsibilities of actors for the execution of tasks and assigns available resources, e.g. IT-tools and information for the activities’ execution.[CIS01] Workflows have at least three independent dimensions<sup>11</sup>:

- **Activities** that are combined to an **Activity Flow/Process Logic** (Main- & Sub-workflows)
- **Actors / Roles of Human Resources** that are combined to an **Organisation**
- **IT-Tools / Technical & Informational Resources** that are combined to the **Technical Infrastructure**

These dimensions are independently defined and linked by a workflow specification.[HEI01] A workflow model is considered as a template for the creation of workflows on an instance level.[HEI04] In the same way process-types are abstractions of process instances. As figure 2-2 illustrates, workflows and processes are single representations of workflow-types and process-types at run-time.

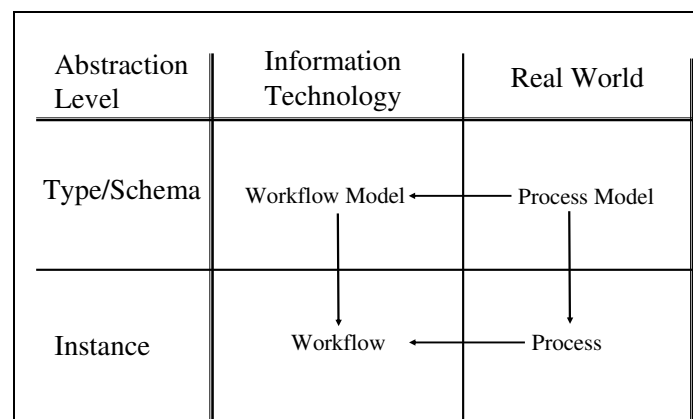


Figure 2-2: Difference between Workflows and Processes – adapted from [HEI04]

Workflows can be categorised according to their repetition rate and their business value. A common categorisation distinguishes four classes [NUR01, LEY01, GON01]:

- **Production workflows:** highly repetitive and high business value. A high system support is assumed as well as a firm predictability.
- **Administrative workflows:** highly repetitive and predictable, but minor business value.

<sup>11</sup> Some Authors identify more than three dimensions, e.g. Stohr defines five perspectives on workflows [STO01]

- **Ad hoc workflows:** low repetition rate, no predefined pattern for process control and a low business value.
- **Collaborative workflows:** high business value and a low repetition rate. These are only executed a few times, but are important for a company's success. An example is project work, where the process is specified within a project plan which might be regular subject to changes.

Nurcam states that workflow technology and approaches to define workflow models on a schema level are usually applicable to **production- and administrative workflows**. [NUR01] For that reason **the thesis focuses on these categories**, which also corresponds to the earlier definition of the business process scope.

### **Interoperability**

The investigated definitions of the workflow term do not restrict the automated process execution to a single organisation. Literature research reveals that definitions forego separate indications of the fact that workflows might cross organisational boundaries, but implicitly assume inter-organisational workflow control. [AAL02, MEN01]

### **Flexibility**

Workflow definitions do not indicate the need for change. Nevertheless, the above categories imply that certain workflows are more firm than others. Changes can generally be assumed for each of the earlier mentioned workflow dimensions, but adaptations of the process logic is most important, as it concerns the dynamic process execution. [AAL01] Publications do also stress that workflow changes may not only happen to workflow instances but also to workflow types. [RIN01]

## **2.2 Business Process Management & Workflow Management**

Many disciplines have contributed towards the concepts of Business Process Management (BPM). Organisational research, management science and computer science as well as fields of knowledge concerned with humans and industrial psychology are of potential interest. [KNO01] BPM can be regarded as an enhancement of process orientation, which treated the business process as the key concept for organisational improvement.<sup>12</sup> [BRA01] Process orientation was characterised by many facets, e.g. it claimed for a switch from functional departments to process teams. [GRI02] Many researchers have introduced their ideas of how organisations need to change in light of processes in the 1990's. [HAM01, HAM02, SIM02] They all have the idea in common that information technology is a facilitator for a process oriented change, or even a Business Process Re-Engineering (BPR). BPM initiatives also assume that process organisations are more convenient for change and that continuous organisational improvements are rather feasible. Especially the fact that BPM emphasises on continuous process improvement (CPI) seems to be a difference to BPR, i.e. an "organic growth" rather than a holistic organisational redesign. Nevertheless, a uniform definition of BPM does not exist. Even the Business Process Management Initiative (BPML.org) left open what exactly BPM encompasses. To sum up, it can be said that BPM

*"includes methods, techniques, and tools to support the design, enactment, management, and analysis of operational business processes".*<sup>13</sup> [AAL04]

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<sup>12</sup> Wetzstein et.al denote BPM as the „third wave“ of process orientation.

<sup>13</sup> In the following the Terms „Business Process Management“ (BPM) and „Business Process Orientation“ are used synonymously.

The BPM-inherent notion of a CPI implies a closed loop life-cycle, as illustrated in figure 2-3.[BRA01] Process-design is the first phase of the life-cycle. It incorporates process modelling activities and ends up with “As-is” and “To-be” process models. These are adopted by the system-implementation- or -configuration-phase, which yields an executable business process based on a rather technical process- or workflow-specification. Process-enactment is the phase of operational use based on a process- or workflow-engine.<sup>14</sup> The analysis- or diagnosis-phase is supposed to permit the (workflow)-system’s adaptation to new requirements or innovations. It links the process-enactment-phase to a new design-phase in which process modifications lead to redesigned process models. Especially an appropriate Business-Process-Analysis (BPA) based on a workflow- or process-monitoring is crucial in this phase to achieve flexibility.<sup>15</sup>

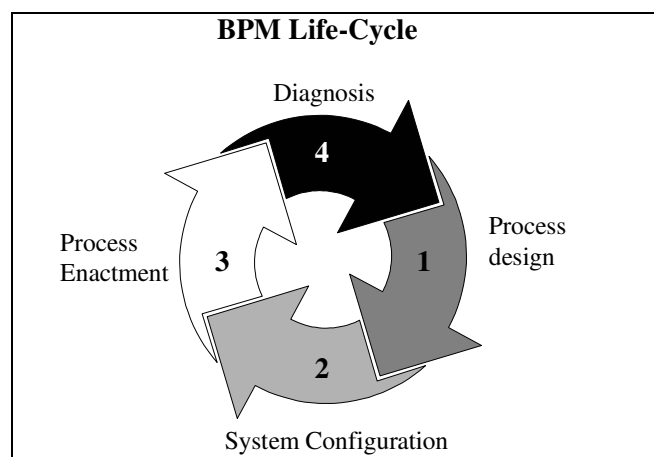


Figure 2-3: BPM Life-Cycle – adapted from [AAL04]

The terms BPM and Workflow-Management (WFM) may be discussed by means of the BPM life-cycle. According to van der Aalst WFM is concerned with the phases 1 to 3. In his view, the objective of WFM is to get an automatically executable workflow. He argues that BPM goes beyond WFM, as it also covers diagnosis, flexibility, human-centric processes, goal-driven process design, etc., which are mainly concerned in the diagnosis phase.[AAL04] Other definitions do also not include the diagnosis aspect and focus on process execution.[TUV01] Nevertheless, most definitions transcend such a limited view.[CIS01] WFM is usually said to

*“... support an integrated definition, validation, analysis, enactment, and monitoring of processes in a heterogeneous environment.”*[HAR01]

Jablonski characterises WFM by means of three major attributes:[JAB01]

- **Process-oriented**, see earlier descriptions.
- **Holistic scope**, all relevant aspects of an application domain are to be analysed and captured within workflow models.
- **Explicit Modelling**, each of the relevant aspects needs to be explicitly modelled.

<sup>14</sup> Van der Aalst terms these systems as „process-aware enterprise information systems“.

<sup>15</sup> Process-Mining & Business Activity Monitoring are emerging Research areas that are related to this issue.



The thesis adopts Härders definition and regards WFM as a fully integrated management approach that also incorporates analysis and monitoring activities. Thereby, the thesis's scope comprises the entire BPM life-cycle as a field for research.

### **Interoperability**

As already discussed in the last section, the control of workflows is not restricted to an organisation's boundaries. Härders definition of WFM points to the "*heterogeneous environment*" which implies that workflows might be executed between organisations. Van der Aalst's definition of BPM includes the involvement of organisations in an operational process, which is a clear indication that interoperability is within the scope of BPM.[MAR01] The thesis also interprets WFM as an approach for inter-organisational process execution.

### **Flexibility**

Both definitions, BPM and WFM, do not explicitly claim for flexibility. Nevertheless, the thesis assumes WFM as an approach of permanent process improvement, which has to cope with process adaptations in light of changing requirements. The indication of an integrated "*process monitoring*" within given definitions suggests flexibility.

## **2.3 Business-Process-Management-Systems & Workflow-Management-Systems**

BPMS-Systems (BPMS) are described as successors of WFM-Systems (WFMS).[MAR01] A survey in the area of BPMS revealed, that WFMS vendors tend to rename their systems as BPMS. According to van der Aalst's definition of BPM a BPMS should

*"...support business processes..." by "...designing, enacting, controlling, and analysing operational processes involving humans, organisations, applications, documents and other sources of information."*

It is assumed that BPMS support the entire BPM life-cycle, thus they offer a more comprehensive set of functionalities than WFMS do. Particularly sophisticated tools for process analysis and process mining are said to be an add-on compared to WFMS. The main purpose of WFMSs is to automate a process's flow of work based on a workflow specification.[UER01] They coordinate activities, resources and data according to the earlier mentioned process descriptions.[MÜH02] Pesic denotes WFMS as process-aware information systems that are utilised to structure and drive complex business processes.<sup>16</sup>[PES01] These systems support the development of Workflow-Management-Applications (WFMA) by providing a building-environment as well as a WFMA's execution and control by means of a run-time environment.[JAB01] The Workflow-Management-Coalition (WFMC) defines a WFMS as

*"a system that defines, creates and manages workflows through the use of software, running on one or more workflow engines, which is able to interpret the process definition, interact with workflow participants and, where required, invoke the use of IT tools and applications."*[TUW01]

There is not much of a difference between these two definitions apart from the process analysis aspect which is explicitly mentioned within the BPMS definition. Nevertheless, the thesis's scope is geared to the entire BPM life-cycle, thus it investigates the WFMA

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<sup>16</sup> The term "Process-Aware Information System" is noticeably used as a synonym for WFMS in recent literature

implementation process and it incorporates activities for process analysis and continuous process improvement (CPI). Although these aspects are attributed to BPMS, the investigation also covers permanent process analysis and optimisation, as the thesis assumes that process flexibility requires a CPI in the sense of a closed-loop process.

A WFMA comprises “*all WFMS specific data with regard to one or more business processes.*”[UER01] These are data for workflow-schemas, workflow-instances, descriptions of involved actors, data-types, descriptions of organisational structures as wells as references to invoked IT-tools and applications. Thus a WFMA is constituted by all WFMS-relevant data of the application domain.

A Workflow-Management-Solution (WFMSO) is composed of the WFMS, all WFMA specific data and all external resources that are required by the WFMS and the WFMA.[UER01] External resources could be WFM participants, e.g. end-users but also workflow applications.[TUW01]

### **Interoperability**

Van der Aalst’s perception of BPMS involves “*humans*” and “*organisations*” and therefore implies an inter-organisational process control.<sup>17</sup> The WFMC definition does not explicitly claim for interoperability, but indicates “*one or more workflow engines*”. Anyhow, interoperability is assumed as a basic requirement for WFMS<sup>18</sup>[CIS01] The thesis also supposes that processes of different organisations are to be controlled by a WFMS.

### **Flexibility**

Neither BPMS nor WFMS are defined within the context of a flexible process control. Nevertheless, academic literature claims that processes are supposed to become more flexible by aid of WFMS.[NUR01,GON01, HOC01] The thesis also assumes that WFMS provide mechanisms for a flexible process execution.

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<sup>17</sup> An involvement of different organisations has also been part of the BPM definition (see last section)

<sup>18</sup> According to [CIS01] WFMS of the fourth generation are characterised by interoperability.

## **2.4 A Taxonomy of Workflow-Management Flexibility**

A major presumption of the thesis is that flexibility is a key issue in WFM. Flexibility has many facets and the purpose of this section is to acquaint with the relevance of flexibility for WFM. For that purpose seven facets that constitute workflow-management flexibility are explained. The first section defines the term “flexibility” whereas the remaining sections explain further facets of flexibility and their relevance for the thesis by means of the following taxonomy:

- Facet 1: Definition of the flexibility term & purpose of flexibility
- Facet 2: Flexibility Drivers
- Facet 3: Aspects of a process / workflow that are affected by changes.
- Facet 4: Scope / Impact of change.
- Facet 5: Valid period when changes can occur.
- Facet 6: Approaches for types of changes.
- Facet 7: Approaches for the handling of partially executed processes/workflows

### **2.4.1 Facet 1: The Flexibility Term & Purpose of Flexibility**

The term flexibility has its roots in Latin language and means pliability, adaptability, convertibility, or mobility.[DUD01] Duden also describes the ability to adapt behaviour to alternating situations. Changing environmental conditions have been stressed within many literature sources, e.g. Herrmann defines flexibility as a system’s ability to behave adequate to its objectives under changing conditions.[HER01] According to the business computing encyclopaedia flexibility is defined as a system’s ability to be potentially adaptable in case of changing requirements.[ROI01] Roithmayr distinguish between business-context-related flexibility and performance-related flexibility in a technical context. A more precise definition introduces the time aspect as a constraint for flexibility. For instance, Gronau specifies that a system is flexible, if it is able to activate potential adaptations in appropriate time.[GRO03] The need for change is mostly seen as an externally imposed event. It has an objective purpose and a temporally purpose, as changes need to be achieved within a determined time span. Grief argues that the adaptation effort is a further constraint of flexibility.[GRI01] Thus a system is only flexible if an adaptation demand does not require an inadequately high adaptation effort. Adaptation efforts have also been stressed by other authors as an aspect for flexibility.[ADA01, FLE02] These four key areas help to understand the flexibility term by means of the purposes that are associated with flexibility.

Flexibility has been early defined as a software quality factor which is subsumed by the “product revision”-category.[MCC01] McCall has identified a set of software quality metrics that contribute to software flexibility. If one understands these metrics as a definition of software flexibility, a flexible software product has to possess the following characteristics: Conciseness, Consistency, Expandability, Generality, Modularity, Self-Documentation, and Simplicity. On closer inspection, one can conclude that some of these metrics would be similarly applicable as quality characteristics to flexible business processes, e.g. consistency which is defined as

*“the use of uniform design and documentation techniques throughout the software development protocol.”*[MCC01]

Figure 2-4 depicts four key areas of the flexibility term which were identified in the context of information systems are likewise applicable to business processes and WFMA. For that

reason the thesis understands process flexibility and WFMA-flexibility as the ability to adapt processes or the WFMA to changing and/or unpredictable requirements within an adequate time-frame and in consideration of an appropriate modification effort.[PER01]

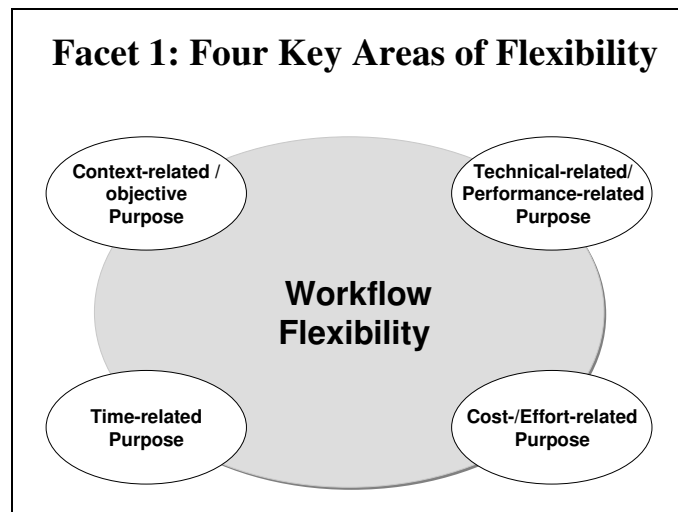


Figure 2-4: Four Key-Areas of the Flexibility-Term

Researchers have broached different issues that are related to process flexibility[BPM01], e.g.:<sup>19</sup>

- How restrictive have constraints and rules to be defined within process descriptions in order to allow process participants to take the initiative for changes.
- How can WFMA enable flexibility, e.g. by allowing users to modify the prescribed process flow.
- What constitutes a flexible organisation, i.e. how gains an organisation the ability to change its processes.<sup>20</sup>
- How can a WFMA adequately facilitate flexible organisations by providing mechanisms to easily adapt workflow models to new process conditions.

#### 2.4.2 Facet 2: Drivers for Workflow-Flexibility

Chapter 1 mentioned some economical trends that impose change on business processes. This section identifies and classifies the reasons that may cause process-/ workflow-changes in more detail.<sup>21</sup> The investigation revealed that relevant reasons for workflow-changes can be classified according to the following categories:

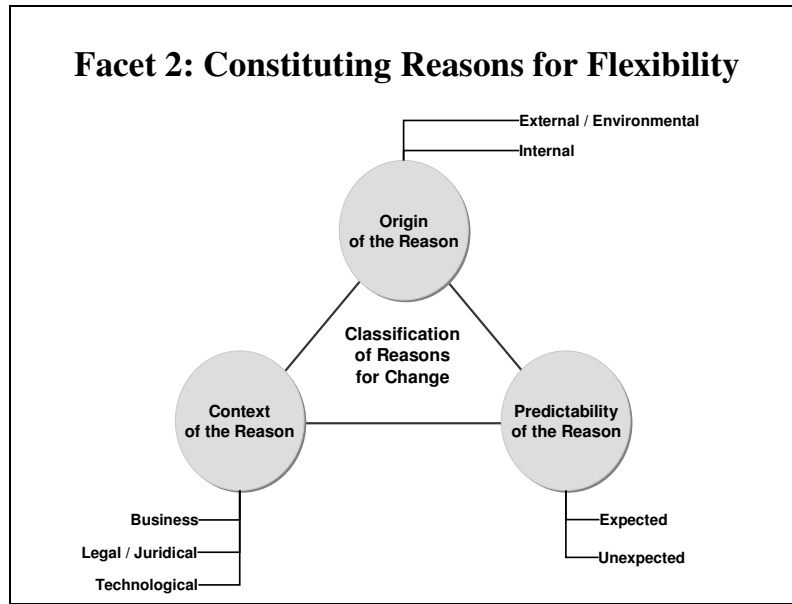
- Origin of the reason
- Predictability of the reason
- Context of the reason

These again have further sub-categories which are summarised in figure 2-5.

<sup>19</sup> These were key issues of the 6th Workshop on Business Process Modelling, Development, and Support: Business Processes and Support Systems: Design for Flexibility, February 2005

<sup>20</sup> taking the four identified aspects of flexibility into account.

<sup>21</sup> In the following the thesis only refers to „workflow-changes“ instead of „process-/workflow-changes“.



**Figure 2-5: Classification of Reasons for Process-/Workflow-Changes**

In table 2-1 reasons for workflow-changes are categorised.<sup>22</sup>

Reason for Workflow Change		Categories for Change Reasons							Thesis Scope / Relevance
No.	Description / Example	Context			Predict.		Origin		
		Business	Legal	Technolo.	Expected	Unexpect.	Internal	External	
R1	Individual or varying customer requirements[CAS01, HAN01, PER01, SAR01]	X			X			X	X
R2	Varying range of products[MAN01, AAL05, HAN01], e.g.: <ul style="list-style-type: none"><li>• Product innovations</li><li>• Elimination of products</li><li>• Product changes</li></ul>	X			X		X		X
R3	Process innovations due to BPR-initiatives[HOC01, TAG01, OUK01, KIR02, KAM02], e.g.: <ul style="list-style-type: none"><li>• Need to improve efficiency</li><li>• Need to reduce process-cycle-time</li><li>• Need to improve customer-orientation</li></ul>	X			X		X		X
R4	Increasing stress of competition[MAN01, OUK01], e.g.: <ul style="list-style-type: none"><li>• New competitors</li></ul>	X			X			X	X
R5	New legislation or jurisdiction[MAN01, CAS01], e.g.: <ul style="list-style-type: none"><li>• Amendments of tax law</li><li>• Amendments of trade law</li></ul>		X		X			X	X
R6	Semantics of the business processes[CAS02, FAU01]. These are predictable deviations from the normal workflow, e.g.: <ul style="list-style-type: none"><li>• Customer cancellations</li></ul>	X			X		X	X	X

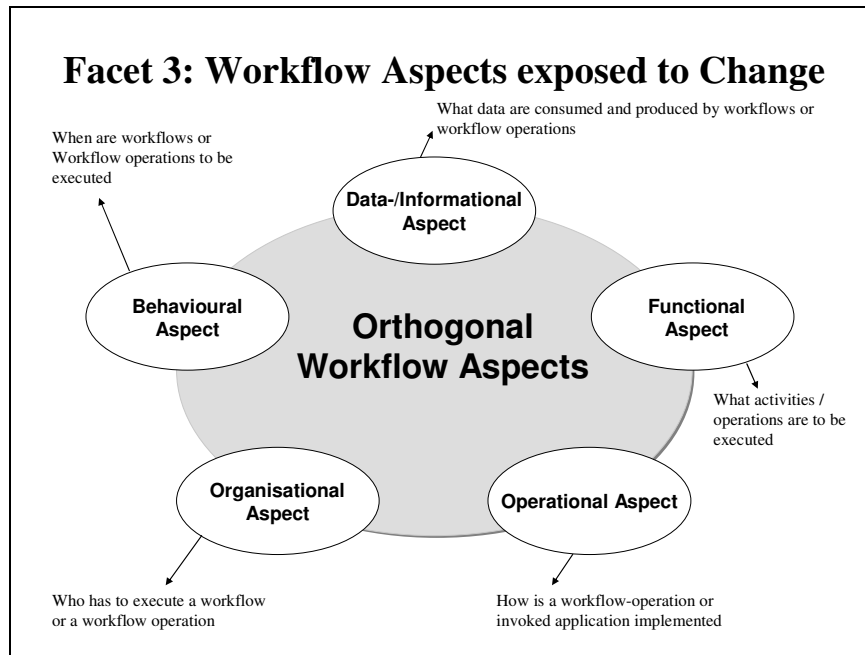
<sup>22</sup> The first column is a thesis internal reference number for each of the described reason for workflow change. The second column briefly describes the reason for change and refers to relevant literature. Columns 3 to 9 categorise the reasons for change according to the categories illustrated in figure 2-5. The last column indicates whether a reason is within the thesis's scope.

Reason for Workflow Change		Categories for Change Reasons							Thesis Scope / Relevance
No.	Description / Example	Context			Predict.		Origin		
		Business	Legal	Technolo.	Expected	Unexpected.	Internal	External	
	<ul style="list-style-type: none"><li>Expired deadlines</li><li>Unavailability of resources due to a previously occurred exceptional situation</li></ul>								
R7	Incomplete workflow specifications due to a high complexity of the application domain[HEI04, MAN01, HOC01, HAN01, KAM02, PER01, SAR01]. It is not almost possible to identify or to determine all workflow details in advance.	X				X		X	X
R8	Semantic errors within workflow specifications, i.e. logical design errors.[CAS02, CAS01, HAN01, KAM02] These are inconsistencies between business processes and their workflow specifications. They may cause that,: <ul style="list-style-type: none"><li>Necessary workflows won't be executed</li><li>Required data are not available</li><li>Deadlock situations</li></ul>	X				X	X		
R9	New technological infrastructure[CAS01, HAN01], <ul style="list-style-type: none"><li>Implementation of a SOA</li><li>New Sourcing Strategy</li></ul>			X	X			X	X
R10	Novel software products (application systems) [CAS01, HAN01], e.g.: <ul style="list-style-type: none"><li>New ERP-System is used to reduce maintenance</li></ul>			X	X			X	X
R11	System failures (DBMS-, OS-, Network-failure). [CAS02, HAN01] They may cause: <ul style="list-style-type: none"><li>Poor performance prevents workflows from execution</li><li>Invoked applications / components aborted</li></ul>			X		X	X		
R12	Application failures [CAS02, HAN01, KAM02], i.e. failures of the applications that are invoked by the WFMS), e.g.: <ul style="list-style-type: none"><li>Invoked applications provide wrong results or error codes</li><li>Invoked applications keep running without returning any value</li></ul>			X		X	X		
R13	Human Learning Curve[TAG01, OUK01]. Process knowledge improves during execution of workflows.	X				X	X		X

**Table 2-1: Reasons for Workflow Change**

### 2.4.3 Facet 3: Aspects of a Workflow that are affected by Changes

This section classifies workflow changes according to the workflow's elements that may be affected by changes. These orthogonal elements of the workflow may also be referred as workflow aspects, dimensions, views or workflow perspectives.[HAR01, CIS01, JAB01] Figure 2-6 illustrates these workflow aspects:



**Figure 2-6: Workflow Aspects that are exposed to Change**

All reasons of facet 2 may cause changes in at least one workflow perspective of facet 3. The behavioural aspect comprises the routing of a workflow. It is mostly subject to changes of the “Re-arrange”-category (T4) of facet 6, e.g. when the sequence of workflow-activities changes. Functional modifications could occur as changes of the categories “Extend” (T1), “Eliminate” (T2), and “Substitute” (T3) (facet 6), e.g. if new tasks are implemented, existing tasks are deleted or a certain task is substituted by another task. The operational and informational aspects may be affected in a similar way. Organisational changes might occur in the form of all categories of facet 6. In table 2-2 workflow-changes are classified by means of a workflow's aspects.<sup>23</sup>

<sup>23</sup> The first column is a thesis internal reference number for each of the described workflow change  
The second column briefly describes the workflow change and refers to relevant literature.

Columns 3 to 7 categorise the changed workflow perspective according to the categories illustrated in figure 2-6. The last column indicates whether a reason is within the thesis's scope.

Changes in Workflow Perspectives		Changeable Workflow Aspects					Thesis Scope / Relevance
No.	Description / Example	Behavioural	Functional	Operational	Information.	Organisatio.	
A1	Adding new workflow activities[GON01, FAU01, ADA01, HOC01]	X	X				X
A2	Elimination of workflow activities[ADA01, GON01]		X				X
A3	Modifications of the workflow's routing, [HOC01, FAU01, ADA01, GON01, GRI01] e.g.: <ul style="list-style-type: none"> <li>• Reordering workflow steps</li> <li>• Parallelise sequential workflow steps</li> <li>• Successive execution of parallel workflow steps</li> <li>• Interruption of a prescribed workflow sequence</li> <li>• Repeated execution of workflow steps</li> <li>• Skip single process steps</li> <li>• Reassignment of workflow steps to other users</li> </ul>	X					X
A4	Automate manual workflow activities[ADA01]		X	X			X
A5	Manual execution of formerly automated operations [GRI01]						X
A6	Adding new functionalities in invoked applications [GON01]			X			X
A7	Modification of functionalities in invoked applications [GON01]			X			X
A8	Deletion of invoked functionality [GON01]			X			X
A9	Adding new data structures [AAL05, SAR01], e.g.: <ul style="list-style-type: none"> <li>• New dunning letter in case of outstanding payment</li> </ul>				X		X
A10	Modification of data structures [SAR01, AAL05], e.g.: <ul style="list-style-type: none"> <li>• Adding a VIP-flag to business partner data</li> </ul>				X		X
A11	Deletion of data structures [SAR01, AAL05], e.g.: <ul style="list-style-type: none"> <li>• Deletion of an insurance claims notification form</li> </ul>				X		X
A12	Adding new roles according to a modified org.structure[HOC01, SAR01]					X	X
A13	Deleting roles according to a modified org.structure[HOC01, SAR01]					X	X
A14	Assign new employees to roles[HOC01]					X	X
A15	Deleting resigning employees from roles[HOC01]					X	X
A16	Changes in the allocation of employees to roles[SAR01, HOC01, GRO03]					X	X
A17	Changing competencies / Assignment of responsibilities of tasks to roles[HOC01, GRO03]	X				X	X
A18	Changing assignment of employees to organisational units[HOC01, GRO03]					X	X

**Table 2-2: Changes in Workflow Perspectives**



#### 2.4.4 Facet 4: Scope / Impact of Workflow Changes

This facet picks up the issue of how effective changes are to the WFMA. Generally two categories can be distinguished, as listed in table 2-3:<sup>24</sup>

Scope / Impact of Workflow Changes		Thesis Scope / Relevance
No.	Description	
S1	Changes of the Workflow-Schema / -model [TAG01, GON01, CAS02, MOU01]	X
S2	Changes of Workflow-Instances [HOR01, CAS02, TAG01, MOU01]	X

**Table 2-3: Scope / Impact of Workflow Changes**

A combination of both categories is possible, if it is necessary to modify workflow-models as well as all existing instances that were specified according to the modified schema. Changes of workflow-schemas (S1) are often initiated by management decisions and are mainly caused by Reason R1, R2, R3, R4, and R5 of facet 2. But also erroneous or imperfect workflow specifications require amendments to workflow schemas in compliance with Reasons R8 and R13 (facet 2). These can occur at build-time (category P1 of facet 5) as well as run time (category P2 of facet 5). Heintz emphasises that schema-modifications require versioning, as a modified version of a workflow-schema replaces the current version.[HEI04] Since only one version can be valid, instances need to be derived from the valid workflow schema which is the modified one.

An exclusive modification of instances for single cases or a selected group of cases is mainly caused by exceptional situations. These are either predictable (category R6 of facet 2) or unexpected (category R7 of facet 2). System- or application failures (categories R11 and R12 of facet 2) might also lead to instance modifications. Changes of this category refer to the run-time category (P2) of facet 5. Casati points to the fact that sole modifications of instances do not prevent from further occurrences of the same exception.[CAS02] Hence the approach is only applicable, if no exceptions of similar type are expected. As mentioned above, a combination of schema- and instance-modification is most appealing and to be applied, if further occurrences of an exception are likely.

#### 2.4.5 Facet 5: Valid Periods when Workflow Changes can occur

Two different periods can be distinguished when workflow changes may occur. These are listed in table 2-4. Modifications at build-time add up to the case of implementing changes before instances are executed. By contrast, run-time changes occur during workflow execution.[NUR01]

Valid Periods for Workflow Changes		Thesis Scope / Relevance
No.	Description	
P1	Workflow Changes are only permitted at Build-Time [HEI04, NUR01, MOU01]	X
P2	Workflow Changes are also permitted at Run-Time[HOR01, NUR01, HEI04, MOU01, ADA02]	X

**Table 2-4: Valid Periods for Workflow Changes**

<sup>24</sup> The first column is a thesis internal reference number to distinguish between different impacts of WF-change. The second column briefly describes the different scopes of WF-change and refers to relevant literature sources.

The last column indicates whether a reason is within the thesis's scope.

Run-time modifications may affect workflow-schemas (category S1 of facet 4) as well as instances (category S2 of facet 4) (See arrows 3 and 4 in figure 2-7). Nurcan denotes those changes as “a posteriori”; he points out that affected processes are not really flexible but rather adaptive.[NUR01] By contrast Heintz introduces the “late-modelling” approach, which also allows schema modifications during run-time, but which relies on (“black-box”) modelling-constructs that need to be specified during workflow execution but which have been anticipated before.[HEI04] Mangan and Shazia refer also to “late-modelling” based on an partially defined model which is fully specified at run-time but which is unique to a single instance.[MAN01]

Modifications at build-time are applied to processes that imply a high degree of control and predictability.[CAS02] This category implies flexible workflow specifications and is also described as “a priori” flexibility (See arrow 1 in figure 2-7).[NUR01] Advanced modelling is an approach of the so called “flexibility by selection”-category that also represents a “build-time”-related methodology.[HEI04] Different execution paths need to be anticipated and specified within the workflow schema.

Van der Aalst refers to the possibility that build-time modifications are possible for workflow-schemas as well as instances (See arrow 2 in figure 2-7).[AAL05] The latter are possibly unapparent at first glance, but cover the case that a customizable workflow model can be customized for single instances before workflow execution. All relevant combinations are illustrated in figure 2-7.

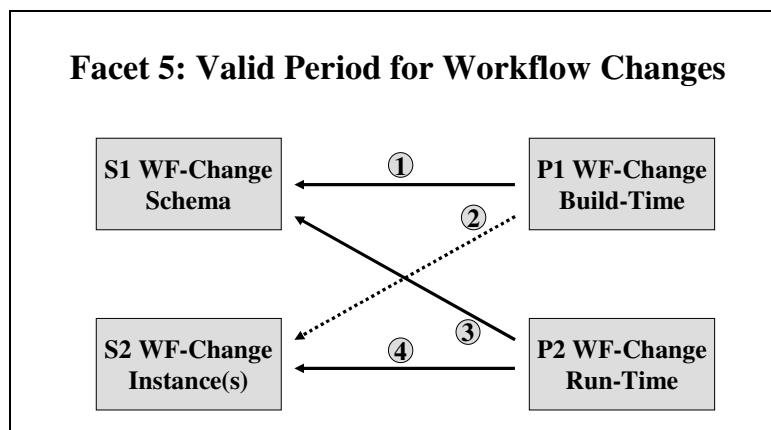


Figure 2-7: Valid Period for Workflow Changes

Most challenging are run-time changes on the schema-level when also workflow instances need to be adapted to the modified workflow schema, as it needs to be decided to which instances the modified schema will be applied (See facet 7; section 2.4.7).

#### 2.4.6 Facet 6: Types of Workflow Changes

Four basic types of change can be identified. These are applicable to the workflow aspects which were explained as aspect three. In table 2-5 a few examples are categorised.

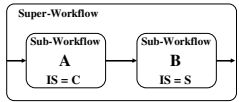
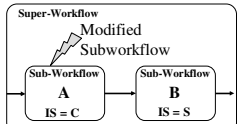
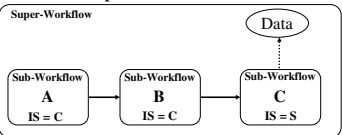
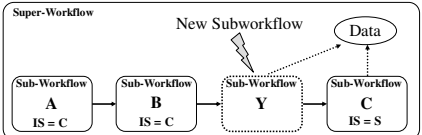
Workflow Changes		Types of Changes				Thesis Scope / Relevance
No.	Description / Examples	Extension	Elimination	Substitution	Re-Arrangement	
T1	New employees are complemented to the organisational perspective	X				X
T2	New roles are defined according to new workplaces[AAL05]	X				X
T3	New workflow activities are specified [SAR01]	X				X
T4	Tasks are removed [MIN01]		X			X
T5	A single task is skipped during execution [AAL05]		X			X
T6	A workplace is removed from the organisational structure		X			X
T7	An invoked functionality or application is removed [MIN01]		X			X
T8	Tasks of the process flow are re-ordered [MIN01]				X	X
T9	An employee is replaced by another employee			X		X
T10	An invoked operation is substituted by another functionality of a new application			X		X
T12	A manual activity is replaced by an automated activity [SAR01]			X		X

**Table 2-5: Types of Workflow-Changes<sup>25</sup>**

<sup>25</sup> The first column is a thesis internal reference number for each of the described workflow change. The second column briefly describes the workflow change and refers to relevant literature. Columns 3 to 6 categorise the changed workflow perspective according to the four identified basic categories. The last column indicates whether a reason is within the thesis's scope.

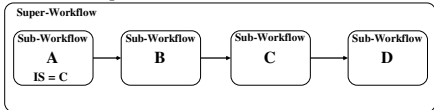
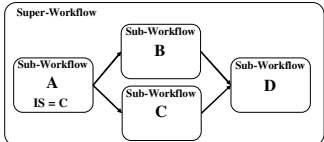
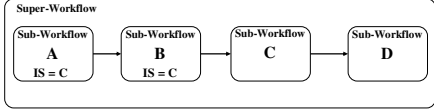
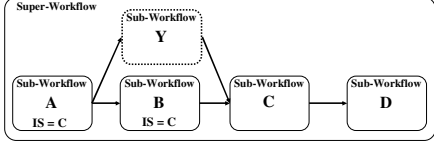
## 2.4.7 Facet 7: Strategies for the Handling of modified Workflow Instances

Approaches for the handling of partially executed workflows (instances) are a necessity in connexion with instance modifications that occur during run-time (change category S2 of facet 4 / category P2 of facet 5). Literature discusses these approaches also in the context of exception-handling mechanisms.[CAS02] They are required because schema-modifications yield new versions of workflow-schemas where it need to be decided how these modifications are supposed to impact affected instances.[HEI04] Affected instances are those who have already been created according to an older version of the modified workflow-schema, i.e. before modification. It is a major concern of this facet to provide approaches that allow affected instances to be finished in a consistent way under consideration of the modified workflow-schema.[HOR01] Many approaches have been proposed to cope with dynamic instance modification.[RIN02] A major challenge is to avoid inconsistent states of the instance, e.g. dead-lock situations, which prevent normal termination of the instance in compliance with the modified specification. Different situations depending on the actual state of the instance and the type of workflow change (facet 6) can be distinguished, as described in table 2-6:

Challenges for Exception Handling		
No.	Description	Example / Visualisation
E1	<p>A modification affects an already executed part of the instance.[HOR01] Changing the past of an instance might lead to an inconsistent state, e.g. dead-lock situations or missing data for following sub-workflows.<sup>26</sup>[RIN02]</p> <p>The instance must not migrate to the new schema unless already executed sub-workflows are repeated in compliance with the new specification. In the example sub-workflows A and B must be undone / rolled-back and restarted before sub-workflow A.</p>	<p><b>Workflow Specification before Modification</b></p>  <p><b>Workflow Specification after Modification</b></p>  <p>Instance Status (IS): C = Completed S = Started</p>
E2	<p>A modification affects the currently executed part of the workflow. The example describes an insertion of a further sub-workflow that is executed prior to the currently executed sub-workflow.[HOR01] The instance may be threatened by the same problems as in E1.</p> <p>Modified steps will not be executed unless the super-workflow is partly repeated and possibly restarted at sub-workflow B.</p>	<p><b>Workflow Specification before Modification</b></p>  <p><b>Workflow Specification after Modification</b></p>  <p>Instance Status (IS): C = Completed S = Started</p>

<sup>26</sup> Sub-Workflow and workflow-task are used synonymously in this context.

Challenges for Exception Handling		
No.	Description	Example / Visualisation
E3	A modification affects the currently executed part of the workflow but instance execution has not yet reached the modified parts.[HOR01] No conflicting situations of inconsistent states endanger the instance's continuation. Instance execution can be pursued.	<p><b>Workflow Specification before Modification</b></p> <p><b>Workflow Specification after Modification</b></p> <p>Instance Status (IS): C = Completed S = Started</p>
E4	A modification affects a part of the workflow that has to be executed in the future.[HOR01] As in E3 modifications appear in subsequent parts of the workflow, i.e. instance execution has reached the modifications. Continuation of the instance modification is possible without further interventions.	<p><b>Workflow Specification before Modification</b></p> <p><b>Workflow Specification after Modification</b></p> <p>Instance Status (IS): C = Completed S = Started</p>
E5	A modification affects a loop structure that is still in execution.[RIN01] If such changes occur, approaches should reasonably appraise a modification's impact, in order to avoid that instances are needlessly expelled from migration to the new schema. A correct setting of loop control variables is required to assure the intended behaviour.[MOU01]	<p><b>Workflow Specification before Modification</b></p> <p><b>Workflow Specification after Modification</b></p> <p>Instance Status (IS): C = Completed S = Started</p>
E6	<p>A deletion of sub-workflows may induce problems, if approaches do not differentiate between the instance states "activated" and "started".[RIN01] Problems could arise, if approaches disallow the deletion of an "activated" sub-workflow, assuming that the system is not aware of the "activated"-status. This is too limiting, as the sub-workflow has not been started. Changes could still occur.</p> <p>On the other hand, Problems could also occur, if approaches permit the deletion of a "started" sub-workflow, assuming that the system is not aware of the "activated"-status. This might imply that already executed work gets lost.</p>	<p><b>Workflow Specification after Modification: Variant 1</b></p> <p><b>Workflow Specification after Modification: Variant 2</b></p> <p>Instance Status (IS): C = Completed A = Activated S = Started</p>

Challenges for Exception Handling		
No.	Description	Example / Visualisation
E7	Changes in the ordering of a workflow's operations concern the behavioural aspect of a workflow (see facet 3; Changes A3).[RIN01] Problems could arise due to a limited ability to determine the further routing, if instance markings are not correctly adapted according to the new process logic. It could be necessary to implement further states to avoid that single sub-workflows are executed repeatedly or not at all after instance migration.[MOU01, AAL06]	<p><b>Workflow Specification before Modification</b></p>  <p><b>Workflow Specification after Modification</b></p>  <p>Instance Status (IS): C = Completed S = Started</p>
E8	An insertion of a new parallel branch represents a modification of a workflow's behaviour (see facet 3; Changes A3).[RIN01] Proceeding the instances' execution is also threatened by the so called "dynamic change bug", as deadlocks could occur. Again the implementation of additional states may help to migrate instances based on a correct workflow specification.[MOU01, AAL06]	<p><b>Workflow Specification before Modification</b></p>  <p><b>Workflow Specification after Modification</b></p>  <p>Instance Status (IS): C = Completed S = Started</p>

**Table 2-6: Challenges of Workflow-Schema Evolution**

As described in table 2-6, the problems that could arise with dynamic instance adaptation are versatile and many approaches have been proposed.[AAL06] Some exception handling strategies are categorised in table 2-7<sup>27</sup>.

Exception Handling Strategies		Challenges/ Problems Exception Handling									
No.	Description	E1	E2	E3	E4	E5	E6	E7	E8		
E1	<b>Proceed:</b> Running instances are handled the old way, whereas new cases are instantiated according to the modified schema.[CAS01, AAL05] Multiple versions of a workflow's instances exist in parallel, as it is not necessary to terminate running instances before applying the new schema to new instances.	X	X			X	X	X	X		
E2	<b>Flush:</b> Running instances are handled according to the old schema. No new instances of the workflow will be started until all instances of the old schema have been completed.[NUR01, CAS01, SHA01] Only now new instances can start according to the modified schema.	X	X			X	X	X	X		
E3	<b>Fool-the-System:</b> human intervention takes place as a workflow agent performs resolving activities outside the control sphere of the WFMA, so that the process can be completed as required.[ CAS02]	X	X			X	X	X	X		
E4	<b>Suspend / Re-initialise:</b> a responsible person can suspend an instance's execution.[MIN01, MOU01] No tasks can be executed during the suspend state. Correctness criteria are not affected. The instance can be continued later on by changing the instance status to "running".	X	X			X	X	X	X		

<sup>27</sup> The first column is a thesis internal reference number for each of the described exception handling strategy  
The second column briefly describes the exception handling strategy and refers to relevant literature.  
Columns 3 to 10 refer to the addressed challenges / problems of exception handling as described by table 2-6.

Exception Handling Strategies		Challenges/ Problems Exception Handling							
No.	Description	E1	E2	E3	E4	E5	E6	E7	E8
E5	<b>Forward Recovery:</b> Running instances are aborted and handled without utilisation of the WFMA.[AAL05]	X	X			X	X	X	X
E6	<b>Backward Recovery:</b> Running instances are aborted, rolled-back and re-started according to the new specification.[AAL05] This strategy has also been discussed as an “Abort”-approach.[CAS01, MOU01, SHA01]	X	X						
E7	<b>Migration to final schema:</b> Running instances are transferred to the new workflow schema.[AAL05, CAS01, SHA01] Such a migration is only possible, if the instance’s state is compliant to the new schema. If the instance is not compliant to the new specification a backward recovery might help.			X	X				
E8	<b>Detour:</b> This strategy is applicable to single instances or a selected group of instances, if workflow schemas do not need to change.[AAL05, GON01] It provides mechanisms that allow a temporary detour in order to solve the unexpected exception.	X	X			X	X	X	X
E9	<b>Forward- / Backward Jumps:</b> These strategies allow skipping back to previous steps or forward to another step.[MOU01] Particularly backward jumps to steps before loop iterations have been proposed if loop structures are modified. As mentioned earlier, correct settings of loop control variables are a precondition to assure the loop’s intended behaviour..					X			
E10	<b>Ad-Hoc Refinement:</b> It encompasses the execution of atomic workflow-activities, e.g. e-mail notifications, letter-preparation.[HOC01] Ad-hoc refinements are not restricted.[MOU01] Former activities can be executed repeatedly or successive activities can be executed in advance. Parallel threads can be initiated to execute other tasks.[FAU01]	X	X			X	X	X	X
E11	<b>Ad-Hoc Extensions:</b> They impact affected instances fundamentally, as new execution paths or new schemas can be applied.[MOU01, GON01] Ad-hoc workflows can be executed, if it is not necessary to roll back to a compliant state in order to migrate the instance in compliance with the new schema.[FAU01] In these cases, a sub-optimal procedure fulfils the goal of the workflow. Ad-hoc extensions rely on temporary schemas, that were created to migrate specific cases.[CAS01]	X	X			X	X	X	X

**Table 2-7: Strategies for Workflow-Schema Evolution<sup>28</sup>**

<sup>28</sup> The table’s second column refers to relevant literature source.

## 2.5 A Taxonomy of Workflow-Management Interoperability

Interoperability is the thesis's second major aspect of investigation. Several authors consider workflow-interoperability and workflow-flexibility as two interwoven requirements, assuming that an inter-organisational control of business processes imposes a higher flexibility demand and vice versa.[ADA01, HAR02, PUR01] Nevertheless, the need for inter-organisational collaboration and its IT-related implications as well as interdisciplinary aspects have been stressed by researchers since the early 1990's.[MAL01] For instance, Malone and Crowston have early foreseen the interdependencies between IT and inter-organisational collaboration as well as the impact that IT would have on markets and the way companies organise collaboration between market participants. The first section provides basic definitions for collaboration and interoperability. It also extracts the purpose of workflow-interoperability whereas the remaining sections address further interoperability issues by means of the following taxonomy:

- Facet 1: Definition of the interoperability term & purpose of interoperability
- Facet 2: Drivers for interoperability
- Facet 3: Aspects of interoperability
- Facet 4: Degrees of interoperability
- Facet 5: Models of interoperability
- Facet 6: Levels of interoperability
- Facet 7: Dimensions of interoperability

### 2.5.1 Facet 1: The Interoperability Term & Purpose of Interoperability

First, it has to be mentioned that the interoperability term is neither explained in Duden nor in the business computing encyclopedia.[DUD01, ROI01] Nevertheless, many sources have contributed to clarify what interoperability means for WFMA. Österle has highlighted a wider context, as he emphasised the organisation of IT-based relationships to internal and external business partners as one of the most important capabilities for companies in the information age.[OES01] Fleisch argues that physical disintegration and networking of business units is driven to global boundaries by means of IT.[FLE01] It facilitates novel ways of business relationships, but also causes new technical and organisational challenges. Four basic terms contribute to a rather clear understanding of interoperability:

- **“Communication”** is the process of exchanging information between individuals and/or systems with the intention to reach an objective in an optimal way.[ROI01] It is based on a common system of symbols, signs, and behaviour.[FON01]
- **“Coordination”** is the act of organising activities between several interdependent persons and/or systems; the necessity results from division of labour and cooperation.[ROI01] It goes beyond communication by adopting the communicated information and applying it for the achievement of an objective.[FON01]
- **“Collaboration”** is the process of acting jointly with partners especially for intellectual efforts.[FON01] Interoperability may be regarded as inter-organisational collaboration where workflows take control of coordination.
- **“Networking-Ability”** is denoted as *“the ability to collaborate internally and externally, particularly the ability to rapidly and efficiently implement, settle and enhance IT-based business relationships.”*[FLE01] The potential for an inter-company networking is therefore driven by an appropriate constitution of the networking-ability. Practice shows that



companies participate in several networks, simultaneously (e.g. buying syndicates, marketing partnerships).

Interoperability has been early described as a software quality factor which is categorised under the product transition class.[MCC01] McCall has assigned several software quality metrics that constitute interoperability. Thus an interoperable software product has to possess the following properties: communication commonality, data commonality, generality, and modularity. Especially communication- and data-commonality are also applicable to process interoperability in a figurative sense, as they imply standardised information and directives for the behaviour at interfaces. The European Community goes a step further and defines that *“Interoperability means the ability of information and communication technology systems and of the business processes they support to exchange data and to enable the sharing of information and knowledge”*. [IDA01] This definition goes beyond pure interoperability of IT-systems, as it includes business processes. Fong et al. argue that it is impossible to separate technical and organisational factors in light of inter-organisational collaboration.[FON01] Both, technical and org. interfaces need to be understood to ensure interoperability of organisations. The European Public Administration discusses interoperability as a characteristic that requires specific standardisations. A respective definition describes interoperability as the *“ability of a system or process to use information and/or functionality of another system or process by adhering to common standards.”* [EPA01] For that purpose a working group has determined a specific architecture which is made up of five interlinked layers. Complementary specifications, systems, standards, guidelines, and policies apply to each of these layers. A more general definition of process interoperability is provided by Berre et al. They do not incorporate any technical solution as a pre-requisite for successful inter-organisational cooperation. According to them business process interoperability is characterised *“as the ability of business activities of one party to interact with those of another party, whether or not these business activities belong to different units of the same business or to different businesses.”* [BER01]

Regarding definitions for workflow-interoperability, one can conclude that these are rather product-oriented, e.g. Wewers points to the *“ability of two or more workflow-engines to communicate and cooperate in order to coordinate and execute workflow instances between engines.”* [WEW01] A rather general definition is provided by Zhao who states that *“Inter-organisational workflow management focuses on the aspects of workflow management across organizational boundaries.”* [ZHA01] An official WfMC publication also centres on product properties but also include objectives of interoperability: *“the enabling of different workflow products to “talk to each other” by exchanging messages that effect process interoperation and integration to drive and manage the operation of the value chain.”* [AND01] The value-chain concept in fact implies inter-organisational collaboration, assuming that value is created by several companies.

The above mentioned definition of the European Public Administration comprised the need for standardisations. In fact, several endeavours were made by academics and the industry to agree upon workflow interoperability standards, e.g:

- WfMC Interoperability Interface 4[WFM03]
- European Interoperability Framework[IDA01]
- Wf-XML by the WfMC[HAR02] (see interoperability level 4 of facet 6; section 2.5.6)
- Object Management Group Workflow Facility[WEW01]
- jFLOW OMG[ZHA01]
- Simple Workflow Access Protocol (SWAP)[MÜH04]

- WSFL: Web services flow language by IBM[ZHA01]

The Thesis assumes that process-interoperability parallels product-(WFMA)-interoperability. It investigates both occurrences, those for WFMA on a product level, but also process interoperability. An investigation of the purpose shows that several authors emphasise imposed benefits such as a higher level of quality, increased productivity, competitiveness, and even employee satisfaction. Regarding the above definitions the thesis regards interoperability according to the key areas illustrated in figure 2-8[BER01, AND01, EPA01]:

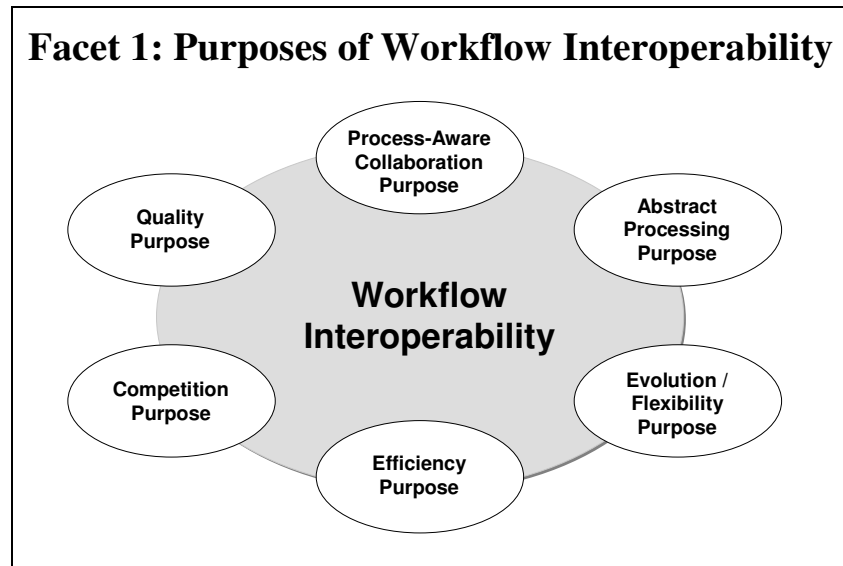


Figure 2-8: Six Key-Areas of Interoperability

These key areas or main purposes help to classify the benefits of interoperability as described in table 2-8.<sup>29</sup>

No.	Benefits of Interoperability Description / Example	Purpose / Key Areas					
		Quality	Collaboration	Abstr. Processing	Flexibility	Efficiency	Competition
B1	Cost Reduction[WFM03, PUR01, EPA01, HAR02]					X	
B2	Increased Visibility and Monitoring capabilities[MÜH04, PUR01]	X					
B3	Increased Service Level[PUR01]	X					
B4	Open Data Format[PUR01]	X					
B5	Rapid Implementation of Process Changes[HAR02, WFM03]			X	X		
B6	Vendor Independence[WFM03]				X		
B7	Scalability[WFM03]			X	X		
B8	Integration of islands of work[WFM03]	X	X				
B9	Faster and more efficient data transfer to customers[HAR02]					X	X
B10	Assured Supplier Reliability[HAR02]						X
B11	Reduced stockouts						X
B12	Less paperwork[PUR01]					X	
B13	Employee Satisfaction	X	X				

<sup>29</sup> The first column is a thesis internal reference number for each of the described benefits of WF-interoper. The second column briefly describes the benefits of WF-interoperability and refers to relevant literature. Columns 3 to 8 refer to the six key areas of WF-interoperability according to figure 2-8.

Benefits of Interoperability		Purpose / Key Areas					
No.	Description / Example	Quality	Collaboration	Abstr. Processing	Flexibility	Efficiency	Competition
B14	Speedier flow information[MÜH04, HAR02]					X	X
B15	Speedier data transfer on receipt of goods					X	
B16	Automated replenishment[HAR02]					X	

**Table 2-8: Benefits of Workflow Interoperability**

### 2.5.2 Facet 2: Drivers for Workflow-Interoperability

A few drivers for interoperability have been mentioned in chapter 1. This section regards the constituting drivers in more detail. The following two categories are used to classify the reasons for WF-interoperability as described in table 2-9:

- Economic drivers
- Technical drivers

Reason for Workflow Interoperability <sup>30</sup>		Category	
No.	Description / Example	Economic	Technical
D1	Standardised shared models of communication and computing, e.g. EDI[AND01, BER01]		X
D2	Developments in networking and telecommunication[PUR01]		X
D3	New mechanisms for an inexpensive exchange of business data over the internet using data, e.g. eXtensible Markup Language (XML)[MÜH04]		X
D4	Approaches for the integration of enterprise IT systems based on platform integration, data integration and portal solutions.[BER01]		X
D5	Distributed Agent Technology[PUR01]		X
D6	Collaborative telecommunication[AAL02]		X
D7	The need for the integration of proprietary legacy systems[TSC01]		X
D8	Virtual Enterprise Approaches[HOF02, BER01, HAR02, AND01]	X	X
D9	Disappearing corporate frontiers due to business process management[HAR02]	X	
D10	The need for integrated / streamlined processes, data exchange without media breaks[TSC01]	X	
D11	Globalisation makes enterprises increasingly dependent of their cooperation partners[BER01]	X	
D12	Electronic-Commerce / Business to Business Integration[AND01, AAL02, ESP01, WFM03]	X	X
D13	Trend for the outsourcing of components[HAR02, WFM03]	X	
D14	Supply-Chain Management[FLE01, WFM03]	X	
D15	Increasing complexity of business processes that involve multiple and distributed functional units, concurrently[PUR01]	X	
D16	The need for responding more quickly and efficiently to changing market conditions led to decentralised and geographically distributed semi-autonomous business units[PUR01, WFM03]	X	
D17	New forms of competition between networks of enterprises instead of between individual enterprises[BER01]	X	

**Table 2-9: Drives for Workflow Interoperability<sup>31</sup>**

<sup>30</sup> The provided constituting reasons for workflow interoperability are not necessarily orthogonal.

### 2.5.3 Facet 3: Aspects of Workflow Interoperability

Successful interoperability relies on approaches with a comprehensive view on inter-organisational collaboration.[MÜH02, MAL01, FLE01] Initiatives propose to distinguish four aspects that constitute a holistic view on interoperability.[EPA01, IDA01, BER01] These four aspects are illustrated in figure 2-9.<sup>32</sup>

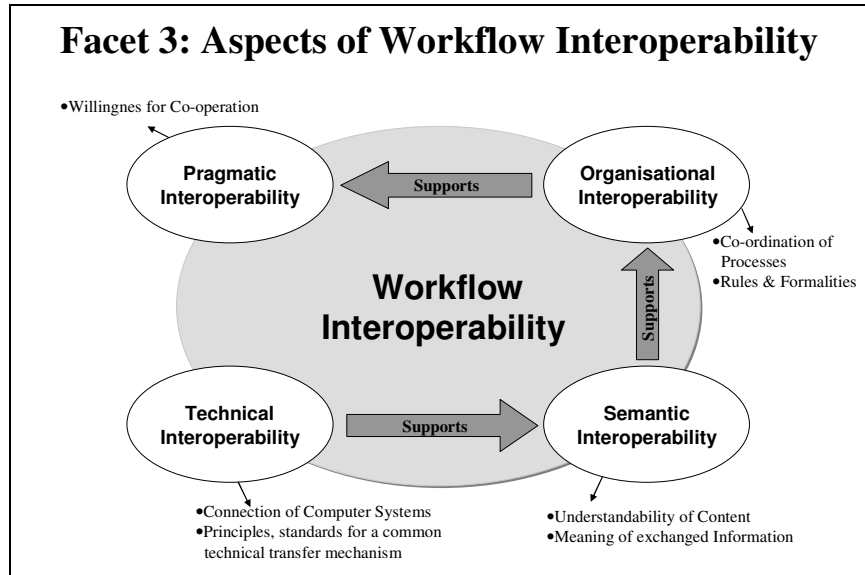


Figure 2-9: Aspects of Workflow Interoperability

**Technical interoperability** pertains to technical issues of connecting IT-systems.[BER01] It covers issues such as open interfaces, data integration, middleware technology, and security services in order to allow that messages can be transported from one application to another.[TSC01, IDA01] It is concerned with setting principles, standards, and guidelines to achieve a common technical transfer mechanism.[EPA01]

**Semantic interoperability** addresses the understandability of the data's meaning for all involved persons and applications receiving the data.[EPA01] It enables systems to combine received information with data of other sources and to process it in a reasonable manner.[IDA01] Agreements on the context and specific meaning of the exchanged data and transformations are required. It leads to standardised and registered data that are valid over time.[TSC01] Semantic interoperability is fostered by technical issues as described above.

**Organisational interoperability** concerns a fair consideration of user requirements, a clear definition of business objectives, and a way of business process modelling that implies collaboration between organisations.[IDA01] It also covers the alignment of organisational structures, rules, and formalities in a way that impeding barriers against collaboration are smoothed out.[EPA01, TSC01, HAR02] This aspect is supported by semantic interoperability.

**Pragmatic interoperability** regards the willingness of partners for necessary collaboration activities. It comprises the capability of executing the requested collaboration activities and guidelines that allow deciding if inter-organisational collaborations comply with the company's objectives. [BER01]

<sup>31</sup> The table's second column refers to relevant literature sources.

<sup>32</sup> The thesis's investigations contribute to all above described aspects of workflow interoperability.

#### 2.5.4 Facet 4: Degrees of Workflow Interoperability

Confidentiality requirements and the actual demand for inter-organisational collaboration lead to several gradations of autonomy and interoperability.[HAR02] It is for instance possible that companies are not willing to disclose internal data for collaboration partners, that are possibly required by the partners' WFMS. Three degrees of interoperability distinguish the extent of access rights to WFMS-data and the degree of autonomy.[ADA01] These three degrees of interoperability can be assigned to following categories:

- **“Send-model”-approaches** do not allow collaborating companies to view an organisation's own data.[HAR02] These approaches are based on structured messages including process data to be exchanged for process execution.
- **“Shared-model”-approaches** rely on a common data area which is part of IT-environments of two or more organisations.[HAR02] Software Engineering denotes such approaches as data-integration.[KIR02]
- **“Federated”-approaches** permit collaboration between autonomous local organisations. Each organisation executes local business processes.[BER01] Interoperability takes place by information exchange where transformation is required to keep the process semantics (See Facet 3: technical and semantic operability; section 2.5.3). Process services are merely loosely coupled.
- **“Unified”-approaches** rely on the utilisation of a shared meta-model, common concepts, and shared specification environments.[BER01] Individual process models are mapped to a shared model which is implemented over a heterogeneous platform.
- **“Integrated”-approaches** enable collaboration by applying a shared execution environment, i.e. they are based on integration on all layers.[BER01]

Table 2-10 describes the three degrees of WF-interoperability and classifies them according to the above mentioned categories.<sup>33</sup>

Degree of Interoperability		Categories					Thesis Scope / Relevance
No.	Description / Example	“Send”-Model	“Shared”-Model	“Federated”	“Unified”	“Integrated”	
C1	<b>Message Coupling</b> is a loosely coupling of processes based on agreed message types.[WEW01] Messages release process executions at collaboration partners.[ADA01] Data cannot be retrieved or viewed between organisations.	X		X			X
C2	<b>Process Coupling</b> relies on cross-organisational schemas where only control takes place in an inter-organisational manner.[ADA01] Data exchange is executed according to message coupling, i.e. common workflow schemas, but data remain local.	X			X		X
C3	<b>Fusion</b> is based on a partially merger between organisations.[ADA01] Each business partner founds sub-units that fuse to a common organisational unit which has access to all process and application data.		X			X	

**Table 2-10: Degrees of Workflow-Interoperability<sup>34</sup>**

<sup>33</sup> The thesis does not regard the fusion scenario, as it assumes that organisations remain independent.

<sup>34</sup> The table's second column refers to relevant literature sources.

### 2.5.5 Facet 5: Models of Workflow Interoperability

The WfMC has defined three models of interoperability as illustrated in table 2-11. They represent conformance levels that can be achieved by WFMS vendors in order to foster interoperability standards within workflow engines.[AND01]

Models of Interoperability			Thesis Scope / Relevance
No.	Description	Example / Visualisation	
M1	<b>Chained Process Models</b> [AND01] This model assumes that one workflow engine creates another workflow instance on a second engine. The workflow instance is enacted on the second engine according to a known schema. Both workflows operate asynchronously.[WEW01] No information is passed back after termination of the child workflow.	<b>Chained Process Model</b> 	X
M2	<b>Nested-Sub-Process Model</b> [AND01] This model assumes a synchronised workflow creation and enactment on a second workflow engine.[WEW01] The parent workflow is blocked until termination of its child workflow. Continuation of the parent workflow is released after the child workflow's notification of termination.[WFM03]	<b>Nested Sub-Process Model</b> 	X
M3	<b>Parallel-Synchronized Model</b> [WFM03] This model also assumes a synchronised workflow enactment.[AND01] As opposed to M2 the parent workflow is not blocked, but both workflows are executed simultaneously.[WFM03] Workflow schemas contain defined synchronisation steps where the parent workflow waits until execution of the child workflow. Data exchange may occur during synchronisation.	<b>Parallel-Synchronized Model</b> 	X

Table 2-11: Models of Interoperability<sup>35</sup>

Chained processes can be implemented with message- or process coupling (categories C1 and C2 of facet 4). It is assumed that nested processes and parallel-synchronised processes require a common meta-model. They rely on the process coupling degree of interoperability (category C2 of facet 4).

<sup>35</sup> The table's second column refers to relevant literature sources.

### 2.5.6 Facet 6: Levels of Workflow Interoperability

Eight levels of interoperability have been defined by the WFMC which differ with respect to *“the architectural and consequential operational characteristics of implementations of workflow engines.”*: [WFM03]

- Level 1: No interoperability
- Level 2: Coexistence (no direct interactions, but same run-time-environment)
- Level 3: Unique Gateways[ZHA01]
  - Co-operating WFMS use interface mechanisms that perform:
    - routing of operations between workflow engines and instances
    - translation and delivery of workflow relevant data
    - translation and delivery of workflow application data
- Level 4: Limited common API Subset:
  - Co-operating WFMS share a common (standard) application-programming-interface (API) that allows them direct interaction.
- Level 5: Complete workflow API
  - Co-operating WFMS share a single standard API that provides access to the WFMSs’ full operational scope.
- Level 6: Shared Definition Formats
  - Co-operating WFMS have a shared format for process definitions
- Level 7 - Protocol Compatibility
  - All API client/server communication including the transmission of definitions, workflow transactions and recovery are standardized.
- Level 8 - Common Look and Feel Utilities
  - Co-operating WFMS present a standard user interface.

The thesis considers levels 3 to 7, as it assumes that level 8 is not relevance in practice.

### 2.5.7 Facet 7: Dimensions of Workflow Interoperability

According to Zhao workflow interoperability posses four dimensions.[ZHA01] These are further classifications of WFMA interoperability characteristics that have also been mentioned within the other facets.

- Connectivity:
  - Hardwired-connection, contract-based access, negotiated access, spontaneous access
- Expressivity: Ability to communicate with other subsystems according to well-defined workflow-standards (See Facet 1, workflow standards; section 2.5.1).
- Visibility: Levels of data and process visibility for (see facet 4, degree of interoperability; section 2.5.4:
  - Announcement of workflow results of various granularity.
  - Real time access to workflow information.
  - Access to historical workflow information.
  - Process control by requesters
- Flexibility: Ability to change process schemas.<sup>36</sup>
  - Provider may change process schemas anytime without prior notice to the requester

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<sup>36</sup> This is a clarification of possibilities to achieve the flexibility purpose of interoperability (see facet 1)

- Provider may change process schemas, but must inform the requester about the new process specification immediately
- Provider cannot change the process specification without prior agreement with the requester

## 2.6 Summarising Remarks / Specification of the Research Scope

The thesis's view on WF-flexibility and WF-interoperability can be summarised as follows:

Aspect of investigation	Specification of the research scope
Business processes	<ul style="list-style-type: none"> <li>• in scope: core-, network, and support-processes</li> <li>• out of scope: management processes</li> </ul>
Workflow-categories	<ul style="list-style-type: none"> <li>• in scope: production- and administrative workflows</li> <li>• out of scope: ad hoc- and collaborative workflows</li> </ul>
Phases of a process-/workflow-life-cycle	<ul style="list-style-type: none"> <li>• in scope: diagnosis, process design, system configuration, process enactment</li> </ul>
Functional scope of WFMS/BPMS	<ul style="list-style-type: none"> <li>• in scope: functionalities that cover all phases of the considered process-/workflow-life-cycle</li> </ul>
Flexibility-Facet 1: Definition of the flexibility term & purpose of flexibility	<p>The thesis assumes the following purposes of flexibility:</p> <ul style="list-style-type: none"> <li>• context-related, technical-related, time-related, cost-/effort-related</li> </ul>
Flexibility-Facet 2: Flexibility Drivers	<p>Generally all categories of change-constituting reasons are within the thesis's scope, but not failure situations which occur unexpectedly and origin from an internal reason</p>
Flexibility-Facet 3: Aspects of a process / workflow that are affected by changes	<ul style="list-style-type: none"> <li>• in Scope: behavioural, functional, operational, informational, organisational aspects</li> </ul>
Flexibility-Facet 4: Scope / Impact of change	<ul style="list-style-type: none"> <li>• in scope: changes on workflow instances and on workflow schemas</li> </ul>
Flexibility-Facet 5: Valid period when changes can occur	<ul style="list-style-type: none"> <li>• in scope: build-time- and run-time-changes</li> </ul>
Flexibility-Facet 6: Approaches for types of changes	<ul style="list-style-type: none"> <li>• in scope: Extensions, Eliminations, Substitutions, Re-arrangements</li> </ul>
Flexibility-Facet 7: Approaches for the handling of partially executed processes/workflows	<p>The thesis assumes all exception-handling-strategies</p>
Interoperability-Facet 1: Definition of the interoperability term & purpose of interoperability	<p>The thesis assumes the following purposes of interoperability:</p> <ul style="list-style-type: none"> <li>• quality, collaboration, abstract processing, flexibility, efficiency, competition</li> </ul>
Interoperability-Facet 2: Drivers for interoperability	<p>The thesis assumes technical and economical drivers of interoperability</p>
Interoperability-Facet 3: Aspects of interoperability	<ul style="list-style-type: none"> <li>• in scope: technical, semantic, organisational, and pragmatic interoperability</li> </ul>
Interoperability-Facet 4: Degrees of interoperability	<ul style="list-style-type: none"> <li>• in scope: message coupling, process-coupling</li> <li>• out of scope: fusion is out of scope</li> </ul>
Interoperability-Facet 5: Models of interoperability	<ul style="list-style-type: none"> <li>• in scope: chained process models, nested-sub-process model, parallel-synchronised-model</li> </ul>
Interoperability-Facet 6: Levels of interoperability	<ul style="list-style-type: none"> <li>• in scope: Unique Gateways, common API Subset, Complete workflow API, Shared Definition Formats, Protocol Compatibility</li> </ul>
Interoperability-Facet 7: Dimensions of interoperability	<ul style="list-style-type: none"> <li>• in scope: visibility and flexibility</li> </ul>

**Table 2-12: Specification of the Research Scope**



### 3 Derivation of Research Variables

The research approach utilizes variables in the form of project objectives, aspects of the project methodology and project conditions (see sections 1.3, 4.1.3, and Appendix C).<sup>37</sup> Aspects of the project methodology and project objectives are composed to research hypotheses. Relevant project objectives are explained in the first section. Aspects of the project methodology and derived hypotheses are explicated in the second section.

All relevant variables have been identified by means of a three-step approach that is illustrated in figures 3-1 and 3-2. An initial literature analysis yielded seven facets of WF-flexibility and WF-interoperability (See sections 2.4 and 2.5). These facets have been used to specify the relevant research view on WF-flexibility and WF-interoperability more precisely. Six structured interviews were conducted in a second step to identify relevant research variables. Three of the interview partners were WF-consultants, whereas the other three were WF-users. The research scope was explained within the course of the interviews by means of the above mentioned facets. Thereupon it was asked which project objectives, methodological aspects, and general project conditions are vitally important for an achievement of WF-flexibility and WF-interoperability.

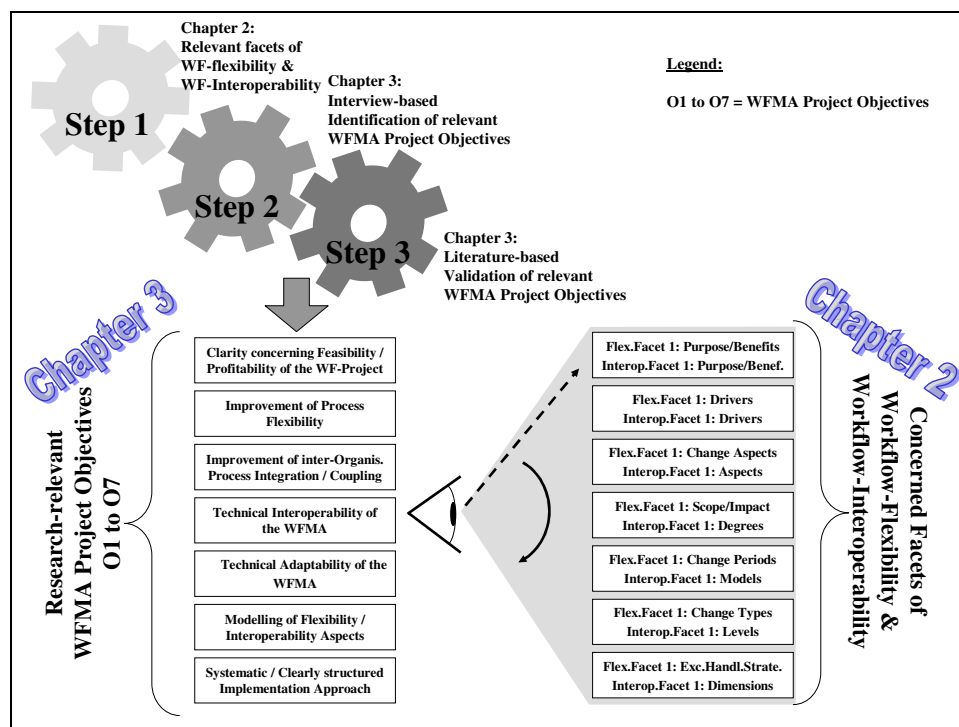


Figure 3-1: Derivation of Research Variables (Project Objectives)

This interview-based investigation retains the implicit view on the facets of WF-flexibility and WF-interoperability. Interview-partners were asked to order project objectives according to their importance. Objectives were only adopted for further analysis if they were mentioned in at least three interviews. The relevance of all identified project objectives was validated by means of a literature analysis in a third step. After identification of the project objectives, relevant aspects of the project methodology were investigated. It is assumed that a relevant methodological aspect contributes to the achievement of the previously identified project

<sup>37</sup> Note that project conditions have been identified and pre-tested within the empirical study but eventually omitted due to a required reduction of the questionnaire

objectives. These interrelationships are formulated by dint of research hypotheses. Thus a view on the facets of WF-flexibility and WF-interoperability is kept. It was essential that methodological aspects were introduced in at least three interviews.

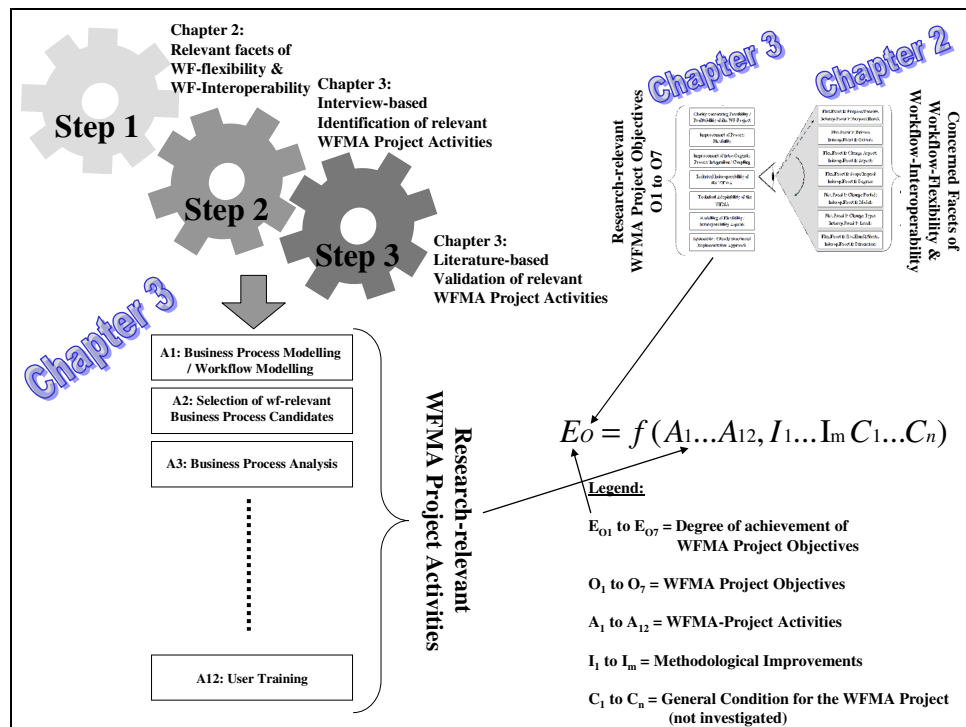


Figure 3-2: Derivation of Research Variables (Aspects of the Project Methodology)

All identified methodological aspects were further investigated based on a literature review. If possible, the applicability of research hypotheses was validated.

### **3.1 Research Variables: Project Objectives**

Corporate objectives are the foundation for entrepreneurial activities. Corporate goal systems describe hierarchical refinements and interdependencies between objectives. An implementation of a WFMA directly contributes to a company's goal attainment (See sections 1.1 and 2.3). As discussed in the thesis, the implementation process for WFMA has to pay attention to these corporate objectives (See sections 1.1 and 5.1). In other words, the WFMA implementation process must be organised in a way that enables achievement of a company's corporate objectives. The idea that an organisational design has to regard environmental conditions and a company's objectives has its origin in Chandler's findings who stated "*structure follows strategy*".[GAB01] The identified research variables define the determinants of this thesis to yield a goal-directed workflow implementation process with special regard to flexibility and interoperability requirements. For that reason, the investigated project objectives are particularly related to these requirements. General corporate objectives, such as the striving for high sales rates, which can be assigned at the top of a goal hierarchy are not within the scope of the thesis and are not described. The effect of alternative design options for WFMA implementation processes on general corporate objectives can be hardly proven. Moreover it is safe to assume that several factors beyond the thesis's scope influence the attainment of such general objectives. Thus the impact of the very specific design options for WFMA implementation processes on general objectives is expected to be of minor importance. But, on the other hand, an increasing specialisation of objectives in light of flexibility and interoperability requirements allows using the objectives as effectiveness-criteria/evaluation-criteria for different WFMA implementation processes.

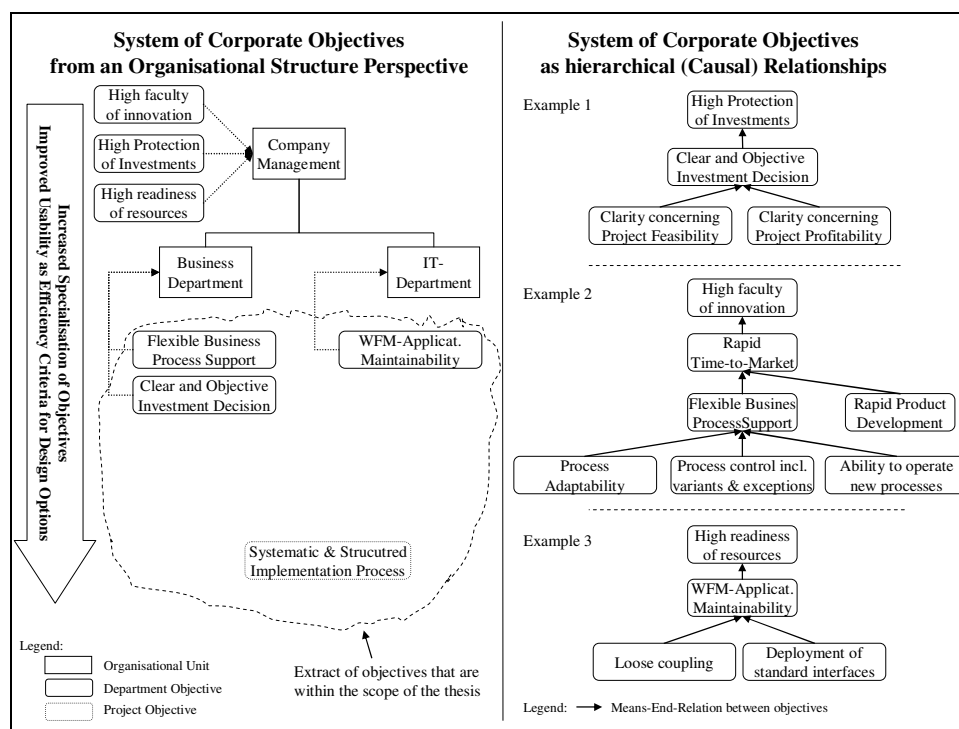
Furthermore, general project management objectives such as rapid implementation cycles or a project cost controlling are not taken up. Again the research variables only consist of objectives that are complementary to flexibility and interoperability requirements. From the perspective of classical goal research and goal hierarchies, they represent refined sub-objectives on which the properties of the implementation process and the actions of project staff have an impact. Such refined sub-objectives are to be used as evaluation criteria for the effectiveness of:

- Current WFMA implementation approaches
- Design options for WFMA implementation processes
- Improvement measures for WFMA implementation processes

All objectives are derived from two intellectual sources, namely classical business management research and the software engineering discipline. McCall provides valuable suggestions, as he introduces a software quality framework that distinguishes between three categories, namely "product use", "product adaptation", and "product transport".[MCC01] A fulfilment of quality criteria of the "product use"-category are primarily interesting for users thus business departments. "Product adaptation" and "product transport" can be rather assigned to software developers thus IT-departments. For this reason, one can distinguish between a business department's view and an IT-department's view on software quality criteria. Wöhe who comprehensively stresses corporate goal systems states that general corporate objectives need to be refined up to operational goals that can be delegated to departments or employees.[WÖH01] In fact, the thesis adopts Wöhe's proposal and McCall's general categories by distinguishing between:

- Objectives of business departments
- Objectives of the IT-department
- Project objectives

Project objectives are within the scope of all project stakeholders. They cannot be clearly assigned to either functional departments or IT-departments, as both parties have an interest in their fulfilment. Particularly WFMA projects are a managerial and a technical subject.[STO01] Besides, they primarily concern procedural objectives such as the striving for an adequate implementation methodology. Figure 3-3 sketches the structure of goal hierarchies.



**Figure 3-3: Goal Categorisation**

Finally, it has to be clarified what the interrelations between relevant objectives and the claims for flexibility and interoperability are. In fact, flexibility and interoperability can be denoted as objectives. But in contrast to very specific objectives of business-units or IT-departments, the thesis understands them also as general requirements on workflow projects which have an abstract character first. They influence several tangible project objectives by defining to which extent an objective has to be reached, i.e. actual project objectives are specifically accentuated by flexibility and interoperability requirements. For that reason flexibility and interoperability have been investigated as project objectives. But moreover, further objectives have been regarded that are influenced by flexibility and interoperability, i.e. which have a complementary relationship with them. The structured interviews have yielded seven relevant WF-project objectives that are complementary to WF-flexibility and WF-interoperability. They are explained in the following sections

### 3.1.1 Research Variable: Project Objective 1

#### Clarity concerning Feasibility / Profitability of the WF-Project

A company's aspiration for an objective investment decision is put into concrete terms by the definition of two sub-objectives:

- Transparency in the technical, organisational, and political feasibility of the WFMA implementation project
- Transparency in the profitability of the WFMA implementation project

An objective investment decision implies the careful anticipation of project risks and the clarification of the project's feasibility in terms of technical, organisational, and political dimensions as well as an analysis of the project's costs and benefits. The investor intends to minimise the risk of a project failure. An evaluation of the feasibility helps to realise where project risks may occur in order to take appropriate measures allowing coping with risks. If necessary, risky projects can be avoided. It improves the quality of the investment decision. This objective is denoted as a procedural objective, since it allows to define means for the attainment of superior project objectives.[LIT01] In fact, these objectives concern the decision process, information gathering and the process in which cost-/benefit estimations are valued, possibly based on probabilities.

However, higher corporate objectives cannot be found among conventional objectives such as a maximisation of profits, sales, or growth rates. Transparency and objective investment decisions do rather pertain to the striving for the minimisation of risks, thus a higher security. Seiwert stresses the interest in security of the investment and assigns it to the striving for the preservation of the company's efficiency.[SEI01] Similarly Heinen emphasises capital conservation as an investor's objective, i.e. object of preservation is the capital that has been invested into the company.[HEI05] Also Humble refers to security as a corporate objective in the context of preservation of resources that are required by functional departments.[HUM01] This indicates that primarily functional departments have an interest in the feasibility and profitability of a project. In fact, functional departments profit from the WFMA. The author assumes that functional departments have to bear the financial investments for the WFMA implementation. For this reason, this objective has been assigned to the objectives of the functional department.

#### **Transparency in the technical, organisational, and political feasibility**

Flexibility and interoperability are important requirements on a WFMA that are not simply realised by a WFMS-product. These requirements do rather impose high demands on the implementation project and the implementation methodology / -process. One cannot assume that flexibility and interoperability are simply reached by installing a WFMS-product that apparently fulfils these requirements, i.e. feasibility evidence is not simply gained. Due to the importance of flexibility and interoperability requirements and their relevance for the WFMS-product and the implementation process, transparency in the feasibility of the workflow implementation project is also desirable in light of these requirements. Burnett mentions three issues for which feasibility evidence is crucial[BUR01]:

- Technical feasibility
- Organisational capability
- Political issues, e.g.: identification of champions who are willing to sponsor the project with resources; identification of key users who do not want to participate. The political

dimension also implies the establishment of a necessary and common company-wide decision-making.[DRÄ01]

These three issues of a feasibility assessment are also relevant for the flexibility- and interoperability requirements. For instance, early clarity concerning the feasibility is required as follows:

- Which aspects of a workflow are affected by changes (Changes A1 to A18 of flexibility facet 3, see section 2.4.3)
- What is the impact of the workflow changes (Categories S1 and S2 of flexibility facet 4, see section 2.4.4)
- Is it possible to realise the wanted degree of interoperability (Categories C1 to C3 of interoperability facet 4, see section 2.5.4)
- What is the required level of interoperability to fulfil inter-organisational process control (Levels 3 to 7 of interoperability facet 6, see section 2.5.6)
- Is process coupling according to three models of interoperability feasible (Categories M1 to M3 of interoperability facet 5, see section 2.5.5)

### **Transparency in the profitability**

Burnett also stresses the necessity to reveal the profitability in terms of costs and benefits in order to yield an economic justification for the project.[BUR01] A workflow implementation is a cost-intensive project that is only paying off, if it leads to a high quality of business processes.[ADA01] The realisation of flexible and interoperable processes is expected to influence the profitability of the project, as it leads to efficiency gains on the one hand and to cost-effective project expenses on the other hand.[KRÜ01] Early clarity concerning the tangible benefits that are imposed by flexibility and interoperability are required[HAR02]:

- The drivers that constituted flexibility requirements provide indications for possible benefits (see categories R1 to R13 of flexibility facet 2, see section 2.4.2)
- It is necessary to reveal interoperability benefits according to the six identified categories (see benefits B1 to B16 of interoperability facet 1, see section 2.5.1)

Several authors have emphasised that early clarity for the above mentioned aspects is necessary in workflow projects.[HAR02, STO01, KUE02] WFMA projects that strive for flexibility and interoperability possess particular facets that demand specific evaluations to gain clarity with regard to feasibility and profitability (See sections 2.4 and 2.5). The interviewed workflow experts have raised the issue of an early insight in the feasibility and the cost-benefit-impact that flexibility and interoperability would have. It was mentioned that these requirements represent both an opportunity for improvements, but also an enormous project risk which is to be assessed early in the project.

### 3.1.2 Research Variable: Project Objective 2 Improvement of Process Flexibility

Process flexibility describes an organisation's ability to flexibly respond to changing environments, i.e. changing customer requirements, changing legal- or market-conditions. Generally, flexibility is an often mentioned prerequisite to cope with unpredictable market fluctuations, hence it became a desired organisational property for successful companies.[PER01] Heinen has already indicated a company's striving for adaptability as a corporate objective within the 1960's.[HEI05] A comparison of several empirical investigations that pertain to corporate objectives revealed in the 1970's that mainly American companies strove for flexibility with respect to competitors and public measures.[SEI01] The Boston Consulting Group regards the ability to take advantage of changing needs and values as a chance for adaptable companies to survive in a market environment with high competition.[OET01] Oetinger states that early reactions to changing demands is even more important than a high plant utilisation rate. Business process flexibility can be classified as a system objective.[LIT01] A comprehensive explanation of process flexibility in light of WFM can be looked up in section 2.4 (Taxonomy of Workflow-Management Flexibility). Interview partners mentioned the following objectives as constituent parts of process flexibility to be of major importance.

#### **Adaptability of business processes to changing customer requirements, legal conditions, and changing market conditions**

An organisation's ability to flexibly respond to changing environments requires the adaptability of its business processes. The workflow project aims to yield business processes and workflows that are redesigned in light of flexibility requirements, so that later adaptations are relieved.[ADA01]

#### **Workflow control of all important business processes, their variants and exceptions**

Flexibility implies the ability to deal with special cases of business processes, such as process-variants and exceptions. They need to be considered within the business process redesign and the workflow specification. In this sense, a far-reaching workflow management control of all important business processes their variants and exceptions is an objective of business units.

#### **Ability to extend the WFMA to control additional processes**

Flexible organisations must be able to quickly implement new business processes. For that purpose, the WFMA must be either extended by new processes or existing interdependent workflows must be adapted to cooperate with new processes.

#### **Improved Handling of customer inquiries**

Customer oriented processes imply an organisation's ability to respond to customer inquiries, quickly and precisely. WFMA's may help to realise this objective by their ability to permanently provide information concerning processing states of customer orders, responsibilities of staff, etc.[GIE01] The WFMA has to be able to provide such information even in the case of inter-company workflows, workflow exceptions or workflow variants.

### 3.1.3 Research Variable: Project Objective 3

#### Improvement of inter-organisational Process Integration / Coupling

Interoperability in this context does not mean technical but organisational interoperability. One could also describe this objective as value-chain integration between departments or organisations (see Section 2.5: Taxonomy of Workflow-Management Interoperability). Available IT and communication-technologies allow the interweaving of a company's locations and an integration of purchasers and suppliers in value-chains on a global level.[LIT02] The implementation of inter-organisational connections is always realised on a process level, i.e. business processes are the supporting structural elements for the value-chain integration.[FLE01] Complementary business trends can be seen in an increasing virtuality of companies and their physical disintegration, i.e. distributed organisational structures.[LIT02] Krüger/Homp regard the development from seller's markets to buyer's markets as constituting reasons for an increasing organisational interoperability, since an increasing market transparency imposes a higher competition.[KRÜ01] Competitive advantages are supposed to be reached by the concentration on core competencies, which again promotes the trend towards connected or even virtual companies (see Section 2.5.2: Drivers for Workflow-Interoperability). An evaluation of the classical business administration literature reveals that Seiwert treats cooperation objectives respectively the striving for alliances. He categorises them as the striving for power.[SEI01] Other classical sources do not point to similar objectives. Recent sources subsume sub-objectives such as an increasing cost-efficiency, reduction of cycle-times, improvements of service quality, development of potentially new markets, etc. within the striving for competitive advantages (see Section 2.5.1: The Interoperability Term & Purpose of Interoperability). Far-reaching value-chain integration by means of harmonised and integrated business processes is a system objective that may be assigned to functional departments. Interview partners emphasised the following issues as important constituent parts of process interoperability.

#### **Far-reaching integration/coupling of all important business processes that cross department borders and company boundaries**

WFMAs are a specific means for the control/coordination and organisation of cooperative production-, business-/administration processes within interwoven/connected companies. These systems are supposed to:

- Automate information flows between organisations and companies
- Automatically trigger process tasks between cooperation partners
- Permanently update an inter-organisational reporting

This objective comprises the integration of upstream and downstream business partners from a process perspective.[FLE02]

#### **Automatic and punctual provision of consistent data according to the requirements of the business processes**

An integration of distributed processes is also supported by the automatic provision of consistent data even across department-, company-, and system-boundaries. The availability and topicality of information that concern business transactions between different partners contributes to the realisation of this objective. In this context Fleisch provides some examples:[FLE02]

- Visibility of stocks inventory of regional storehouses and suppliers
- 100% visibility of orders and their working progress
- Tracking of orders up to regional production units, storehouses and suppliers



### **Coherent process tasks according to the “one-face-to-the-customer” principle**

This objective amounts to a holistic customer care service, i.e. the company aims to provide one customer counsellor that takes care of customers with respect to all customer-relevant business processes.[OET01] Process orientation implies a strong coherence of tasks that belong to a business process. Business process optimisation, which is often executed as part of a WFM project, strives for coherent process tasks.[MÜL01] Companies might even follow the objective of a reassignment of inter-company tasks as part of inter-company business process control.

#### **3.1.4 Research Variable: Project Objective 4**

##### **Technical Interoperability of the WFMA**

The necessity for a technical interoperability of software systems can be directly derived from the need for an inter-company connection of business processes. An inter-company integration of software systems requires their interoperability. This objective can be assigned to the IT-department, which is responsible for the realisation of the connection of the software applications. Most definitions of the interoperability objective that are provided by common literature pertain to the coupling of software systems.[HEI01] According to Litke, interoperability can be categorised as a system objective.[LIT01] Interview partners mentioned that it is an important objective of WFMA implementation projects that strive for an inter-organisational process control.

##### **Ability to technically control workflows between different WFMA**

The WFM workflow interoperability as “*the ability for two or more Workflow Engines to communicate and work together to co-ordinate work*”.[WFM01] In this context, it is desired that both homogeneous and heterogeneous workflow systems may be coupled. Workflow interoperability has been stressed by standardisation committees since the mid 1990’s (see Section 2.5.1; important standardisations are mentioned). This objective mainly concerns the technical and semantic aspects of interoperability (interoperability facet 3; section 1.5.3), the application of an appropriate interoperability level (facet 6, section 1.5.6), and the connectivity- / expressivity- / visibility-dimensions of interoperability (facet 7, section 1.5.7).

#### **3.1.5 Research Variable: Project Objective 5**

##### **Technical Adaptability of the WFMA**

Relevant software-engineering sources define the requirements that are to be fulfilled in the context of this objective. For instance, Stahlknecht and Brössler stress the ability to efficiently execute error corrections on a system which is in operational use.[STA01, BRÖ01] But most authors grasp the maintainability objective more comprehensively. Denert, for instance, considers both, the ability to correct errors and defects as well as the further development of the system’s functionality.[DEN01] McCall subsumes the ability to correct, change, and extend a software system within the maintainability objective.[HEI01] For the purpose of this thesis, the maintainability term is best described by McCall, i.e. it also encompasses the adaptability and extendibility of a WFMA. Further authors go even beyond these definitions by distinguishing corrective maintenance, adaptive maintenance, and perfective maintenance.[ROI01, DUM01]

An improved flexibility and interoperability of the business processes and the entire organisation can be seen as complementary corporate objectives. Ultimately, one can describe maintainability as an objective that contributes to the preservation of the company’s

effectiveness. In this context, Heinrich/Roithmayr summarise software maintenance as measures for the preservation of the system functions' readiness and the upkeeping of the resources' performance.[ROI01]

According to McCall's quality framework, the maintainability concerns the software developer, thus this objective has been assigned to the IT-department.[BAL01] Since it concerns the properties of the project results, maintainability is categorised as a system objective.[LIT01]

A WFMA's maintainability is required for many reasons. For instance, modifications caused by changing business processes or the supplementary coupling of further workflow systems. An easy maintenance contributes to both the adaptability and the interoperability objective. Technical adaptability of the WFMA has been emphasised as an important objective within the executed interviews. The following issues were raised:

A **loose coupling of the inter-operating WFMA's and the invoked applications** is seen as an objective that contributes to the system's interoperability. Similarly an **absence of superfluous interfaces** relieves the system's modification and the coupling of further WFMA's. A **deployment of standardised interfaces** allows the coupling of heterogeneous workflow engines and helps to reduce maintenance efforts.[WFM01, GÖT01] A **strong cohesion of the controlled application systems** (module strength) strives for non-redundant system functions but also aims at encompassing all system functions covering coherent and meaningfully delimited business tasks.[DEN01] Such a functional cohesion is also required, if distributed WFMA's control workflows that cross company- and system boundaries but belong to the same value chain.

In the context of flexible WFMA's, companies strive for the **ability to technically modify the WFMA (schemas and instances) as easy as possible**.[HEI01]

Maintainability focuses on entire software systems, i.e. it includes functions as well as data. For instance, system modifications might require that application data have to be migrated in accordance with modified software functions. In this sense, the **availability of consistent and non-redundant data** relieves system modifications and contributes to the flexibility objective.

### 3.1.6 Research Variable: Project Objective 6 Modelling of Flexibility / Interoperability Aspects

Models are used as a means for the analysis/explanation and design of real systems.[VOS01] This implies that models are supposed to fulfil an explanatory tasks as well as a design task. The underlying principle of modelling is simplification, i.e. a neglect of the real world's aspects that are not relevant for the purpose of the modelling person. In the figurative sense of IT-projects, such a simplification has to regard a project's purpose in order to depict those aspects that substantially contribute to the specific requirements of a system's implementation. To understand business processes and to have an effect on their implementation, it is also necessary to create adequate models.

The meaning of the word adequacy can be best described by the word appropriateness.[DUD01] The modelling approach's adequacy or appropriateness aims at the fulfilment of the project's special purpose. In other words, an adequate modelling approach contributes to a complete and correct realisation of the project requirements towards a new system. This implies that also flexibility and interoperability aspects need to be depicted within process-/workflow modelling approaches that strive for adequacy. Apart from correctness and completeness objectives, Steinbuch points to the efficiency of the modelling approach and the ability to derive improvement possibilities from obvious shortcomings and

weaknesses depicted within process models.[STE01] A comprehensive explanation of quality criteria for process models is provided by Kuehl.[KUE01]

Some sub-objectives of this category can be classified as procedural objectives, since they concern the execution of modelling task. Others represent system objectives, as they prescribe the properties of process models.[LIT01]

### **Semantically complete, clear, and readable business process-/workflow models**

The claim for semantically complete, clear, and readable models focuses on the properties of process models and can therefore be classified as a system objective. The first sub-objective, namely the semantic completeness of models amounts to the aspects that a process-/workflow modelling approach can depict.[HEI01] In the sense of this thesis, a semantically complete modelling approach has to be able to depict aspects imposed by the requirements on flexible and interoperable business processes. Hence an appropriate semantic expressiveness of the business process- and workflow modelling approaches means that respective modelling objects are available. Clarity and readability are supposed to enable the reader of a model to rapidly understand the depicted content. For instance, users and developers strive for clear and readable models, as they regularly have to fall back on business process- and workflow-models in order to adapt them to changing business processes.

### **Dynamically adaptable business process- and workflow-models**

Modifications of workflows may occur more or less regularly. Hence, users and developers need to be put in the position to understand and change such process- and workflow-specifications. For that purpose, models are supposed to ease their later modifications. In other words the modelling methodology should yield dynamically adaptable business process- and workflow-models. This claim has to be first considered during the initial creation of process-/workflow-models. As this objective describes properties of models which belong to the project results, this objective can be classified as a system objective.

### **Efficiency and relevance of business process- and workflow modelling**

From a project management's point of view, efficiency of the modelling efforts and the concentration on merely relevant business processes is important.[KUE01] Irrelevant processes or processes for which flexibility or interoperability requirements cannot be fulfilled by the WFMA, need to be marked off. Efficiency and relevance are characterised as procedural objectives.[LIT01]

#### **3.1.7 Research Variable: Project Objective 7**

##### **Systematic / Clearly structured Implementation Approach**

The claim for a systematic and structured implementation process is a procedural objective that can be derived from software engineering principles.[BAL01] According to Lehner, a systematic project methodology refers to the following two basic objectives:[LEH01]

- An increased productivity of the software implementation project
- An improved quality of the implemented software product

A systematic and structured implementation process aims at the domination of the project- and software-inherent complexity in order to completely and correctly realise all requirements

on a software product. Both, the connection of heterogeneous WFMA as well as changing workflows impose more complex requirements. That's just why a systematic and structured implementation process is particularly required in order to cope with these specific requirements on workflow projects. Several concerns have been mentioned within the interviews that can be assigned to this objective:

A systematic and structured implementation process aims to **avoid analysis-, design- and implementation errors** that cause belated modifications of the requirements on the process design and the WFMA.

**Complementary project deliverables based on methodological patency** yield continuously refined project deliverables in each phase. Particularly interdependent project deliverables, e.g. process models and workflow specifications need to be mutually adapted to each other.

The **ability to consider new findings throughout the implementation process** is a further objective. Generally all requirements should be investigated as early as possible, but particularly process exceptions that deviate from standard workflows can be hardly investigated in the early stages of the project, completely.

Finally the **selection of an appropriate workflow system** is a crucial task. To cope with adaptable and interoperable workflows a careful selection process possibly based on well-defined criteria is an objective to cover all requirements well.

### **3.2 Research Variables: Project Methodology**

Variables of potential interest are those methodological aspects that generally help to achieve WF-flexibility and WF-interoperability. In other words relevant aspects are those for which a potential influence on the identified project objectives can be reasonably expected, i.e. they are supposed to contribute to the seven project objectives selected in the last section. All variables of this category are described by means of hypotheses in order to clarify this interrelationship. General methodological aspects that do not specifically affect flexibility and interoperability requirements, such as project time frames, quantitative team composition, etc. are not included.

Since the thesis regards all phases of the BPM-life cycle, methodological aspects are identified according to the following general phases (see section 2.2):

- Build-Time: Preliminary-/Feasibility-study
- Build-Time: Initial Implementation Project
- Run-Time: Permanent Enactment, Diagnosis and Improvement

#### **3.2.1 A1: Business-Process-/Workflow-Modelling**

This variable refers to the measures that need to be taken to gain business process- and workflow-models that sufficiently depict flexibility and interoperability aspects. For this, the carefully choosing of an adequate business process modelling approach aims to provide a meta-model with a comprehensive set of modelling objects. Interviews revealed that the modelling of business-processes and workflows is a methodological aspect with a potential influence on relevant project objectives. Participants assumed an impact as described in the following hypotheses:

Hypothesis 7: Modelling Methodology (A1) – Process Flexibility (O2)

“Modelling flexibility aspects is a prerequisite for flexible business process support”

Hypothesis 18: Modelling Methodology (A1) – Process Interoperability (O3)

“Modelling a business process’s interoperability aspects (A1) helps to gain interoperable and integrated business processes (O3)”

Hypothesis 26: Modelling Methodology (A1) – Technical Interoperability (O4)

“Modelling technical interoperability aspects (A1) of the application systems that are invoked by a WFMS helps to reach technical interoperability of the workflow-management-application (O4).”

Hypothesis 32: Modelling Methodology (A1) – Technical Flexibility (O5)

“Modelling flexibility aspects / process variants and process exceptions (A1) within business process models helps to improve the flexibility and maintainability of the workflow-management-application WFMA (O5).”

Hypothesis 40: Modelling Methodology (A1) – Clear Process Models (O6)

“The selection of business process- and workflow modelling approaches with comprehensive and complementary meta-models i.e. a comprehensive semantic expressiveness (A1) is a prerequisite for semantically complete, clear, readable, and adaptable business process- and workflow models that depict flexibility and interoperability aspects (O6).”

#### Hypothesis 43: Modelling Methodology (A1) – Clear Project Approach (O7)

“The selection of business process- and workflow modelling approaches with comprehensive and complementary meta-models i.e. a comprehensive semantic expressiveness (A1) contributes to a systematic and clearly structured project methodology that avoids analysis-, design- and implementation errors (O7).”

#### **Literature-based Validation:**

An essential part of a process-aware project (BPM- and WFM-projects) is the selection of an adequate modelling approach.[BID01] The research community intensively regards the relationship between modelling and flexibility / interoperability. For instance, the BPMDS'06 conference founded a research forum to discuss concepts and techniques for modelling of flexible inter-organizational BPMS/WFMS. Several authors discuss WF-flexibility and WF-interoperability in conjunction with process-/workflow-modelling approaches.[HOR01, GRI01, LEH03] Sadiq even states that dynamic adaptability is founded by the underlying workflow model.[SHA01] In fact, rapidly changing business conditions establish the demand for adequate representations of current and future business situations and the depiction of the impact of change.[BAR04] Some approaches have been proposed that are supposed to improve WF-flexibility, e.g. decentralised modelling.[STO01, GEI01] Process modelling formalism can be classified into three categories: activity-oriented, product-oriented, and decision-oriented approaches.[NUR01] For instance, approaches characterized as advanced-modelling and late-/lean-modelling can be applied at build-time (P1 of facet 5) and at run-time (P2 of facet 5) to provide WF-flexibility (see section 2.4.5).[HOR01, MIN01, WWM01, GRO03] The latter allows to specify unpredictable sub-workflows at run-time in case of certain events.[GRO03] Generally modelling approaches should enable WF-designers to adapt WF-schemas (S1 of facet 4) and WF-instances (S2 of facet 4) (see section 2.4.4).[HEI04] Thereby appropriate modelling methodologies allow to react to most reasons for change, e.g. to unexpected events (R7, R13 of facet 1) that may occur due to incomplete WF-specifications.[HEI04] A considerable part of the literature discusses the issue of model-based instance adaptation at run-time (S2 of facet 4 & P2 of facet 5) without consistency violations of affected instances (facet 7).[TEE01, FAU01]

It is important not to lose sight of the difference between business-process-models and workflow-models. Despite the need to already depict flexibility aspects within process-models, they are usually not sufficiently detailed to allow flexible WFMS-control or to decide if the process can be flexibly supported by a WMFS. Thus more detailed specifications are demanded.[LEH03] Yet, important design decisions concern the adequate level of abstraction and modularisations to facilitate later flexibility mechanisms.[GRI01] Highly prescriptive models would probably impose a too rigid WF-control and might avoid individualism and adaptability.[SHA01]

Interoperability has been broadly acknowledged as a matter of process-/workflow-modelling.[GEP01, KLI01, ADA01, STO01] Organisational and semantic interoperability (facet 3; see section 2.5.3) mainly imposes requirements on modelling approaches. For instance, semantic interoperability requires a common inter-organisational clarity/understandability concerning application- and process-data. So called WF-contracts are a means to specify how inter-company workflows need to behave. To conclude, kind and quality of BPM-activities are influenced by the modelling languages, which are applied to create an effective and efficient way to conduct collaborative business.[SEE01] Nevertheless, the WPMC has not yet released a standard to depict process interoperability within models.[WFM03] Considerable research attention has been paid to the issue of extended process models to support inter-organisational business processes.[HAR02, BER01] Yet,

correctness issues for inter-organisational process-models have been hardly addressed.[AAL02] Selection of an adequate modelling approach in an inter-organisational scenario strongly depends on the interoperability degree (C1 to C3 of facet 4; see section 2.5.4), as it implies a common meta-model or diverse meta-models with the need of transformation to keep the process semantics.[BER01, ADA01]

### 3.2.2 A2: Selection of relevant Business Processes

This variable alludes to the fact that not every business process is suited for a workflow-management control. A selection process aims to thoroughly choose only those business processes for which a workflow control is feasible and promises significant benefits. Interviews showed that a sophisticated selection process that is based on a variety of selection criteria is regarded as a methodological aspect with an impact on project objectives. Participants assumed a cause-effect-relationship as described in the following hypotheses:

Hypothesis 1: Process Selection (A2) – Clarity (O1)

“A criteria-based identification and selection of business process candidates (A2) helps to reveal findings concerning the feasibility / profitability of the workflow project (O1)”

Hypothesis 8: Process Selection (A2) – Process Flexibility (O2)

“Selecting business process candidates by means of their flexibility requirements (A2) helps to improve the processes’ flexibility (O2).”

Hypothesis 19: Process Selection (A2) – Process Interoperability (O3)

“A criteria-based identification and selection of business process candidates, which takes interoperability and integration requirements into account (A2) helps to improve the processes’ interoperability.”

Hypothesis 27: Process Selection (A2) – Technical Interoperability (O4)

“A criteria-based identification and selection of business process candidates, which examines technical interoperability and integration requirements (A2) contributes to the technical interoperability of the workflow-management-application (O4).”

#### **Literature-based Validation:**

It is widely agreed that different types of processes are more or less suitable for a WFMS-based control. For that reason the thesis’s scope has been constrained to core-, network-, and support-processes (see section 2.1). Workflow related correspondents are production- and administrative-workflows (see section 2.1). Implications for the WFM-implementation-methodology exist in so far as the project scope has to focus on processes that are adequate for a workflow control and for which a workflow control implies high benefits. Anyhow, the selection of WF-adequate process candidates is often disregarded; an inadequate assignment of processes to WFMS has even led to the failure of WF-projects.[MÜH06] It is therefore important to evaluate the process candidates in light their workflow-appropriateness early in the project.[SHA01] Some authors claim for a criteria-based evaluation of process candidates in order to choose those process candidates which might maximum benefit from workflow management.[DIC01] Selection criteria, such as weak-points, e.g. insufficient cycle-times, or customer satisfaction, process costs, but also flexibility- and interoperability requirements may be used.

Some authors emphasise that a WF-project should initially choose processes for which maximum optimisation benefits can be expected.[SCH03] Anticipated weak points may be

interpreted as supposed optimisation needs for business processes. Utilising this knowledge in a systematic way early in the project increases the transparency concerning the project's profitability as companies gain insights in possibilities to increase a process's efficiency (see Hypothesis 1). Companies basically tend to select cost intensive processes with a view to cutting process costs.[DIC01] Comparing those costs helps to reveal findings concerning monetary benefits. It is also assumed that companies tend to select processes with a poor IT-Support for improvement purposes which again helps to reveal findings to do with the project's feasibility. Applying the structuredness of a business process as a selection criterion implies the belief that highly structured processes are generally more applicable for WFMS than others. Evaluating the structuredness may also yield insights in the project's technical feasibility.

Flexibility requirements may be used as a selection criterion if process flexibility is a declared project objective.[DIC01, BEC02, MÜH06] It is important to accurately appraise flexibility demands, so that modellers, for instance, are able to depict an adequate degree of flexibility mechanisms. Processes with high flexibility demands are generally threatened by an inflexible WF-design. For that reason the appropriate degree of flexibility is an important aspect of investigation and might be a crucial selection criterion.[SHA01] In this sense, the thesis arrives at two conclusions with regard to this variable:

- Processes with too high flexibility demands must not be in scope of the project
- Flexibility requirements for processes within the project scope need to be sufficiently met later in the project

Literature clearly indicates that interoperability-based business strategies require early investigation of issues to do with inter-organisational collaboration, e.g.: identification of processes and services (products) to be realized on a certain platform. Intra-organizational business processes (e.g. user management on the platform) and inter-organizational business processes (e.g. application and claims processes) need to be distinguished.[BER01] Fleisch argues that the selection of WF-relevant process candidates is to be done by assessing the processes' networking-ability (see chapter 2.5.1).[FLE01] Hartman stresses that inter-company areas of processes need to be chosen before implementing the WFMS.[HAR02] As corporate borders tend to become fuzzy in inter-organisational collaboration scenarios, it is necessary to early identify the different parts of the process on each side of the participating companies.

### 3.2.3 A3: Business Process Analysis

This variable pertains to the necessity to early understand an organisation's flexibility- and interoperability-requirements. For that purpose it is assumed that a targeted business process analysis investigates flexibility- and interoperability aspects. Early insights in those requirements are to leverage subsequent project activities for a facilitated achievement of WF-flexibility and WF-interoperability. According to the participants' opinions interdependencies with project objectives are expected as described the following hypotheses:

Hypothesis 2: Process Analysis (A3) – Clarity (O1)

“An adequate scope of the business process analysis (A3) reveals findings concerning the project's profitability and the project's feasibility (O1).”

Hypothesis 9: Process Analysis (A3) – Process Flexibility (O2)



“Analysing a business process’s flexibility aspects (A3) uncovers potential fields for an improvement of a process’s flexibility and thus leads to an amended flexibility (O2).”

Hypothesis 20: Process Analysis (A3) – Process Interoperability (O3)

“Analysing a business process’s interoperability aspects (A3) yields insights into potential fields for an inter-organisational process coupling and therefore contributes to inter-organisational business process interoperability (O3).”

Hypothesis 28: Process Analysis (A3) – Technical Interoperability (O4)

“Analysing a business process’s contributing IT-systems and the quality of these systems in terms of interoperability (A3) allows an improvement of these systems’ technical coupling in a heterogeneous environment and it eventually contributes to technical interoperability of the workflow-management-application (O4).”

Hypothesis 33: Process Analysis (A3) – Technical Flexibility (O5)

“An appropriate scope of the business process analysis which considers modification requirements on business processes (A3) has a positive influence on the flexibility and maintainability of the workflow-management-application (WFMA) (O5).”

Hypothesis 41: Process Analysis (A3) – Clear Process Models (O6)

“An appropriate scope of the business process analysis which considers modification requirements on business processes (A3) has a positive influence on semantically complete, clear, readable, and adaptable business process- and workflow-models that depict flexibility- and interoperability aspects (O6).”

### **Literature-based Validation:**

Many authors have addressed the issue of an appropriate process analysis initiative as a prerequisite for meaningful process-/workflow-models and for the provision of insights into a project’s feasibility and profitability.[KUE01, KNO01, KIR01]

Some sources stress the increasing unpredictability of flexibility-induced requirements on processes and claim for more appropriate analysis approaches.[STO01, MAN01, HEI04] Analysis of the processes’ flexibility aspects is considered as a research issue since the early 2000s.[STO01, PER01] For instance, the BPMDS'06<sup>38</sup> conference discussed methods and conceptual frameworks for the analysis of flexible business processes to distinguish requirements for different kinds of flexibility. Some authors differ between qualitative and quantitative approaches.[PER01] Usually process analysis is closely regarded together with process-/workflow-specification approaches. It is common sense that process knowledge in current business environments became more diffuse. Thus a WF-project’s process-analysis phase calls for much broader investigations. For instance, it is necessary to identify and specify not predictable parts of processes and process variants in order to enable users to adapt a workflow-instance’s properties to the precise requirements of a concrete business process during run-time.[GRO03] Recent publications regard process analysis as a continuous task which is not only executed once.[BRA01] One of the main difficulties is seen in bridging the gap between business- and IT-views on business processes. Process mining is a more recent approach to business process analysis within WFM projects.[RIN02] In this context, it is assumed that diagnosis activities help to cope with flexibility-imposed deviations during run-time.

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<sup>38</sup> <http://lamswww.epfl.ch/conference/bpmds06>

Process analysis with a special perspective on inter-organisational collaboration mainly concerns organisational & pragmatic interoperability (facet 3; see section 2.5.3). It has been declared as a research issue in the early 2000s.[DAY01] Fleisch campaigns for an inter-organisational analysis of the processes' net-working-ability.[FLE01] For that purpose he applies several metrics that are supposed to assess a company's maturity for interoperability. The interoperability initiative of European public administration states that full examination of processes, procedures and structures is required to coordinate processes across organisational boundaries.[EPA01] Fong argues that technical and organisational interfaces are closely coupled factors for collaboration involving several organisations.[FON01] He highlights the necessity to analyse both factors when implementing IT-based process control between different enterprises. The specific analysis view also imposes new requirements on modelling approaches that need to depict organisational interfaces and other aspects of cross-company collaboration.[BER01]

Interviews revealed that process analysis is a methodological aspect in the following phases:

- Build-Time: Preliminary-/Feasibility-study
- Build-Time: Initial Implementation Project
- Run-Time: Permanent Enactment, Diagnosis and Improvement

### 3.2.4 A4: Business Process Optimisation

This variable concerns the effects of process optimisation activities on process-flexibility /- interoperability. Subject of investigation is the question if a specific BPO might help to improve process-flexibility- and interoperability. It is also assumed that BPO initiatives yield findings that allow to better evaluation of a WF-project's feasibility and profitability. Interviews revealed a supposed impact of the variable as described in the following hypotheses:

Hypothesis 3: Process Optimisation (A4) – Clarity (O1)

“An appropriate scope of the business process optimisation which focuses on efficiency gains and the elimination of weak points helps to reveal the workflow project's profitability (O1) and the organisational feasibility (O1).”

Hypothesis 11: Process Optimisation (A4) – Process Flexibility (O2)

“An appropriate scope of the business process optimisation (A4) which concentrates on process flexibility yields an improved adaptability of the considered business processes (O2).”

Hypothesis 22: Process Optimisation (A4) – Process Interoperability (O3)

“An appropriate scope of the business process optimisation (A4) which incorporates the coupling of processes between different organisations contributes to business process interoperability (O3).”

#### **Literature-based Validation:**

Many authors are of the opinion that WF-projects are to be used as an opportunity for a BPO/BPR-initiative.[HOC01, TAG01, OUK01, KIR02, KAM02] BPO initiatives could emphasise on different aspects of optimisation, e.g. efficiency gains, reduced cycle-times, improved customer orientation.[KNO01] Usually companies strive for flatter hierarchies and for eliminations of weak points.[KUE05, MÜH09, KAI01] Anticipated or investigated weak points are regarded as supposed optimisation needs for business processes. Utilising this knowledge in a systematic way early in the project increases the transparency concerning the

project's profitability as companies gain insights in possibilities to increase a process's efficiency. It is also assumed that sophisticated BPO approaches evaluate the feasibility of process improvements and therefore provide sound insights into the project's feasibility.[KNO01] A rather recent approach to BPR is based on process patterns that are utilised as best-practice templates.[AND02] The author assumes that existing proofs of concepts relieves feasibility appraisals for applicable process patterns.

Von der Mühlen investigates inter-company workflow projects and concludes that WF-interopability provides opportunities for process optimisation.[MÜH05] In fact, literature reveals that the scope of today's BPR/BPO-initiatives is not only intra-enterprise, but noticeably shifted to an inter-enterprise perspective with distributed processes in a heterogeneous WF-environment.[KAI01] Fleisch emphasises the importance of inter-company collaboration and claims for an improvement of enterprises' networking-ability as a major concern of IT-projects.[FLE01] The interoperability initiative of the European Union highlights that inter-company change-management ambitions are of major importance.[EPA01] A further issue of inter-company process optimisation in light of WFM is to agree on inter-company process descriptions of deviating cases, shared duties and responsibilities etc.[HAR02] Such arrangements need to be concluded before implementing the WFMA. Most authors expect an increasing degree of automated transactions between organisations. Companies strive for reduced transaction costs that way, but studies show that costs for problematic inter-company transactions exceed those for regular workflows by 300 percent.[BEC04] This calls for the optimisation of inter-company processes prior to the technical WFMA implementation.

The scope of BPR/BPO has also been shifted to flexibility, as current BPO-approaches highly prioritise the flexibilisation of companies.[KAI01] Delfmann states that WF-projects must serve as a means to improve a company's adaptation efficiency.[DEL01]

Interview partners mentioned that BPO-aspects are to be regarded in the following phases:

- Build-Time: Preliminary-/Feasibility-study
- Build-Time: Initial Implementation Project
- Run-Time: Permanent Enactment, Diagnosis and Improvement

### 3.2.5 A5: WFMS Selection / Vendor Workshops

This variable refers to the question if an intensive participation of WFMS vendors during early project stages leads to sophisticated feasibility- and profitability-findings. Particularly workshops with WFMS vendors have been identified as an instrument for such an early feasibility evaluation. Participants assumed an impact as described in the following hypothesis:

Hypothesis 4: System Selection / Vendor Workshops (A5) – Clarity (O1)

“Requirements- and gap-analysis workshops with WFMS-vendors lead to findings concerning the technical feasibility and the profitability of the workflow project (O1).”

#### **Literature-based Validation:**

Literature does hardly raise the issue of WFMS vendor workshops. Nevertheless, some authors emphasise the selection of an appropriate WFMS as a crucial task of WF-projects.[BAR01, MÜH06] Practice shows that inadequately chosen WFMS could even lead to the failure of WFM-projects.[MÜH06] Selection tasks are affected by the fact that the

WFMS market is polypolistic and product selection plays a rather important role than in the standard-software or ERP-market.[KAM01] It is widely accepted that the evaluation of a WFMS's appropriateness is a time-consuming task.[KUE02] For that reason, vendor workshops might relieve this task by commonly evaluating crucial requirements together with WFMS vendors. It is also conceivable that workshops may cover not only vendors but also potential business partners for which an inter-company collaboration is intended.[AND01] In that case workshops are supposed to investigate compatibility features with respect to workflow-interoperability (facet 3, facet 6 and facet 7, see section 2.5).

Interviews revealed that WFMS-vendor workshops may occur in the following phases:

- Build-Time: Preliminary-/Feasibility-study
- Build-Time: Initial Implementation Project

### 3.2.6 A6: WFMS Selection Process

This variable pertains to the issue that a WFMS need to be chosen that meets technical interoperability- and flexibility-requirements. It is assumed that specific selection criteria help to choose a WFMS that better fulfils technical requirements on the WF-flexibility and WF-interoperability. Interviews revealed a supposed impact of the variable as described in the following hypotheses:

Hypothesis 30: Selection Process for the WFMS (A6) – Technical Interoperability (O4)  
“Considering possibilities for a coupling of different or even heterogeneous WFMS within the system selection process (A6) is a prerequisite for the technical interoperability of the workflow-management-application (O4).”

Hypothesis 34: Selection Process for the WFMS / Scope (A6) – Technical Flexibility (O5)  
“Considering the adaptability for a WFMS within the system selection process (A6) is a prerequisite for the flexibility and maintainability of the workflow-management-application (O5).”

#### **Literature-based Validation:**

As already discussed WFMS selection is a time-consuming task that is aggravated by the polypolistic structure of the WFMS market.[KUE02, KAM01] A requirements catalogue may arise from investigations conducted within the feasibility study or within process analysis activities. Some authors have outlined possible selection criteria.[SCH03, ADA01, HAR02, LOE01] Literature suggests to execute an initial process analysis and process-design prior to the WFMS selection with a product-independent scope.[THI01] Yet, a few authors state that a to-be-design should be based on a selected WFMS-product.[HER02]

Interviews revealed that the WFMS selection is executed in the following phases:

- Build-Time: Preliminary-/Feasibility-study
- Build-Time: Initial Implementation Project

### 3.2.7 A7: Feasibility Study

This variable investigates the effects of a WF-feasibility study on the achievement of WF-flexibility and WF-interoperability. It is of particular interest if the consideration of specific analysis aspects helps to better accomplish more flexible and interoperable business

processes. A feasibility study is also expected to provide sophisticated findings with regard to technical and political obstacles and the WF-project's cost-effectiveness. Interviews revealed a supposed impact of the variable as described in the following hypotheses:

Hypothesis 5: Feasibility Study (A7) – Clarity (O1)

“The execution of a feasibility study (A7) helps to reveal findings concerning the feasibility and the profitability of the workflow project (O1).”

Hypothesis 12: Feasibility Study (A7) – Process Flexibility (O2)

“Considering flexibility requirements within a feasibility study of a workflow project (A7), helps to improve the flexibility of the considered business processes (O2).”

Hypothesis 23: Feasibility Study (A7) – Process Interoperability (O3)

“Considering an inter-organisational collaboration within a feasibility-study of a workflow project (A7), helps to reach an inter-organisational business process interoperability (O3).”

Hypothesis 44: Feasibility Study (A7) – Clear Project Approach (O7)

“A feasibility study which is executed prior to the workflow implementation project contributes to a systematic and clearly structured project methodology (O7).”

### **Literature-based Validation:**

Academic literature provides little guidance for the execution of feasibility studies for WFM-projects. Topical sources rather pertain to general requirements-engineering in the field of BPM- and WFM-projects. For instance, the 2006 executed “Seventh Workshop on Business Process Modelling, Development, and Support” (BPMDS’06) focussed on several aspects of process-related requirements-engineering. Even if the literature rarely broaches the issue of feasibility studies, there are some indications that such early studies are required prior to WFM-projects. Frankova distinguishes between early requirements-engineering and late requirements-engineering.[FRA02] Andersson emphasises that process patterns could be used as best-practice templates to assess feasibility of certain process design notions.[AND02] A further issue within early requirements analysis for WFM-projects could be a stakeholder analysis.[ROB01] The above mentioned BPMDS’06 conference highlighted the investigation of requirements on process flexibility and ways to achieve it. A 2008 published approach to workflow-design founds a requirements-engineering on identified business goals as a first step of investigation.[SUN01] In fact, other authors centre requirements-engineering around the business strategy, e.g. Berre et al. recommends to analyse interoperability questions at a strategic level as a starting point for projects:[BER01]

- Identification of interoperability-relevant processes and services
- Identification of relevant business partners for inter-organisational processes
- Alignment of a company's business plan to the business plans of the identified partners
- Common pricing model for inter-company process costs

An assessment and measurement of a company's networking-ability was also raised by Fleisch.[FLE01] Basically, the identification and assessment of interoperability issues seems to be an important task for early analysis within WF-feasibility studies.[AND01] Further authors term technical prerequisites, risks and benefits as aspects of early investigations before implementing an inter-company WFMA.[HAR02, NEI01, STO01]

### 3.2.8 A8a: Prototyping

This variable refers to the contribution of prototyping within workflow projects to flexibility and interoperability on a process- and on a system-level. It is supposed that an evaluation of flexibility- and interoperability-requirements by means of WFMA prototypes helps to better achieve these objectives. Besides, prototyping should contribute to a well structured and clearly designed implementation approach that yields early insights into the feasibility of flexibility- and interoperability-requirements. Interviews revealed a supposed impact of the variable as described in the following hypotheses:

Hypothesis 6: Prototyping (A8) – Clarity (O1)

“Early Prototyping helps to gain findings concerning the project’s feasibility (O1).”

Hypothesis 13: Hypothesis 13: Explorative Prototyping (A8) – Process Flexibility (O2)

“Executing an early Prototyping (A8) helps to reveal flexibility requirements on business processes and it improves flexibility in the end (O2).”

Hypothesis 24: Explorative Prototyping (A8) – Process Interoperability (O3)

“Early Prototyping (A8) of a workflow management application’s interoperability features yields insights in the fulfilment of interoperability requirements and eventually improves business process interoperability (O3).”

Hypothesis 31: Explorative Prototyping (A8) – Technical Interoperability (O4)

“Early Prototyping (A8) of a workflow management application’s interoperability features yields insights in the fulfilment of interoperability requirements and eventually improves the technical interoperability of a WFMS in an inter-organisational context (O4).”

Hypothesis 35: Early Prototyping (A8) – Technical Flexibility (O5)

“Early Prototyping (A8) of possibilities to adapt a WFMA according to process variants improves the technical maintainability of the workflow-management-application (O5).”

Hypothesis 45: Early Prototyping (A8) – Clear Project Approach (O7)

“Early prototyping (A8) contributes to a systematic and clearly structured project methodology that avoids analysis-, design- and implementation errors (O7).”

#### **Literature-based Validation:**

Considerable literature about the benefits of prototyping for systems development has been provided by researchers, e.g. Boehm’s Spiral model, RAD, and DSDM.[BAL01, AV01] By contrast, little literature about the importance of prototyping for WFM-projects has been published. Drivers for the application of prototyping within WFM-projects may be the projects’ complexity and the fact that organisational aspects and IT-issues are interwoven. Project work requires an intensive dialogue between users that think in terms of business processes and IT-experts. Different perceptions of problems and solutions are caused by unequal perspectives on the problem domain which is even aggravated by the fact that users are requested to abstract from IT-issues and to regard business processes, whereas IT-experts have to cope with the IT-implications of complex integration needs. Misunderstandings and solutions that do not fulfil user requirements might follow. Nevertheless, WFM-projects are mostly executed without prototyping.[STR01] Altenhofen has acknowledged the importance of organisational aspects for the acceptance of WFMA and claimed for an early employee involvement.[ALT02] He proposed a “think-big – start small”-approach for WFM-projects to better regard employee requirements. Stohr has also mentioned that new analysis- and design-methodologies would be required for WFM-projects.[STO01] He argued that particularly

verifications of process models in light of flexibility requirements require user participation. Prototyping in this sense is regarded together with variable “8c Iterative Implementation Process”. Complex systems for newly designed business processes can not be implemented in one step with poorly conceived components.[KUE04] For that reason WF-prototyping focuses the early validation of user requirements and the verification of technical solutions.[KUE04] Berre et al. emphasise that WFMA's should be implemented incrementally based on WF-prototypes.[BER01] They suggest to discover technical problems much earlier with WF-prototypes than with top-down methodologies and argue that this contributes to early insights in a WFM-project's feasibility.[STR01, BER01]

Prototyping aspects could be:[BER01, STR01]

- High complexity processes
- Inter-organisational processes
- Interfaces and complex application architectures
- Adaptation of processes during run-time

Interviews revealed that the Prototyping is an issue in the following phases:

- Build-Time: Initial Implementation Project

### 3.2.9 A8b: Consolidation of Business Process Models, Workflow Specifications and technical Concepts

This variable alludes to the need for seamlessly integrated project deliverables as part of a clearly structured project methodology. It is expected that semantically complementary deliverables are less prone to errors. Investigations particularly analyse the positive impact on flexibility and interoperability on a process- and on a system-level. Interviews yielded effects as described in the following hypotheses:

Hypothesis 10: Consolidation of Project Deliverables (A8) – Process Flexibility (O2)

“A consolidation business process models and workflow models in light of flexibility aspects (A8) facilitates the consideration of flexibility requirements throughout the implementation process and improve flexibility in the end (O2).”

Hypothesis 21: Consolidation of Project Deliverables (A8) – Process Interoperability (O3)

“An integrated consideration of business process models and technical project deliverables such as workflow specifications (A8) facilitates the consideration of interoperability requirements throughout the implementation process and improves business process interoperability in the end (O3).”

Hypothesis 29: Consolidation of Project Deliverables (A8)–Technical Interoperability (O4)

“An integrated consideration of business process models and technical project deliverables such as workflow specifications (A8) facilitates the consideration of technical interoperability requirements throughout the implementation process and finally improves technical interoperability (O4).”

Hypothesis 36: Consolidation of Project Deliverables (A8) – Technical Flexibility (O5)

“A consolidation of business process models and technical deliverables such as workflow models in light of flexibility aspects (A8) contributes to the consideration of flexibility

requirements throughout the implementation process and improves the technical flexibility and maintainability of the workflow-management-application (O5).”

Hypothesis 47: Consolidation of Project Deliverables (A8) – Clear Project Approach (O7)  
“Consolidated project deliverables (A8) contribute to a systematic and clearly structured project methodology that avoids analysis-, design- and implementation errors (O7).”

### **Literature-based Validation:**

Seamless implementation approaches with integrated project deliverables are still regarded as an open issue for the WFM life-cycle.[BAR04, MÜH08, BER01, RAD01] Authors recognise a gap between high-level process models and detailed technical specifications for implementation- and enactment purposes.[MÜH08] The problem turns out to be manifold:[RAD01, MÜH08, BER01]

- Lack of appropriate specification methodologies to depict high-level process designs and technical process- and system-specifications (lack of an integrated meta-model)
  - Technical specifications are not capable to depict process semantics
- Lack of appropriate transformations between specification methodologies / deliverables of different life-cycle stages
  - Failures occur from inappropriate mapping of analysis outcomes to design models
- Lack of instructions for the derivation of technical deliverables from high-level process designs
  - Information gets lost during the transformation process
- Lack of communication between process designers and stakeholders
  - Designers ignore organisational perspectives
  - Models do not fit the current organisational structure
  - Models do not fit the current infrastructure
- Lack of common modelling conventions and standardisations
  - Different process designers use different levels of abstractions

Considering the issues in light of WF-flexibility and WF-interoperability reveals specific problem characteristics. Gronau argues that WF-flexibility requires sustainable WFMA and calls for implementation approaches that allow integration of design levels.[GRO03] Rapidly changing business requirements establish a critical need for business models and aligned specifications of technical business objects.[BAR04] The strong relationship between these levels of perception is fostered by flexibility requirements as adequate representations of change must include the current and future business conditions, derived organisational impacts and the specification of what needs to be changed on a technical level.[BAR04] Specific issues in an inter-organisational project environment might arise from the higher complexity of processes that cross organisational boundaries, but also from the need to integrate models of different organisations.[RAD01] The above problems appear even more challenging as several applied modelling-tools and -techniques, a possibly duplicated modelling content, and political interests might prevent models and specifications from integration.

Solving these issues cannot be detached from the selection of an appropriate modelling approach as described for variable A1.

Interviews revealed that a seamless integration of project deliverables is a methodological aspect in the following phases:



- Build-Time: Preliminary-/Feasibility-study
- Build-Time: Initial Implementation Project
- Run-Time: Permanent Enactment, Diagnosis and Improvement

### 3.2.10 A8c: Iterative Implementation Process

This variable concerns the effects of an iterative implementation process on the clarity and correctness of the process-/workflow-models. It is assumed that iterations in analysis and design help to generate rather sound models which also apply to the depiction of flexibility- and interoperability aspects. Furthermore, an iterative life-cycle aims to stepwise eliminate design-errors, thus leads to a more sophisticated project approach. Interviews revealed a supposed impact of the variable as described in the following hypotheses:

Hypothesis 42: Iterative Implementation Process (A8) – Clear Process Models (O6)

“An iterative implementation process (A8) contributes to semantically complete, clear, readable, and adaptable business process- and workflow-models that depict flexibility- and interoperability aspects (O6).

Hypothesis 46: Iterative Implementation Process (A8) – Clear Project Approach (O7)

“An iterative implementation process (A8) contributes to a systematic and clearly structured project methodology that avoids analysis-, design- and implementation errors (O7).”

#### **Literature-based Validation:**

Literature indicates that WFM project methodologies are mostly executed sequentially and focus on technical implementation aspects.[FRE01] Those approaches are criticized not to sufficiently regard interdependencies between people, organisations, technology, and tasks.[FRE01] It is assumed that iterative life-cycle models are rather people oriented. A repeated execution of project phases is proposed by so called integrated WFM-approaches.[JAB01] Although they are actually sequential approaches, returns to earlier project phases are permitted.[HOL02] For that reason, integrated approaches are also denoted to be evolutionary.[JAB01] In fact, the literature does not argue in a uniform way, as Gronau mentions that the usually applied workflow methodologies have an iterative character.[GRO03]

Nevertheless, Lehmann and Ortner have early mentioned that WFMA must not be implemented by means of sequential project activities.[LEH03] They rather claim for an iterative process with retraces and mutual interactions between project phases. Appropriate implementation methodologies for workflow projects are regarded as a research issue since the late 1990's.[STO01] Also Küng has early emphasised that WFMA are supposed to be implemented iteratively.[KUE04] He argues that requirements cannot be analysed and specified within one single step. One of the main arguments is the specific characteristic of a WFM-project, namely a combined trait of a BPR-/BPO-project and a software-implementation project, which imposes a high complexity and therewith a high risk for analysis- and design-errors.[KUE03] Becker et al. have also described an iterative WFM-implementation methodology, where the WFM-appropriateness of process candidates is evaluated in an iterative way.[BEC01] Nevertheless, project methodologies does not seem to be mature yet. For instance, it is criticized that methodologies lack well-defined feedback mechanisms between project phases.[MÜH07] Many authors noticed that requirements emerge over time.[KLE01] For that reason, it is commonly accepted that the operational use phase is also subject to permanent change.[RAD01, MÜH09, KLE01]

### 3.2.11 A9: Continuous Process Improvement

This variable pertains to the need for a CPI-process in a rapidly changing business environment. It is expected that a CPI-process leads to improved process flexibility and to rather technically adaptable WFMA. Thus it is investigated if it also yields an improved technical flexibility of the WFMA. Interviews revealed an expected coherence between variables as described in the following hypotheses:

Hypothesis 14: Continuous Process Improvement (A9) – Process Flexibility (O2)

“The execution of a Continuous Process Improvement (CPI) (A9) helps to permanently adapt business processes and workflows to new requirements and thus leads to more flexible business process support (O2).”

Hypothesis 37: Continuous Process Improvement (CPI) (A9) – Technical Flexibility (O5)

“Organisational procedures for a CPI contribute to the technical flexibility of the workflow-management-application (O5).”

#### **Literature-based Validation:**

Chapter 2 has shown that several reasons provoke process changes after completion of the WFMA implementation project (see facet 3; section 2.4.3). Essential reasons were changing requirements, new regulations, technological advancements, new methods, process improvements.[SHA01]

The fact that WFMA and new business processes often evolve concurrently, yields immature WFMA implementations which require post-project amendments.[KLE01] In other words, high efforts in initial requirements-engineering and process modelling do not essentially ensure the project’s success.[KLE01] Anyhow, companies usually concentrate on initial process-optimisations/-automation and neglect a CPI.[MÜH09] As continuous process engineering is only implemented in few cases, authors claim to shift the attention from initial requirements-engineering to CPI during operational use of the WFMA.[KLE01, MÜH09] The notion of a continuous improvement of processes and the WFMA is also denoted as WF-Change-Management.[OUK01] Besides the above reasons for change, other authors develop a further perception of CPI-drivers:[OUK01, KLE01]

- Uncertainty in management and design-decisions
- Incomplete information that found design decision
- Organisational learning / emergent work practice
- Conflicts, collaboration and irrational behaviour leads to sub-optimum design decisions

To sum up, it is common sense that not everything within WFMA can be sufficiently kept flexible at build-time, so that CPI is required.[SHA01, MÜH02] In fact, a CPI is one important aspect of organisational agility.[PER01] It provides the following elements:[BIT01]

- Permanent performance monitoring of workflows
- Periodical re-engineering of workflows, if required
- Consideration of new workflows in light of process innovations

Other authors differ between qualitative, quantitative, active, and reactive CPI-mechanisms.[PER01] However, it imposes an evolutionary characteristic on WF-Change-

Management with the objective to achieve process- and WFMA-flexibility. More recent publications regard CPI as part of the BPM-life-cycle.[RIN02, AAL03] In this context, CPI is assigned to the diagnosis- and process-design-phases.[AAL04] Recent studies show that current BPMS provide little support for the diagnosis- and re-design-phases.[AAL03] Particularly technical components between process-mining and the automated derivation of re-designed WF-models cause problems. Further problems are: [MAG01, MÜH07]

- Weak link between WF-metrics and business relevant data
- Information overload of monitoring recipients
- Insufficient recognition of human violations of the WF
- Monitoring data are too raw for useful evaluation and cause misinterpretations
- CPI-objectives differ from process design objectives
- No sufficient CPI standards, methodologies

Regarding CPI in view of process- and WF-interopability reveals peculiar aspects. For instance, the need for an inter-organisational WF-monitoring of up- and down-stream parts of processes.[WFM03, HAR02] Such an inter-company CPI may become part of a “interoperability governance”.[EPA01] An inter-organisational WF-monitoring needs to convey relevant inter-company monitoring metrics and consolidates this data with company-internal WF-metrics.[HOL01]

### 3.2.12 A10: Target Group for a Continuous Process Improvement

This variable investigates relevant groups of stakeholders for an efficient CPI-process. It is of particular interest if certain groups of stakeholders are essential to achieve process-flexibility and flexibility of the WFMA. Interviews revealed a supposed impact of the variable as described in the following hypotheses:

Hypothesis 15: CPI-Process/Responsibility (A10) – Process Flexibility (O2)

“A Continuous Process Improvement that involves users, workflow-experts as well as process owners (A10) improves the business processes’ flexibility (O2).”

Hypothesis 38: CPI-Process/Responsibility (A10) – Technical Flexibility (O5)

“A CPI-Process that involves IT-/workflow-experts (A10) improves the technical flexibility of the workflow-management-application (O5).”

#### **Literature-based Validation:**

Little empirical evidence about relevant stakeholders in a CPI-process has been gained so far. Some authors recommend to mainly involve business staff, e.g. enterprise managers, process managers and process participants.[MAG01] Mainly process participants are often authorised to modify workflows as “empowered knowledge workers”.[PER01, TEE01] Though some problems of the WF-CPI-process have been recognised that allude to the issue of an appropriate stakeholder assignment, e.g.: [MÜH07]

- Stakeholders prevent process transparency
- Stakeholders provide invalid monitoring information
- Lack of communication among CPI stakeholders and participants
- Monitoring and process improvements are executed by different stakeholders

It is also not clear how to assign process-ownership within distributed workflow-environments.[BER01] Nevertheless, authors claim to assign the authority to modify certain aspects of sub-WFs to local representatives.[PUR01]

Apart from these issues, literature recommends a stakeholder-analysis in order to identify relevant staff for a post-project CPI-process.[MAG01, ROB01]

### 3.2.13 A11: Exception Handling

This variable concerns the effects of a regulated exception-handling process on process-flexibility and WFMA-system flexibility. Practitioners expected that exception handling regulations improve process- as well as WFMA-flexibility. Interviews revealed a supposed impact of the variable as described in the following hypotheses:

Hypothesis 16: Exception Handling (A11) – Process Flexibility (O2)

“An Exception Handling for the Workflow Management System (WFMS) (A11) improves flexible business process support (O2).”

Hypothesis 39: Exception Handling (A11) – Technical Flexibility (O5)

“Implementing an exception handling (-process) for the workflow-management-application (A11) improves the application’s technical flexibility (O5).”

#### **Literature-based Validation:**

Literature provides a clear statement that exception handling is an approach to an improved WF-flexibility.[PER01, WWM01, CAS01, KIR02] It mainly pertains to flexibility facets 4, 5, and 7 (see section 2.4.4, 2.4.5, 2.4.7). Issues in this context are bipartite. They concern the WFMS product that needs to provide exception handling mechanisms to adapt running instances.[CAS02, KAM02] On the other hand, an exception handling process needs to be defined within the WFM-implementation project, thus it concerns the project methodology.[CAS02, FAU01] Specific issues arise in an inter-enterprise environment. Participating organisations need to agree on exception handling protocols and service-/escalation arrangements.[WFM03] It needs to be clearly defined how to express and support exceptions that occur during collaborative business.

### 3.2.14 A12: User Training

This variable applies to the need for well-trained users that are aware of flexibility- and interoperability requirements and that are acquainted with the possibilities of the WFMA to cope with inter-organisational process control, dynamic process adaptations in exceptional situations, and CPI regulations. It was an outcome of the interviews that user trainings are considered as an important aspect of the project methodology to achieve WF-flexibility and WF-interoperability. Participants assumed an impact as described in the following hypotheses:

Hypothesis 17: User Training (A12) – Process Flexibility (O2)

“A User Training which focuses on techniques for a flexible adaptation of the Workflow Management Application (A12) facilitates the flexible reaction on process exceptions and leads to more flexible business processes (O2).”

Hypothesis 25: User Training (A12) – Process Interoperability (O3)

“A User Training which encompasses the execution of inter-organisational business processes (A12) improves companies’ organisational interoperability (O3).”

### **Literature-based Validation:**

The literature does not provide many indications that user-training may serve as a crucial aspect for the achievement of the WF-flexibility and WF-interoperability.[STO01] Nevertheless, user training is regarded as an element of a Change-Management initiative for WF-projects.[ALT02, KUE02, WES02] It can be regarded as a methodological aspect that contributes to the achievement of pragmatic interoperability (facet 3, see section 2.5.3).[BER01] A major concern is to establish understanding for the regulations and procedures of an inter-organisational collaboration. Hence an improved willingness towards collaboration is an ambition of user trainings. Willingness is particularly affected by a sense of heteronomy, bureaucratization and isolation caused by a networked way of labour.[STO01] Anxieties and resistance may also be induced by WFM-inherent monitoring functionalities.[LEH02] Corresponding problems might be:[MÜH07]

- Lack of communication and a common language among stakeholders
- Resistance from stakeholders to perform process-oriented activities
- Stakeholders take too long to adapt to process-oriented work style
- Stakeholders are unable to collaborate across organizational boundaries
- Stakeholders feel uncomfortable under process-oriented leadership

Some authors claim for an inter-organisational change-mgt. programme to improve willingness and trust for WFMA-based inter-organisational collaboration.[EPA01, BIT01] Recent publications acknowledge trust as key facilitator for such business-to-business collaboration.[LED01] Seel states that trust is a vital issue in dynamic environments where an organisation establishes collaborations with different companies and exposes information regarding its own processes.[SEE01] Lederer et al. perceive three aspects of trust[LED01]:

- ability (expertise, information, competence, expertness, dynamism)
- integrity (fairness in transaction, fairness in data usage, fairness in service, morality, credibility, reliability, dependability)
- benevolence (empathy, resolving concerns, goodwill, responsiveness)

Freudenberg has identified three general methodological aspects that he recommends to improve willingness and trust within WFM-/BPM-projects:[FRE01]

- High degree of user participation
- Conflict management
- Organisational learning (which includes transfer of corporate knowledge to all users)

User Training is a means to counteract resistance and to inspire confidence towards the WFMA. Employees must be able to understand where and how value creation is executed.[KLI01] Altenhofen mentions that timing and tailor-made training contents for different audiences are important for WFMA implementations.[ALT02] Weske assigns user training to a so-called installation-phase. Generally training may be complemented by online documentations to communicate process knowledge.[BER01]

However, WFM-projects and flexibility has been a major issue of the Seventh Workshop on Business Process Modeling, Development, and Support (BPMDS'06-Conference). Topics that bear upon this research variable were discussed as follows:

- Consequences of flexibility – who will be affected and how

- How much flexibility can be coped with – the human and organizational aspect
- Flexibility in relation to change management in business processes and BPS systems

### 3.3 Summarising Remarks / Research Hypotheses

The three-step approach for the identification of research variables has yielded seven project objectives and twelve aspects of the project methodology. These are further investigated in the empirical study and the evaluation of popular WF-implementation approaches. Forty-five research hypotheses have been defined that specify a supposed cause-and-effect relationship between methodological aspects and project objectives. The following table describes these effects of the project methodology on the project objectives in the form of hypotheses. Each of these hypotheses is further explained in the next chapter together with the gained empirical evidence.

<b>Research Variables: Project Objectives</b>			<b>Research Variables: Aspects of the Project Methodology</b>											
			<b>A1</b> Business Process / Workflow Modelling	<b>A2</b> Selection of workflow-relevant Business Processes	<b>A3</b> Business Process Analysis	<b>A4</b> Business Process Optimisation	<b>A5, A6</b> WFM-System selection	<b>A7</b> Feasibility analysis	<b>A8</b> Iterative implementation process	<b>A8</b> Prototyping	<b>A8</b> Consolidation of Process- / Workflow Specifications and Technical Concepts	<b>A9, A10</b> Continuous Process Improvement	<b>A11</b> Exception Handling	<b>A12</b> Training
Objectives of the Business Department	Objective investment decisions (Clarity concerning the feasibility and the project's profitability) <b>O1</b>			H1	H2	H3	H4	H5		H6				
	Business process quality	Flexible business processes <b>O2</b>	H7	H8	H9	H11		H12		H13	H10	H14 H15	H16	H17
		Business process interoperability <b>O3</b>	H18	H19	H20	H22		H23		H24	H21			H25
Objectives of the IT Department	WFM-application quality	WFM-application interoperability <b>O4</b>	H26	H27	H28		H30			H31	H29			
		WFM-application maintainability / Flexibility <b>O5</b>	H32		H33		H34			H35	H36	H37 H38	H39	
Methodological objectives	Adequate modelling approach <b>O6</b>		H40		H41				H42					
	Systematic and structured implementation process <b>O7</b>		H43					H44	H46	H45	H47			

**Table 3-1: Research Hypotheses / Effect of the Project Methodology on Project Objectives**

## 4 Empirical Study

### 4.1 Structure and Methodology

The survey is based on the epistemological framework which defines the relevant variables for the empirical study. This framework consists of project objectives and ‘parameters’ that are characteristics of the implementation methodology for a WF-project. The framework’s underlying variables have been defined in chapter 3 by means of a literature study and interviews with WF-experts. All project objectives and parameters were part of the questionnaire. An objective of the empirical study was to learn more about the objectives of workflow projects, their relevance and how companies succeed to achieve them. An analysis of activities in the project methodology and how they contributed to the fulfilment of certain project objectives was also undertaken. The correlation between project methodology and project objectives, particularly for the achievement of flexible and interoperable processes, indicates how the improvement of implementation methodologies for WFM-applications can be achieved (Basic statistical analysis tables and statistical charts remain in the Appendix A).

The specific research outcome of this chapter is to provide empirical evidence for the following questions:

- Which are the objectives that companies try to achieve in WF-projects and how do companies prioritise them?
- How did companies succeed to achieve these project objectives?
- Which of the project activities that were defined in the research framework contributed to the achievement of the project objectives?

This chapter is not concerned with the reasons for an objective’s prioritisation. Neither does it clarify the reasons for the impact that a project activity has on a project objective.

#### 4.1.1 Allocation of the Sample

It was initially intended to survey companies in the United Kingdom and in Germany in order to achieve comparative data. These data would have uncovered similarities and differences in the execution of WF-projects and for the WF-projects’ objectives. Focussing on these two countries was driven by three reasons:

1. It was assumed that the outcome would be applicable to other European countries.
2. It was intended to provide significant conclusions for the European WF-market.
3. Local proximity would ease the survey’s execution.

The company’s contact data were initially provided by the ‘Dun&Bradstreet’ database (D&B). Although not all of the D&B-data were up-to-date, this pre-selection of contact data led to a considerable simplification. Further contact data were retrieved by an internet search.

Unfortunately the UK survey only yielded a marginal response during the questionnaire’s pre-test. Due to the fact that a further attempt of telephone interviews did not provide sufficient response, the survey of UK companies has not been pursued.

The survey was executed within the following business segments:

- Insurance
- Banking
- Healthcare
- Retail
- Logistics

Many of the questionnaires were completed by experienced IT-consultants who had their main focus on WF-projects. This provided the survey with a broad basis, as these consultants had considerable project experience in the execution of WF-projects.

#### 4.1.2 Design of the Questionnaire

The questionnaire consists of the following parts (see Appendix B):

- Indication of the overall project success
- Stage of the WF-project's termination
- Project objectives: certain pre-defined project objectives were given and companies were able to indicate the priority and the achievement for each objective.
- Companies were able to indicate further relevant project objectives
- Project Methodology: certain pre-defined project activities were given and companies were able to indicate whether or not these project activities were executed as part of the implementation approach.
- Companies were able to indicate further mission-critical project activities

An original version also included questions that concerned the companies' internal characteristics, e.g. strategy, organisational structure, etc. and the external environment, such as stability and market specifics. These questions were omitted after the disappointing response in the pre-test.

#### 4.1.3 Survey Methodology & Response

Initially, the study was intended as a written survey. A fixed budget was reserved for the postage. The questionnaires were tested in an acceptance trial with a few randomly selected companies. The outcome was disappointing as no company returned a completed questionnaire. On inquiry the companies stated two reasons why they have not participated:

1. The questionnaire was too extensive
2. Daily business duties had priority, so the completion of the questionnaire was postponed

Given this feedback, the survey methodology was changed in two ways:

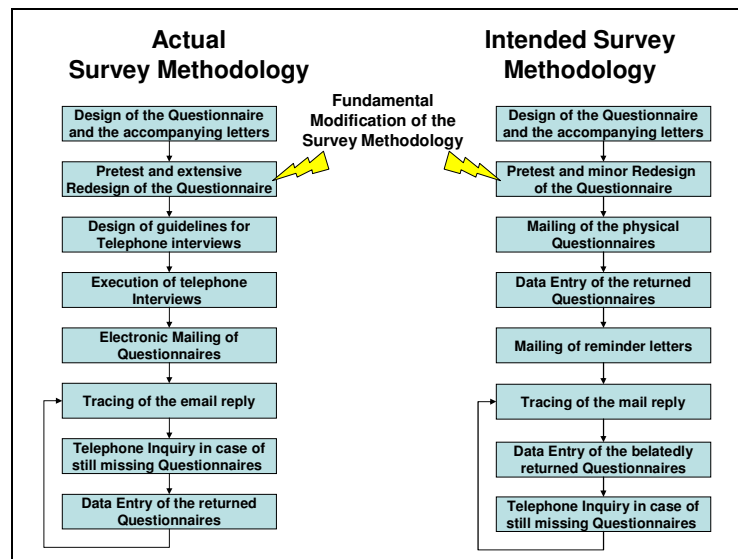
1. The extent of the questionnaire was reduced
2. Telephone interviews were substituted for written survey.

Telephone interviews offered the advantage of direct enquiries and 'immediate' contact between the interview partners. The phases for the alternative approaches are represented in Figure 4-1.



Furthermore, telephone interviews imply the following advantages:

1. Relevant addressees can be quickly identified during the telephone call
2. Efficiency: if the relevant skill / project experience is not available within the company, the interview is terminated. Non-productive survey activities can be avoided this way.
3. The interview situation may be controlled
4. Misunderstandings may be resolved immediately during the conversation



**Figure 4-1: Survey Methodologies by comparison**

The interviewees had the choice to either answer directly within the telephone conversation or to fill in the questionnaire in an electronic form and to reply via email. Only 10% of the replies were gained directly in the telephone call. 90% of the replies were obtained by email. For approximately 70% of the email responses, follow up calls were required. The interviews were aimed at IT-managers, 30% of them delegated the reply to the respective managers of the workflow projects.

In a preliminary talk background information to do with context and objectives of the survey was offered. It was also necessary to describe the design of the questionnaire.

A return of 79 questionnaires was obtained. 39 questionnaires were completed by IT-Consultants of Mummert Consulting AG and CSC Germany. 40 questionnaires resulted from the telephone survey. 139 companies were contacted to get this return of 40 questionnaires. The telephone survey was carried out from February 2004 to October 2004.

31% of the companies who did not participate stated that their company does not apply workflow management technology. It was not revealed whether companies who rejected the interview for other reasons apply workflow management systems. 17% of the companies stated that they would generally not take an interest in any academic studies as the number of enquiries for surveys has considerably increased in recent years. Some companies did not

want to publish confidential data. Others stated that the completion of questionnaires is too time consuming.

A rather low rate of 10% did not reply, as relevant interviewees could not be located, though these companies applied workflow management technology. 18% rejected the survey by arguing that neither flexibility nor interoperability were relevant criteria for which experience was gained during a workflow project. The breakdown for the overall replies is illustrated in figure 4-2.

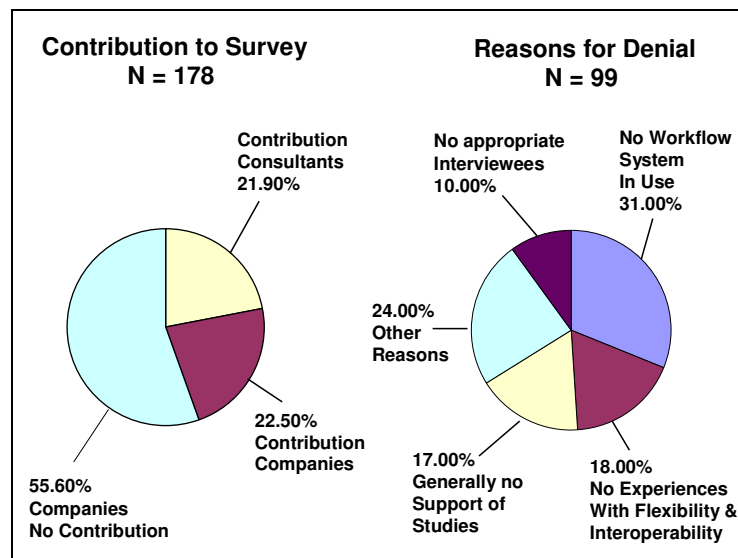


Figure 4-2: Survey Statistics / Reply and Reasons for Denial

All questionnaires were directly entered and analysed using SPSS 12.0. Its structure was initially used as a template for the SPSS Database-design.

### **Reflections on the survey methodology:**

(The lessons-learned are highly practice-oriented and apply to the feasibility of an empirical survey)

- It is important to design brief and comprehensible questionnaires. All questions need to be intuitively clear
- Relevant contact persons need to be identified in advance in order to avoid a repeated and time consuming forwarding of the questionnaire
- Extra time must be allowed for follow up calls. Necessary contacts average out at approximately 2 to 3 calls to gain one valid questionnaire
- Interviews must be scheduled to incorporate natural delays e.g. holiday times.
- A written survey does not assure success. Personal contact via telephone imparts the impression of a brief interview and it increases the commitment of the respondent

#### 4.1.4 Statistical Methodology

The statistical methodology comprises the following elements:

1. Construction of research hypotheses, i.e. a formal representation of relevant research questions described as efficient causations between variables
2. Definition of categories for the variables and their scales of measurement
3. Execution of statistical analysis procedures determined by key data and test procedures for the proof of generality

##### **1. Construction of research hypotheses**

The thesis's underlying focus of research yielded questions that were described in terms of hypotheses. These hypotheses describe the efficient causations between the implementation methodology and project objectives. For instance, it was interesting to examine whether the analysis of certain process aspects improved the fulfilment of process flexibility, or which objectives were really relevant in workflow projects and to what degree these objectives have been reached.

##### **2. Categorisation of variables and scales of measurement**

All variables have been categorised in the epistemological framework as (see Chapter 3):

- Project objectives
- Project parameters (aspects of the project methodology)

A third category scrutinizing the business environment was included initially, but was subsequently omitted following the reduction of the questionnaire.

The following scales of measurement have been applied for the variables:

Category / Variable	Scale of Measurement
Overall Project Success	Metric Scale
Point of Project Termination	Ordinal Scale
Project Objectives Priority	Metric scale
Project Objectives Achievement	Metric scale
Project Methodology	Ordinal scale

**Table 4-1: Variables and their Scale of Measurement**

##### **3. Statistical Analysis Procedures**

Several statistical analysis procedures have been applied to the questionnaire. These can be assigned to either univariate or bivariate analysis procedures. They differ according to the number of involved variables. Univariate procedures analyse only one single parameter in order to calculate purely descriptive figures. By contrast, bivariate procedures analyse the correlation between two parameters. The applied methods differ with respect to the variables' level of measurement. Multivariate analysis methods have not been applied.

Statistical Analysis Procedure			
Category	Description	Definition[SCH05]	Scale Level of Variable(s)
Univariate	• Frequencies: absolute Frequencies	$f_i$	Metric, Ordinal
	• Frequencies: relative Frequencies	$f_i^{rel} = \frac{f_i}{\sum f_i}$	Metric, Ordinal
	• Frequencies: percentaged Frequencies	$f_i^{\%} = f_i^{rel} \cdot 100$	Metric, Ordinal
	• Frequency Distribution	$f(x_i)$	Metric, Ordinal
	• Cumulative Frequency	$F_i = \sum_{j=1}^n f_j$	Metric, Ordinal
	• Mean Value: Arithmetic Mean	$\bar{x} = \frac{1}{n} \sum_{i=1}^n x_i$	Metric
	• Statistical Distribution: Variance	$\sigma^2 = \frac{1}{n} \sum_{i=1}^n x_i^2 - \bar{x}^2$	Metric
	• Statistical Distribution: Standard Deviation	$\sigma = \sqrt{\frac{1}{n} \sum_{i=1}^n (x_i - \bar{x})^2}$	Metric
Bivariate[DUR01]	• Correlation Coefficient: Pearson's product-moment coefficient	$s_{xy} = \frac{1}{n-1} \sum (x_i - \bar{x})(y_i - \bar{y})$ $r = \frac{s_{xy}}{s_x \cdot s_y}; \quad -1 \leq r \leq 1$	Both variables are metrically-scaled X and Y are normally distributed
	• Correlation Coefficient: Spearman's rank correlation coefficient	$R = 1 - \frac{6 \sum d_i^2}{n \cdot (n^2 - 1)}$ $d_i = \text{Difference of pair on rank } i$	At least one variable is ordinal-scaled
	• Difference Hypotheses t-Test for Mean Value Comparison		

**Table 4-2: Categories for Statistical Analysis Procedures**

Defined hypotheses mainly refer to the bivariate procedures that analyse correlations. They statistically evaluate the relationship between two variables in order to gain insights in the causal relationships that may exist between them. In this way the analysis aims to reveal that a certain variable “A” is related to another variable “B”. In this sense one class of applied hypotheses are so called coherence-hypotheses. Other evaluations aim to reveal the difference between certain key figures. For this purpose so called difference-hypotheses are defined.

The statistical outcome, that verifies the hypotheses, is evaluated by means of statistical test values. These are compared with limit values, so called levels of significance. The fact that hypothesis-tests are merely based on a sample implies the possibility of a wrong decision. Nevertheless, the test result determines the acceptance or rejection of a hypothesis. Possible errors are:[SCH05]

- Type-1-Error /  $\alpha$  – Error : The Null-hypothesis is rejected, although it is true. The Null-hypothesis is wrongly rejected.
- Type-2-Error /  $\beta$  – Error : The Null-hypothesis is not rejected, although it is false. The Null-hypothesis is wrongly accepted.
- Power =  $1 - P(\beta - \text{Error})$  : The Power of a statistical hypothesis test measures the test’s ability to reject the Null-hypothesis when it is in fact false, i.e. it is the probability to make a correct decision.

Both errors may occur with a certain probability. The analysis aims to keep the probability for the occurrence of the above errors as low as possible. The above mentioned levels of significance are limiting values for the error occurrence. The statistical outcome must not exceed these levels of significance. They are determined as follows:

$P \leq \alpha = 5\% \rightarrow \text{significant}$

$P \leq \alpha = 1\% \rightarrow \text{highly\_significant}$

$P > \alpha = 5\% \rightarrow \text{not\_significant}$

All the presented results are statistically significant, i.e. they fulfil at least the significance level of 0.05. Non significant correlations have been ignored.

The statistical key data have been calculated with SPSS. Diagrams were generated with SPSS and Microsoft Graph. The calculated meaningful key figures are categorised in table 4-3:

Category Variable	Statistical Analysis	Diagrams	Interpretation
Project Success	Mean Value	None	<ul style="list-style-type: none"> <li>• Indicates the mean project success for the workflow-projects within the sample</li> <li>• How have companies succeeded in implementing WFMS on average?</li> </ul>
	Standard Deviation	None	<ul style="list-style-type: none"> <li>• Indicates the average deviation from the mean project success</li> <li>• How has the project success deviated from mean project success?</li> </ul>
	Statistical Distribution of absolute Frequencies	Pie graph	<ul style="list-style-type: none"> <li>• Indicates the frequency for the project success’s parameter values</li> <li>• How many companies within the sample have reached each possible value of the</li> </ul>

Category Variable	Statistical Analysis	Diagrams	Interpretation
Point of Project Termination	Statistical Distribution of absolute Frequencies	Pie graph	<ul style="list-style-type: none"> <li>project success?</li> <li>When have companies within the sample terminated the project?</li> </ul>
Project Objectives' Priority & Project Objectives' Achievement	Mean Value	Net graph Bar graph	<ul style="list-style-type: none"> <li>Indicates the mean importance and achievement of the surveyed project objectives</li> <li>Which objectives are important in workflow projects?</li> <li>Which objectives could be reached in workflow projects?</li> <li>How could the objectives been reached in successful and unsuccessful workflow projects?</li> </ul>
	Standard Deviation	Boxplot	<ul style="list-style-type: none"> <li>Indicates the average deviations from the mean objective priority and achievement</li> <li>Do companies value an objective's priority in a similar way?</li> <li>Have companies achieved the objectives to a rather equally or differentially extent?</li> </ul>
	Statistical Distribution of absolute Frequencies	Bar graph	<ul style="list-style-type: none"> <li>Indicates the frequency for the objectives' parameter values</li> <li>How many companies within the sample have indicated each possible value of the objective's priority and achievement?</li> </ul>
	Correlation coefficient between Project Objectives (Priority)	None	<ul style="list-style-type: none"> <li>Which project objectives were intended in conjunction with other objectives?</li> </ul>
	Correlation coefficient between Project Objectives (Achievement)	None	<ul style="list-style-type: none"> <li>Which project objectives were achieved in conjunction with other objectives?</li> </ul>
	Correlation coefficient between an Objective's Priority and its Achievement	Bar graph	<ul style="list-style-type: none"> <li>Which of the important project objectives were really achieved?</li> <li>Which of the unimportant project objectives were not achieved?</li> </ul>
Project Methodology	Statistical distribution of absolute frequencies	Bar graph	<ul style="list-style-type: none"> <li>Indicates how often a certain project activity was executed in conjunction with the level of achievement for selected project objectives</li> <li>How could a project objective been achieved, if a certain project activity was executed / not executed?</li> </ul>

Category Variable	Statistical Analysis	Diagrams	Interpretation
	Correlation coefficient between project activities and an objective's priority and achievement	None	<ul style="list-style-type: none"> <li>• How was a project objective's priority, if a certain project activity was executed / not executed?</li> <li>• How could a project objective been achieved, if a certain project activity was executed / not executed?</li> </ul>
	Mean Value of an objective's priority and achievement depending on the execution of certain project activities	Boxplot Bar graph	

**Table 4-3: Types of Statistical Analysis**

#### **Reflection of the statistical methodology:**

- It is possible to create a variety of statistical conclusions by executing different analysis procedures particularly by analysing correlations between variables
- Although it seems attractive to correlate each of the investigated variables with each other, the verification should comprise a limited number of significant research hypotheses. This is to avoid spurious correlations and to avoid informational overload.
- A highly sophisticated statistical tool such as SPSS is essential
- A clearly structured research framework that describes the variables and the hypotheses is mandatory
- The entire analysis requires careful planning. Pre-planning needs to include:
  - Research hypotheses and variables (research framework)
  - Questionnaire
  - Statistical Database and wanted statistical key figures
- The questionnaire which has been derived from the hypotheses needs to be directly transferred into a design for the statistical database. The scale of measurement needs to be determined as soon as possible as well as the tool's analysis- and visualisation-features

## 4.2 Research Findings / Achieved Project Success and Project Termination

Just 58.23% of the companies appraise their workflow project to be successful. On the other hand, 82.28% stated that the project was terminated after a successful technical implementation of the workflow application. At first view, these contradictory results might be confusing, but it turns out that companies who indicated 'largely' or 'medium' project success also achieved a successful technical implementation. This outcome shows that a technically implemented workflow application is not the only criterion for a fully perceived project success. Opinions on project success seem to be influenced by project objectives that go beyond a technically executable workflow application. It is assumed that perceived project success is gradually influenced by the achievement of further relevant project objectives. A closer inspection of a workflow project's objectives is therefore undertaken in the next sections.

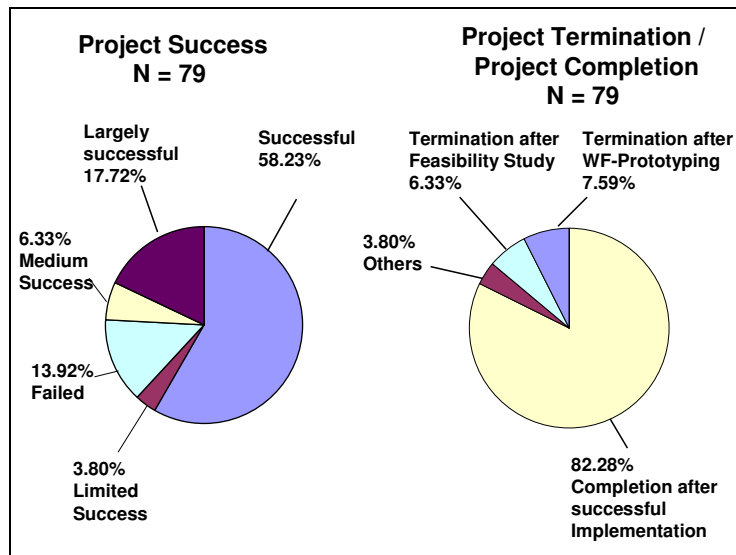


Figure 4-3: Project Success and Project Termination / Completion

However, 13.92% of the projects were judged to have failed and 3.8% of the companies stated a 'limited' success. An analysis of the projects' termination stages shows that 6.33% of the companies cancelled the workflow project after a feasibility study. A further 7.59% implemented a workflow prototype for experimental purposes and then stopped the further implementation. These results are also illustrated in figure 4-3.



### 4.3 Research Findings / Prioritisation and Achievement of Project Objectives<sup>39</sup>

#### 4.3.1 Overall Priority and Achievement of Project Objectives

Firstly, it is important to analyse if companies achieve the stated project objectives. For this, the prioritisation and achievement of the project objectives is compared for companies who successfully finished their project with companies who did not achieve project success.<sup>40</sup> The results are presented in figure 4-4. The diagram indicates that companies who accomplished a successful workflow project achieved the agreed project objectives according to their importance. For them, priorities and achievements of the project objectives are linked, i.e. important objectives were fully achieved whereas objectives of lesser importance gained a lower achievement. By contrast, in unsuccessfully executed workflow projects the objectives were missed. A high deviation between an objective's priority and its achievement was measured for each objective, i.e. even highly prioritised objectives have only been achieved to a limited extent. It seems that companies who executed a successful workflow project were able to manage their project activities in a goal-oriented manner.

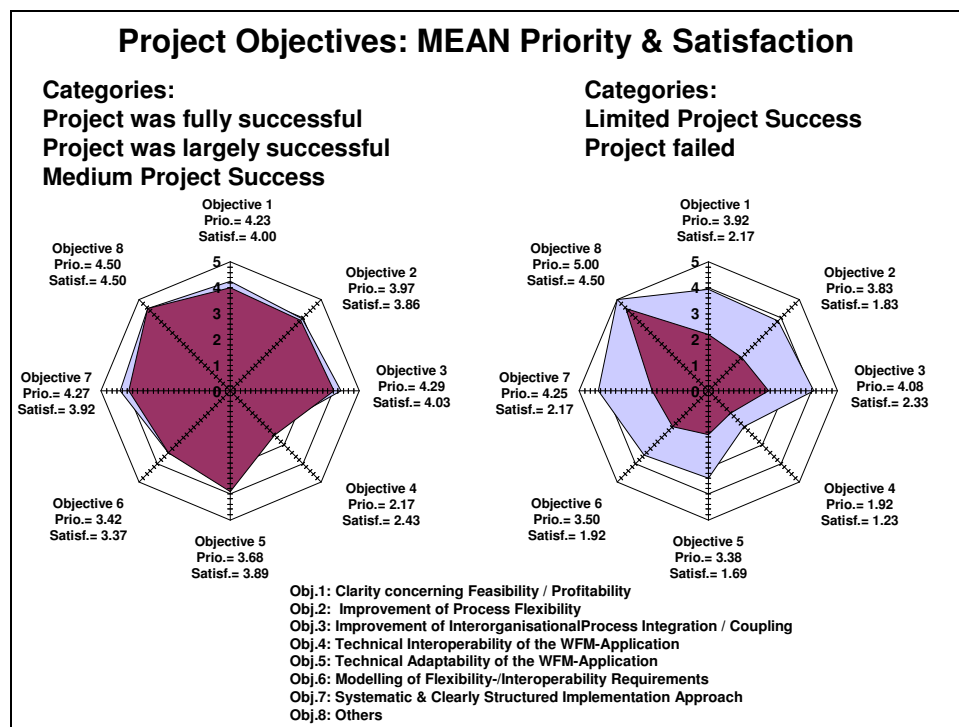


Figure 4-4: Project Objectives depending on the Project Success

The standard deviations reveal a higher scatter for the achievement than for the prioritisation of the objectives. The low scatter for the objectives' prioritisation indicates that the companies appraise the objectives' importance in a similar way, i.e. ratings with regard to each goal hardly diverge for both goals with a high and with a low importance. For the goals' achievement a more differentiated view is presented. Here the higher standard deviation indicates a more distributed response. Hence, one can say that the surveyed achievements for

<sup>39</sup> Categorisations for the project objectives' priorities and degrees of achievement are described in section 4.4.

<sup>40</sup> Successful Projects are classified according to the following categories: "Successful"; "Largely successful"; "Medium Success"

Unsuccessful Projects are classified as follows: "Limited Success"; "Failed"

the project objectives diverge, i.e. the response covers the entire scale between total goal achievement and failure.

In addition to the agreed project objectives the participating companies indicated the following objectives to be relevant for their Workflow projects.

Project Objective No.	Description	Response	Mean Priority	Mean Achievement
1	Increased process coherence / Integration of separated processes and the participating employees	8	4.8	4
2	Documentation and Comprehensibility of Business Processes for management, users, and quality assurance	6	3.8	4.7
3	Automation of Business Processes, e.g. escalation processes Cost Cutting / Improvement of Process Efficiency	6	4.7	4.7
4	Explicit Monitoring and Control of Business Processes	5	4.7	4.2
5	Increased ergonomic / usability of the application	5	4.8	4.8
6	Reduction of cycle times	3	5	4
7	Standardisation of business processes	3	4	4.7
8	Increased customer satisfaction	3	4.7	4.7
9	Elimination of error sources	2	4.5	4
10	Independence of single employees / Flexible team work	2	5	5
11	Technological modernisation / Use of future-oriented technologies	2	5	5
12	Improved system integration	2	5	4.5
13	Delegation of decision-making authority to employees	1	4	4
14	Rapid Prototyping of Business Processes by means of WFMS	1	5	3

**Table 4-4: Miscellaneous Project Objectives**

Although not statistically significant, the most frequently mentioned projects objectives were:

- Increased process coherence or integration of separated processes was evaluated as a very important objective which has been achieved at nearly all times. Inter-organisational coupling of business processes constitutes a more far-reaching stage of extension which gained similar ratings in the survey.
- Documentation and comprehensibility of business processes for management, users, and quality assurance was denoted as an important aim. The companies who stated this

objective always succeeded to achieve comprehensible process documentation as an outcome of the workflow project.

- Automation of processes for increased efficiency and cost cutting was a very important aim which has always been fully achieved.
- Explicit monitoring of process data and the data-based control of processes as well as an increased ergonomics and usability of IT-systems. Both aims have also been achieved by all respondent companies who stated this objective.

#### 4.3.2 Analysis of commonly required Project Objectives

Examining the correlation coefficient between the prioritisation of project objectives allows conclusions to be drawn with respect to the objectives which are linked together within single projects (The Correlations are significant at the 0.01 level / 2-tailed. Correlation coefficients can be found in Appendix A: Statistical Analysis / Table A-4). It was proven that companies who strive for more flexible business processes also appreciate the technical adaptability of the WFM-Application to be a very important aim. Furthermore, these companies also try to depict flexibility aspects within business process models. It also emerged that striving for flexibility aspects within business process models is associated with the objective of technical adaptability of the WFM-application. As these three objectives are related to the higher-ranking objective of improved flexibility for business process control by means of WFM, it can be accepted that they are commonly pursued to reach flexibility in practice.

On the other hand, it was assumed that companies who strive for an improved inter-organisational coupling / integration of business processes would also try to improve the technical interoperability of the WFM-application. Yet, there is no statistical evidence of coherence between these objectives in terms of their prioritisation.

#### 4.3.3 Analysis of commonly achieved Project Objectives

Verifying the correlation coefficients between the data for the achievement of the objectives reveals which goals have been reached together within a single project. For this the observed results are very complex. The data shows that:

(The Correlations are significant at the 0.01 level / 2-tailed. Correlation coefficients can be found in Appendix A: Statistical Analysis / Table A-7)

- Companies who succeed in applying a systematic and clearly structured project approach also achieve almost all the other given project objectives. For instance, these companies also gain clarity concerning the feasibility / profitability of the WF-project. A successfully applied systematic project approach is also associated with improved process flexibility and the implementation of technically adaptable WFM-applications. Also the inter-organisational coupling / integration of business processes cohere with a structured project methodology.
- Considering flexibility aspects within process models reveals that the successful modelling of these aspects relates to the successful improvement of process flexibility and the implementation of adaptable WFM-applications.
- In the same way companies have successfully improved the inter-organisational coupling / integration of business processes in conjunction with the modelling of interoperability aspects within process models. A closer inspection shows that these companies succeed to achieve inter-organisational coupling / integration as well as an improved flexibility of their business processes.

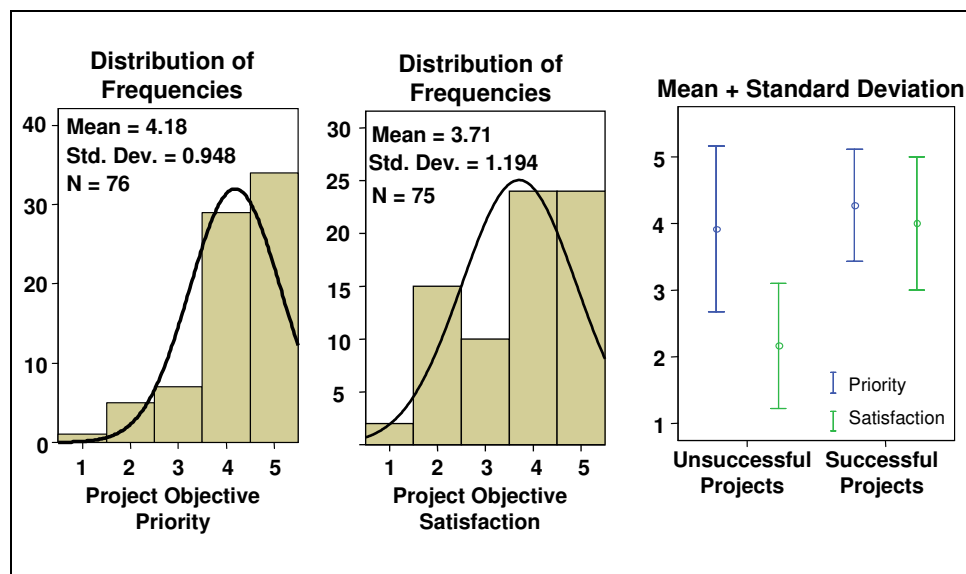
- Companies who successfully implemented adaptable WFM-applications also improved the flexibility of their processes as well as achieving coupled / integrated interoperable business processes.
- Clarity concerning the feasibility and profitability of the WF-project seems to be a precondition for the achievement of the other project objectives. A high degree of clarity shows strong correlation with an achievement of almost all other project objectives. On the other hand, a lack of clarity is associated with a non-achievement of the other objectives.

#### 4.3.4 Findings for Project Objective:

##### Clarity concerning Feasibility / Profitability of the WF-Project

Clarity as a project objective gained high to very high importance and a low standard deviation (see Appendix A: Tables A-3, A-5). This shows that companies consider clarity as an important objective in principle. 92% of the surveyed companies attached a medium, high or even very high importance and merely 8% declared clarity to be not relevant or to be of minor importance.

The average achievement of clarity was high but not very high. Comparing the mean values and the statistical spreads of the goal's achievement and its prioritisation shows that clarity could not be reached to the required degree. 77% of the companies attached a medium, high or even very high goal fulfilment whereas 23% declared total failure or a marginal success for the achievement of clarity.



**Figure 4-5: Project Objective: Clarity concerning Feasibility / Profitability; Descriptive Statistical Data**

Figure 4-5 compares the prioritisation and achievement of the project objective for companies who successfully finished their project with companies who did not achieve project success. Companies who manage their WF-project successfully strive for a high clarity and accomplish clarity (See figure 4-5). These companies are aware of the project's feasibility, its risks and they understand how to implement WF-technology so that they benefit from WF-projects. The statistical spread for the goal priority turns out lower for successful WF-implementations than for unsuccessfully executed WF-projects, i.e. companies with successful projects have a rather high prioritisation for the clarity objective in common (See figure 4-5). The latter also strive for this objective but hardly succeed to achieve sufficient

clarity in their projects. A higher statistical spread for the attached importance refers to the fact that companies with an unsuccessful WF-project have partially rated a low importance for the clarity objective (See Appendix A: Figures A-1, A-3).

The sample reveals that companies who set no great store by clarity had no transparency about the project's feasibility and profitability. None of the companies who rated clarity to be not relevant or to be of minor importance achieved clarity (See Appendix A: Figure A-2). 81% of the companies who attached a high importance to clarity achieved the objective. Yet, the survey yields a medium coherence between the goal's prioritisation and its achievement as 19% of the companies who strove for clarity failed to achieve it (See Appendix A: Table A-6, Figure A-2).

#### 4.3.5 Findings for Project Objective: Improvement of Process Flexibility

Improved flexibility for business processes was deemed an important project objective (see figure 4-6). The survey yielded a comparatively low standard deviation which emphasises that most companies perceive improved business processes as an important outcome of WFM-projects (See Appendix A: Tables A-3, A-5). 89% of the surveyed companies attached a medium, high or even very high importance and just 10% declared improved process flexibility to be not relevant or to be of minor importance. The average attainability of this objective is the median between high and medium, i.e. companies have not improved their processes' flexibility to a high extent on average, though it was rated as an important objective. On closer inspection, one can conclude that companies have not improved process flexibility to the aspired extent. 72% stated a medium, high or very high goal fulfilment whereas 28% declared total failure or a marginal success for the attainment of the wanted process flexibility.

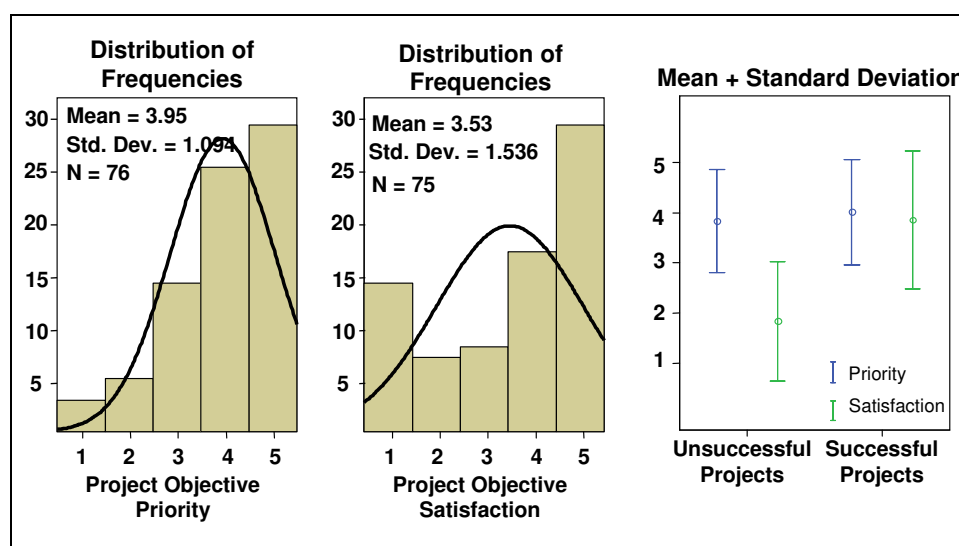


Figure 4-6: Project Objective: Improvement of Process Flexibility; Descriptive Statistical Data

Comparing the objective's prioritisation and achievement for companies who successfully finished their projects with companies who attained no project success shows that only companies who achieve total project success also reach sufficient flexibility for their processes (See figure 4-6; see Appendix A: Figure A-6). These companies gained more flexible business processes by means of the WF-project and are able to adapt them to a frequently changing environment, changing requirements and exceptional situations. The objective's high prioritisation is statistically independent of the project success. Even

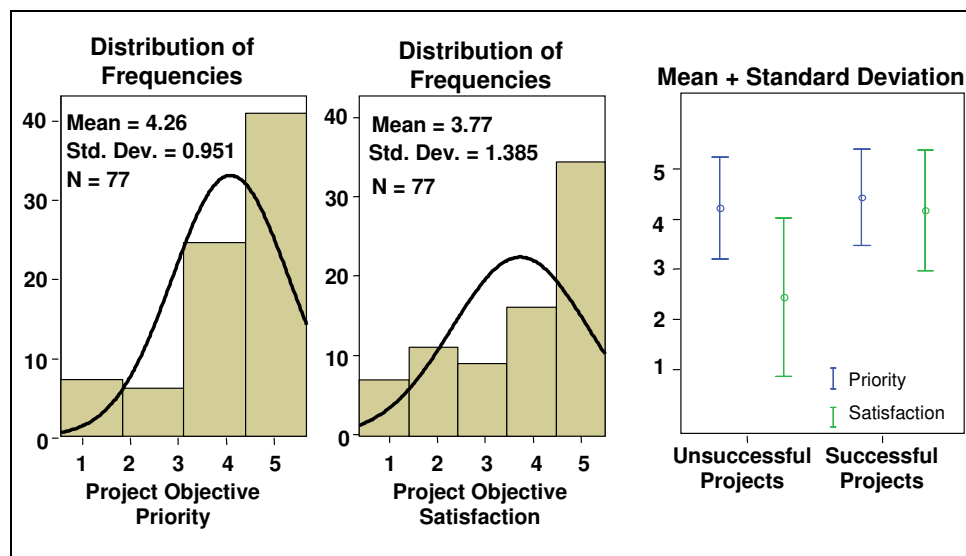
companies without project success have attached a high importance, though they hardly achieve more flexibility (See Appendix A: Figure A-6).

The survey reveals a medium coherence between the goal's prioritisation and its achievement, i.e. companies who perceive more flexible business processes as an important objective do not necessarily accomplish flexibility (See Appendix A: Table A-6). This outcome is due to the fact that companies who attached a low or medium priority to the objective also succeeded in implementing more flexibility. 50% of these companies reached a sufficient flexibility, whereas 22% of the companies who strove for flexibility failed to achieve it (See Appendix A: Figure A-5).

#### 4.3.6 Findings for Project Objective:

##### Improvement of inter-organisational Process Integration / Coupling

The integration of business processes between companies (or the inter-organisational coupling) is rated as an important or even very important objective (See Appendix A: Tables A-3, A-5). The standard deviation is small which indicates that organisational interoperability is considered as an essential goal for WF-projects in general. 91% of the companies in the sample assigned a medium, high or very high importance and merely 9% declared organisational coupling to be not relevant or to be of minor importance. Interoperability could be nearly achieved but it could not be reached to the required degree. 77% of the surveyed companies declared a medium, high or even very high goal fulfilment whereas 23% indicated total failure or a marginal success for the inter-organisational process integration.



**Figure 4-7: Project Objective: Improvement of Process Integration/Coupling; Descriptive Statistical Data**

Organisational interoperability could hardly be achieved by companies who declared no sufficient project success (See Appendix A: Figure A-9: for categories: “Project failed”, “Limited Project Success”, “Medium Project Success”). Companies who manage their WF-projects successfully strive for inter-organisationally integrated business processes and they accomplish this objective (See figure 4-7). These companies alone were able to integrate and couple business processes that cross organisational boundaries or even integrate different companies. The statistical spread for the goal's achievement is ambiguous and does not allow further conclusions to be drawn (See Appendix A: / Figure A-9). Yet, the valuation of organisational interoperability seems not to cohere with the project success. For instance, 84%

of the companies who attached a minor or medium importance to this objective (not relevant, low priority, medium priority) successfully completed their WF-project and 81% of the companies who stated no sufficient project success perceived interoperability as an important or even very important objective for WF-projects (See Appendix A: / Figure A-7, A-8).

It appears that there is a medium coherence between the stated importance of organisational interoperability and its achievement (See Appendix A: / Table A-6, Figure A-8). 81% of the surveyed companies who attached a high or even very high importance have achieved the objective but 19% of them have not adequately integrated inter-organisational business processes. Approximately 50% of the companies who allocated interoperability a low priority have at least achieved a medium success for it.

#### 4.3.7 Findings for Project Objective:

##### Technical Interoperability of the Workflow-Management-Application

As an objective, the technical interoperability of the WFM-Application was of low priority (See Appendix A: Tables A-3, A-5). A medium-rise standard deviation and a cascading distribution of frequencies show that most companies perceive the realisation of technical interoperability for WFM-applications as not an important outcome of WFM-projects (See Figure 4-8). Just 38% of the surveyed companies attached a medium, high or even very high importance and remarkably 62% declared technical interoperability to be not relevant or to be of minor importance. Therefore, technical interoperability seems not to be a desirable objective in spite of the fact that companies strive for inter-organisational process coupling (See Figure 4-7).

Technical interoperability of WFM-applications could hardly be achieved on average. 36% of the surveyed companies attached a medium, high or even very high goal fulfilment whereas 64% declared total failure or a marginal success for the goal's achievement. 16% indicated full achievement of technical interoperability. A comparison of the mean values shows that that the average achievement of technical interoperability exceeds its prioritisation. This could not be established for any of the other examined project objectives. Measurements of a comparatively high standard deviation and a view on the frequency scale show that 50% of the companies could not attain technical interoperability at all. Though, there is no descending frequency scale for higher rated goal achievements.

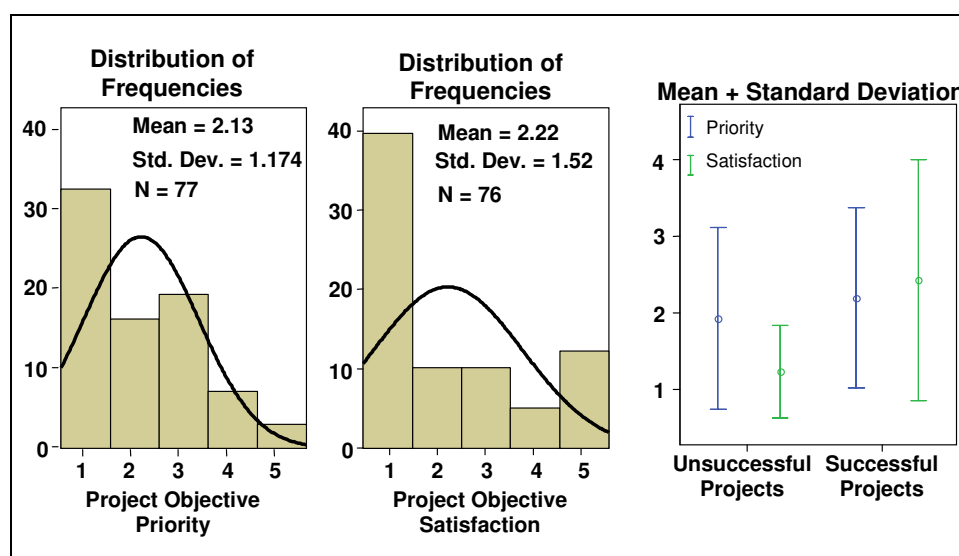


Figure 4-8: Project Objective: Technical Interoperability of the WFM-Application; Descriptive Statistical Data

The objective's low prioritisation is independent of the companies' overall project success. The low average priority was attached by companies who indicated successful completion as well as by companies whose WF-projects failed, i.e. companies barely aimed for the integration and coupling of different heterogeneous WFM-applications in general. Almost total failure for the achievement of interoperability was measured for unsuccessful projects. Equally, interoperability could hardly be attained in successful WF-projects. A comparatively low standard deviation for unsuccessful projects shows that interoperability could generally not be achieved in this category. In contrast, a high statistical spread for successful projects points to the fact that 22% of these companies could achieve sufficient technical interoperability (See Figure 4-8; See Appendix A: / Figure A-11, A-12).

The survey discloses a higher-than-average coherence between the goal's prioritisation and its achievement. 90% of the companies who did not strive for technical interoperability of their WFM-applications were not able to couple different WFM-applications, whereas the other 10% have successfully integrated heterogeneous WFM-applications. Considering the companies who aimed for technical interoperability, one can conclude that 80% of them achieved this objective (See Appendix A: / Figure A-10, A-11).

#### 4.3.8 Findings for Project Objective:

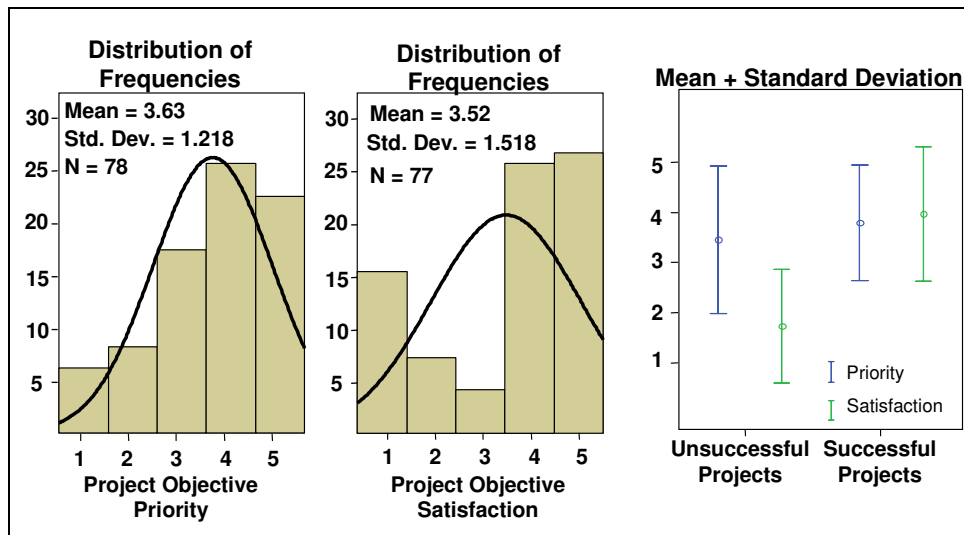
##### Technical Adaptability of the Workflow-Management-Application

The technical adaptability of the WFM-application gained a nearly high importance (See Appendix A: Tables A-3, A-5). A medium-rise standard deviation and a cascading frequency scale show that adaptability is a generally important objective. 82% of the surveyed companies attached a medium, high or very high importance, and 18% declared adaptability to be not relevant or to be of minor importance.

The average attainability of this objective is the median between high and medium, i.e. companies have not improved their WFM-systems adaptability to a high extent on average, though it was rated as a nearly important objective. By comparison of the mean values and the distribution of frequencies one can conclude that WF-projects did not provide WFM-applications that are as adaptable as desired. 71% of the surveyed companies declared a medium, high or very high goal fulfilment whereas 29% declared total failure or a marginal success for the achievement of technical adaptability. The frequency scale does not show the usual cascading increase for the goal achievement in higher rating categories (See figure 4-9). The medium goal achievement gained the least response, i.e. technical adaptability was either achieved or it was not achieved.

Figure 4-9 indicates that successful companies strive for adaptable WF-systems and they succeed to achieve the wanted technical adaptability (See figure 4-9). These companies have realised a flexible WFM-application that is rapidly adaptable to changing business processes. Adaptability gained a slightly lower importance in unsuccessful projects, but here it was hardly achieved. A more differentiated analysis reveals that only companies who reached maximum project success achieved a high or very high technical adaptability (See Appendix A: / Figure A-15). In contrast, nearly successful WF-implementations only achieved medium goal fulfilment. Analysing the data the other way around shows that companies with a medium, high or total realisation of adaptability state total project success, i.e. the project is also perceived to be successful if adaptability is only implemented to medium extent (See Appendix A: / Figure A-13).





**Figure 4-9: Project Objective: Technical Adaptability of the WFM-Application; Descriptive Statistical Data**

The correlation between the valuations for the objective's priority and its achievement was below average (See Appendix A: / Table A-6). 74% of the companies who attached a high or even very high importance to adaptability achieved the objective, whereas 26% of the companies who strove for technical adaptability failed to achieve it (See Appendix A: Figure A-14). On the other hand, 35% of companies who did not strive for adaptability realised a technically adaptable WFM-application.

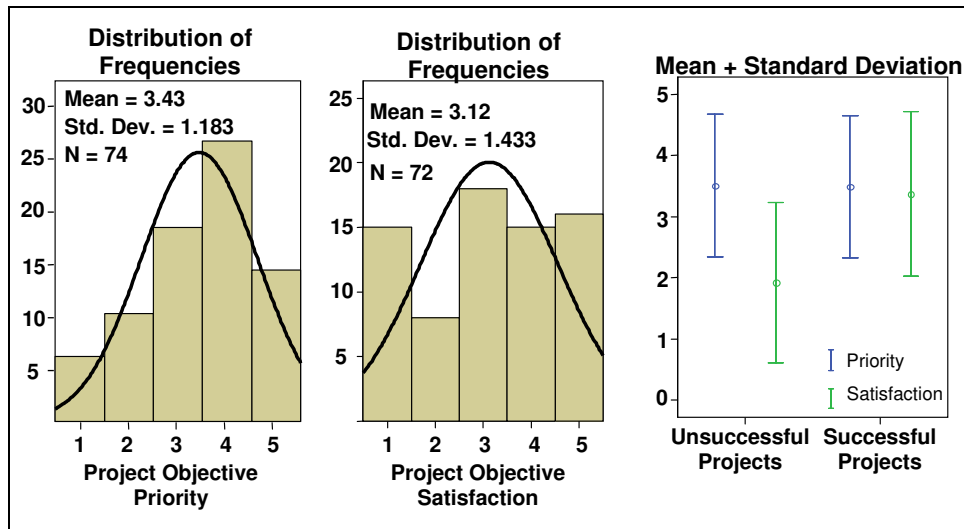
#### 4.3.9 Findings for Project Objective: Modelling of Flexibility / Interoperability Aspects

The surveyed companies attached medium importance to this objective or more precisely the statistical importance is the median between a medium and a high priority (See Appendix A: Tables A-3, A-5). A medium-rise standard deviation and a cascading frequency scale depict that this kind of process model is perceived as a rather medium important objective (See figure 4-10). 54% of the companies in the sample assigned a high or very high importance and 22% declared flexibility/interoperability aspects in process models to be not relevant or to be of minor importance. The medium priority was indicated by 24% of the companies.

As expected, flexibility/interoperability aspects as part of business process models could only be achieved to a medium extent on average. 43% of the companies in the sample stated a high or even very high achievement, whereas 32% reported total failure or marginal success for the depiction of flexibility/interoperability aspects. 25% indicated a medium goal fulfilment.

The medium goal prioritisation is independent of the project's degree of success. However, a more differentiated view on the goal's achievement reveals that only companies who finished their projects with total success also developed process- and workflow-models that sufficiently depicted all flexibility and interoperability aspects for the final WF-application (See Appendix A: Figure A-18). Projects which were nearly successful barely achieved a medium fulfilment. From a medium project success down to project failure, process models were hardly created. The statistical spread for the goal's achievement is ambiguous and does not allow further conclusions to be drawn (See Appendix A: Figure A-18). On closer inspection of the companies who terminated the project without success, one can discover that

these companies have attached a high or very high importance to this objective but failed to achieve it (See Appendix A: Figure A-16).



**Figure 4-10: Project Objective: Modelling of Flexibility / Interoperability Aspects; Descriptive Statistical Data**

The survey discloses a medium coherence between the goal's prioritisation and its achievement (See Appendix A: Table A-6). 72% of the companies who assigned a medium importance also achieved the objective to a medium extent. 67% of the companies who strove for such process-/workflow-models were able to create them, whereas 25% of them have not successfully depicted flexibility-/interoperability aspects within process models. Considering the companies who have not aspired for the objective, one can conclude that 13% of them achieved this objective, whereas 67% did not (See Appendix A: Figure A-16, A-17).

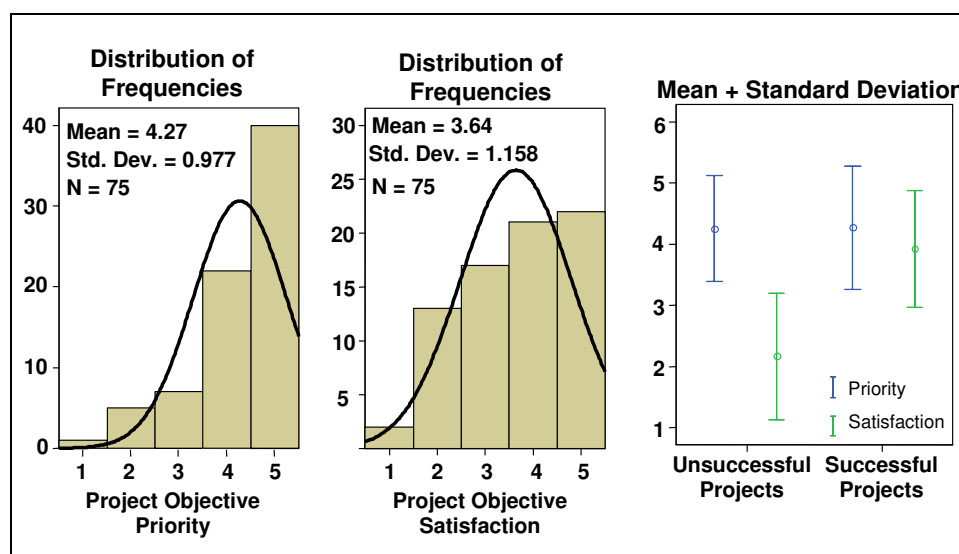
#### 4.3.10 Findings for Project Objective:

##### Systematic / Clearly structured Implementation Approach

A systematic and clearly structured project methodology averaged out as an important objective. The mean value for the objective's importance slightly exceeds the high priority valuation (See Appendix A: Tables A-3, A-5). The standard deviation is small which suggests that a systematic project methodology is considered as an essential goal for WF-projects in general. 92% of the companies in the sample assigned a medium, high or very high importance and merely 8% declared a clearly structured implementation approach to be not relevant or to be of minor importance. This objective could not be reached to the wanted degree, as the mean value is centred between a medium and a high goal fulfilment. 80% of the surveyed companies declared a medium, high or very high goal fulfilment, whereas 20% indicated total failure or a marginal success for the successful application of a systematic project methodology. (Total failure only amounts to 3%).

Companies generally pay high attention to the degree of structure in the implementation approach. All companies strove for systematic project methodology regardless of project success (See Appendix A: Figure A-21). On the other hand, the quality of a clear project methodology matures with increasing overall project success. Only companies who finished their projects with total success stated that they applied a systematic and clearly structured project methodology that avoided analysis-, design-, and implementation errors (See Appendix A: Figure A-21). Projects which were nearly successful barely achieved a medium

fulfilment. Companies who gained no project success stated that they had not applied a structured project methodology. On closer inspection of the companies who terminated the project without success one can discover that these companies attached a high or very high importance to this objective but failed to achieve it (See Appendix A: Figure A-19).



**Figure 4-11: Project Objective: Systematic / Clearly structured Implementation Approach; Descriptive Statistical Data**

The correlation between the valuations for the objective's priority and its achievement was low (See Appendix A: Table A-6). Only 63% of the companies who attached a high or very high importance to the project methodology achieved the objective, whereas 18% of the companies failed to achieve it (See Appendix A: Figure A-14). On the other hand, 16% of the companies who allocated a low importance to the implementation approach indicated that they applied a nearly well structured project methodology (nearly achievement of the objective). A sufficient project methodology was only applied by companies who attached a high and very high importance to it. None of these companies have totally missed the objective.

#### 4.4 Research Hypotheses and Findings / Project Methodology

The statistical outcome for the project methodology describes the impact that surveyed aspects of the project methodology have on the goal fulfilment. The outcome of the statistical analysis and most charts are presented in Appendix A. The following sections summarise significant findings by means of the generic table structure described in table 4-5.

Surveyed Aspect of the Methodology	Correlation Coefficient	Objective Achievement		Objective Priority	
		Applied	Not Applied	Applied	Not Applied
Aspect	Strength of the correlation	Degree of Fulfilment	Degree of Fulfilment	Degree of Importance	Degree of Importance

Table 4-5: Table Structure Definition for Hypotheses

##### Column: Surveyed Aspect of the Methodology

This column refers to the project activity for which a significant correlation with a project objective has been measured. Project activities that have a no or a low influence on project objectives are indicated but not described in-depth. Correlations without significance are ignored.

##### Column: Correlation

The strength of the impact that an aspect of the project methodology has on a project objective is described by using the following value ranges [COH01]:

- Correlation Coefficient: 0.0 to 0.0999999 No Coherence
- Correlation Coefficient: 0.0 to -0.0999999 No Coherence
- Correlation Coefficient: 0.1 to 0.2999999 Small Coherence (red colour code)<sup>41</sup>
- Correlation Coefficient: -0.1 to -0.2999999 Small Coherence (red colour code)
- Correlation Coefficient: 0.30 to 0.4999999 Medium Coherence (yellow colour code)
- Correlation Coefficient: -0.30 to -0.4999999 Medium Coherence (yellow colour code)
- Correlation Coefficient: 0.50 to 1.0 Strong Coherence (green colour code)
- Correlation Coefficient: -0.50 to -1.0 Strong Coherence (green colour code)

##### Columns: Objective Achievement / Applied / Not Applied

These two columns describe a project objective's mean degree of fulfilment in comparison for both cases, namely that a surveyed aspect of the project methodology was applied or not applied. Used value ranges:

- Mean Objective Achievement: 1 to 1.5 Not Achieved
- Mean Objective Achievement: 1.51 to 2.5 Hardly Achieved
- Mean Objective Achievement: 2.51 to 3.5 Medium Achievement
- Mean Objective Achievement: 3.51 to 4.5 Nearly Achieved
- Mean Objective Achievement: 4.51 to 5 Fully Achieved

##### Columns: Objective Priority / Applied / Not Applied

These two columns describe the mean priority of a project objective that was attached by the companies in the sample. An objective's priority is compared as follows: priority that was

<sup>41</sup> This colour code is used in Appendix A to differentiate the strength of coherence between variables.

attached by companies who applied (respectively not applied) the surveyed aspect of the project methodology. Used value ranges:

- Mean Objective Priority: 1 to 1.5 Not Relevant
- Mean Objective Priority: 1.51 to 2.5 Low Priority
- Mean Objective Priority: 2.51 to 3.5 Medium Priority
- Mean Objective Priority: 3.51 to 4.5 High Priority
- Mean Objective Priority: 4.51 to 5 Very High Priority

#### 4.4.1 Hypothesis 1: Process Selection (A2) – Clarity (O1)

“A criteria-based identification and selection of business process candidates (A2) helps to reveal findings concerning the feasibility / profitability of the workflow project (O1)”

The hypothesis has been confirmed, i.e. the early availability of findings concerning the profitability and feasibility of the WF-project can be fostered by a careful and systematic identification and selection of workflow-relevant business processes. The survey revealed that the following significant selection criteria impact the objective (See table 4-6).

Selection Criterion for Business Processes	Strength of Coherence	Mean Objective Achievement		Mean Objective Priority	
		Applied	Not Applied	Applied	Not Applied
Strategic Importance	Medium	n.a.	n.a.	n.a.	n.a.
Process Structuredness	Medium	Nearly	Medium	High	High
Relative Process Costs	Medium	Nearly	Medium	High	High
Quality of IT-Support	Medium	Nearly	Medium	High	High
Flexibility	Medium	Nearly	Medium	High	High
Requirements of a Business Process					
Interoperability	Medium				
Requirements					
A Process's supposed Optimisation needs	Strong	Nearly	Medium	High	High

**Table 4-6: Findings for the Coherence: Process Selection (A2) – Clarity (O1)**

A closer view on the surveyed aspects shows that a process's optimisation needs served as the most effecting selection criterion to achieve early clarity in the WF-project. 68% of the companies in the sample stated use this criterion for the identification and selection of WF-relevant business processes (See Appendix A: Figure A-28; Table A-15). 82% fully achieved or nearly achieved early insights in the feasibility and profitability of the WF-project.

The study also revealed that flexibility- and interoperability requirements, quality of IT-support, relative process costs, and a process's structuredness and strategic importance had a medium impact on the achievement of a higher clarity. Nevertheless, companies who applied these criteria nearly achieved or fully achieved the clarity objective, whereas companies who neglected such a criteria-based process selection solely indicated medium success for sufficient clarity (See table 4-6).

An examination of the attached priorities shows that companies always attached a high importance to the early availability of feasibility / profitability knowledge even those that do not systematically select project relevant business processes on a criteria basis.

The following aspects of a business process have not been proven to be useful selection criteria for the identification of relevant business process candidates in order to gain findings concerning the feasibility and profitability of the WF-project:

- Customer Value
- Repetition Frequency

#### 4.4.2 Hypothesis 2: Process Analysis (A3) – Clarity (O1)

“An adequate scope of the business process analysis (A3) reveals findings concerning the project’s profitability and the project’s feasibility (O1).”

The survey confirmed the hypothesis, i.e. analysing certain aspects of a business process leads to more valuable insights in the WF-project’s feasibility and profitability. The survey revealed that the following significant analysis aspects impact the objective (See table 4-7).

Aspects/Scope of the Business Process Analysis	Strength of Coherence	Mean Objective Achievement		Mean Objective Priority	
		Applied	Not Applied	Applied	Not Applied
Process Flow	Medium				
Organisation.	Medium				
Responsibilities					
Process Costs	Medium	Nearly	Medium	High	High
Flexibility / Adaptation	Strong	Nearly	Medium	High	High
Needs					
Separation of Standard Processes and Exception Variants	Strong	Nearly	Medium	High	High
Inter-/Intraorganisational	Medium				
Coupling of Processes					
Process Weak Points	Medium	Nearly	Medium	High	High

**Table 4-7: Findings for the Coherence: Process Analysis (A3) – Clarity (O1)**

A separation of standard processes and exception variants has the strongest impact on the fulfilment of the clarity objective. 49% of the surveyed companies have separated standard processes and exception variants as part of the process analysis (See Appendix A: Figure A-32; Table A-21). It is a notable outcome that 95% of these companies have gained the demanded findings concerning feasibility and profitability to a sufficient extent.

Other relevant analysis aspects were a process’s flow and its organisational responsibilities, process costs, flexibility / adaptation needs, and process weak points. An analysis of these aspects had a medium influence on the fulfilment of early clarity. Particularly process weak points were a prominent analysis aspect, as 61% of all companies have analysed such weak points. 78% of the companies who analysed critical points have gained sufficient findings (fully achieved) concerning feasibility and profitability of the WF-project (See Appendix A:

Figure A-34; Table A-23). On average one can conclude that companies who analysed the above mentioned aspects of business processes nearly fully achieved the clarity objective. By contrast, companies who avoided such a process analysis merely indicated a medium achievement of clarity.

Ratings for the objective's priority do not differ for companies who executed an aspect based process analysis. All companies stated clarity to be of high importance.

Analysing the quality of the IT-support for a business process has not been proven to be a useful analysis criteria to gain early findings concerning the feasibility and profitability of a WF-project.

#### 4.4.3 Hypothesis 3: Process Optimisation (A4) – Clarity (O1)

“An appropriate scope of the business process optimisation which focuses on efficiency gains and the elimination of weak points helps to reveal the workflow project's profitability (O1) and the organisational feasibility (O1).”

The statistical outcome has corroborated the hypothesis, i.e. the execution of a business process optimisation with a focus on the elimination of weak points and the achievement of time / cost savings helps to yield knowledge about the profitability and feasibility of the WF-project. The survey revealed that two significant optimisation criteria impact the objective (See table 4-8).

Aspects/Scope of the Bus.Process Optimisation	Strength of Cohesion	Mean Objective Achievement		Mean Objective Priority	
		Applied	Not Applied	Applied	Not Applied
Efficiency Gains (Time & Cost Savings)	Strong	Nearly	Hardly	High	High
Elimination of Weak Points	Medium	Nearly	Hardly	High	High

**Table 4-8: Findings for the Coherence: Process Optimisation (A4) – Clarity (O1)**

An efficiency focused optimisation has the strongest cohesion with the clarity objective. 84% of the companies claimed to have optimised processes in light of time and cost savings (See Appendix A: Figure A-36; Table A-25). There are nevertheless 75% of these companies who indicated a sufficient fulfilment for the clarity objective, which amounts to a nearly achievement on average. By contrast, companies who did not optimise business processes hardly achieved sufficient insights in the project's feasibility and profitability (see table 4-8).

The elimination of weak points as part of a process optimisation influences the clarity objective to a medium extent. 74% of the companies who optimised processes in light of their weak points accomplished sufficient clarity (nearly achievement). The sample shows that 82% of the companies attempted to eliminate process weak points (See Appendix A: Figure A-38; Table A-27).

The early availability of feasibility / profitability knowledge is always rated as an objective of high importance. Different prioritisations depending on the applied optimisation approach were not established.

It was not part of the study to survey the optimum time for an optimisation in the project life-cycle. However, it is assumed that early clarity is fostered by early process optimisation.

#### 4.4.4 Hypothesis 4:

##### System Selection / Vendor Workshops (A5) – Clarity (O1)

“Requirements- and gap-analysis workshops with WFMS-vendors lead to findings concerning the technical feasibility and the profitability of the workflow project (O1).”

The hypothesis has been corroborated, i.e. the early availability of findings concerning the profitability and feasibility of the WF-project can be fostered by executing requirements- and gap-analysis workshops with WFMS-vendors. Table 4-9 shows the significant data.

Measures of the WFMS Selection Process	Strength of Coherence	Mean Objective Achievement		Mean Objective Priority	
		Applied	Not Applied	Applied	Not Applied
Workshops with WFMS Vendors	Medium	Nearly	Medium	High	High

**Table 4-9: Findings for the Coherence: System Selection / Vendor Workshops (A5) – Clarity (O1)**

The execution of vendor workshops contributes to a medium extent to the achievement of early clarity. This is a surprising result, as a strong coherence was the expected outcome. 49% of the companies in the sample conducted workshops with WFMS-vendors (See Appendix A: Figure A-40; Table A-30). 85% stated that findings concerning the feasibility and the profitability have fully or nearly been achieved. A nearly fulfilment has been measured on average for those companies who executed vendor workshops, whereas companies who forgo such workshops indicated medium clarity. Nevertheless, all companies stated the clarity objective to be of high importance regardless of the execution of workshops with WFMS-vendors (See table 4-9).

#### 4.4.5 Hypothesis 5: Feasibility Study (A7) – Clarity (O1)

“The execution of a feasibility study (A7) helps to reveal findings concerning the feasibility and the profitability of the workflow project (O1).”

The survey confirmed the hypothesis, i.e. a feasibility study yields valuable insights in the WF-project’s feasibility and profitability. Table 4-10 shows the significant topics of a feasibility study that impact the objective.

Aspects/Scope of the Feasibility Study	Strength of Coherence	Medium Objective Achievement		Medium Objective Priority	
		Applied	Not Applied	Applied	Not Applied
Project Costs / Profitability	Strong	Nearly	Medium	High	High
WFM Ability of BPs	Medium	Nearly	Medium	High	High
Adaptability/Flexibility of the WFM Application	Strong	Nearly	Medium	High	High



Aspects/Scope of the Feasibility Study	Strength of Coherence	Medium Objective Achievement		Medium Objective Priority	
		Applied	Not Applied	Applied	Not Applied
Exception Handling Requirements	Medium	Nearly	Medium	High	High
Organis. Interoperability Requirements	Medium				
A Feasibility Study has been executed	Strong	Nearly	Hardly	High	High

**Table 4-10: Findings for the Coherence: Feasibility Study (A7) – Clarity (O1)**

The analysis shows that the execution of a feasibility study strongly coheres with the clarity objective. 83% of the companies executed a feasibility study. 73% of these companies succeeded in providing the required information concerning feasibility and profitability of the WF-project (See Appendix A: Figure A-48; Table A-39). 75% of the companies who did not conduct a feasibility study failed to achieve the clarity objective. This amounts to a hardly goal fulfilment on average for these companies. All companies attached a high priority to the achievement of early clarity.

Further analysis shows that a cost-benefit analysis served as the most effecting object of investigation to achieve clarity in a WF-project. 66% of the surveyed companies analysed costs and benefits of a WF-project as part of a feasibility study. 84% of these companies gained the wanted profitability findings (See Appendix A: Figure A-42; Table A-33). Merely 2% of the companies who analysed costs and benefits hardly achieved profitability insights.

The study also revealed that the workflow-management-ability of business process candidates, flexibility- and adaptability requirements, and exception handling requirements were relevant topics for a feasibility study with a medium impact on the fulfilment of the clarity objective. The latter were indicated by companies who have also rated process flexibility and adaptability of WFM-application as important project objectives. A consideration of exception handling requirements was made by 63% of the companies (See Appendix A: Figure A-46; Table A-37). 47% of the companies also analysed flexibility- and adaptability requirements as part of the feasibility study (See Appendix A: Figure A-44; Table A-35).

The following subjects have not been proven to be useful objects of investigation in a feasibility study in order to gain insights into the feasibility and profitability of a WF-project (See Appendix A: Table A-32):

- User Acceptance
- Technical Interoperability

#### 4.4.6 Hypothesis 6: Prototyping (A8) – Clarity (O1)

“Early Prototyping helps to gain findings concerning the project’s feasibility (O1).”

The survey has confirmed the hypothesis, i.e. early prototyping leads to a better understanding of the WF-project’s feasibility. Table 4-11 indicates the significant data.

Activity	Strength of Coherence	Mean Objective Achievement		Mean Objective Priority	
		Applied	Not Applied	Applied	Not Applied
Early Prototyping	Medium	Nearly	Medium	High	High

**Table 4-11: Findings for the Coherence: Prototyping (A8) – Clarity (O1)**

Early prototyping has a medium coherence with the clarity objective. 23% of the companies who achieved or nearly achieved clarity did not prototype a WFM-application, and 84% of the companies who developed a WFM-prototype gained sufficient insights in the WF-project's feasibility (See Appendix A: Figure A-50). Companies could nearly acquire the relevant feasibility findings if they had prototyped the WFM-application (nearly achievement), in contrast to companies who did not use prototyping. The latter only achieved a medium clarity. All companies attached a high priority to the achievement of early clarity (See table 4-11).

#### 4.4.7 Hypothesis 7: Modelling Methodology (A1) – Process Flexibility (O2)

“Modelling flexibility aspects is a prerequisite for flexible business process support”

The hypothesis has been corroborated, i.e. flexible business processes that are adaptable to a frequently changing environment, changing requirements and exceptional situations can be better achieved if business process- and workflow models depict flexibility aspects (See table 4-12).

Aspects/Objects of the Modelling Methodology	Strength of Coherence	Mean Objective Achievement		Mean Objective Priority	
		Applied	Not Applied	Applied	Not Applied
Process Exceptions	Medium	Nearly	Medium	High	High
Process Variants / Flexibility Aspects	Strong	Fully	Hardly	High	High

**Table 4-12: Findings for the Coherence: Modelling Methodology (A1) – Process Flexibility (O2)**

A closer view on the modelling approach shows that the differentiated depiction of process variants / flexibility aspects are the most effecting modelling objects to achieve improved process flexibility. 47% of the companies in the sample tried to depict such flexibility aspects as part of their process models (See Appendix A: Figure A-52; Table A-45). 88% of these companies achieved or nearly achieved improved process flexibility which amounts to a total fulfilment on average. All companies who did not yield an improved flexibility neglected a respective modelling of process variants and flexibility aspects. Neglecting process variants and flexibility aspects in process models hardly lead to improved process flexibility (hardly achievement).

The modelling of process exceptions has a medium influence on the achievement of more flexible processes (See table 4-12). Companies who depicted such exceptions nearly improved the aspired process flexibility. All companies who did not gain more flexible processes also ignored process exceptions. 43% of the companies declared that process exceptions were part of the modelling approach (See Appendix A: Figure A-54; Table A-47).

84% of them successfully improved the process' flexibility. This amounts to a nearly fulfilment of the objective on average.

A crosscheck with the impact of the process analysis approach on the flexibility objective confirms that process variants and flexibility aspects are crucial. It seems that these aspects need to be considered continuously in the project life-cycle.

#### 4.4.8 Hypothesis 8: Process Selection (A2) – Process Flexibility (O2)

“Selecting business process candidates by means of their flexibility requirements (A2) helps to improve the processes' flexibility (O2).”

The statistical data corroborated the hypothesis, i.e. the consideration of flexibility requirements as a criterion for the selection of business processes, that are relevant for the workflow project, helps to achieve an improved flexibility for the selected business processes. The survey revealed that the significant selection criterion in table 4-13 impacts the objective.

Selection Criterion for Business Processes	Strength of Coherence	Mean Objective Achievement		Mean Objective Priority	
		Applied	Not Applied	Applied	Not Applied
Flexibility Requirements of a Business Process	Strong	Fully	Medium	Very High	High

**Table 4-13: Findings for the Coherence: Process Selection (A2) – Process Flexibility (O2)**

Flexibility Requirements were used as a criterion for business process selection by 34% of the companies. 65% did not consider this criterion (See Appendix A: Figure A-56; Table A-51). It is a remarkable outcome that companies who did not achieve or hardly achieved more flexible processes, did not select processes by means of their flexibility requirements (95% of the companies, who did not achieve the objective, have also not considered flexibility requirements). Companies who regarded this criterion have almost nearly or totally realised process flexibility (92% of the companies, who considered flexibility requirements, have totally or nearly achieved the objective). On the other hand, process flexibility could be reached without a flexibility based process selection activity (47% of the companies, who totally or nearly achieved the objective, have not considered flexibility requirements).

An examination of the attached priorities shows that companies always attached a high importance to the implementation of more flexible business processes.

#### 4.4.9 Hypothesis 9: Process Analysis (A3) – Process Flexibility (O2)

“Analysing a business process's flexibility aspects (A3) uncovers potential fields for an improvement of a process's flexibility and thus leads to an amended flexibility (O2).”

The study's outcome provided evidence for the hypothesis, i.e. an analysis of flexibility and adaptation requirements as well as a separation of standard processes and exception variants as part of a process analysis help to gain more flexible business processes. The study yielded the following significant results for both analysis criteria (See table 4-14).

Aspects/Scope of the Business Process Analysis	Strength of Coherence	Mean Objective Achievement		Mean Objective Priority	
		Applied	Not Applied	Applied	Not Applied
Flexibility / Adaptation Needs	Strong	Nearly	Medium	High	Medium <sup>42</sup>
Separation of Standard Processes and Exception Variants	Medium	Nearly	Medium	High	High

**Table 4-14: Findings for the Coherence: Process Analysis (A3) – Process Flexibility (O2)**

The analysis aspect of flexibility requirements has the strongest correlation with the flexibility objective. 70% of the projects with successfully flexibilised processes systematically analysed respective requirements (See Appendix A: Figure A-63; Table A-58). A neglect of this analysis aspect was associated with a failure of the objective for 51% of the companies. Note that almost all companies who failed to achieve more flexible business processes have not analysed flexibility requirements. The survey provided similar results for the second relevant aspect, namely the systematic separation of standard processes and exception variants (See Appendix A: Figure A-64; Table A-60). Process flexibility was mostly rated as an objective of high importance.

#### 4.4.10 Hypothesis 10: Implementation Process /

##### Consolidation of Proj. Deliverables (A8) – Process Flexibility (O2)

“A consolidation business process models and workflow models in light of flexibility aspects (A8) facilitates the consideration of flexibility requirements throughout the implementation process and improve flexibility in the end (O2).”

The study has confirmed the hypothesis and provided the following results (See table 4-15).

Activity	Strength of Coherence	Mean Objective Achievement		Mean Objective Priority	
		Applied	Not Applied	Applied	Not Applied
Consolidated Business Processes and Workflow-related Project Activities	Strong	Nearly	Hardly	High	High

**Table 4-15: Findings for the Coherence: Implementation Process (A8) – Process Flexibility (O2)**

Nearly Two-thirds of the companies in the survey tried to consolidate project deliverables. 80% of these companies succeeded to achieve improved flexibility for their business processes (See Appendix A: Figure A-66; Table A-63). 60% of the companies who have not harmonised their project activities and deliverables failed to reach the flexibility objective. An overall hardly goal fulfilment was measured for these companies. Nevertheless, process flexibility was rated as an important objective by all companies.

<sup>42</sup> The value has slightly missed the threshold for the “High” valuation by 0.04

#### 4.4.11 Hypothesis 11:

##### Process Optimisation (A4) – Process Flexibility (O2)

“An appropriate scope of the business process optimisation (A4) which concentrates on process flexibility yields an improved adaptability of the considered business processes (O2).”

This hypothesis has been clearly confirmed, i.e. taking action in focussed flexibility improvements helps to gain more flexible business processes that are adaptable to changing requirements. The following significant findings were obtained (See table 4-16).

Aspects/Scope of the Bus.Process Optimisation	Strength of Coherence	Mean Objective Achievement		Mean Objective Priority	
		Applied	Not Applied	Applied	Not Applied
Improvement of Process Flexibility	Strong	Fully	Medium	Very High	High

**Table 4-16: Findings for the Coherence: Process Optimisation (A4) – Process Flexibility (O2)**

The objective attracted high attention in general. Companies who optimised their processes in light of flexibility requirements have even attached a very high importance to an improved process flexibility (see table 4-16). These companies were able to fully accomplish the wanted improvements. The data turned out that none of the companies who missed the objective executed respective optimisation measures (See Appendix A: Figure A-70). 39% of the companies, who did not take flexibility-focused optimisation measures, nearly achieved the objective. In 80% of the cases, where companies tried to improve flexibility, an improvement could be achieved.

#### 4.4.12 Hypothesis 12: Feasibility Study (A7) – Process Flexibility (O2)

“Considering flexibility requirements within a feasibility study of a workflow project (A7), helps to improve the flexibility of the considered business processes (O2).”

The survey’s results provided evidence for this correlation, i.e. an early examination of the processes’ flexibility requirements as part of a feasibility study helps to reach more flexible business processes in connexion with the workflow management implementation. Significant data are presented in table 4-17.

Aspects/Scope of the Feasibility Study	Strength of Coherence	Mean Objective Achievement		Mean Objective Priority	
		Applied	Not Applied	Applied	Not Applied
Exception Handling Requirements	Medium	n.a.	n.a.	n.a.	n.a.
Adaptability / Flexibility of the WFM-Application	Strong	Nearly	Medium	High	High

**Table 4-17: Findings for the Coherence: Feasibility Study (A7) – Process Flexibility (O2)**

Nearly half the surveyed companies took flexibility requirements into account when executing a feasibility study (See Appendix A: Table A-73). 86% of them fully or nearly accomplished the required process flexibility. All companies who did not successfully improve process

flexibility failed to consider this aspect within a feasibility study (See Appendix A: Figure A-74). However, all companies rated process flexibility as an important objective.

#### 4.4.13 Hypothesis 13:

##### Explorative Prototyping (A8) – Process Flexibility (O2)

“Executing an early Prototyping (A8) helps to reveal flexibility requirements on business processes and it improves flexibility in the end (O2).”

The hypothesis has been confirmed, i.e. early prototyping helps to better understand flexibility requirements on business processes, thus it helps to realise a flexible business process support as part of the workflow project. Table 4-18 indicates significant data.

Activity	Strength of Coherence	Mean Objective Achievement		Mean Objective Priority	
		Applied	Not Applied	Applied	Not Applied
Early explorative Prototyping	Medium	Nearly	Medium	High	High

**Table 4-18: Findings for the Coherence: Explorative Prototyping (A8) – Process Flexibility (O2)**

49% of the companies in the sample prototyped the workflow-management application. 75% of these achieved more flexible business processes. Only 8% of the companies, who executed a prototype, were not able to accomplish more flexible business processes (See Appendix A: Figure A-76). On the other hand, 35% of the companies who did the workflow project without prototyping achieved just the same process flexibility. Flexibility was always rated as a high priority objective (see table 4-18).

#### 4.4.14 Hypothesis 14:

##### Continuous Process Improvement (A9) – Process Flexibility (O2)

“The execution of a Continuous Process Improvement (CPI) (A9) helps to permanently adapt business processes and workflows to new requirements and thus leads to more flexible business process support (O2).”

The survey corroborated the hypothesis, i.e. a well organised CPI-process especially for the stepwise realisation of new requirements yields more flexible business processes. The significant results are summarised in table 4-19.

Aspects/Scope of the Continuous Proc.Improv.	Strength of Coherence	Mean Objective Achievement		Mean Objective Priority	
		Applied	Not Applied	Applied	Not Applied
Workflow Monitoring	Medium	Nearly	Medium	High	High
Performance Optimisation (Bus.Proc./WF-Applicat.) BPO	Medium	Nearly	Medium	High	High
New Requirements/Modif.	Strong	Nearly	Hardly	High	High

Aspects/Scope of the Continuous Proc.Improv.	Strength of Coherence	Mean Objective Achievement		Mean Objective Priority	
		Applied	Not Applied	Applied	Not Applied

Workflow-Specifications

A CPI-Process has been executed	Strong	Nearly	Hardly	High	High
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**Table 4-19: Findings for the Coherence: Continuous Process Improvement (A9) – Process Flexibility (O2)**

An overall view proves that the execution of a CPI-process strongly coheres with the flexibility objective. 50% of the surveyed companies implemented a CPI-process (See Appendix A: Table A-79). The mean valuation of the objective's relevance gives a high rated importance. However, companies who did not undertake a CPI hardly achieved the objective on average, whereas the execution of a CPI averaged out at a nearly goal fulfilment (see table 4-19).

Considering the aspects of the CPI in more depth proves that a formal process that stepwise transfers new requirements into business process- and workflow-specifications and finally leads to an amended system is the most effecting aspect of a CPI-process. 85% of the surveyed companies who applied such a formal process totally or nearly achieved flexibility (See Appendix A: Figure A-82). A comparable success could only be achieved by 27% of the companies who did not execute a CPI. Neglect of a CPI has led to not sufficiently flexible processes for 61% of the companies.

Other relevant aspects of a CPI were a regular workflow monitoring as well as a permanent BPO. These had a medium impact on the flexibility objective (see table 4-19). They are rather driven by internally released optimisations, unlike the above mentioned aspect which adapts processes to triggered new external requirements.

#### 4.4.15 Hypothesis 15:

##### CPI-Process/Responsibility (A10) – Process Flexibility (O2)

“A Continuous Process Improvement that involves users, workflow-experts as well as process owners (A10) improves the business processes' flexibility (O2).”

The hypothesis has only been confirmed for workflow-experts and process owners, i.e. an involvement of workflow-experts and process owners in a CPI leads to more flexible business processes. A significant correlation with user involvement could not be proven. The significant data is presented in table 4-20.

Involved Participants	Strength of Coherence	Mean Objective Achievement		Mean Objective Priority	
		Applied	Not Applied	Applied	Not Applied
Process Owner	Medium	Nearly	Medium	High	High
Technical WFMS Experts	Medium	Nearly	Medium	High	High

**Table 4-20: Findings for the Coherence: CPI-Process/Responsibility (A10) – Process Flexibility (O2)**

#### 4.4.16 Hypothesis 16: Exception Handling (A11) – Process Flexibility (O2)

“An Exception Handling for the Workflow Management System (WFMS) (A11) improves flexible business process support (O2).”

The survey corroborated the hypotheses, i.e. well organised exception handling mechanisms lead to flexibly reactive workflows and thus to a more flexible business process support (See table 4-21).

Activity	Strength of Coherence	Mean Objective Achievement		Mean Objective Priority	
		Applied	Not Applied	Applied	Not Applied
Exception Handling is well organised	Medium	Nearly	Medium	High	High

**Table 4-21: Exception Handling (A11) – Process Flexibility (O2)**

Half the companies in the study paid attention to exception handling. A crosscheck with the results for hypotheses 9 (process analysis) confirms this outcome. It is assumed that a well organised exception handling process adopts the results of the process analysis activity as an intellectual pre-condition that establishes the basis which is to be enhanced to a technical solution.

All surveyed companies attached a high importance to process flexibility. The objective was achieved by 81% of the companies who implemented exception handling (See Appendix A: Figure A-90). By contrast, 38% of the companies who did the workflow project without exception handling also reached the objective. 95% of the companies who failed to achieve flexible processes stated that exception handling was not a relevant activity within the workflow project.

#### 4.4.17 Hypothesis 17: User Training (A12) – Process Flexibility (O2)

“A User Training which focuses on techniques for a flexible adaptation of the Workflow Management Application (A12) facilitates the flexible reaction on process exceptions and leads to more flexible business processes (O2).”

The study confirmed the hypothesis, i.e. training users in how to adapt the WFMA to changing requirements and in exception handling mechanisms helps to achieve more flexible business processes. The study uncovered the following significant findings (See table 4-22).

Scope of the User Training	Strength of Coherence	Mean Objective Achievement		Mean Objective Priority	
		Applied	Not Applied	Applied	Not Applied
Exception handling mechanisms	Medium	n.a.	n.a.	n.a.	n.a.
Modification of the WFM-Application	Medium	Nearly	Medium	Very High	High

**Table 4-22: User Training (A12) – Process Flexibility (O2)**



One-third of the companies in the study trained users in the respective flexibility mechanisms. 88% of these gained more flexible business processes (See Appendix A: Figure A-92). There are nevertheless 24% of the companies who neglected such training content, but however also sufficiently reached the objective. By contrast, 41% of these companies failed to achieve more flexible processes.

For the purpose of a streamlined approach, it seems promising to consider mechanisms for achieving flexibility throughout the implementation process, as already proven by hypotheses 9 and 16.

#### 4.4.18 Hypothesis 18:

##### Modelling Methodology (A1) – Process Interoperability (O3)

“Modelling a business process’s interoperability aspects (A1) helps to gain interoperable and integrated business processes (O3)”

The hypothesis has been corroborated, i.e. an inter-organisational coupling of business processes can be better achieved if business-process- and workflow-models clearly depict interoperability aspects (See table 4-23).

Aspects/Objects of the Modelling Methodology	Strength of Coherence	Mean Objective Achievement		Mean Objective Priority	
		Applied	Not Applied	Applied	Not Applied
Interoperability Aspects	Strong	Fully	Medium	Very High	High

**Table 4-23: Findings for the Coherence: Modelling Methodology (A1) – Process Interoperability (O3)**

43% of the surveyed companies claimed to model interoperability aspects (See Appendix A: Figure A-94; Table A-99). 87% of these achieved or nearly achieved improved interoperability for the processes that are coupled beyond the companies’ boundaries. These companies fully achieved this objective on average. Those companies who did not consider process interoperability also did not depict these aspects within their process models. However, companies that applied interoperability aspects as part of their modelling approach valued the objective higher than companies who did not use a modelling methodology.

A crosscheck with the impact of the process analysis and -optimisation approach on the interoperability objective confirms that these aspects are crucial.

#### 4.4.19 Hypothesis 19:

##### Process Selection (A2) – Process Interoperability (O3)

“A criteria-based identification and selection of business process candidates, which takes interoperability and integration requirements into account (A2) helps to improve the processes’ interoperability.”

The statistical data confirmed the hypothesis, i.e. the consideration of interoperability requirements as a criterion for the selection of business processes, that are relevant for the workflow project, helps to achieve an improved interoperability for the selected business

processes. The survey proved a significant correlation for the following selection criterion that impacts the interoperability objective (See table 4-24).

Selection Criterion for Business Processes	Strength of Coherence	Mean Objective Achievement		Mean Objective Priority	
		Applied	Not Applied	Applied	Not Applied
Interoperability / Integration Requirements	Medium	Fully	Medium	Very High	High

**Table 4-24: Findings for the Coherence: Process Selection (A2) – Process Interoperability (O3)**

Interoperability requirements were used as a criterion for business process selection by 32% of the companies. 68% did not take this criterion into account (See Appendix A: Figure A-96; Table A-102). Those companies who did not implement interoperable processes also did not select workflow-relevant processes by means of interoperability requirements. Companies who rated this criterion have almost nearly or totally accomplished interoperability (96% of the companies, who considered interoperability requirements, totally or nearly achieved the objective). Nevertheless, it was observed that interoperability was also achieved by companies that do not consider interoperability requirements as a means of selection for workflow-relevant processes (40% of the companies, who totally or nearly achieved the objective, did not consider interoperability requirements).

An examination of the attached priorities shows that companies always attached a high or very high importance to the implementation of more flexible business processes.

#### 4.4.20 Hypothesis 20:

##### Process Analysis (A3) – Process Interoperability (O3)

“Analysing a business process’s interoperability aspects (A3) yields insights into potential fields for an inter-organisational process coupling and therefore contributes to inter-organisational business process interoperability (O3).”

The hypothesis was confirmed by the statistical data, i.e. an analysis of organisational responsibilities and a consideration of possibilities for an inter-organisational coupling of processes as part of a process analysis helps to implement business processes that go beyond companies’ boundaries. The study provided evidence for the following analysis criteria (See table 4-25).

Aspects/Scope of the Business Process Analysis	Strength of Coherence	Mean Objective Achievement		Mean Objective Priority	
		Applied	Not Applied	Applied	Not Applied
Inter-/Intra-organisational Coupling of Processes	Strong	Fully	Medium	Very High	High
Organisational Responsibilities	Medium	Nearly	Hardly	High	High

**Table 4-25: Findings for the Coherence: Process Analysis (A3) – Process Interoperability (O3)**

An analysis of requirements and possibilities for an inter-organisational process coupling has the strongest influence on the objective. 44% of the companies in the sample analysed this aspect as part of process analysis (See Appendix A: Figure A-100; Table A-107). It is a considerable outcome that 91% of these companies indicated that process interoperability could be achieved.

A further correlation was measured for the analysis aspect of organisational responsibilities, which has a medium influence on the objective. It is assumed that an analysis of organisational responsibilities is a pre-condition for the analysis of the above mentioned aspect. Organisational responsibilities were analysed by 83% of the participating companies. Thus many companies analysed these responsibilities but did not extend the analysis scope beyond the company's boundaries. 70% of the companies who analysed organisational responsibilities achieved the objective (See Appendix A: Figure A-98; Table A-105). Note, that this was not guarantor for success, as 47% of the companies who missed the objective also analysed organisational responsibilities. On average one can conclude that companies who analysed organisational responsibilities nearly achieved the interoperability objective. By contrast, companies who did not undertake such a process analysis indicated hardly goal fulfilment (see table 4-25).

Ratings for the objective's priority do not differ for companies who executed an aspect based process analysis. All companies rated clarity to be of high importance.

#### 4.4.21 Hypothesis 21: Implementation Process / Consolidation of Project Deliverables (A8) – Process Interoperability (O3)

“An integrated consideration of business process models and technical project deliverables such as workflow specifications (A8) facilitates the consideration of interoperability requirements throughout the implementation process and improves business process interoperability in the end (O3).”

The hypothesis has not been confirmed.

**Interpretation:** A consolidation of business-oriented project deliverables such as process models with technical project deliverables mainly contributes to project objectives of the IT-department, such as technical interoperability of the WFMA. However, technical interoperability of the WFMA has neither been prioritised nor been achieved by the surveyed companies. The author assumes that the hypothesis would have been confirmed if companies had aspired process interoperability and with it technical WFMA-interoperability.

#### 4.4.22 Hypothesis 22:

##### Process Optimisation (A4) – Process Interoperability (O3)

“An appropriate scope of the business process optimisation (A4) which incorporates the coupling of processes between different organisations contributes to business process interoperability (O3).”

The statistical outcome has corroborated the hypothesis, i.e. the optimisation of inter-company collaboration processes is an efficient means for the achievement of process interoperability. The survey revealed that the following significant optimisation criteria impact the objective (See table 4-26).

Aspects/Scope of the Bus.Process Optimisation	Strength of Coherence	Mean Objective Achievement		Mean Objective Priority	
		Applied	Not Applied	Applied	Not Applied
Organisational Integration	Medium	Nearly	Medium	High	High
Organisational Coherence	Strong	Fully	Medium	High	High

**Table 4-26: Findings for the Coherence: Process Optimisation (A4) – Process Interoperability (O3)**

Organisational coherence between companies is the most effecting optimisation aspect in this context. 89% of the companies, who optimised their processes respectively, indicated sufficient fulfilment of the interoperability objective which amounts to a fully goal achievement on average (See Appendix A: Figure A-102; Table A-111). By contrast, companies who did not optimise business processes only accomplished process interoperability to a medium extent (See table 4-26).

The organisational integration focuses on the improvement of the company-internal process organisation, i.e. activities that belong to a logically coherent business process are to be aggregated to the respective organisational units. Such an organisational process-oriented integration is assumed to be the pre-condition for the earlier mentioned inter-company process coherence. 48% of the companies in the study took the initiative and undertook optimisations for an internal organisational integration. 91% of them succeeded in reaching this objective (See Appendix A: Figure A-104; Table A-113). Nearly 50% of the companies who did not carry out respective optimisations stated that organisational integration could not be improved.

#### 4.4.23 Hypothesis 23:

##### Feasibility Study (A7) – Process Interoperability (O3)

“Considering an inter-organisational collaboration within a feasibility-study of a workflow project (A7), helps to reach an inter-organisational business process interoperability (O3).”

The survey’s results provided evidence for this correlation, i.e. an early exploration of the processes’ interoperability requirements within a feasibility study contributes to an inter-organisational process coupling in connexion with the workflow management implementation. Significant data were collected as follows (See table 4-27).

Aspects/Scope of the Feasibility Study	Strength of Coherence	Mean Objective Achievement		Mean Objective Priority	
		Applied	Not Applied	Applied	Not Applied
Organisational Interoperability Requirements	Medium	Fully	Medium	Very High	High

**Table 4-27: Findings for the Coherence: Feasibility Study (A7) – Process Interoperability (O3)**

40% of the surveyed companies claimed to take interoperability requirements into account when executing a feasibility study (See Appendix A: Table A-116). 89% of them have totally

or nearly accomplished the required process interoperability. All companies who did not successfully improve process interoperability have also not considered this aspect within a feasibility study (See Appendix A: Figure A-106). 43% of the participants stated that such a feasibility scope was not relevant. All companies rated process interoperability as an important or very important objective.

#### 4.4.24 Hypothesis 24:

##### Explorative Prototyping (A8) – Process Interoperability (O3)

“Early Prototyping (A8) of a workflow management application’s interoperability features yields insights in the fulfilment of interoperability requirements and eventually improves business process interoperability (O3).”

The survey has not clearly confirmed the hypothesis.

**Interpretation:** Prototyping in an inter-company context has been applied by few companies. For that reason a significant correlation has not been measured. The author assumes that inter-company process prototyping is possibly too complex or is affected by insufficient methodologies for inter-company process-prototyping. This might prevent companies from applying process prototyping in an inter-company context.

#### 4.4.25 Hypothesis 25: User Training (A12) – Process Interoperability (O3)

“User Training which encompasses the execution of inter-organisational business processes (A12) improves companies’ organisational interoperability (O3).”

The study confirmed the hypothesis, i.e. user training that imparts how inter-company workflows may be executed by means of the WFMA contributes to a coupling of business processes between different organisations. Table 4-28 summarises the significant findings.

Scope of the User Training	Strength of Coherence	Mean Objective Achievement		Mean Objective Priority	
		Applied	Not Applied	Applied	Not Applied
Execution of Inter-organisational Processes	Medium	n.a.	n.a.	n.a.	n.a.

**Table 4-28: User Training (A12) – Process Interoperability (O3)**

#### 4.4.26 Hypothesis 26:

##### Modelling Methodology (A1) – Technical Interoperability (O4)

“Modelling technical interoperability aspects (A1) of the application systems that are invoked by a WFMS helps to reach technical interoperability of the workflow-management-application (O4).”

The hypothesis has not been confirmed, i.e. a correlation between the modelling methodology and the achievement of technical interoperability could not be proven. Note that technical interoperability was rated as an objective of low importance (see section 4.3.7). Only a few companies aimed for this objective.

**Interpretation:** Technical WFMA-interoperability was not an aspired project objective. It has also not been achieved by surveyed companies. For that reason, a correlation could not be discovered. A pre-condition for a proven impact of the modelling methodology on technical WFMA-interoperability would have been a significant achievement of this project objective.

#### 4.4.27 Hypothesis 27:

##### Process Selection (A2) – Technical Interoperability (O4)

“A criteria-based identification and selection of business process candidates, which examines technical interoperability and integration requirements (A2) contributes to the technical interoperability of the workflow-management-application (O4).”

The statistical data have corroborated the hypothesis, i.e. the consideration of technical requirements on the inter-company coupling of different WFMA as a selection criterion for business processes, that are relevant for the workflow project, helps to achieve an improved technical interoperability. Table 4-29 summarises the significant findings.

Selection Criterion for Business Processes	Strength of Coherence	Mean Objective Achievement		Mean Objective Priority	
		Applied	Not Applied	Applied	Not Applied
Interoperability / Integration Requirements	Medium	Medium	Hardly	Medium	Low
Quality of IT-Support	Medium	Medium	Hardly	Low	Low

**Table 4-29: Findings for the Coherence: Process Selection (A2) – Technical Inter-operability(O4)**

Technical interoperability requirements were used as a criterion for business process selection by 33% of the companies. 67% did not consider this criterion (See Appendix A: Figure A-110; Table A-124). 28% of the companies who applied this criterion failed to achieve relevant success. 44% of the companies who applied this criterion have nearly or totally realised technical interoperability. Just 9% indicated relevant success, though technical requirements have not been applied for the selection of workflow-relevant business processes.

The study has revealed similar results for a further selection criterion, which evaluates the actual status quo of the IT-support, i.e. the quality of the support.

#### 4.4.28 Hypothesis 28:

##### Process Analysis (A3) – Technical Interoperability (O4)

“Analysing a business process’s contributing IT-systems and the quality of these systems in terms of interoperability (A3) allows an improvement of these systems’ technical coupling in a heterogeneous environment and it eventually contributes to technical interoperability of the workflow-management-application (O4).”

The survey confirmed the hypothesis, i.e. analysing the technical ability of workflow-relevant applications for a technically interoperable WFMA leads to insights in the technical feasibility and helps to reach technical interoperability. The survey revealed that the quality of IT-

support is a relevant analysis aspect that impacts the objective. Table 4-30 summarises the significant findings.

Aspects/Scope of the Business Process Analysis	Strength of Coherence	Mean Objective Achievement		Mean Objective Priority	
		Applied	Not Applied	Applied	Not Applied
IT-Support	Medium	Medium	Hardly	Low	Low

**Table 4-30: Findings for the Coherence: Process Analysis (A3) – Technical Interoperability (O4)**

A medium correlation was measured for the hypothesis. 45% of the surveyed companies had analysed the IT-systems' quality as part of the process analysis (See Appendix A: Figure A-112; Table A-127). Only 38% of these companies reached technical interoperability, whereas 38% failed though a technical analysis was carried out. Companies who did not incorporate technical interoperability in their analysis scope could not achieve the objective. On average one can conclude that this analysis criterion is not sufficient for success but necessary, a disregard inevitably led to a failure of the technical interoperability objective.

#### 4.4.29 Hypothesis 29: Implementation Process / Consolidation of Project Deliverables (A8)–Technical Interoperability (O4)

“An integrated consideration of business process models and technical project deliverables such as workflow specifications (A8) facilitates the consideration of technical interoperability requirements throughout the implementation process and finally improves technical interoperability (O4).”

The hypothesis has not been confirmed.

**Interpretation:** Technical WFMA-interoperability was not an aspired project objective. It has also not been achieved by surveyed companies. For that reason, a correlation could not be discovered. A pre-condition for a proven impact of the project methodology on technical WFMA-interoperability would have been a significant achievement of this project objective (see also: Hypothesis H21).

#### 4.4.30 Hypothesis 30: Selection Process for the WFMS (A6) – Technical Interoperability (O4)

“Considering possibilities for a coupling of different or even heterogeneous WFMS within the system selection process (A6) is a prerequisite for the technical interoperability of the workflow-management-application (O4).”

The hypothesis has not been confirmed.

**Interpretation:** Technical WFMA-interoperability was not an aspired project objective. It has also not been achieved by surveyed companies. For that reason, a correlation could not be discovered. A pre-condition for a proven impact of the WFMA-selection process on technical WFMA-interoperability would have been a significant achievement of this project objective.

#### 4.4.31 Hypothesis 31:

##### Explorative Prototyping (A8) – Technical Interoperability (O4)

“Early Prototyping (A8) of a workflow management application’s interoperability features yields insights in the fulfilment of interoperability requirements and eventually improves the technical interoperability of a WFMS in an inter-organisational context (O4).”

The hypothesis was confirmed, i.e. early prototyping helps to better understand interoperability requirements on WFMA. Therefore, prototyping helps to implement technically interoperable WFMA. Table 4-31 summarises the significant findings.

Activity	Strength of Coherence	Mean Objective Achievement		Mean Objective Priority	
		Applied	Not Applied	Applied	Not Applied
Early explorative Prototyping	Medium	n.a.	n.a.	n.a.	n.a.

**Table 4-31: Findings for the Coherence: Explorative Prototyping (A8) – Technical Interoperability (O4)**

#### 4.4.32 Hypothesis 32:

##### Modelling Methodology (A1) – Technical Flexibility (O5)

“Modelling flexibility aspects / process variants and process exceptions (A1) within business process models helps to improve the flexibility and maintainability of the workflow-management-application WFMA (O5).”

The hypothesis was corroborated, i.e. process- and workflow models that depict flexibility requirements help to implement a WFMA that is more flexible and adaptable to changing requirements. Table 4-32 summarises the significant findings.

Aspects/Objects of the Modelling Methodology	Strength of Coherence	Mean Objective Achievement		Mean Objective Priority	
		Applied	Not Applied	Applied	Not Applied
Possible Process Exceptions	Strong	Fully	Medium	High	Medium
Possible Process Variants / Flexibility Aspects	Strong	Nearly	Medium	High	Medium

**Table 4-32: Findings for the Coherence: Modelling Methodology (A1) – Technical Flexibility (O5)**

Regarding the surveyed modelling approach in more detail indicates that a differentiated depiction of process variants / flexibility aspects is a significant modelling aspect to gain a flexible / adaptable WFMA. 47% of the companies in the sample tried to depict such flexibility aspects within process models (See Appendix A: Figure A-116; Table A-134). 91% of these companies stated that a WFMA could be implemented that sufficiently fulfils flexibility requirements.

95% of the companies who stated a failure for this objective had disregarded process variants and flexibility aspects in their modelling approach. However, a minority of participants were



able to implement a sufficiently flexible WFMA without having depicted flexibility aspects as part of their process models (22% of the companies in the sample indicated a success for the objective, though flexibility was modelled).

The modelling of process exceptions also has the strongest influence on the achievement of the objective (See table 4-32). Companies who depicted such exceptions nearly achieved the required adaptability of the WFMA. All companies who did not gain a sufficiently adaptable WFMA had also ignored process exceptions. 44% of the companies declared that process exceptions were part of the modelling approach (See Appendix A: Figure A-114; Table A-133). These companies have achieved the objective. It seems that process exceptions are essential for process- and workflow models.

A crosscheck with the impact of the process analysis approach on the flexibility objective confirms that process variants and flexibility aspects are crucial. It seems that these aspects need to be considered continuously in the project life-cycle.

#### 4.4.33 Hypothesis 33: Process Analysis (A3) – Technical Flexibility (O5)

“An appropriate scope of the business process analysis which considers modification requirements on business processes (A3) has a positive influence on the flexibility and maintainability of the workflow-management-application (WFMA) (O5).”

The study’s outcome provided evidence for the hypothesis, i.e. a process analysis that incorporates flexibility and adaptation requirements on processes contributes to the flexibility and maintainability of the WFMA. Table 4-33 summarises the significant findings.

Aspects/Scope of the Business Process Analysis	Strength of Coherence	Mean Objective Achievement		Mean Objective Priority	
		Applied	Not Applied	Applied	Not Applied
Flexibility / Adaptation Needs	Strong	Nearly	Medium	High	Medium

**Table 4-33: Findings for the Coherence: Process Analysis (A3) – Technical Flexibility (O5)**

The hypothesis was confirmed by a strong correlation. 48% of the companies in the study analysed flexibility and adaptation requirements on business processes. 89% of them stated that technical flexibility could be reached for the WFMA (See Appendix A: Figure A-118; Table A-138). However, 46% of the companies who have not analysed flexibility requirements as part of a process analysis have achieved technical flexibility. Due to this fact, one can conclude that disregarding this analysis aspect does not inevitably lead to insufficient technical flexibility. To conclude, the study shows that an execution of such an analysis mostly led to a goal achievement, whereas disregarding them led to a failure for half of the cases.

#### 4.4.34 Hypothesis 34: Selection Process for the WFMS / Scope (A6) – Technical Flexibility (O5)

“Considering the adaptability for a WFMS within the system selection process (A6) is a prerequisite for the flexibility and maintainability of the workflow-management-application (O5).”

The statistical data confirmed the hypothesis, i.e. the consideration of features that allow to modify the WFMS helps to achieve a technically flexible WFMA that can be adapted to changing requirements after implementation. Table 4-34 summarises the significant findings.

Scope / Criteria of the System Selection Process	Strength of Coherence	Mean Objective Achievement		Mean Objective Priority	
		Applied	Not Applied	Applied	Not Applied
Adaptability of the WFMS	Strong	Nearly	Hardly	High	High

**Table 4-34: Selection Process for the WFMS / Scope (A6) – Technical Flexibility (O5)**

A strong correlation has been measured. Adaptability requirements have been regarded by 68% of the companies within the system selection process. A considerable rate of 87% of them have totally or nearly accomplished technical flexibility for their WFMA which amounts to a nearly goal achievement on average (See Table 4-34). Only 4% of the participants stated that a flexible WFMA could not be reached, if adaptability was a relevant criterion for WFMS selection, i.e. nearly all companies who stated failure disregarded this criterion within the system selection process (See Appendix A: Figure A-122; Table A-143). 8% of companies implemented WFMA with sufficient technical flexibility, although system adaptability was not in the scope.

#### 4.4.35 Hypothesis 35: Early Prototyping (A8) – Technical Flexibility (O5)

“Early Prototyping (A8) of possibilities to adapt a WFMA according to process variants improves the technical maintainability of the workflow-management-application (O5).”

The hypothesis was confirmed, i.e. early prototyping helps to better understand flexibility requirements on the WFMA, thus it helps to implement a technically flexible WFMA. Table 4-35 summarises the significant findings.

Activity	Strength of Coherence	Mean Objective Achievement		Mean Objective Priority	
		Applied	Not Applied	Applied	Not Applied
Early explorative Prototyping	Medium	Nearly	Medium	High	Medium

**Table 4-35: Findings for the Coherence: Early Prototyping (A8) – Technical Flexibility (O5)**

Companies who prototyped their WFMA have nearly achieved the objective on average (see table 4-35). 53% of the companies who disregarded prototyping did not achieve sufficient technical flexibility (See Appendix A: Figure A-124).

#### 4.4.36 Hypothesis 36: Implementation Process / Consolidation of Project Deliverables (A8) – Technical Flexibility (O5)

“A consolidation of business process models and technical deliverables such as workflow models in light of flexibility aspects (A8) contributes to the consideration of flexibility requirements throughout the implementation process and improves the technical flexibility and maintainability of the workflow-management-application (O5).”

The hypothesis has not been confirmed.

**Interpretation:** Technical WFMA adaptability has also been achieved if project deliverables were not continuously consolidated. For that reason it could not be proven that consolidated project deliverables significantly contribute to the achievement of WFMA-flexibility.

#### 4.4.37 Hypothesis 37: Continuous Process Improvement (CPI) (A9) – Technical Flexibility (O5)

“Organisational procedures for a CPI contribute to the technical flexibility of the workflow-management-application (O5).”

The survey corroborated the hypothesis, i.e. a well organised CPI-process especially for the stepwise realisation of new requirements yields a more flexible WFMS. Table 4-36 summarises the significant findings.

Aspects/Scope of the Continuous Proc.Improv.	Strength of Coherence	Mean Objective Achievement		Mean Objective Priority	
		Applied	Not Applied	Applied	Not Applied
Workflow Monitoring	Medium	Nearly	Medium	High	Medium
Performance	Medium	Nearly	Medium	High	High
Optimisation (Bus.Proc./WF-Applicat.)					
New	Strong	Nearly	Medium	High	High
Requirements/Modif.					
Workflow-Specifications					
A CPI-Process has been executed	Medium	Nearly	Hardly	High	Medium

**Table 4-36: Findings for the Coherence: Continuous Process Impr.(A9) – Technical Flexibility (O5)**

Earlier Hypotheses 14 showed that a CPI strongly coheres with the achieved flexibility of business processes. Similar results were obtained for the influence that a CPI has on the technical flexibility of a WFMA (see table 4-36 in comparison with table 4-19). Altogether, a nearly strong correlation was measured for the CPI-process’s impact. As observed for the process flexibility objective, companies who executed a CPI-process could nearly achieve a sufficiently flexible WFMA. On the other hand, companies without an implemented CPI-process stated that WFMA flexibility was hardly achieved.

The survey proved that the consideration of new requirements in the form of process specifications and refined technical workflow specifications is the most impacting aspect of a

CPI process on the technical flexibility of the WFMA. It was measured that 88% of the companies, who systematically considered new requirements, indicated that the implemented WFMA possesses a sufficient technical flexibility (See Appendix A: Figure A-130). By contrast, only 37% of the companies without such a CPI-process did not achieve a technically flexible WFMA. The correlation becomes more clearly by the fact that 59% of these companies ended up without technical flexibility.

A systematic workflow monitoring and a performance optimisation for business processes and the WFMA were further relevant aspects of a CPI with a medium impact on the technical flexibility. These optimisations are internally driven, by contrast to the externally imposed new requirements on the WFMA.

#### 4.4.38 Hypothesis 38:

##### CPI-Process/Responsibility (A10) – Technical Flexibility (O5)

“A CPI-Process that involves IT-/workflow-experts (A10) improves the technical flexibility of the workflow-management-application (O5).”

The hypothesis was confirmed, i.e. an involvement of technically skilled workflow-experts into a CPI leads to a technically more flexible WFMA. It could not be proven that user involvement as part of a CPI would improve the technical flexibility. Table 4-37 summarises the significant findings.

Involved Participants	Strength of Coherence	Mean Objective Achievement		Mean Objective Priority	
		Applied	Not Applied	Applied	Not Applied
Technical WFMS Experts	Medium	n.a.	n.a.	n.a.	n.a.

**Table 4-37: Findings for the Coherence: CPI-Process/Responsibility (A10) – Technical Flexibility (O5)**

#### 4.4.39 Hypothesis 39:

##### Exception Handling (A11) – Technical Flexibility (O5)

“Implementing an exception handling (-process) for the workflow-management-application (A11) improves the application’s technical flexibility (O5).”

The hypothesis was confirmed, i.e. an exception handling helped to realise WFMA that responded more flexible to process exceptions. Table 4-38 summarises the significant findings.

Activity	Strength of Coherence	Mean Objective Achievement		Mean Objective Priority	
		Applied	Not Applied	Applied	Not Applied
Exception Handling is well organised	Medium	n.a.	n.a.	n.a.	n.a.

**Table 4-38: Exception Handling (A11) – Technical Flexibility (O5)**

#### 4.4.40 Hypothesis 40:

##### Modelling Methodology (A1) – Clear Process Models (O6)

“The selection of business process- and workflow modelling approaches with comprehensive and complementary meta-models i.e. a comprehensive semantic expressiveness (A1) is a prerequisite for semantically complete, clear, readable, and adaptable business process- and workflow models that depict flexibility and interoperability aspects (O6).”

The study corroborated the hypothesis, i.e. process models that clearly depict flexibility- and interoperability requirements are mainly influenced by a modelling methodology which syntax and semantics include respective aspects. It could be proven that the following modelling aspects presented in table 4-39 impact the objective.

Aspects/Objects of the Modelling Methodology	Strength of Coherence	Mean Objective Achievement		Mean Objective Priority	
		Applied	Not Applied	Applied	Not Applied
Process Tasks	Medium	n.a.	n.a.	n.a.	n.a.
Time-Constraints	Medium	Nearly	Medium	Medium	Medium
Process Exceptions	Strong	Nearly	Medium	High	Medium
Process Variants / Flexibility Aspects	Strong	Nearly	Hardly	High	Medium
Interoperability Aspects	Medium	Nearly	Medium	High	Medium

**Table 4-39: Findings for the Coherence: Modelling Methodology (A1) – Clear Process Models (O6)**

Flexibility aspects and process variants were modelled by 46% of the companies. 75% of them indicated that process models sufficiently depicted flexibility requirements (fully or nearly achieved), whereas 9% failed to achieve this objective (See Appendix A: Figure A-138). Most companies who did not create process models with sufficient expressiveness in terms of flexibility, have also not applied a modelling approach that included flexibility aspects (86% of the companies the companies with an unsophisticated modelling approach did not reach the objective). The mean values show that clear process models could hardly be achieved by companies who did not apply a modelling methodology that includes flexibility aspects (see table 4-39). The survey provided similar results for the depiction of process exceptions and interoperability aspects. Companies who applied respective modelling approaches stated that the achievement of clear process-models was an objective of high importance. Other relevant modelling aspects were process tasks and time-constraints. An impact of medium strengths could be proven for these modelling aspects.

#### 4.4.41 Hypothesis 41: Process Analysis (A3) – Clear Process Models (O6)

“An appropriate scope of the business process analysis which considers modification requirements on business processes (A3) has a positive influence on semantically complete, clear, readable, and adaptable business process- and workflow-models that depict flexibility- and interoperability aspects (O6).”

The statistical data corroborated the hypothesis, i.e. analysing a business process’s flexibility- and interoperability requirements uncovers possibilities for an improvement of process-flexibility and –interoperability and it thus provides the elements for a clear depiction of these

aspects within process models. The survey revealed that the following significant analysis aspects impact the objective (See table 4-40).

Aspects/Scope of the Business Process Analysis	Strength of Coherence	Mean Objective Achievement		Mean Objective Priority	
		Applied	Not Applied	Applied	Not Applied
Organisational Responsibilities	Medium	Medium	Hardly	Medium	High
Flexibility / Adaptation Needs	Medium	Nearly	Medium	High	Medium
Inter-/Intra-organisational Coupling of Processes	Medium	Nearly	Medium	High	Medium
Separation of Standard Processes and Exception Variants	Medium	Nearly	Medium	Medium	Medium

**Table 4-40: Findings for the Coherence: Process Analysis (A3) – Clear Process Models (O6)**

Findings indicated that inter-/intra-organisational coupling of processes has the strongest impact on the fulfilment of the clarity objective. 43% of the surveyed companies have analysed interoperability aspects as part of the process analysis (See Appendix A: Figure A-146; Table A-174). 64% of these companies were able to clearly depict them within process models. Organisational responsibilities are an even more common analysis aspect. Altogether 85% of the participating companies analysed organisational responsibilities. The study revealed that all companies who achieved clear interoperability aspects within process models also analysed interoperability aspects (See Appendix A: Figure A-142; Table A-170). Nevertheless, 25% of the companies who analysed organisational responsibilities did not achieve the objective.

The study also provided evidence that the analysis of flexibility needs and the separation of standard processes from exception variants leads to more clear process models for the depiction of flexibility requirements. 58% of the companies who analysed these aspects also gained process models with ‘sufficiently depicted’ flexibility requirements (See Appendix A: Figure A-144; Table A-172). Note that 83% of the companies whose process analysis scope did not include these aspects, were also not able to depict flexibility aspects within process models.

Ratings for the objective’s priority slightly differ from each other. All companies have attached a medium or high importance.

#### 4.4.42 Hypothesis 42:

##### Iterative Implementation Process (A8) – Clear Process Models (O6)

“An iterative implementation process (A8) contributes to semantically complete, clear, readable, and adaptable business process- and workflow-models that depict flexibility- and interoperability aspects (O6).

The survey has confirmed the hypothesis, i.e. analysing, designing and modelling flexibility- and interoperability requirements in an iterative way leads to more clearly process models.

Table 4-41 summarises the significant findings.

Activity	Strength of Coherence	Mean Objective Achievement		Mean Objective Priority	
		Applied	Not Applied	Applied	Not Applied
Iterative Analysis, Design, Implementation	Medium	Nearly	Medium	High	Medium

**Table 4-41: Findings for the Coherence: Iterative Implementation Process (A8) – Technical Flexibility (O5)**

Considering the mean values reveals that those participants who executed an iterative implementation process nearly gained process models with clearly described flexibility- and interoperability requirements, whereas companies who did not apply an iterative approach only stated medium achievement of the objective. The latter rated clear process models as a medium important project objective. Companies who pursued the iterative strategy attached a high importance to the objective.

#### 4.4.43 Hypothesis 43:

##### Modelling Methodology (A1) – Clear Project Approach (O7)

“The selection of business process- and workflow modelling approaches with comprehensive and complementary meta-models i.e. a comprehensive semantic expressiveness (A1) contributes to a systematic and clearly structured project methodology that avoids analysis-, design- and implementation errors (O7).”

The hypothesis was corroborated, i.e. companies stated that their project approach was sophisticated, if they applied a comprehensive modelling methodology that also included flexibility- and interoperability requirements (See table 4-42).

Aspects/Objects of the Modelling Methodology	Strength of Coherence	Mean Objective Achievement		Mean Objective Priority	
		Applied	Not Applied	Applied	Not Applied
Process Tasks	Medium	Nearly	Hardly	High	High
Process Flow	Medium	Nearly	Hardly	High	High
Process Exceptions	Medium	Nearly	Medium	High	High
Process Variants / Flexibility Aspects	Medium	Nearly	Medium	High	High
Interoperability Aspects	Medium	Nearly	Medium	High	High

**Table 4-42: Findings for the Coherence: Modelling Methodology (A1) – Clear Project Approach (O7)**

Modelling aspects like a process’s flow and its tasks are constitutional. Those companies who did not include them in their modelling approach indicated that their project approach was hardly sophisticated (hardly achievement; see table 4-42). It is assumed that these companies disregarded further important activities that constitute a sophisticated implementation approach. However, only approximately 13% of the companies in the sample did not model a

process's tasks and the process flow. Nearly all of them stated that their project approach was not clearly structured (See Appendix A: Figures A-154, A-156; ; Tables A-184, A-186).

A closer view on the modelling aspects that pertain to flexibility and interoperability reveals similar results. Contrary to the above mentioned modelling of rather general aspects that were frequently applied, flexibility and interoperability aspects have been modelled with lesser frequency. Those companies who made use of them also indicated a clear project approach. Companies who disregarded these aspects have just stated medium achievement for satisfaction with their project methodology.

#### 4.4.44 Hypothesis 44:

##### Feasibility Study (A7) – Clear Project Approach (O7)

“A feasibility study which is executed prior to the workflow implementation project contributes to a systematic and clearly structured project methodology (O7).”

The hypothesis has not confirmed.

**Interpretation:** Companies have achieved a clear project approach independent of a feasibility study's execution. For that reason a correlation could not be measured. The author assumes that companies regard feasibility studies and WFMA implementation projects as independent projects, so that a feasibility study is not considered as a means for the improvement of the WFMA project methodology as a whole.

#### 4.4.45 Hypothesis 45: Prototyping (A8a) – Clear Project Approach (O7)

“Early prototyping (A8a) contribute to a systematic and clearly structured project methodology that avoids analysis-, design- and implementation errors (O7).”

The statistical data confirmed the hypothesis, i.e. a sophisticated project approach for workflow projects is constituted by prototyping. Table 4-43 summarises the significant findings.

Activity	Strength of Coherence	Mean Objective Achievement		Mean Objective Priority	
		Applied	Not Applied	Applied	Not Applied
Early Prototyping	Medium	n.a.	n.a.	n.a.	n.a.

**Table 4-43: Findings for the Coherence: Prototyping (A8a) – Clear Project Approach (O7)**

A medium correlation was measured for this aspect of an implementation approach.

#### 4.4.46 Hypothesis 46: Iterative Project Approach (A8c) – Clear Project Approach (O7)

“An iterative implementation process (A8c) contributes to a systematic and clearly structured project methodology that avoids analysis-, design- and implementation errors (O7).”



The statistical data confirmed the hypothesis, i.e. a sophisticated project approach for workflow projects is constituted by an iterative methodology. Table 4-44 summarises the significant findings.

Activity	Strength of Coherence	Mean Objective Achievement		Mean Objective Priority	
		Applied	Not Applied	Applied	Not Applied
Iterative Analysis, Design, Implementation	Medium	n.a.	n.a.	n.a.	n.a.

**Table 4-44: Findings for the Coherence: Iterative Implementation Process (A8c) – Clear Project Approach (O7)**

A medium correlation was measured for this aspect of an implementation approach.

#### 4.4.47 Hypothesis 47: Consolidation of Project Deliverables (A8b) – Clear Project Approach (O7)

“Consolidated project deliverables (A8) contribute to a systematic and clearly structured project methodology that avoids analysis-, design- and implementation errors (O7).

The statistical data confirmed the hypothesis, i.e. a sophisticated project approach for workflow projects is constituted by concerted project deliverables. Table 4-45 summarises the significant findings.

Activity	Strength of Coherence	Mean Objective Achievement		Mean Objective Priority	
		Applied	Not Applied	Applied	Not Applied
Consolidated Business Processes and Workflow-related Project Activities	Medium	n.a.	n.a.	n.a.	n.a.

**Table 4-45: Findings for the Coherence: Consolidated Project Deliverables (A8b) – Clear Project Approach (O7)**

A medium correlation was measured for this aspect of an implementation approach.

## **4.5 Summary of Findings**

The empirical study revealed that the perception of project success for workflow projects is influenced by a broader range of criteria than just a successful implementation of a technically running workflow system. 25% of all participating companies have not indicated full project success, though they claim to have successfully implemented a WFMA in technical way. More detailed inspections show that project objectives such as flexible business processes, a flexible and adaptable WFMA, improvements of interoperability both on a process and on a system level could not be achieved within these projects in spite of a successful technical implementation of a WFMA.

### **4.5.1 Findings: Project Objectives**

The findings for the pivotal objects of investigation of the survey can be summarised as follows:

- An achievement of more flexible business processes and a flexible/adaptable WFMA were considered as important or even very important objectives for workflow projects. Nevertheless, they could only be nearly achieved by companies who also declared an overall sufficient project success. Companies who did not finalise the workflow implementation successfully have also not or hardly implemented more flexible business processes. It is fair to conclude, that companies who strive for these objectives do not necessarily achieve them. It was also proven that companies who strive for more flexible business processes also appreciate the technical adaptability of the WFMA to be a very important aim. These companies also try to depict flexibility aspects within business process models. It also turned out that striving for flexibility aspects within business process models is associated with the objective of technical adaptability of the WFM-application. As these three objectives are related to the higher-ranking objective of an improved flexibility for business process control by means of WFM, it will be accepted that they are commonly pursued to reach flexibility in practice.
- The survey provided evidence concerning commonly achieved project objectives. Companies who succeed in implementing more flexible business processes also successfully implement a flexible and adaptable WFMA. They have also created business process models and workflow specifications which depict flexibility aspects. These objectives could be achieved by companies who applied a systematic and clearly structured project approach. It also turned out that early clarity concerning feasibility and profitability of the workflow project is associated with the attainment of the above mentioned objectives.
- A well organised inter-company execution of business processes was considered to be an important project objective, but could only be reached by companies who finished their workflow project with overall success. It is a surprising outcome that technical interoperability of the WFMA was considered as an objective with low priority and an accordingly low achievement within the sample, i.e. companies have hardly implemented a technically interoperable WFMA.
- Companies who strive for an inter-company process control have not necessarily accomplished it. It was also assumed that companies who strive for an improved inter-organisational coupling / integration of business processes would also try to improve the

technical interoperability of the WFM-application. Yet, there is no statistical evidence for coherence between these objectives in terms of their prioritisations.

- Companies have successfully improved the inter-organisational coupling / integration of business processes in conjunction with the modelling of interoperability aspects within process models. A closer inspection shows that these companies achieve inter-organisational coupling / integration as well as an improved flexibility of their business processes. These companies have applied a clearly structured project methodology and have gained early clarity concerning the feasibility and profitability of the workflow project.

#### 4.5.2 Findings: Project Methodology

Regarding the impact of the applied methodology for the workflow project on flexibility- and interoperability objectives, the study provided the following findings:

Companies who are able to implement flexible business processes execute project methodologies with activities that differ from companies who do not achieve this objective. Those effective project activities can be assigned to the phases of a coherent project methodology. In particular the following project activities had an impact on the successful implementation of flexible business processes<sup>43</sup>:

- An early feasibility study that captures the evaluation of flexibility requirements on business processes.
- A selection of workflow-relevant business processes where flexibility requirements were used as selection criteria.
- Process analysis activities that evaluate not only process tasks and the process flow, but also flexibility aspects. These process analysis activities have also separated standard process flows and process variants.
- The depiction of process variants and further flexibility aspects within business process models.
- An optimisation of business processes that specifically tries to improve the processes' flexibility.
- Users have been acquainted with the measures and techniques for the flexible execution of workflows. These users have been explicitly trained in the execution of standard processes, but also in the handling of exceptions.
- An implementation of exception handling mechanisms.
- Adaptability requirements on the WFMA for a flexible execution of workflows have been early evaluated by means of a prototype.
- A permanent CPI-process was organised that regularly monitors workflow executions and that evaluates new requirements on the WFMA. This CPI-process particularly involves process owners as business experts and technical workflow experts.
- Semantically complementary project deliverables, e.g. for business process- and workflow-models. These project deliverables are supposed to stepwise refine design details for flexible processes from a business description into a technical specification.

The achievement of technically flexible and adaptable WFMA is also associated with the above mentioned project activities. Furthermore, successful companies have also based the

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<sup>43</sup> i.e. a statistically significant correlation was measured between project activities and the objective

WFMS selection process on the system's ability to flexibly execute workflows and business processes.

Companies, who realise an inter-organisational process control by means of a workflow project, have executed the following project activities:

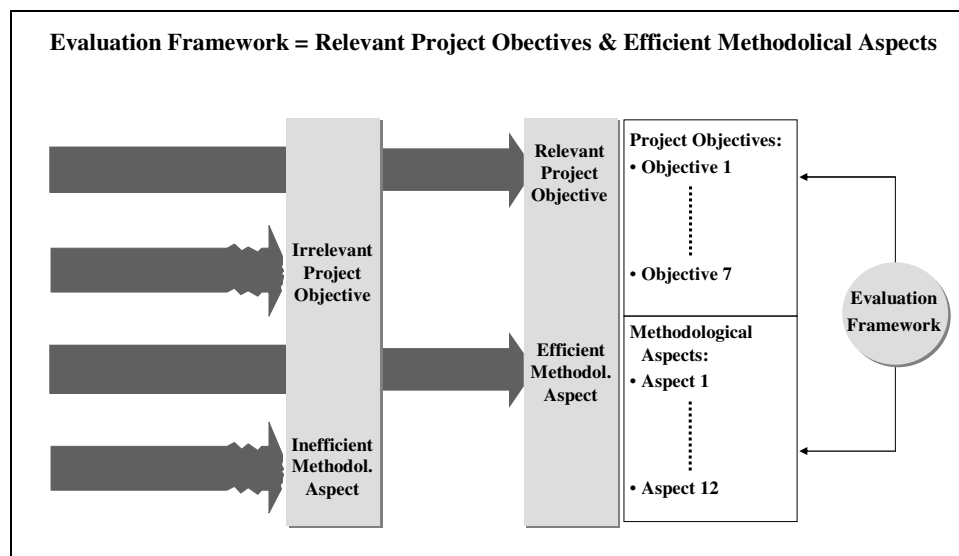
- A feasibility study that aimed on the evaluation of the project's technical feasibility and profitability also evaluated requirements on an execution of business processes beyond an organisation's boundaries.
- The selection of business processes that are in scope of the workflow project was based on interoperability aspects and requirements on an inter-organisational execution of processes.
- Organisational responsibilities between companies and further aspects of an inter-company process control were analysed as part of the business process analysis.
- The modelling methodology for business processes was able to clearly depict the execution and control of the processes that go beyond the organisation's boundaries.
- An optimisation of business processes was executed to improve the organisational integration and coherence.
- Users were trained with respect to the execution of interoperable processes with an involvement of business partners.
- An early prototyping of an interoperable process control and consolidated project deliverables have not been proven to be effective measures for the achievement of process interoperability.

Technical interoperability of heterogeneous WFMA was an objective of minor importance. Nevertheless, a few activities were identified that had an effective influence on the objective's achievement:

- The selection process for the determination of the processes that are in scope of the workflow project considered the quality of the IT-support and interoperability requirements.
- Process analysis activities evaluated the quality of the IT-systems that were used to execute the processes.

## 5 Workflow Implementation Methodologies / Workflow Project Approaches

This chapter investigates peculiarities of WFM-projects. For that purpose five implementation approaches that were proposed in academic literature are scrutinized. The main object of the investigation is their contribution to WF-flexibility and WF-interoperability. Evaluation is twofold as it concerns project objectives and methodological aspects. Both are based on the research variables that were identified and validated in chapter 3. These variables are used as assessment criteria and establish an evaluation framework. Though, the framework only adopts relevant project objectives and efficient methodological aspects, i.e. variables for which empirical evidence was proven in chapter 4. Accordingly not relevant variables are not applied as evaluation criteria, as illustrated in figure 5-1.



**Figure 5-1: Evaluation Framework for WFMA-implementation Methodologies**

The evaluation is eventually supposed to obtain insights into the methodologies' maturity. Reflection of established methodologies in light of the framework's proven project objectives intends to reveal if WF-flexibility and WF-interoperability are concerns within the methodologies' scope (convergence of objectives). Comparing methodological aspects is to find out if the approaches take appropriate measures to achieve WF-flexibility and WF-interoperability (convergence of methodologies). A marginal methodological convergence in the sense of the thesis is considered as a potential field for methodological improvements.

Specific characteristics of WF-projects are introduced in the first section. Section two is then concerned with the evaluation of WFM-implementation approaches. Chapter 6 adopts these findings to derive potential methodological amendments.

## **5.1 Specific Characteristics of Workflow Projects**

### **5.1.1 General Character and Scope**

WFM-projects are a combination of organizational- and IT-projects. A sole technical WFMS implementation would marginally improve process efficiency.[KUE03] For that reason, organizational improvements are a major concern. Schreyögg even states that the technological project character gains subordinated importance.[SCH02] Process optimizations or even BPR which precedes the technical WFMS implementation may have a considerable impact on business procedures and employees. WFM-technology allows new intra- and inter-organisational ways of cooperation.[FRE01] The implied interdependencies between organisations and IT requires an integrated design of both aspects. Change Management is therefore often regarded as an important challenge within WFM-projects. The WF-life-cycle can be regarded as an iterative process of organizational development, process-design, and IT-implementation.[LEH03] Processes dominate the organizational development which concentrates on the design of organizational structures. Eventually IT-systems are developed to achieve best possible process implementations. IT-options, in turn, impact process-designs and lead to cyclic process of organizational-design and IT-development.[BÖH01, WES01]

The WFMA-development process does not fundamentally differ from SW-development processes.[LEH04] WF-life-cycles generally follow certain IT-methodologies that are well known from software-engineering. Yet, pure IT-development methodologies do not sufficiently address the specific focus of WF-projects.[WES01] Lehman emphasises the importance of the business-analysis-phase, in which business-staff works closely with business-analysts and WFMA-developers. He recommends a split analysis phase with a method-neutral and a WF-method-specific part. It was also proposed to apply techniques for the later design of WF-schemas already within a method-specific step of the business blueprint phase. Early findings concerning the applicable implementation-platform and the WFMS are required within the business-analysis-phase for such an approach.[BÖH01]

The workflow-life-cycle does usually not only comprise the WFMA-implementation, but also a CPI as part of the operational use. It is a cyclic process of feedback loops between the WFMA's operational use and WFMA-amendments. Freudenberg takes up the position that early WFMS supported only rigid workflows which possessed a low adaptation frequency. Flexibility requirements have evolved over time and imposed also higher requirements on the WFMA implementation approaches.

Literature discusses vendor-specific and vendor-independent WF-implementation approaches. Life-cycles proposed by WFMS-vendors usually distinguish between the following project-phases: analysis of as-is processes, improvement and design of to-be processes, creation of workflow-models, conception of the system implementation, technical WFMS implementation, user-approval, and transformation to operational use.[MÜH01] These methodologies are influenced by vendor-specific tools. Particularly modelling tools for organisational structures and processes as well as transformation tools for WF-schemas lead to regulated phase descriptions. By contrast, vendor-independent approaches often contain a separate phase for WFMS-selection. Practice shows variations of above phase-arrangements. A stringent run through the phases is often not kept in practice.[BÖH01]

A generic WF-life-cycle comprises the following phases:[WES02]

- Phase 1: business information gathering (Interviews and document analysis)
- Phase 2: business process modelling /design-phase

- Phase 3: Workflow modelling (Enhancement of process models with further information)
- Phase 4: System selection
- Phase 5: Implementation phase
- Phase 6: Test
- Phase 6: Operational use

Phase iterations and repeated project task executions are permitted.[WES02] For instance, organisational and technical aspects are to be designed and revised iteratively, as WF changes can only be made in light of technical performance under consideration of invoked application systems and the surrounding business organization.[MÜH03] Some authors also discuss incremental implementation approaches where single processes are realized step-by-step.[KUE02]

### 5.1.2 Project-Cycle-Time

Literature reveals that WFMA are extremely difficult to set up. Implementation efforts are often underestimated.[SCH03] Organizations are frequently concerned with purchasing hardware and software; implementation is regarded as a training challenge to get familiar with a new system. A company-wide WFM-implementation typically takes nine to fifteen month.[BAR01] Other authors surveyed up to three years for WFMA projects.[MÜH01] The literature does hardly recommend techniques to accelerate project-cycle times.[WES01] A difficult step is to move from WFM-pilots for full implementations. It was observed that merely sixty-five percent of companies, who investigated WFM-technology, have finalized a WFM-project with a productive WFMA.[KUE02, BAR01] The project duration to move from WFM-pilots to operational-use often takes one year.[KUE02]

### 5.1.3 Strategic Relevance

As mentioned earlier, WFMA considerably impact companies' organisations. They can be applied for different business strategies. Some authors stress that WFM-projects can not be executed detached from strategic business objectives. They call for the alignment of business strategies and WFMA-implementations.[LEH04, BAR01] The high strategic relevance demands sound surrounding conditions, e.g. top-management commitment to achieve acceptance for organisational changes. Some implementation approaches have acknowledged the strategic relevance and derive individual project goals from strategic business objectives. Development of an organisational vision and goal definitions are usually conducted in the very beginning of a WFM-project.[BIT01]

### 5.1.4 Importance of Business Analysis

A lesson learned from projects is that many WFM-initiatives fail because developers do not understand the work process to be automated.[BAR01] WFMS vendors have been criticised for disregarding process-analysis and –modelling as critical first steps in building successful WFMA. Cultural differences between vendors, who focus on product capabilities, and users were quoted as an explanation for failures. Nevertheless, Martyn Christian who is Director of Filenet has acknowledged “*you need to analyze your business processes and then implement systems.*” A cooperative approach to business analysis regards process investigations and –modelling as a prerequisite for improvement and workflow-automation.[HER02] As knowledge becomes more critical for organizations, the analysis-phase needs to apply a broad requirements analysis scheme.[STO01] Business-related and people-related aspects should ideally be applied, e.g. efficiency, process-quality, flexibility, quality of labour,

overstrainings, etc.[HER02] A further challenge for analysis is the identification of WF-relevant business processes to determine the actual project scope.[MÜH06] Choosing processes with the highest potential for automation is vital for any WF-project. Processes are the pivotal determinants from which requirements are to be derived. For that reason an economical, technical and methodological sound analysis of processes that are potentially appropriate to WF-automation is indispensable.

### 5.1.5 Importance of Process- and Workflow-Modelling

Modelling is driven by the necessity to structure a noticeably unstructured business environment. Process modelling and organisational design are necessary tasks prior to WF-modelling. Working schemes need to reflect a decision-, an execution-level and the combination of both levels.[LEH03] Practitioners experienced WF-modelling as a complex part of development due to the need for comprehensive meta-models which also include organisational structures, roles, and people.[LEH04]

Practitioners recommend to gain process knowledge by aid of employees and to recognise process-modelling as a joint project activity.[HER02] Users should be regarded as experts who are often best aware of weakpoints and potential improvements. Joint teams with users, analysis- and modelling-specialists should closely work together and mutually decide on improvements.[HER02, SCH03]

Weske recommends to model processes and workflow WFMS-independent.[WES02] A few implementation approaches suggest the selection of an appropriate modelling approach as one of the initial project steps. A frequently mentioned critique is the lack of methods and tools for the transition of process models into WF-models and WF-schemas.[BÖH01, WES02] Several methodologies provide WFMS-specific WF-schemas that are hardly portable and poorly reusable. The absence of transition methodologies leads to WF-modelling activities that are denoted to be experimental rather than methodological founded.[BÖH01]

### 5.1.6 Relevance of WFMS-Selection

Choosing a WFMS is an often neglected task, as it is frequently regarded as an additional activity of a BPR-project for which technical selection criteria are to be used.[BIT01, MÜH06] Issues that pertain to the technical scope of operation prevail business-related requirements and lead to inappropriate system selections. An inappropriate WFMS is a major project risk.[WES02] It was generally observed that WFMS selection is a time-consuming task.[KUE02] Some authors recommend prototyping and life-demos as an additional basis to reach better decisions, though this would increase project-costs.[HER02, WES01] A separate survey-phase to investigate and pre-test shortlisted WFMS has also been suggested.[WES02] A potentially high number of users and WF-instances principally impose performance demands. Investigation of these issues may be a further aspect of prototyping, but indeed an aspect for WFMS-selection. Further issues of a structured selection process are specification-based requests-for-proposals, vendor workshops, and criteria-based evaluations of different proposals under consideration of value-benefit-analysis and sensitivity-analysis.

As mentioned in section 5.1.1. WFMS-selection is part of vendor-independent life-cycle models. Former implementation approaches have proposed an early system selection, whereas today's methodologies choose WFMS rather late in the project. The problem of a too early system selection is that a chosen WFMS does possibly not fulfil specific project requirements. Such projects suffer from too late interventions and major WFMS adaptations with additional coding to enhance the functional scope.[WES02]



#### 5.1.7 Importance of Process-Improvements

Although a few methodologies do not regard process optimisations as an aspect of the WF-life-cycle, most methodologies imply certain project steps for BPR. These are usually part of a design-phase where optimised to-be processes are the main deliverable.[WES02] Some approaches even centre BPR as the main aspect of WFMA implementations and try to organise the implementation process in light of BPR-activities from the very project beginning.[BIT01] It is common sense, that continuous process improvements are desired after successful WFMA implementations.[MÜH02] Usually a CPI process is designed as a closed-loop. Last but not least the BPM-life cycle well demonstrates this issue (See section 2.2).

#### 5.1.8 Importance of Change Management

The WF-life-cycle is often depicted as an iterative process of process-design, organisational development, and IT-development.[LEH03] Redistribution of work and information, redesigned structures, and new requirements on peoples' skills calls for a project-accompanying Change Management (CM).[SCH03] It is necessary to appropriately develop peoples' skills and to keep motivation for the WFMA. People involvement should be carried out from the first project step to ensure acceptance towards the WFMA and the imposed organisational changes.[WES02] BPR-related WF-life-cycles rather emphasise CM initiatives and recommend pro-active programmes throughout the organisation. Employees need not only to be trained in light of the WFMA's utilisation, but they also need to be acquainted with anticipated modifications on business operations. Involvement of senior management is also an aspect of CM to gain sponsors for change. They might help to overcome obstacles and resistance and help to secure funding for adequate CM measures.[BIT01] An initial environmental analysis may help to investigate organisational and political aspects with potential impact on the WFMA-project.

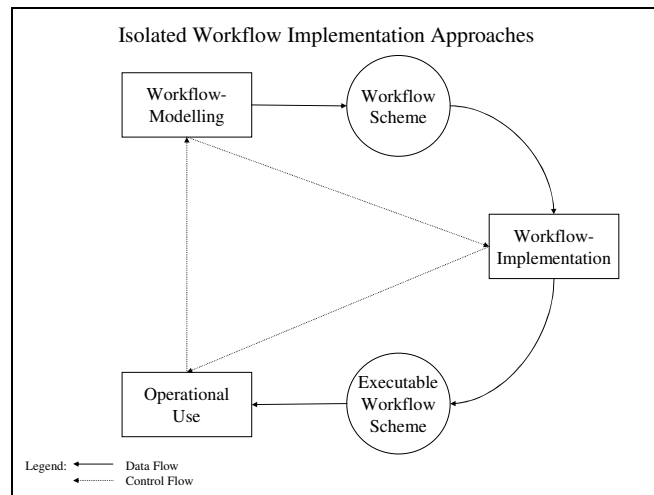
#### 5.1.9 Technical Integration of External Applications

The technical integration of external applications or legacy systems is appreciated as a critical factor for any WFM-project.[WES02] Almost everywhere complex systems need to be integrated. A general condition is that re-implementation of legacy systems is usually not an option. The following risks could affect the WFMA: poor performance, poor robustness, inappropriate user interfaces, incomplete interface-structures, and inappropriate modularity.

An early investigation of technical infrastructures is supposed to yield an anticipated integration scenario.[HER02] Technical integration aspects and organisational design options need to be worked out under consideration of mutual dependencies. An iterative technical design might help to provide a solid architecture.[WES02] Particularly the modularity of invoked systems is a concern, as a too coarse granularity might not fit to the steps defined within WF-models. Authors mention that WMFS customisation and adaptations of invoked legacy systems may occur in parallel, but require mutual reviews and adjustments. Early tests should already occur in the implementation phase. Inter-organisational process control and interoperability imposes an even higher complexity on technical integration tasks, as inter-company interdependencies are to be considered.[FRE01]

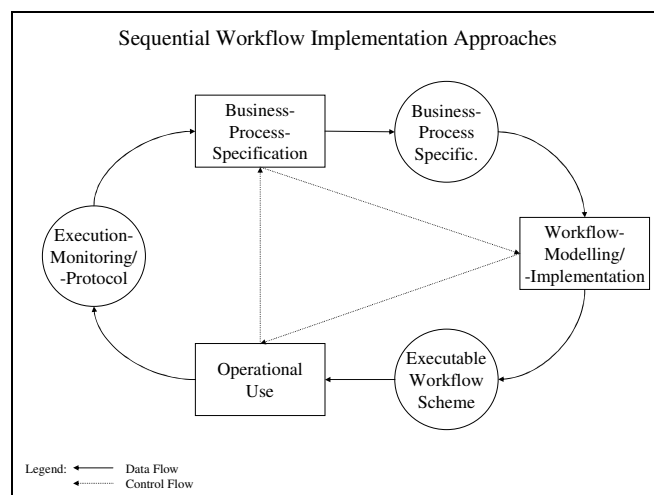
### 5.1.10 Reference Models for Workflow-Implementation-Approaches

Jablosnki distinguishes between three general approaches for WF-implementations processes.<sup>44</sup>[JAB01] Isolated approaches are illustrated in figure 5-2. They assume the availability of business process knowledge, so that IT-managers, IT-developers and consultants can transform this pre-existing information into WF-schemes. For that reason, isolated approaches do not include an information-collection-/process-analysis phase. The first phase, the WF-modelling phase, adopts the process knowledge and converts it into WF-specifications by means of WF-languages and graphical editor tools. In the following WF-implementation phase IT-developers specify technical workflow characteristics and properties that are relevant for workflow automation. This phase yields an executable WF-scheme.



**Figure 5-2: Isolated WFM-approaches- adapted from [JAB01]**

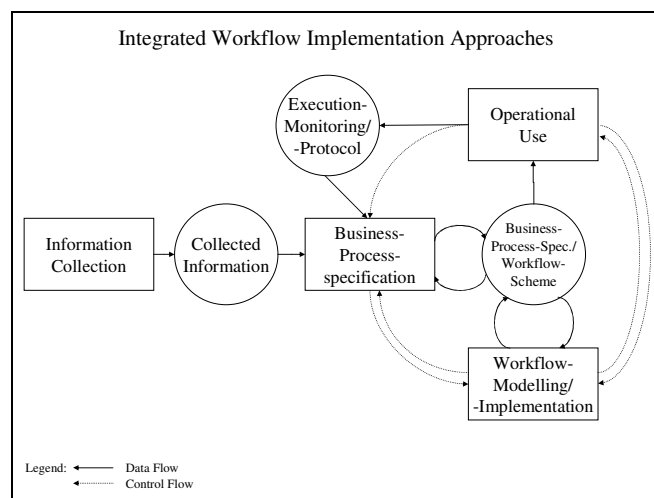
Sequential approaches base WF-modelling activities upon business-process specifications, which are developed within a single phase prior to the WF-modelling phase. Thus business-process specifications serve as input-documents that are enriched by workflow-specific information and converted into WF-schemes. Jablonski states that the business-process specification phase is executed by IT-developers and business departments. WF-modelling and WF-implementation activities are combined in one single phase and executed by IT-developers sequentially. Sequential approaches are sketched in figure 5-3.



**Figure 5-3: Sequential WFM-approaches - adapted from [JAB01]**

<sup>44</sup> The explanations made for these three approaches are based on [JAB01]

Integrated approaches integrate different project phases by means of developed deliverables. All project phases are based on a centralised model-repository. According to Jablonski integrated approaches are often denoted to be evolutionary. Business process specifications developed within the respective phase are the basis for the workflow-modelling-/implementation-phase. The outcome is an executable WF-scheme that is specified in the same specification language but that is supplemented by further execution-relevant information. These WF-schemes are interpreted within the operational use without further conversion activities. Apart from the initial information collection, integrated approaches do not distinguish between specification means. Nearly all phases utilise the same specification language which needs to provide sufficient modelling objects to depict all relevant organisational and technical aspects. Feedback loops between phases are allowed just as concurrently executed project phases, since transformations of process-/WF-specifications are not required. These principles of integrated approaches are depicted in figure 5-4.



**Figure 5-4: Integrated WFM-approaches - adapted from [JAB01]**

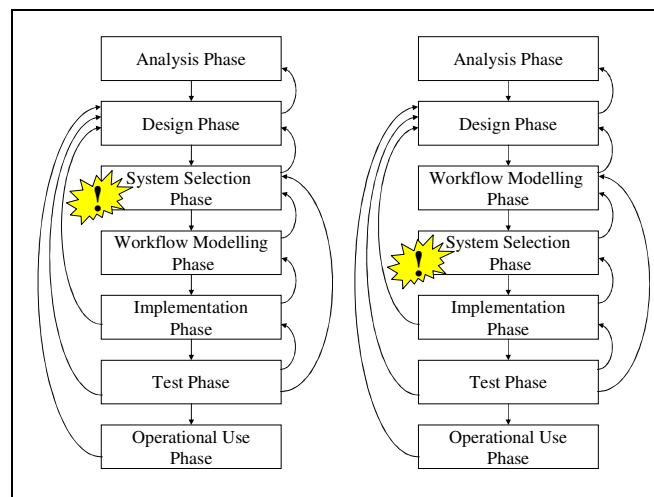
Weske describes a general WF-implementation procedure which is based on the reference-model for sequential approaches. It consists of the following four phases:[WES01]

- Phase 1 focuses on the analysis and collection of information that are relevant for the considered processes. Technical issues are neglected in that early stage, but empirical studies, interviews and document analysis are executed to reveal specifics of the business domain.
- Phase 2 yields business process models based on the outcome of phase 1. These models are supposed to be used by domain experts and IT-experts to optimise and validate the business processes.
- Phase 3 adopts the process models and converts them into WF-models/-specifications. Application specific information that is not relevant for workflow execution is abandoned, but technical aspects for the workflow control are added. Weske states that WF-specification languages are used in that phase.
- Phase 4 implements the workflow application in the target environment and prepares the system for its operational use.

A further procedure model introduces an additional operational-use phase from which monitoring protocols are passed back to the process modelling- and WF-modelling phases.[JAB01] A CPI-cycle is implemented that way. Figure 5-5 illustrates the structure of a workflow implementation process that is used as a framework for the development of

methodological amendments in chapter six.<sup>45</sup> Thus the depicted implementation process is used for the remainder of the thesis. It is based on the previously described characteristics of workflow processes particularly on the above mentioned sequential approach, i.e.:

- The general execution direction of the implementation process is straight forward, i.e. ideally all phases are carried out sequentially.
- Business process knowledge is not available right from the project start, so that an information gathering needs to be carried out in the early beginning of the project. A separate analysis phase meets the importance of that project task.
- BPR is a WFMS-neutral cyclic process of initial analysis and process-design. It is carried out early in the project. The implementation approach satisfies organisational aspects prior to technical aspects that way.
- A CPI is established between the operational-use phase and the design phase
- Feedback loops between project phases allow an iterative business process design and technical WF-implementations. Transition and consolidation of deliverables and models is expected as a manual task. An automatic model transition is not assumed.



**Figure 5-5: Assumed Structure for WFM-approaches**

- The iterative character does also allow the stepwise development of the entire WFMA, as it is stressed by Kueng and Weske.[KUE02, WES01]
- Modelling is considered as a crucial task which is why business processes as well as workflows are specified in two separate phases. A centralised model repository with a uniform process-/modelling language, as it is intended by the integrated approach, is not assumed for the implementation process.
- WFMS selection is a separate project phase to emphasize the importance of this activity. It follows the design phase, i.e. it takes the necessity of a late system selection based on to-be business processes into account. A feedback loop from the test phase to the system selection phase allows revising certain system decisions, though this would imply a major impact for the project. WFMS selection can alternatively occur after WFM-modelling.
- User trainings are assumed as an activity of the operational-use phase. It is also assumed that the project scope is not a pilot-system, but a productive WFMA.

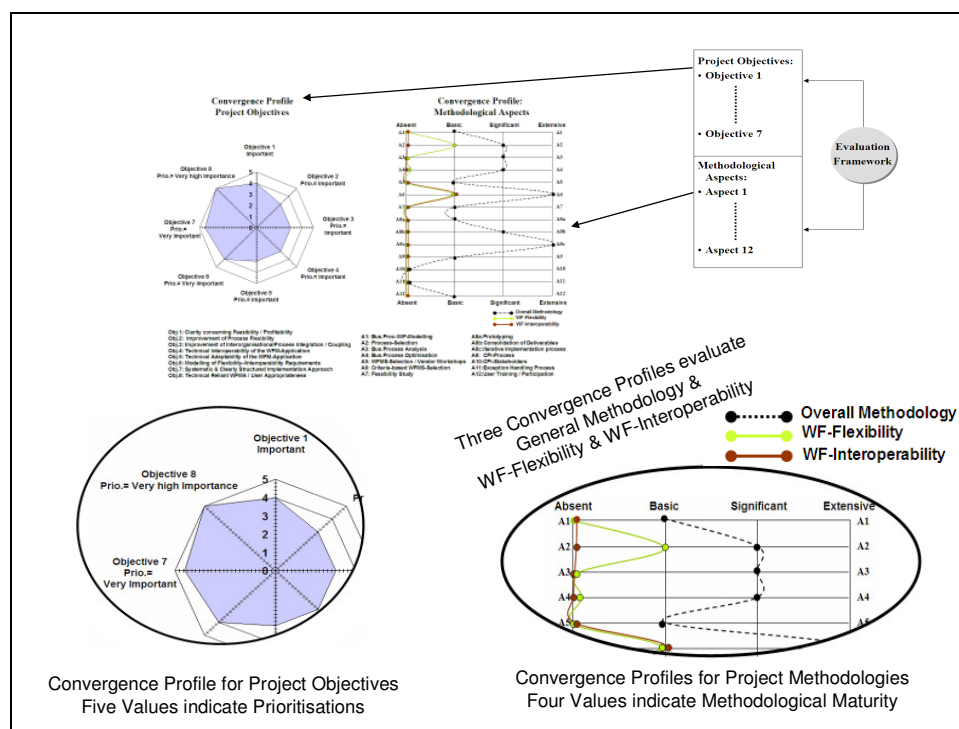
<sup>45</sup> Framework in this context means that improvement measures are assigned to certain project phases and discussed in light of these project phases in order to make clear in which part of the implementation process an improvement measure may take place. Note that this implementation process does not include any improvement measures; it is merely derived from common workflow literature.

## 5.2 Evaluation of Workflow Implementation Methodologies

In the following established WFM-implementation approaches are assessed in light of their contribution to WF-flexibility and WF-interoperability. Corresponding maturity levels are expressed by means of convergence profiles. Proven research variables serve as an evaluation framework that is composed of project objectives and methodological aspects. Evaluation is based on a literature analysis, as it is not possible to survey methodologies in the course of action-research in practice. Figure 5-6 illustrates these evaluation principles.

It is assumed that the methodologies pursue specific objectives. Investigating these project scopes reveals compliance with the framework's seven project objectives. For the sake of completeness and objectivity, the convergence profiles also depict the main purpose of each methodology as an eighth objective. Assessment applies the following rating scale:

- 1 = Objective is slightly relevant (very low priority)
- 2 = Objective is hardly important (low priority)
- 3 = Objective is important (medium priority)
- 4 = Objective is very important (high priority)
- 5 = Objective is vital (very high priority)



**Figure 5-6: Approach to Evaluate Project Methodologies / Convergence Profiles**

Three different convergence profiles for methodological aspects reveal if the methodologies apply effective project measures:

- with a special emphasis on WF-flexibility
- with a special emphasis on WF-interoperability
- in a general manner without a specific focus on WF-flexibility & WF-interoperability

A quadrivalent rating scale is applied to assess methodological maturity. It follows the bootstrap approach and differs between methodological aspects that are:

- not fulfilled (Absent)
- partially fulfilled (Basic)
- broadly fulfilled (Significant)
- completely fulfilled (Extensive)

Comparison of convergence profiles allows methodological gaps to be identified. A low maturity may be generally regarded as an option for methodological enhancements. Chapter 6 therefore utilises these findings to derive effective project activities.

It should be pointed out that a low maturity in the sense of the convergence profiles does not represent a “poor” assessment. It is appreciated that each approach pursues a specific purpose which is the basis for the applied methodological aspects. In this respect the evaluation aims to show if popular approaches incorporate a sufficient focus on WF-flexibility and WF-interoperability. A methodology’s intrinsic purpose is not subject to investigations.

The five evaluated WF-implementation methodologies have been selected for the following reasons:

- They are sufficiently documented, which is a precondition for a sound evaluation.
- They represent the WF-scene in the German-speaking area. The evaluation of WF-methodologies that were developed and applied in Germany is a necessary additional research activity to the survey which was also executed in Germany. The author does not expect that a different outcome would have been yielded in the U.K. or the U.S.
- They should possess a sound academic basis to guarantee that basic software engineering principles are kept.

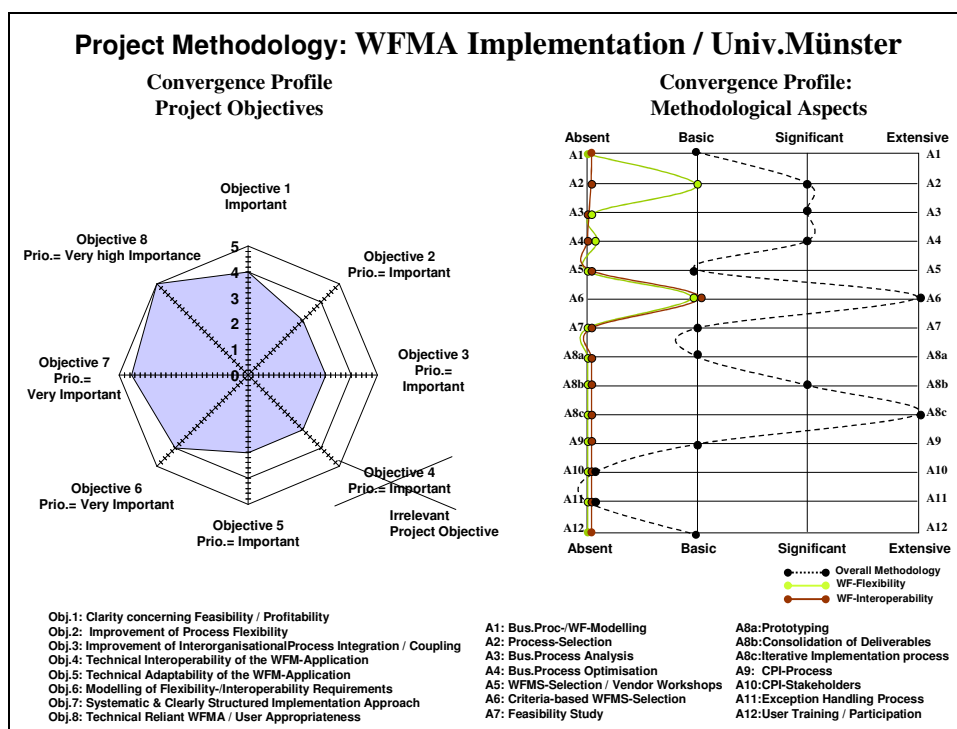
The author has not gained findings with respect to these methodologies' utilisation in practice. A literature study has not provided any further or newer WF-implementation methodologies in Germany, U.K. or the U.S. that specifically regard WF-flexibility and WF-interoperability.

### 5.2.1 Implementation Methodology: Univ. Münster

The implementation approach is comprehensively described and seems to provide a sound basis for WFM-projects.[WES02] It clearly depicts project phases, sub-phases, project activities and interrelations between activities. All project phases succeed in a logical sequence, but allow several possibilities for iterative executions. Authors have identified six pivotal problems of WFM-projects which are the origin for the methodological definition. Hence, the proposed approach is supposed to cope with these problems. The following issues have been mentioned as critical success factors. They constitute the methodology’s particular scope:

- Adequate selection of a WFMS
- Consolidation of business-process-models and technical concepts
- Manual transformation of business-process-descriptions in technical deliverables
- Iterative implementation process
- Technical integration of WFMS and invoked applications
- Sophisticated test procedures
- Performance- and reliability-assessment

Evaluation of the project methodology has revealed the following results. These are sketched in figure 5-7. The main purpose is a sophisticated technical WFMA integration that fulfils a company's specific requirements. This objective is pursued with very high importance. Accordingly, a clearly structured methodological proceeding is a very important aim. Clarity concerning the technical feasibility is considered as a very important asset. Respective findings are revealed comparatively late in the project, namely after finalisation of the to-be WF-design. Profitability has not been mentioned as an important aspect of investigation. Process-flexibility and an inter-organisational process control are considered as general requirements of mean importance. Coupling of heterogeneous WFMA's is mentioned but not regarded as a special purpose of the approach. Similarly the authors touch on a WFMA's technical adaptability as a worthwhile goal, but it is not pursued with a high importance. Although process interoperability and the integration of heterogeneous WFMA's are regarded as medium important goals, the approach does not significantly apply any of the investigated methodological aspects with a focus on interoperability. Merely the project activity for WFMS selection incorporates integration criteria. A similar impression was received by investigating the methodology in light of process-flexibility and WFMA-adaptability. Only the selection of WFM-relevant business processes and the selection of an adequate WFMS are executed under consideration of processes' flexibility aspects.



**Figure 5-7: Convergence Profile for WFM-Methodology / Univ.Münster**

Nevertheless, the implementation approach seems to be methodologically sound if we do not think in terms of flexibility and interoperability. Convergence profiles diverge, as the methodology generally addresses nearly all investigated aspects. Only exception handling and an adequate stakeholder-analysis for CPI-purposes are disregarded. Particularly the following methodological aspects are worth mentioning:

- Phase 1, the survey phase, comprises the selection of an adequate methodology for process-modelling, i.e. a specific meta-model is not prescribed, but depends on the specific modelling requirements of the current project. Similarly a WF-modelling method is chosen

in the design-phase after finalisation of the to-be process-models and after the final feasibility decision. Both, the process-modelling- and WF-modelling-methodology are WFMS-independent.

- WF-relevant processes are chosen in phase 1. The approach provides a respective project step which applies well-defined selection criteria. It is based on an organisational survey and regards the outcome of a document analysis.
- A business process analysis is executed in phase 1, but repeatedly conducted in the design-phase. Only thoroughly selected processes are subject to a detailed organisational and technical analysis. Compulsory review steps assure the models' consistency. Applied investigation methods are document analysis and sporadic interviews. Authors emphasize the need for iterative analysis steps.
- Processes are optimised within the design-phase which yields to-be-processes. For this, organisational and technical aspects are designed in parallel and consolidated iteratively.
- A WFMS is selected in a separate phase. Authors emphasize that a too early WFMS selection endangers the project's success. Several selection criteria are applicable. Pre-selected WFMS are tested in an iterative way, but vendor workshops are not applied. System selection has to be based on a complete requirements list, normally after the modelling of the to-be-WFs. Authors stress that WF-modelling and WFMS selection might be conducted in parallel, provided that requirements are completely understood.
- Feasibility assessment occurs in the design-phase and is based on the to-be process-models. Each relevant process is verified in light of its feasibility. It is supposed to scrutinize if WFM-technology is adequate to fulfil the process-imposed requirements.
- The absence of prototyping is considered as a key-problem of WFM-projects. The investigated approach applies some sort of prototyping by means of early system tests, extensive lab simulations and field tests that are executed in an iterative way. Flexibility- and interoperability are not regarded within prototyping.
- Iterations between project phases and project steps are provided throughout the implementation approach. Certain deliverables are incrementally developed that way, e.g. process-models, WF-models, etc. New requirements may be accepted consistently. Authors mention that project management has to define premises for iterations to avoid unnecessary recurrences of project activities.
- Consolidations of process-models, WF-models and technical specifications are particularly intended within the design-phase by means of respective review-steps.
- CPI is mentioned but monitoring focuses mainly on performance aspects. Neither flexibility nor interoperability are subject to CPI. Nevertheless, the approach strives for an organisationally well-defined CPI-process.
- The methodology is concerned with user participation from a project's start. Though, user training is executed immediately before run-time, it is not described in detail.

## 5.2.2 Implementation Methodology:

### Workflow Reengineering Methodology WRM

The authors provide a sound methodological description with clearly indicated project-phases and project-steps.[BIT01] Altogether five project phases with thirty-two project-steps make up the entire methodology. Succession of project-steps is precisely stipulated, but the approach lacks recommendations for parallel executions and iterations of project-tasks and – phases. In this sense, the approach follows a strictly sequential WFMA-implementation. Recurrent phase-executions are only applied after initial WFMA-implementation for new workflows or process improvements.



The results of the project methodology's evaluation are illustrated in figure 5-8. The project methodology focuses on BPR and appreciates WFM as a respective enabler. It proposes process optimisations not within the initial WFMA-implementation, but rather after the going-live as part of a CPI. Indications for potential process optimisations are to be gained by monitoring of operative workflows. This is a clear difference to other WFM-methodologies, which firstly re-engineer business processes and then implement optimised to-be-workflows. Accordingly the methodology yields as-is process-descriptions but disregards to-be specifications as part of the initial WFMA-implementation. Again, BPR as proposed by WRM is not based on historical process-knowledge, experiences and employees' assessments. The emphasis on optimisation and change coins the entire methodology from the very first step. Change-Management activities are explicitly described. Optimisations aim at improved efficiency, effectiveness, and flexibility. In this sense, process flexibility, a straight-forward methodological BPR-process, early clarity concerning potential process improvements and looming resistance to change are very important project objectives. Case studies showed that the approach achieves success in reduced cycle-times, cost-cutting and staff-reductions.[BIT01] On the other hand, the approach provides no guidance for a technical WFMA implementation. It is debatable whether the methodology provides adequate support for the technical challenges of a WFM-project. Utilisation of the approach is most likely in combination with rather technical methodologies.

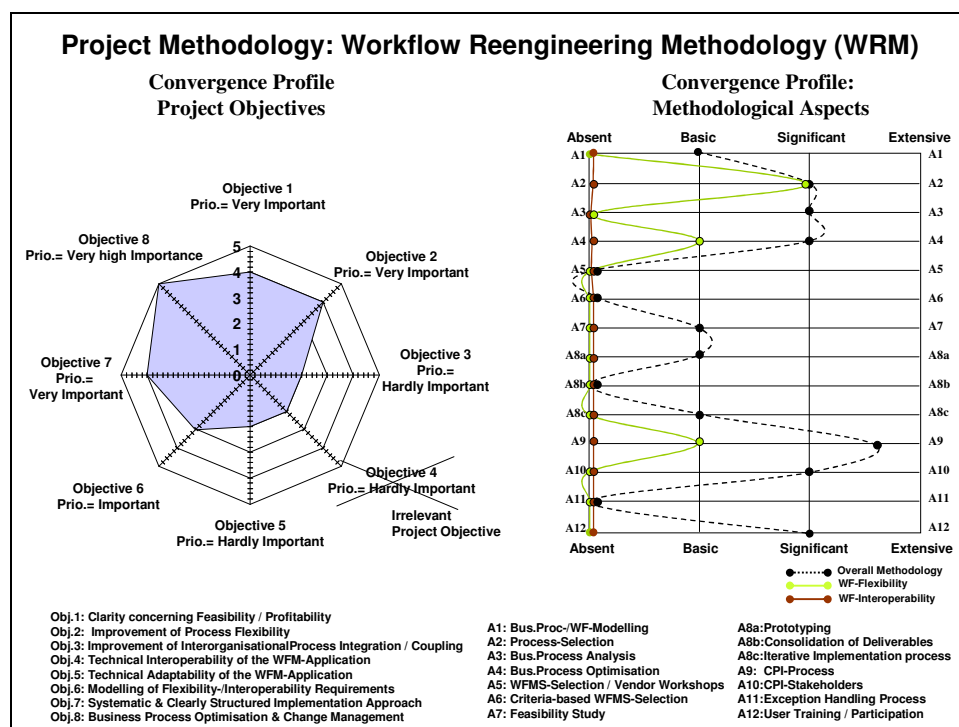


Figure 5-8: Convergence Profile for WFM-Methodology / WRM

As mentioned above the convergence profile for project objectives draws a clear picture of the methodological scope. Although process flexibility is mentioned as an important optimisation aim, WFMA-adaptability is of minor importance. Process interoperability and the coupling of heterogeneous WFMA's of different organisations are also out of scope. Comprehensible process models are pursued with mean importance.

Investigation of methodological aspects shows that the approach completely ignores interoperability. The convergence profiles also show that flexibility is not comprehensively pursued. Flexibility criteria are only considered for selection of project-relevant business

processes. It is also regarded as an aspect of process optimisation, but the approach lacks respective optimisation measures. As mentioned above WRM gives the impression of a sophisticated Change-Management framework but leaves technical issues open. Accordingly the convergence profile for the overall methodology indicates four absent aspects and four basically addressed aspects. Six aspects are significantly or extensively covered by WRM:

- Process modelling is alluded but the selection of an adequate modelling approach with a specific meta-model is not intended. A simple meta-model for task- and process-specifications is explained. It addresses the specific BPR-view and captures aspects, such as cycle-times, wait-times, transport-times.
- A criteria-based process selection is proposed. Changeability is one aspect in this context.
- The authors describe a rough process analysis and respective criteria that may be used.
- BPR techniques are explained and criteria for improvements are provided. As mentioned above processes are re-engineered after WFMA implementation. In so far, BPR is part of the CPI. Customer interviews and industry benchmarks are also intended and briefly described. Process flexibility is mainly addressed by definition of several process variants.
- A WFMS selection is neither based on vendor workshops nor criteria-based. It is executed in the first project-phase before process-identification, -analysis, and -modelling. For that reason the entire project runs the risk of an inadequately chosen WFMS, that not fulfils requirements.
- Prototyping arrangements are not explicitly made. But WFMS installation is followed by an orientation- and adjustment-step that takes several weeks. Authors emphasise that the WFMA will only become operative when it provides satisfactory operation.
- Early technical feasibility assessments are not conducted, but organisational and political barriers are highlighted and reported to the senior management. Indications on the project's profitability are derived from potential process improvements that again are deduced from process weak-points. A technical proof of concept is first conducted immediately before operation as part of a workflow-simulation
- The CPI is extensively explained. The approach applies key-performance-indicators for the simulation and comparison of different WF-variants. Flexibility is one mentioned process-KPI; authors refer to the difficulties of measuring process-flexibility.
- Relevant CPI-stakeholders are also recommended. Particularly process owners are provided with comprehensive CPI-responsibilities. They are supposed to assess impacts of process improvements.
- Change management, employee information, and trainings are conducted from the first project phase. Trainings also cover BPR-methodologies and WF-modelling approaches. It is expected that users become familiar with the WFMA within the above mentioned orientation- and adjustment-phase.

### 5.2.3 Implementation Methodology: Univ. Linz

The implementation methodology follows a top-down approach, which is conducted by means of fourteen project steps. A major premise of the approach is the perception of a WFM-project as a combined technical and organisational challenge. It constitutes neither a pure technical nor a sole organisational character. The authors stress that the specific nature of WFM-projects requires an adequate methodology.[KUE03] They enumerate important success factors:

- WFMA-implementations need to conform to the companies' business objectives. The approach identifies relevant objectives and regards them as premises for the project. A two-stage goal identification with provisional and definite business objectives is executed.
- The WFMA-implementation views on the identified business objectives and applies organisational and technical measures to achieve respective fulfilment.
- Organisational and technical impact of a WFMA needs to be considered. An investigation of implications for security, profitability, and ergonomics is required prior to operational use.
- User-acceptance is crucial for successful WFMA-operation. Appropriate measures and user participation are applied.

The overall methodology is highly geared to a company's business objectives. These are appraised in a qualitative and quantitative way, prioritized and classified according to a four-field-portfolio. Business objectives are used to delimit the project scope by defining the project-relevant business processes. For that purpose, business processes are assessed in light of their contribution to the investigated objectives. A worth mentioning methodological characteristic is the fact that only **one** business process is subject to the WFMA implementation, i.e. one project-cycle automates one process and its variants, but not several processes in parallel. Concentration on single processes is supposed to ensure that thoroughly optimised processes are implemented. Automation of not optimised processes is to be avoided that way. However, the methodology does not describe iterative or parallel executions of project phases. It does also not provide guidance for technical implementation issues, but refers to specific vendor instructions, instead.

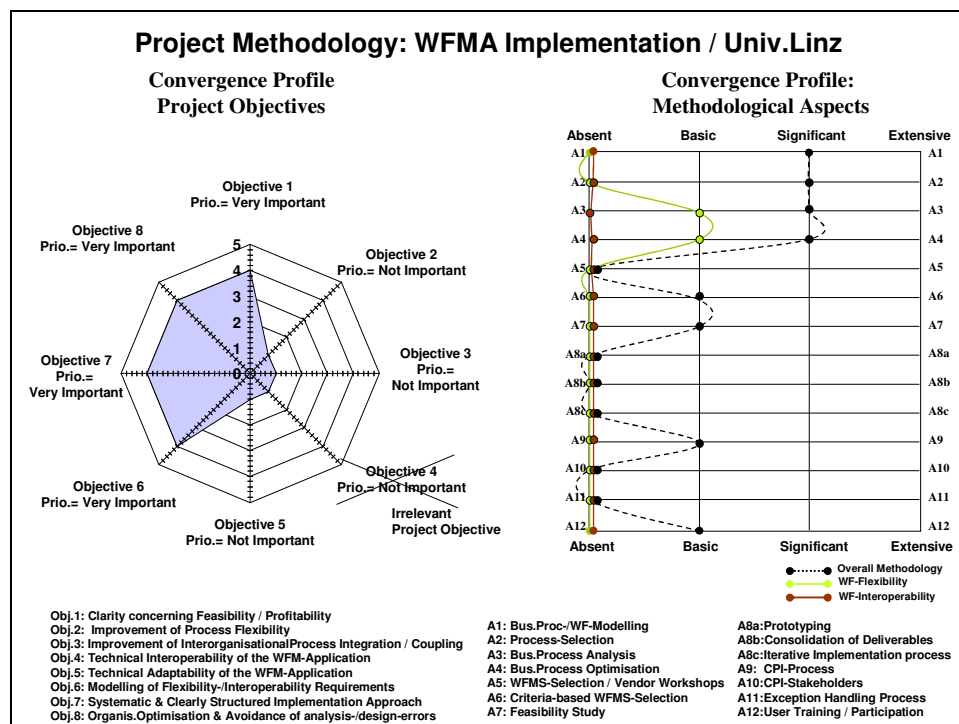


Figure 5-9: Convergence Profile for WFM-Methodology / Univ.Linz

Evaluation of the methodology has yielded the following results. These are also illustrated in figure 5-9. Most important aim of the approach is to appropriately realize a company's business objectives by means of the WFMA. For that purpose, a clearly structured project execution is regarded to be of high importance. Accuracy also applies to the process- and

workflow-modelling activities. Accordingly the approach attaches a high importance to meaningful specifications. The authors also strive for clarity concerning the feasibility and the organisational impact that the WFMA would impose. Process- and WFMA-flexibility and – interoperability are not considered as relevant project objectives. The convergence profile for project objectives depicts flexibility- and interoperability objectives accordingly. An investigation of the methodological aspects in light of process- and WFMA-interoperability reveals that these are not taken into account. Process flexibility is only mentioned as an aspect within process analysis and –optimisation, but the approach lacks detailed guidance for achievement.

Altogether one can conclude that the methodology provides significant guidance for a goal-oriented process-selection, -analysis, and –optimisation. Modelling is also significantly described based on petri-nets. The remaining ten investigated aspects are either absent or merely basically addressed. A detailed reflection reveals the following:

- Modelling to-be processes occurs product-independent, i.e. prior to the WFMS selection. As-is processes are not specified within models. Petri-net specifications are recommended for process modelling. The top-down approach distinguishes between rough- and detailed-models. Rough models only specify the process sequence, whereas detailed models also define further aspects, e.g. roles and responsibilities.
- Process selection occurs criteria-based and regards analysis findings. Only one process is selected for automation, i.e. the project scope is fairly narrow.
- A criteria-based process analysis concerns KPIs, such as cycle-times, costs, error-rates, etc. These KPIs are derived from the earlier investigated objectives.
- The approach outlines process-optimisation measures. It is a premise that optimisations need to contribute to corporate objectives. Most effective optimisations are identified by means of a portfolio approach. Optimisations have to take place before WFMS-selection and technical implementation of the WFMA.
- WFMS-selection is a single project step that is executed after process optimisation. This aims to fairly avoid automation of not optimised as-is processes. The approach does not provide WFMS-specific selection criteria, but refers to general directives for IT-interaction as a source for selection criteria, e.g. ISO9241
- A separate feasibility assessment is not conducted as a single project phase or –activity, but several project steps contribute to a rather late feasibility- and profitability-assessment. This assessment is executed immediately before the WFMA’s operational use. A few relevant criteria are mentioned, but these are certainly incomplete.
- The approach briefly touches on CPI, but does not provide clear guidance for its execution.

#### 5.2.4 Implementation Methodology: Development of WF-Types

Böhm describes an implementation approach that focuses on the development of WF-types.[BÖH01] It is not intended to be a comprehensive life-cycle-model that gives detailed guidance from early project-preparation and requirements-engineering to a WFMA’s operational-use. Nevertheless, all project-tasks that pertain to WF-type-development are described in a very sound manner. It is worth mentioning that the description’s detailedness is outstanding compared to the other investigated approaches. The author assigns the focussed WF-type-development to a system-design-phase and recommends a general life-cycle that is derived from the waterfall-model. Six phases constitute the overall approach:

- Preliminary investigation (Process-selection, Process-optimisation)
- Business-design/-blueprint (Process-modelling, Process-simulation)

- System-design (see below sub-phases & activities)
- Implementation & Test
- Configuration & initial operation
- Stabilisation & Revision

System-design is particularly concerned with specifying WFs as executable process representations. Detailed guidance is provided for WF-type derivation from process-models and the transition into WF-schemas. A major objective is to gain continuous deliverables with clearly defined transition steps. All project phases except the system-design are merely roughly described. In this sense, the system-design presumes an existing process-model or a method-neutral business-blueprint. Those deliverables have been possibly developed for documentation or process-optimisation purposes. For that reason, blueprints are relevant, but not sufficiently detailed for the depiction of all technical WF-aspects.

This phase is composed of the following steps:

- Planning
- Conception
- Development
- Adaptation
- Validation

WF-Type development is WFMS-independent, so that the conceptual system-design is not affected by specific WFMS-characteristics. This allows keeping all requirements on WFMS within WF-types, which eases a sound WFMS-selection in favour of an optimum system-decision. Böhm argues that WF-types can be used for any WFMS. Later specifications of WF-schemas are in contrast based on a certain WFMS.

The methodology's evaluation revealed the following outcome, which is also illustrated in figure 5-10. Böhm's approach runs through different transition stages and allows addressing specific project- or user-requirements. Considering peculiar functionalities of the later WFMS is also an objective of the methodology. The life-cycle also provides a methodology to stepwise integrate control flows between the WFMS and the invoked external applications. Though, systems integration is also a concern of the approach.

As mentioned above, Böhm's main objective is to provide a clearly structured development process for WF-type-development and WF-schema-implementation. Weaknesses of other methodologies are supposed to be avoided. Böhm argues that WFMA development often suffers from experimental proceedings, an absence of methodologies, and a shortage of appropriate tools. For that reason the application of a systematic implementation process is an objective of very high importance. Clear guidelines for the execution of project tasks and design-principles are to aid a systematic construction process.

Clarity concerning the feasibility is regarded as an important objective. The methodology supports a criteria-based assessment of WF-type specifications. Developers need a clear picture of the project's feasibility and the WFMA's characteristics. An assessment and validation of WF-types should be carried out as early as possible within the system-design-phase. Such an assessment must be also applicable to WF-types that have been retrieved from libraries or repositories. Note that Böhm does not offer an early feasibility study. The preliminary-investigation-phase is concerned with findings to do with the fulfilment of general business objectives, benefits of process optimisations and the investigation of conditions that impact the WFMA development.

Böhm regards process flexibility as an important objective and argues that it is important to know the WF-types that are affected by process-modifications. In fact, the methodology's scope is rather concerned with WFMA adaptability, i.e. it primarily pays attention to the modification of WF-types and WF-schemas as a consequence of changed business processes. Accordingly, WFMA adaptability is regarded as a very important objective and the methodology provides operations for type- and schema-adaptations.

Process- and WFMA-interoperability are of minor importance. Integration is merely regarded as an imperative for the integration of external applications, but not for the coupling with heterogeneous WFMS.

Process- and WF-models are regarded as very important deliverables that need to be stepwise refined into WF-schemas. WF-specification languages are the most important design medium. It must allow stepwise refinement of WF-independent process models. The author recommends to combine method-neutral coarse process-specifications with a method-specific WF-specification language.

Considering the methodological convergence-profile in more depth, shows that a few interoperability aspects are basically regarded, though WF-interoperability is actually not within scope. The high importance of WFMA adaptation has a methodological analogy, as considerable four methodological aspects are at least significantly addressed. Criteria-based process selection and an iterative implementation process are basically addressed in light of WFMA-adaptability.

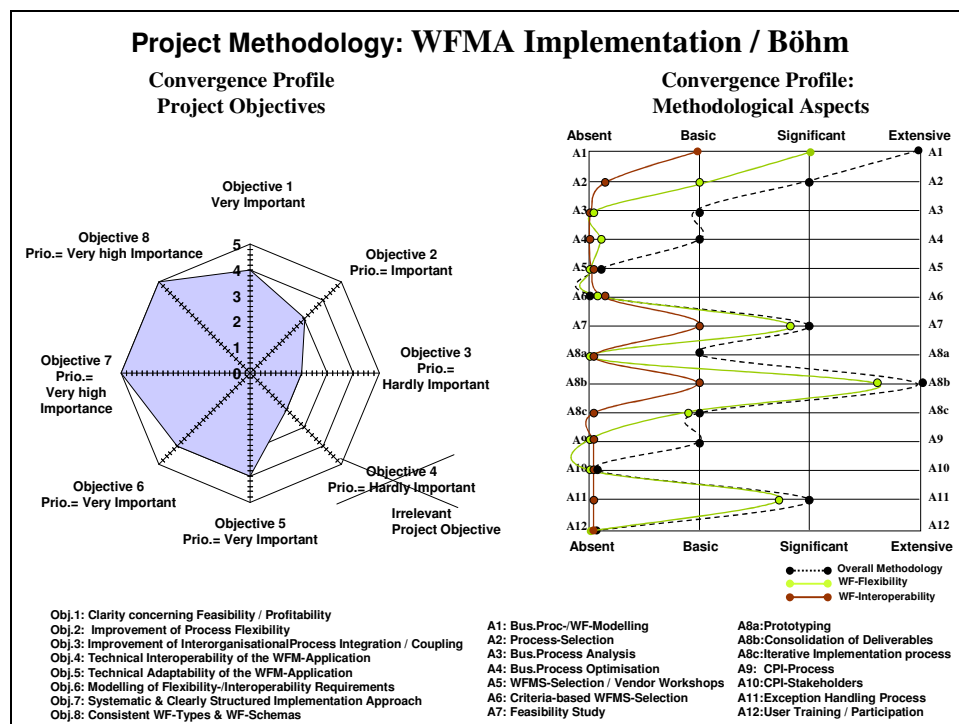


Figure 5-10: Convergence Profile for WFM-Methodology / Development of WF-Types

The convergence profile for the overall methodology shows a high maturity, apart from some aspects that are actually not within the primary scope.

- A process modelling tool is selected within the business-blueprint-phase. Modelling abets a better understanding of task executions and is to be refined to single process steps. The author provides clear guidance for the transition of process-models to WFMS-neutral WF-types. Böhm's specification methodology includes means to express adaptability on a WF-type level.
- WF-relevant business processes are selected within the preliminary-investigation-phase. Böhm mentions that selection criteria are to be derived from a company's individual business objectives.
- Process-analysis is attached to the preliminary-investigation- and business-design-phase, but not significantly explained. A second selection step for variants of WF-types is executed within the system-design-phase.
- Process optimisation is part of the preliminary-investigation. Böhm argues that such an early optimisation protects the business blueprint from as-is deficits. The author also alludes to the limitations of process-optimisation. According to Böhm, weak business processes can hardly be improved if weaknesses are induced by poor legacy-systems.
- WFMS-selection is not within the methodological scope
- The approach does not offer a separate feasibility-study, but an early identification of potential WFMA application areas. Feasibility is first assessed within the system-design-phase. A criteria-catalogue and guideline for WF-type evaluation is part of the methodology. These are not only to assess the feasibility but also to evaluate the expected degree of goal achievement. Criteria for the evaluation of WF-type adaptability and for the assessment of the integration of external applications are also provided.
- Prototyping is not mentioned, but Böhm touches on process-simulation as part of the business-blueprint-phase
- Phase iterations and repeated task executions are generally depicted as part of the waterfall-model, but not specifically described between certain project steps. Pre-conditions for phase iterations are not addressed.
- CPI is part of the stabilisation- and revision-phase but only basically addressed
- The transition of process models to WF-types and executable WF-schemas is described in extensive depth. A manual transition is favoured.
- Exception handling mechanisms are a significant concern of WF-type specifications and for the derivation of WF-schemas. An exception handling process is not described.
- User training is outside the scope

### 5.2.5 Implementation Methodology:

#### PROWORK / WFMA for PPS-Systems

ProWork is a methodology for the implementation of WFMA within production environments.[WWM01, BEC01] It assumes technical collaboration of a WFMA and a PPS-system as parts of a heterogeneous IT-environment. The process scope is mainly focussed on production-planning and –control. Therewith the target domain differs from the usually addressed service sector. Authors indicate a higher complexity of the production sector which imposes increased requirements for WFM-projects. Process flexibility is also expected to be more demanding within the production domain. Authors argue with unexpected events that occur due to machine malfunctions, staff absence, or short availability of resources. Production processes are also subject to modifications as a result of changing customer preferences. Becker et al. mention that existing life-cycle approaches to WFMA implementations are not applicable to the very specific production domain. Yet, the fact that WFMA projects in the production domain show characteristics of organisational- and IT-projects was also noticed within service industry.

ProWork consists of five phases with altogether 21 project-steps:

- Project preparation phase
- Analysis phase
- Conception phase
- Implementation phase
- Operational use

The convergence profile for the aspired project objectives shows a rather balanced picture, which is illustrated in figure 5-11. In fact, the actual purpose namely an efficient control of production processes and a high-quality order processing are of very high importance. The authors stress that an early precision of project objectives in light of selected processes is a further important concern. Project objectives are to be valued in terms of their fulfilment and reachability. All objectives are supposed to be prioritised. Clarity is also wanted for the benefits that the WFMA would provide. Yet, the authors do not allude to feasibility findings as an aspect of interest. Further objectives of high importance are process flexibility for production processes and an adaptable WFMA. An inter-organisational process execution is important but not the actual scope. Technical interoperability in only defined as an objective is so far as WFMS-functionalities are to be callable by external applications. Interoperability is an aspect that concerns the coupling of the WFMS and the PPS-system, but not the coupling of heterogeneous WFMA in an inter-organisational context. Clear and valid models are regarded as very important objectives. The life-cycle utilises a PPS-specific modelling approach.

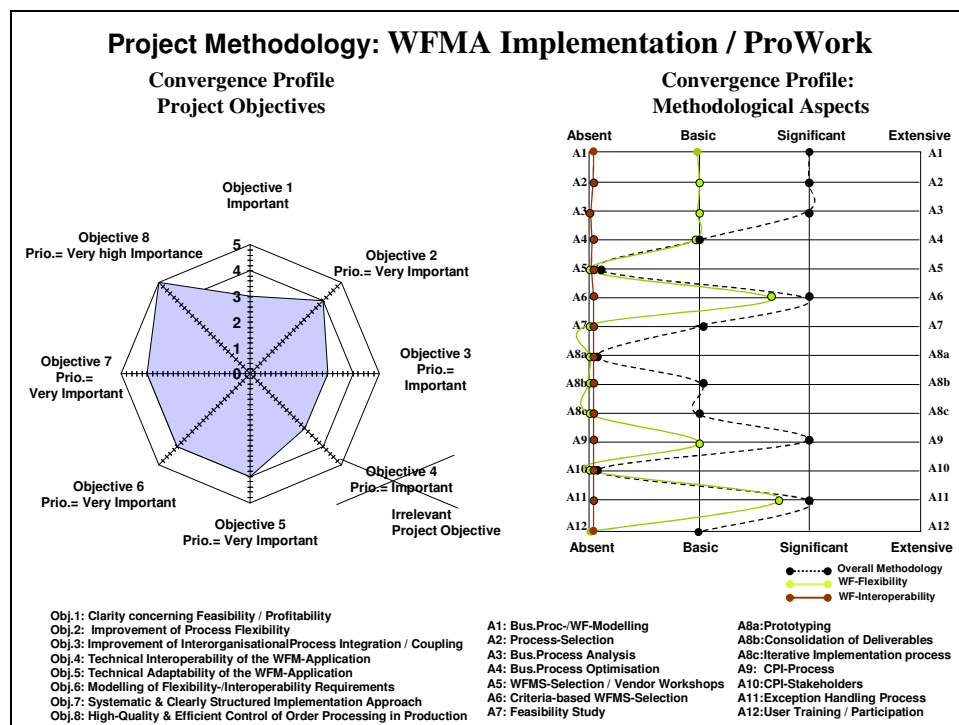


Figure 5-11: Profile for WFM-Methodology / ProWork

Convergence profiles for methodological aspects appear unbalanced (see figure 5-11). ProWork does not provide guidance for any of the investigated aspects in light of interoperability. However, flexibility is rather pursued, as the convergence profile shows seven aspects that are at least basically addressed. The general convergence profile depicts a



well maturity of the overall approach. ProWork neglects merely three methodological aspects namely vendor workshops for WFMS-selection, prototyping, and a stake-holder assignment to CPI. A detailed view on ProWork reveals the following:

- Process-modelling is significantly described by means of a meta-model and modelling-objects. ProWork's modelling approach meets the specifics of the production domain. Criteria for tool selection are provided. The issue of depicting flexibility within process models at build-time and at run-time is discussed.
- A selection of WF-relevant processes is regarded as a vital success factor for WFM-projects. The variety of selected processes impacts achievable business benefits as well as technical and modelling-specific requirements on the WFMA. Authors criticise the poor availability of sufficient selection procedures. Value-benefit-analysis is criticised for a marginal expressiveness. ProWork offers a comprehensive set of criteria for the evaluation of processes' WFM-ability. These criteria are derived from rather general PPS-objectives. An iterative evaluation procedure is recommended to gain a sound process-shortlisting. Flexibility is termed as an aspect for process selection, though precise criteria are not part of the catalogue.
- Process analysis is based on a checklist of typical flexibility requirements on PPS-processes. These are to be utilised to clarify the sufficient flexibility-degree for process-definitions, -coordination, and the assignment of roles to activities.
- An objective of process optimisation is to reduce the occurrence of exceptions, i.e. to reduce the likelihood that unexpected events lead to modifications of WF-instances at run-time.
- ProWork implies an approach for WFMS-selection which also regards flexibility requirements. It is intended to select the WFMS after the refinement and transition of process-models into WF-models.
- Iterative execution of certain project activities are defined together with abort-criteria.
- ProWork regards the organization of exception-handling procedures as a project task, i.e. a process for solving exceptions is an organizational design task.

### **5.3 Concluding Remarks**

Analysis revealed that each methodology strives for the achievement of specific secondary objectives.<sup>46</sup> Some of the approaches quote certain problems of WF-projects and gear the life-cycle towards a respective methodological emphasis. Corresponding objectives are usually well addressed, i.e. methodologies meet the declared purpose. These are, for instance, improved efficiency, reduced cycle-time, clear process-documentations, appropriate degree of regulation and automation, automatic generation of WF-schemas. It turned out that both WF-flexibility and WF-interoperability are not explicitly within scope. One can conclude that methodologies possess a low maturity in dealing with these objectives, so that very specific amendments may lead to a better achievement of WF-flexibility and WF-interoperability.

A closer inspection of the convergence profiles for project objectives shows that process- and WFMA-interoperability are hardly prioritised, whereas process-flexibility and WFMA-adaptability are considered with a medium importance. Clarity concerning the project's feasibility and profitability has been pursued with a high importance, just as clear process models. All approaches highly strive for a clearly structured project methodology. A few cases even recommend iterative project structures for that purpose. One approach also provides extensive guidance for the consolidation of project deliverables.

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<sup>46</sup> Main objective is of course the WFMA-implementation.

Convergence profiles for methodological aspects show a rather divergent picture. Not any of the approaches broadly addresses process- and WFMA-interoperability. A few times project activities are carried out in light of process- and WFMA-flexibility. If so, these are mostly basically covered. Only one investigated life-cycle significantly applies four methodological aspects in light of flexibility issue.

All things considered, it appears that methodologies have a specific emphasis. It is therefore not possible to conclude that one approach has a higher general maturity than another. Nevertheless, conclusions with regard to WF-interoperability and WF-flexibility are possible. As mentioned above, methodologies regard WF-interoperability actually not at all, whereas WF-flexibility is addressed only to a limited extent.

## 6 Improvements in WFMA Implementation Approaches

This chapter recommends approaches to effectively improve process-/WFMA-flexibility and -interoperability through WF-projects. It is not intended to provide a complete life-cycle model, but singular measures to enrich already existing methodologies. Chapter 5's methodological evaluation revealed that WF-project methodologies have specific scopes that do not usually imply WF-flexibility and WF-interoperability, but that sufficiently cover other relevant project objectives. It is not intended to propose a complete WF-methodology with an emphasis on flexibility and interoperability, as this might neglect other important issues that are sufficiently covered by existing methodologies. Singular measures to amend existing methodologies are described instead. Figure 6-1 illustrates how this chapter's measures are derived from previous chapters.

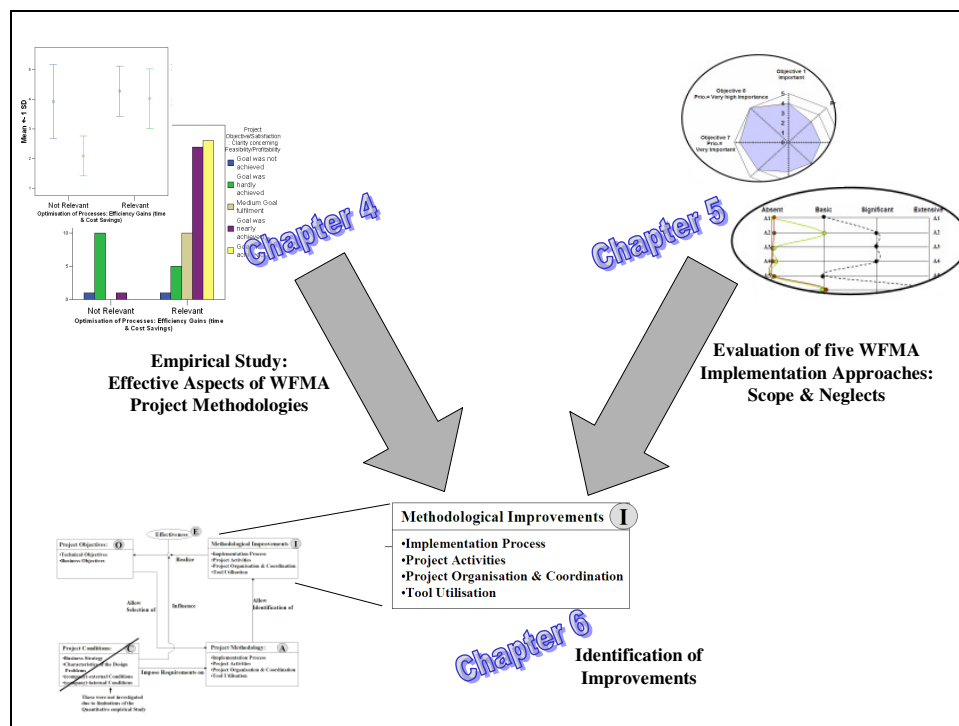


Figure 6-1: Derivation of Methodological Improvements

The described measures are derived from chapter 3's research variables that concern methodological aspects of WF-projects, and the relevance of these aspects was fully reviewed in that chapter. Similarly this chapter draws on the empirical study's hypotheses provided and discussed with regard to an aspect's effectiveness in chapter 4. References to chapter 5 clarify how the investigated WF-methodologies apply recommended measures. The chapter outlines methodological improvements, but does not deeply describe the measures. Many of the improvements refer to facets of WF-flexibility and WF-interoperability as described in chapter 2. To conclude, recommendations for improvements to WFMA implementation approaches are based on the following requirements:

- Improvement measures need to be based on relevant methodological aspects. Aspects' relevance need to be secured by means of interviews with domain experts and a literature survey (See Chapter 3).
- Effectiveness of potential measures need to be proven by means of the empirical study (See Chapter 4).

- Measures must complement existing life-cycle models (See Chapter 5).
- A validation of the suggested improvements with experts is necessary (See Chapter 7).
- The recommendations will be capable of being worked into existing approaches as “plug-in improvements” (The improvements do not represent a complete life-cycle model.). Measures will specifically address WF-flexibility and WF-interoperability, i.e. they should refer to a framework of relevant criteria (See Chapter 2).

The scope of improvements is varying, e.g. measures to improve WF-flexibility may address:

- Enhancement of WFs’ adaptability
- Avoidance of WF-adaptations
- Enabling users to adapt WFs (this applies to adaptations that could not be avoided)

### 6.1 Overview: Improvements & Assumed WFMA-Life-Cycle

As the purpose of the thesis is not a novel life-cycle model, a generic implementation process is utilised as a framework for improvements. According to this framework measures need to take effect in the phases of the WF-life-cycle that is illustrated in figure 6-2:

- Feasibility study (prior to build-time)
- Implementation project (build-time)
- Continuous improvement and maintenance (run-time)

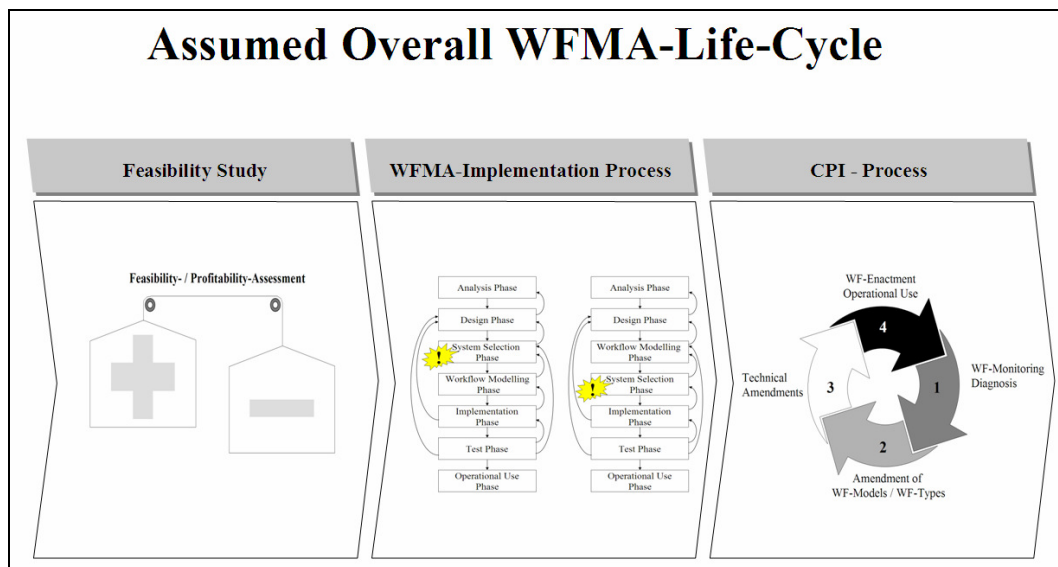


Figure 6-2: Assumed WFMA-Life-Cycle

The following assumptions are the basis for the chosen phase structure:

- Phases of the WFMA-implementation process are geared to a sequential approach (See Section 5.1.10)
- Repeated phase executions allow iterations to a limited extent
- Process knowledge is investigated in the early stages of the project, as process documentations are not available prior to the project
- Project feasibility and profitability need to be investigated
- WFMS-selection occurs late in the project
- Models for process- and WF-specifications are required

Table 6-1 provides an overview of recommended improvement measures for a feasibility study.

Measures		Relevant Research Variables	
No.	Description	Objective	Aspect
M1	Evaluation of the technical, organisational, and political feasibility. Rough evaluation of the economical profitability	O1	A7
M2	Definition & Qualification of Project Objectives	O1, O2, O3	A4, A7
M3	Criteria-based Identification and pre-selection of Business Process candidates	O1, O2, O3, O4	A2, A7
M4	Flexibility and Interoperability focussed Business Process Analysis (Initial business process analysis)	O1, O2, O3, O4, O5, O6	A3
M5	Initial technical analysis: Systems to be invoked, available interfaces, connection requirements with other WFMS	O1, O7	A7, A8b
M6	Consolidation of business-related- and technical deliverables	O2, O7	A8b
M7	Pre-Selection of potentially applicable WFMS	O1, O5	A5, A6

**Table 6-1: Improvement measures / feasibility study**

Table 6-2 provides an overview of recommended improvement measures for the WF-implementation process.

Measures		Relevant Research Variable		Project phases
No.	Description	Objective	Aspect	
M2	Definition & Qualification of Project Objectives	O1, O2, O3	A4, A7	Analysis
M4	Flexibility and Interoperability focussed business process analysis	O1, O2, O3, O4, O5, O6	A3	Analysis
M5	Detailed technical analysis	O1, O7	A7, A8b	Analysis Design
M6	Consolidation of Business Process models and technical deliverables	O2, O7	A8b	Design Implementation
M8	Criteria-based evaluation and repeated review of the processes' "Workflow-Management Capability" (See measure M3)	O1, O2, O3, O4, O7	A2, A8c	Analysis
M9	Iterative Implementation Process	O6, O7	A8c	All phases
M10	Selection of an adequate Process-Modelling methodology	O2, O3, O5, O6, O7	A1	Analysis
M11	Modelling of flexibility- and interoperability-aspects	O2, O3, O5, O6, O7	A1	Analysis Design Implementation
M12	Flexibility- and Interoperability focussed Business Process Optimisation	O1, O2, O3	A4	Analysis Design
M13	Comprehensive System Selection	O1, O5	A5, A6	System-Selection
M14	Prototyping	O1, O2, O4, O5, O7	A8a	Different phases
M15	Repeated analysis of possible process exceptions (See measure M5)	O7	A8c	Design phase System-Selection Test Implementation
M16	Comprehensive System Test	n.a.	n.a.	Test
M17	Comprehensive Training	O2, O3	A12	Test, Operation. Use
M18	Implementation of a CPI-Process	O2, O5	A9	All phases
M19	Effective CPI-Stakeholders	O2, O5	A10	All phases

**Table 6-2: Improvement measures / WFMA implementation process**

Table 6-3 provides an overview of recommended improvement measures for a CPI-Process.

Measures		Fostered Research Variables	
No.	Description	Objective	Activity
M15	Repeated analysis of possible process exceptions (See measure M5)	O7	A8c
M8	Criteria-based evaluation and repeated review of the processes' "Workflow-Management Capability" (See measure M3)	O1, O2, O3, O4, O7	A2, A8c
M4	Business Process analysis: Flexibility and Interoperability focussed Business Process Analysis	O1, O2, O3, O4, O5, O6	A3
M12	Flexibility- and Interoperability focussed Business Process Optimisation	O1, O2, O3	A4
M6	Consolidation of Business Process models and technical deliverables	O2, O7	A8b

**Table 6-3: Improvement measures / CPI-Process**

## 6.2 M1: Analysis of the Project's Feasibility

This measure extends a feasibility study's scope by flexibility- and interoperability aspects. Accordingly, the fulfilment of requirements that pertain to process- and WFMA-flexibility and –interoperability is subject to verification. Thus, M1 is a super-ordinate measure that generally enhances a feasibility study's scope. Further measures are associated with M1.<sup>47</sup> M1 is represented by the research variable (methodological aspect) A7 (see Chapter 3). Given the confirmed hypotheses H5, H12, and H23, an impact of M1 was proven on the following objectives (See Chapter 4):

- O1 (early clarity of the feasibility & profitability)
- O2 (process flexibility)
- O3 (inter-organisational process execution)

It is widely acknowledged in the literature that a preliminary WFM-study is an instrument for the verification of potential process optimisations.[THI01, AND01] By contrast, M1 regards a preliminary investigation as a proof of feasibility and profitability. It is intended to reduce the risk of a WF-project's failure and respectively the risk that a WF-project does not yield an operative WFMA, despite long project durations. M1 does not investigate all issues of a WF-project's feasibility, but focuses on aspects that pertain to the fulfilment of flexibility- and interoperability requirements.

Chapter 5 revealed that the WF-implementation methodologies provide only basic support for feasibility studies. A detailed proof of feasibility, which is executed prior to the implementation project, is not intended. Likewise a pre-selection of potentially applicable WMFS products or a market survey is not executed (see section 6.8). Contrary to the outcome of chapter 5, the empirical study showed that WF-feasibility studies have been carried out in

<sup>47</sup> These further measures of a feasibility study are: M2, M3, M4, M5, M6, M7

practice. The survey also showed that a negative proof of feasibility has prompted companies to abort their WF-projects (6.33% of the companies have terminated the WF-implementation after a feasibility study). WF-projects require high resources and with it considerable investments, so that feasibility studies are justifiable with the intended protection of the investment.

The primary objective of a feasibility study is to achieve an objective investment decision based on a high degree of transparency concerning the technical, organisational, and political feasibility (including risk- and cost-/benefit-assessment). A secondary objective is to gain reusable findings from analysis and investigation for the following steps of a WF-implementation project. The thesis recommends analysis of feasibility and profitability in light of flexibility requirements according to flexibility-facet 1 (see: four key areas of WF-flexibility in section 2.4.1):

- Context-related
- Technical-related
- Time-related
- Cost-/Effort-related

The investigation of interoperability requirements should be carried out in light of the interoperability-facet 1 (see: key areas of interoperability in section 2.5.1):

- Process-aware collaboration
- Abstract processing
- Evolution / Flexibility
- Efficiency
- Competition
- Quality

These key areas allow derivation of benefit-types which must be investigated within a profitability appraisal (See section 2.5.1.: Sixteen benefit types of WF-interoperability. Valuation of benefit-types is often based on assumptions). A few derived issues are provided below.

General conditions of a feasibility study are:

- Cost estimation is difficult without a WFMS-product selection
- Relevant actual costs are often unknown
- Benefits of WF-projects are difficult to appraise on an abstract level
- Resources for a feasibility study are not available to the required extent (Reason: a feasibility must often not create high cost)
- Feasibility study requires highly skilled and motivated employees and analysts which possess a sound methodological background.

It is recommended to analyse the following aspects to gain insights in the achievability of WF-flexibility:

- Which processes possess a sufficient WFM-ability and are potentially automatable under consideration of their flexibility requirements? Processes that impose too high flexibility requirements are not suitable candidates.



- Which requirements on WFMS-products are imposed by the processes' flexibility needs? An early investigation is sensible, as belatedly analysed requirements are usually difficult to realise.
- Are available WFMS-products able to cope with the processes' flexibility requirements?
- Process flexibility might require organisational changes, e.g. modified competencies. It is necessary to find out required organisational regulations, e.g.:
  - Who may modify processes and workflows within the CPI?
  - Who is responsible for the handling of process exceptions?
  - How can organisational measures prevent process exceptions?
- It is necessary to utilise assumptions for the cost-benefit-analysis, e.g.:
  - Types and costs per process exception
  - Number of process variants
  - Costs for the automation of a process variant
  - Costs per modification of a WF-instance during run-time
  - Costs per modification of a WF-model during run-time
  - Quantity structure for processes, workflows, exceptions, modifications, etc.
- Is it possible to keep allowed process cycle-times in the case of a WF-modification?
- How frequent occur customer triggered modifications? How important are these modifications for customer satisfaction?
- Do product- and process-innovations lead to a high modification frequency for processes and workflows?

It is recommended to analyse the following aspects to gain insights in the achievability of WF-interoparability:

- Which intra- and inter-organisational processes can be distinguished? Which processes and functionalities need to be implemented on different platforms?
- Which business partners take part in inter-organisational processes and what requirements are imposed by contractual relationships?
- Are the business plans of business partners compatible to the company's own business plan?
- Is it possible to agree with business partners on a common process- and platform-strategy? It is necessary to keep in mind that it might be difficult to agree on a standardised strategy among competitors due to an imminent loss of competitive advantages of single business partners.
- Is it technically feasible to couple inter-organisational processes? Aspects such as coupling mechanisms and functional cohesion are subject to investigation. Which processes can be completely automated beyond organisational boundaries? For which processes are semi-automated solutions feasible?
- Is it possible to organisationally couple inter-organisational processes? Is it possible to agree on inter-organisational responsibilities and functionalities?
- Is it possible to agree on new responsibilities for IT-systems, WF-types, and interfaces? Who is responsible for the respective heterogeneous WFMS and how is the cost allocation in an inter-organisational process execution?
- Who are the project stakeholders in an inter-organisational WFMA-implementation project? Who needs to be involved? Who is the project sponsor?

### **6.3 M2: Definition & Qualification of Project Objectives**

The measure corresponds to the research variables (methodological aspects) A4 and A7 (see Chapter 3). M2 specifies and quantifies project objectives in light of flexibility and interoperability. Given the confirmed hypotheses H3, H5, H11, H12, H22 und H23, an impact of M2 was proven on the following objectives (See Chapter 4):

- O1 (early clarity of the feasibility & profitability)
- O2 (process flexibility)
- O3 (inter-organisational process execution)

M2 acquaints all project stakeholders with the stepwise refinement of a company's strategic corporate objectives into project objectives for the achievement of flexible processes and an inter-organisational coupling. Refinement of objectives is intended within the course of the feasibility study. Quantified project objectives provide specifications for project activities such as the design of to-be processes and workflows. But also further components of the WFMA are supposed to be technically specified in light of these objectives. It is also necessary to assess how corporate objectives may change over time and how these changes may impact process designs and the WFMA. An assessment of the objectives' achievability is firstly subject to the feasibility study. It is necessary to clearly indicate the impact of flexibility- and interoperability requirements on the achievability of project objectives.

Project objectives must not only be defined on an abstract level at the beginning of the project, without continuous consideration throughout the project. It is necessary to regard them as a standard or even as a benchmark for several project activities:

- They need to be stepwise refined and finally influence project deliverables such as process- and WF-models, e.g. specified as time-constraints or process restrictions. For that purpose quantified objectives must relate to processes (translation into process-related objectives).
- It is necessary to analyse conflicting objectives
- They influence criteria for the evaluation of the processes' WFM-ability
- They impose aims for process optimisations and the design of to-be processes
- Evaluation of their fulfilment is subject to prototyping
- They provide the basis for the derivation of WFMS-selection criteria
- They provide the basis for test criteria and the specification of test-scenarios
- They become part of user trainings, as these explain how the WFMA contributes to the fulfilment of process objectives and corporate objectives. In this sense, clearly communicated objectives are important for user acceptance towards the WFMA.

It is part of the feasibility study to derive process-related objectives from corporate objectives. If a feasibility study is not carried out, goal refinement needs to become an initial step of the implementation project. The thesis recommends specification of project goals in light of Flexibility- and interoperability-requirements, e.g.:

- X % of the exceptions shall be directly processed by the operating user who discovered the exception (See section 2.4.7: flexibility facet 7)
- X % of WF-model modifications shall be directly processed by users without changing responsibilities (possibly for certain WF-aspects) (See sections 2.4.4 & 2.4.5: S1 of flexibility-facet 4 in combination with P2 of flexibility-facet 5)

- A modification of WF-models for process X needs be finished within Y hours/days (See section 2.4.1: Time related purpose of flexibility-facet 1)
- X % of variants for process Y are to be covered by early modelling.
- Incomplete WF-specifications and semantic errors shall be avoided (only X occurrences are allowed) (See section 2.4.2: R7 and R8 of flexibility-facet 2)
- A process-related coupling of new business partners and their WFMA's needs to be executed within X days.
- X % of workflow-instances of inter-organisational WFs need to be executed automatically.
- Manually operated inter-organisational WF-instances are to be processed within maximum X hours by a specified manual process. For that purpose service level agreements for inter-organisational processing are to be concluded.
- A system of process metrics ought to measure process performance.

#### **6.4 M3: Criteria based (pre-) selection of WFM-relevant Business Processes**

This measure is derived from the research variables (methodological aspects) A2 and A7 (see Chapter 3). It (pre-) selects WFM-relevant business processes in light of criteria that are derived from flexibility- and interoperability requirements /-objectives. Given the confirmed hypotheses H1, H8, H19, and H27, an impact of M3 was proven on the following objectives (See Chapter 4):

- O1 (early clarity of the feasibility & profitability)
- O2 (process flexibility)
- O3 (inter-organisational process execution)
- O4 (WFMA interoperability)

A two-step approach is recommended for process identification and –selection:

1. Pre-selection of processes is intended as project task within the feasibility study.
2. A final selection of processes is based on the pre-selected processes within the implementation project.

Literature provides a meta-model for process selection within WFMA projects.[MÜH06] Comparison of WF-implementation methodologies has shown that a sound methodological support is common (See Chapter 5). Solely aspects to do with WF-flexibility and WF-interoperability are hardly considered or even disregarded. M3 aims to provide respective amendments:

- Criteria for the evaluation and selection of processes based on flexibility- and interoperability aspects.
- Process selection portfolio for the visualisation and evaluation of identified processes based on the criteria mentioned before.

Evaluation criteria may be categorised in different ways, e.g. as risk-oriented or benefit-oriented criteria. Further categories are offered by the earlier described facets of WF-flexibility and WF-interoperability (See sections 2.4 & 2.5). Process candidates may be

identified by means of a derivation from strategic corporate objectives. It is also possible to use industry-specific reference models that illustrate typical processes.[HAR02]

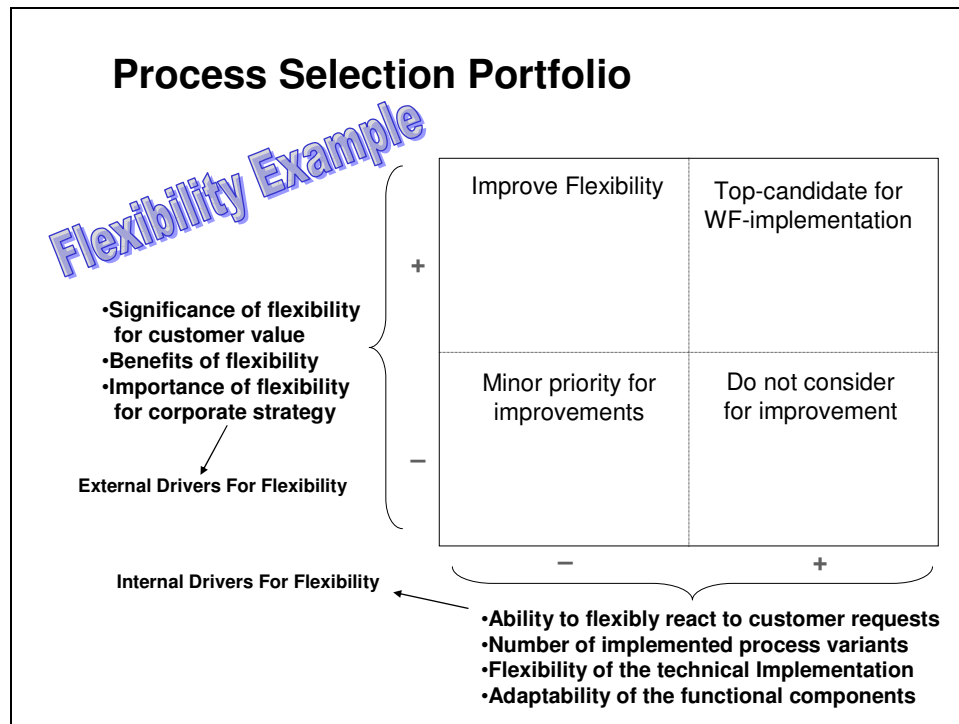
Recommended evaluation- / selection criteria are:

- Number of process variants
- Execution probability for the standard process
- Process structuredness:
  - Level of granularity to which a process can be specified in advance
  - Percentage of process exceptions
- Relative cycle-time for the operation of process variants
- Relative cycle-time for the operation of process exceptions
- Relative cycle-time for the operation of inter-company processes
- Relative cycle-costs for the operation of process variants
- Relative cycle-costs for the operation of process exceptions
- Relative cycle-costs for the operation of inter-company processes
- Frequency of organisational changes
- Frequency of change for IT-applications and data-structures
- Process interdependence: degree of influence between different processes
- Adaptability of the process: expected modifications of the process-/WF-model
- Importance of the process's adaptability for the company's flexibility
- Importance of a WF's adaptability for the flexibility of the entire application landscape
- Importance of the inter-company process for customer satisfaction
- Importance of a flexible process for customer satisfaction
- Error frequency for inter-company processes

An evaluation of processes by means of a process-selection portfolio applies flexibility- and interoperability aspects as objectively as possible within process selection activities. For instance, it is necessary to sort out processes with too high flexibility requirements. In this case process automation by means of a WFMA would impose too rigid process control mechanisms with constraints that limit the required degree of freedom. In a contrary example with marginal flexibility requirements only few measures are required to achieve the wanted degree of process flexibility. A required outcome of the process selection portfolio is the ability to comprehensibly distinguish between these cases. As depicted in the figure 6-3, the portfolio consists of two axes and four fields (developed from Kühl et al [KNO01]).<sup>48</sup>

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<sup>48</sup> A similar process selection portfolio was presented by Kühl, Knöll, Moreton in [KNO01]



**Figure 6-3: Process Selection Portfolio / Flexibility Example**

The horizontal axis shows flexibility-related process characteristics that are internally induced, e.g. ability to flexibly react to customer requests, flexibility of the technical implementation, number of implemented process variants, etc. The vertical axis covers aspects that are out of the company's sphere of influence, e.g. significance of flexibility for customer value, benefits of flexibility, etc. Several aspects can be clustered and depicted on either axis. Each process is located in one field. Prime candidates for further flexibility improvement are those processes with a high rating for externally induced aspects and a low rating for internally induced aspects. Processes with a low rating for both dimensions are of minor importance. However, optimisation must attempt to improve the processes' internal aspects, so that selected processes are moved to the right hand side, in the end.

### **6.5 M4: Flexibility and Interoperability focussed Business Process Analysis**

This measure extends the scope of the process analysis task by flexibility- and interoperability aspects. M4 is applicable within the feasibility study as a rough analysis as well as within the implementation project as a detailed analysis and within the CPI-process during operational use. The measure refers to the research variable (methodological aspect) A3 (see Chapter 3). Given the confirmed hypotheses H2, H9, H20, H28, H33 and H41, an impact of M4 was proven on the following objectives (See Chapter 4):

- O1 (early clarity of the feasibility & profitability)
- O2 (process flexibility)
- O3 (inter-organisational process control)
- O4 (technical WFMA-interoperability)
- O5 (technical WFMA-adaptability)
- O6 (clear process-models) was proven

Chapter 5 revealed that investigated WF-implementation methodologies hardly provide methodological guidance for the analysis of flexibility- and interoperability requirements. However, investigated analysis methodologies possess a general high maturity. Already existing workshop- and interview-approaches need to be simply extended in order to capture flexibility- and interoperability aspects.

Analysis within feasibility studies should start with an investigation of domain relevant drivers of flexibility and inter-company collaboration. Such an environmental analysis reveals, if industry specific flexibility- and interoperability requirements are also applicable to the respective company. A framework of applicable analysis-criteria is provided by flexibility-facet 2 and interoperability-facet 2 (See sections 2.4.2 & 2.5.2). Basing analysis on these criteria provides information of the required degrees of WF-flexibility and WF-interoperability. A later analysis is carried out on a process level and interdependent with measure M3 (pre-selection of processes), as a pre-selection already needs to regard flexibility- and interoperability demands on a process level.

Having selected WFM-relevant processes, analysis is further detailed on a process level. Objects of analysis are changeable workflow aspects. A respective framework of analysis criteria is provided by flexibility-facet 3 (See section 2.4.3). Precise modification requirements can be derived from analysis in the context of facet 3, which again can be classified according to flexibility-facets 4 (Scope / Impact of WF-changes), 5 (Valid periods for WF-changes), and 6 (Types of WF-changes) (See sections 2.4.4, 2.4.5, 2.4.6). Basing an appraisal of processes' flexibility aspects on these criteria allows sound findings. Detailed process analysis during the implementation project has to investigate exception handling requirements. For that purpose flexibility facet 7 is to be applied as an analysis framework (See section 2.4.7).

M4 also bases the analysis of inter-company processes on the described facets of WF-interoperability. A framework is provided by interoperability-facet 3, which initially emphasises aspects such as pragmatic, organisational, and semantic interoperability (See section 2.5.3). Technical interoperability is a concern for the technical analysis (M5).

It is also recommended to analyse the following interoperability aspects:

- Integration of customers via internet
- Integration with Customer-Relationship-Management
- Involvement of business units / Closing of business units
- Implementation of virtual organisations
- Scope of interoperability:
  - Between locations / branches
  - Between organisations within one company
  - Between companies within one group
  - Between groups of companies
- Period of collaboration: temporary versus Permanent collaboration

## **6.6 M5: Scope of the Technical Analysis and Conception**

This measure relates to the research variables (methodological aspects) A7 (feasibility study) and A8 (consolidation of business-related and technical concepts) (see chapter 3). M5 intends to analyse technical requirements on a WFMA and to technically design the WFMA in light of business-related flexibility- and interoperability requirements. It aims to technically

implement a WFMA that fulfils process-related flexibility- and interoperability requirements. Given the confirmed hypotheses H5 and H45, an impact of M5 was proven on the following objectives (See Chapter 4):

- O1 (early clarity of the feasibility & profitability)
- O7 (clearly structured implementation process).

A correlation with O4 (WFMA interoperability) and O5 (technical WFMA-adaptability) was not proven by the survey. The thesis recommends execution of a technical analysis within the feasibility study as a rough analysis and within the implementation project in a detailed manner.

The WF-flexibility related scope of M5 covers for instance, exception handling mechanisms. It is assumed that all business related findings have already been discovered by means on M4 before M5 is carried out. Technical analysis then investigates exceptions on the basis of flexibility facet 7 (See section 2.4.7). All therein described exception handling strategies represent a guiding framework for the execution of M5.

A technical analysis of interoperability aspects is based on the business related interoperability findings of M4. It is represented by the technical aspect of interoperability facet 3 (See section 2.5.3). Further issues for technical analysis are described by interoperability facet 4, namely investigations of message-coupling, process-coupling, and fusion approaches which are based on send-model-, shared-model- federated-, unified-, and integrated approaches (See section 2.5.4). Analysis is also concerned with a proof of applicability of interoperability models, such as chained process models, nested-sub-processes, and parallel synchronized models. These are described within interoperability facet 5 (See section 2.5.5). Finally, a technical design requires decisions with regard to interoperability levels (facet 6) and interoperability dimensions (facet 7) (See sections 2.5.6 & 2.5.7).

It is also recommended to analyse the following technical aspects:

- Interface design:
  - Evaluation of interfaces according to WFMC-standard interfaces
  - Standardised interfaces
  - Loose coupling
  - Middleware, standards for inter-organisational workflow integration, standardised interface technologies
- Changes in the functional cohesion of systems
- Granularity of invoked IT-functionality

### **6.7 M6: Consolidation of Business Process models and technical deliverables**

This measure consolidates business related concepts, such as blueprints and process models with technical deliverables, e.g. WF-specifications, interface-designs, module specifications. The thesis intends to apply M6 within the feasibility study as well as within the implementation project and within the CPI during operational use. It is represented by the research variable (methodological aspect) A8b (see Chapter 3). Given the confirmed hypotheses H10 and H45, an impact of M6 was proven on the following objectives (See Chapter 4):

- O2 (process flexibility)
- O7 (clearly structured implementation process)

A correlation with O3 (inter-organisational process control), O4 (WFMA interoperability), and O5 (technical WFMA-adaptability) was not proven by the survey.

Chapter 5's investigation of WF-implementation methodologies provides a divergent picture, as some methodologies do not consolidate deliverables at all, whereas others provide very sophisticated guidance for consolidation on different abstraction levels. However, flexibility- and interoperability aspects are disregarded by all approaches.

Consolidation of project deliverables is recommended as follows:

- In the feasibility study:
  - Process analysis findings – with – Initial technical analysis outcome
  - Process weaknesses report – with – Potential benefits for the investment analysis
- Implementation project:
  - To-Be process models – with – WF-models, WF-types, interface-design, specification of invoked IT-functionalities
  - To-Be process models – with – Test scenarios

Consolidation of business related models with WF-models and technical specifications requires utilisation of semantically complementary meta-models. Transformations and refinement of deliverables might cause further detailed analysis steps, as deliverables need to be enhanced by new modelling objects that can not be derived from rather abstract models of a previous project step. It is also important not to lose design information concerning WF-flexibility and WF-interoperability during consolidation and refinement steps. Generally refined models need to be semantically equivalent.

Reasons for consolidation are:

- The WFMA's technical implementation needs to be geared to the WF-models, e.g. characteristics of invoked application systems must fit to the defined WF with its granular functionalities that are to be invoked. These application systems implicitly prescribe workflows and sequences of data access.
- An appropriate granularity for invoked IT-functionalities must be developed. Granularity is prescribed by business functions depicted within to-be processes.  
Granularity problem: application systems do frequently not offer interfaces for invoked functionality. Interfaces do often not possess sufficient granularity, which in turn requires re-design of to-be processes to adjust process designs to the capabilities of the IT-applications. Granularity of the to-be processes' organisational design is then artificially raised to a higher level. Activities need to be integrated, which actually conflicts the ideal to-be process.

An inter-organisational process scenario even aggravates such a consolidation. Inter-organisational consolidation relates to deliverables such as interfaces, applied interoperability-standards, cohesion of systems, middleware technology. Further consolidation between organisations concerns:

- Is it possible to integrate inter-organisational processes on an organisational level?



- Does the to-be scenario provide a sufficient process cohesion and process coupling?

### **6.8 M7: Pre-Selection of potentially applicable WFMS**

This measure recommends a market survey and pre-selection of potentially applicable WFMS within the feasibility study. Pre-selection regards aspects of WF-flexibility and WF-interoperability in order to early gain insights into the feasibility of respective requirements by means of available WFMS products. It is obvious that requirements cannot be completely analysed within a feasibility study. Accordingly, a pre-selection is an initial product overview. Yet, it should be investigated if the required degrees of WF-flexibility and WF-interoperability correspond to available technology. Given the confirmed hypotheses H4 and H34, an impact of M7 was proven on the following objectives (See Chapter 4):

- O1 (early clarity of the feasibility & profitability)
- O5 (technical WFMA-adaptability)

A correlation with O4 (WFMA interoperability) was not proven by the survey.

Chapter 5 revealed that investigated WF-implementation methodologies hardly provide methodological guidance for the (pre-) selection of WFMS, particularly not for a WFMS-selection based on WF-flexibility and WF-interoperability criteria.

It is recommended that an initial market survey is carried out prior to the pre-selection. Professional journals, studies, and fair visits are a good means to gain first insights. Applicable criteria for pre-selection are those that have been investigated in the context of measures M1, M4, and M5 (process- and technical-analysis within the feasibility study), i.e. criteria which are represented by flexibility facet 1 and interoperability facet 1.

Initial vendor workshops are a further concern of M7 in order to gain insights in the fulfilment of initially analysed requirements. Vendors should be acquainted with:

- WFMS-relevant project objectives according to M2
- Pre-selected WFM-relevant business processes according to M3
- Roughly analysed process-related requirements according to M4
- Roughly analysed technical-related requirements according to M5

It is imperative that vendor workshops are undertaken, as only few topical studies allow comparison of flexibility- and interoperability features of commercial WFMS products. A wanted outcome of vendor workshops is a validated proof of feasibility, identified gaps, necessary functionally enhancements and an initial costs estimation. Vendor workshops and pre-selections within the feasibility study do not anticipate a final WFMS-selection.

Vendor workshops should also pay attention to the following aspects:

- First-cut estimated implementation costs (according to vendors' experience)
- Licence fees
- Costs for WFMS configuration / customisation
- Functional gaps (based on roughly analysed requirements)
- WMFS's modification mechanisms, adaptation policies, user interface for modification of WF-models, simplicity of the WF-modelling approach

- Exception handling mechanisms; Types of permitted exceptions
- Interoperability mechanisms according to inter-organisational collaboration scenarios
  - Determining factor: WFMS of partner organisations may impose requirements for the interoperability

Findings of different vendor workshops should be compared. Vendor workshops might also reveal that requirements on WF-flexibility of WF-interoperability are too demanding, so that requirements are adapted accordingly.

### **6.9 M8: Criteria-based evaluation and repeated review of the processes' "Workflow-Management Capability"**

This measure relates to the research variables (methodological aspects) A2 (Selection of WFM-relevant business processes) und A8c (Iterative implementation process) (see Chapter 3). M8 complements measure M3 (see section 6.4). The measure recommends iteratively reviewing selected processes in light of their WFM-relevance at different times during the implementation project. Reason for M8 is the assumption that new revealed findings may lead to a different appraisal of the processes' WFM-capability.

Given the confirmed hypotheses H1, H8, H19, H27 and H45, an impact of M8 was proven on the following objectives (See Chapter 4):

- O1 (early clarity of the feasibility & profitability)
- O2 (process flexibility)
- O3 (inter-organisational process control)
- O4 (WFMA interoperability)
- O7 (clearly structure implementation process)

Evaluation criteria and the process-selection portfolio have already been described for measure M3 (See section 6.4). Beyond these instruments M8 recommends to repeatedly review selected processes according to newly-discovered flexibility- and interoperability-characteristics. Reason for M8 is an impending loss of flexibility, if selected processes possess too high flexibility requirements[DIC01]:

- Relevance in the analysis-phase:
  - Investigation of the As-Is-processes' WFM-ability
  - Indication of process improvements for optimisations (M12) in order to achieve WFM-ability of To-Be processes
- Relevance in the design-phase:
  - Investigation of the To-Be-processes' WFM-ability
  - Design of To-Be processes might deviate from As-Is-processes
  - Confirmed To-Be processes are released for implementation
- Relevance in the system-selection-phase:
  - Investigation of the To-Be-processes' WFM-ability in light of the selected WFMS for flexibility- and interoperability requirements.
  - Is it possible to extend the process scope in light of the selected WFMS

### **6.10 M9: Iterative Implementation Process**

This measure relates to the research variable (methodological aspect) A8c (iterative implementation process) (see Chapter 3). M9 permits iterations and feedback loops within the implementation process in order to incorporate late findings for flexibility and interoperability requirements. Deliverables of previous project steps are to be adapted that way, e.g. process- and WF-models. For that purpose M9 enables returns to previous project phases (See section 6.1; Generic implementation approach). It may lead to an iterative development of process- and WF-models. M9 aims to make models and the WFMA more flexible.

Given the confirmed hypotheses H42 and H45, an impact of M9 was proven on the following objectives (See Chapter 4):

- O6 (clear process models)
- O7 (clearly structure implementation process)

Chapter 5 revealed that a highly iterative implementation process is only recommended in one case.

Iterations facilitate consolidation of technical and organisational interoperability aspects, but also for the management of process modifications. In each phase of the implementation process, one has to repeatedly analyse the possibility for the appearance of process exceptions. It is possible that the development of test scenarios uncovers further requirements on inter-company collaboration, which lead to the adaptation of To-Be-processes and WF-models. Feedback loops to previous phases require transformations or adaptations of previous deliverables in order to avoid inconsistencies. Permitted iterations need to be based on clear guidelines that prescribe pre-conditions for the execution of iterations.

It is not meaningful to return to the WFMS-selection phase in practice. A repeated execution of the design-phase must not lead to a repeated execution of the system-selection phase. It is unrealistic that newly-discovered findings that arise during the implementation phase lead to a cancellation of the WFMS-decision. This would imply project failure.

### **6.11 M10: Selection of an adequate Business Process Modelling (BPM)-approach**

This measure is derived from the research variable (methodological aspect) A1 (Business-process-/WF-modelling) (see Chapter 3). It is concerned with the systematic selection of a BPM- and WF-modelling approach whose meta-models allow continuous depiction of a process's flexibility- and interoperability aspects. For that reason respective modelling objects need to be utilised in accordance with flexibility- and interoperability requirements which were analysed within the feasibility study. A major constraint of M10 is the fact that many BPM methodologies exist, so that there is no general approach that fulfils specific requirements of all WFM-projects. Thus, the BPM-approach to be utilised is not prescribed, but need to be thoroughly selected within the course of the project.

Given the confirmed hypotheses H7, H18, H32, H40, and H43, an impact of M10 was proven on the following objectives (See Chapter 4):

- O2 (process flexibility)
- O3 (inter-organisational process control)
- O5 (technical WFMA-adaptability)

- O6 (clear process-models),
- O7 (clearly structure implementation process)

A correlation with O4 (WFMA interoperability) was not proven by the survey.

An investigation of WF-implementation methodologies shows that BPM is usually supported to a significant extent (See Chapter 5). However, flexibility- and interoperability aspects are disregarded by all approaches, but only one methodology concerns modelling of flexibility aspects.

If a feasibility study has revealed that WF-flexibility and WF-interoperability are wanted process properties, it is necessary to select a BPM-approach that is able to depict respective requirements. Selection occurs within the implementation project and is based on several factors. It is important to choose complementary BPM- and WF-modelling approaches. Both approaches should not be proprietary, hence do not refer to a certain WFMS. A proprietary approach is required for later WF-type specifications, which will be selected as an implicit part of the WFMS.

According to Bider three general factors need to be considered [BID01]:

1. Properties of modelling objects, i.e. characteristics of business processes
2. Characteristics of the modelling environment
3. Intended use of the model

The first factor, namely process characteristics, represents criteria for the selection of an ideal modelling approach, as they stand for:

- Expressive modelling objectives that are able to express
  - Standard processes and process variants with alternative flows
  - Time constraints
  - Black box constructs to allow late-modelling
  - Modelling objectives to indicate activities beyond an organisation's boundaries, e.g. external actors, organisational interfaces
  - Expected exceptions
- Techniques for the refinement and distinction of sub-processes and variants
- Methodologies for the transformation of process models into WF-models

## **6.12 M11: Modelling of Flexibility and Interoperability Aspects**

M11 is based on the research variable (methodological aspect) A1 (Business-process-/WF-modelling) (see Chapter 3). It is concerned with the same project objectives as M10 and refers to the same research hypotheses (See section 6.11). The outcome of chapter 5's comparison of methodologies is transferable to M11.

M11 applies the selected modelling methodology (measure M10) and depicts flexibility- and interoperability aspects on the requested degree of granularity. Modelling occurs in accordance with the methodology's meta-model. Main objective is a complete and correct depiction and a stepwise transformation of process models into WF-models and therewith a consistent continuation of flexibility- and interoperability aspects in rather technical deliverables. It is a concern of M11 that project team members are not only acquainted with the BPM methodology but also with the aims and benefits of clear process- and WF-models.

A further recommendation of M11 is to consider the following aspects for BPM and WF-modelling:

- Review of all processes to guarantee that all events that trigger process modification and inter-organisational WF executions are completely defined
- Definition of team members who are responsible for BPM
- Definition of modelling standards for the depiction of inter-organisational interfaces, WFMA-interfaces, etc.
- Definition of an adequate degree of granularity
- BPM training for team members for the modelling of robust process- and WF-models
- Specification and depiction of flexibility- and interoperability related process objectives and process risks within models
- Utilisation of pre-defined process templates for expected exceptions, process variants and inter-organisational interfaces
- Avoidance of semantic errors in order to reduce later modifications
- Modelling of generic / standardised processes and WFs to reduce the number of special cases
- Modelling of process variants to depict complex processes in a clearly arranged way
- Modelling of expected exceptions
- Modularisation and decoupling of process- and WF-models relieves later modifications
- Late-modelling of WFs that cannot be anticipated during build-time allows precise WF-specifications during run-time. Black-box constructs are a possible means to Late-modelling.
- Inter-organisational consolidation of process models

### ***6.13 M12: Flexibility- and Interoperability focussed Business Process Optimisation (BPO)***

This measure is derived from the research variable (methodological aspect) A4 (Business-process-optimisation) (see Chapter 3). BPO according to M12 strives for the improvement of a processes' flexibility. A further aim is to enable inter-organisational process execution. Furthermore, M12 evaluates weak points that were revealed during the feasibility study in light of potential improvements and benefits which a WFMA implementation might provide.

Given the confirmed hypotheses H3, H11, and H22, an impact of M12 was proven on the following objectives (See Chapter 4):

- O1 (early clarity of the feasibility & profitability)
- O2 (process flexibility)
- O3 (inter-organisational process control)

Chapter 5 revealed that investigated WF-implementation methodologies significantly provide methodological guidance for BPO. Yet, comparison of methodologies has turned out that an improvement of process flexibility and WF-interoperability is not within the BPO scope.

It is first necessary to choose processes that are to be optimised. This selection activity adopts the findings of measures M3 (selection of WFM-relevant business processes) and M4 (Flexibility and Interoperability focussed Business Process Analysis). BPO generally pays attention to processes for which optimisation promises maximum benefits. From a flexibility perspective, the thesis proposes to optimise processes as follows:

- Reduction of processes' complexity
  - Abolition of special processes without value creation, insubstantial orders, or insubstantial customers
  - Abolition of process variants, which are hardly executed
  - Appraisal of process variants' value creation and benefits
- Standardisation of processes by considering the condition that standardisation must not constrain competitiveness and customer-orientation
  - A primacy is to avoid modifications. Not any WF-modification must be permitted.
  - Definition of rules that help to decide if process deviations may lead to WF-modifications, e.g. depending on customer groups or ABC-classifications
  - Frequently occurring special processes can be harmonised and standardised to one process.
- Simulation of processes and WFs to avoid errors that would cause later amendments
- Anticipation of possible exceptions and modifications.
  - Increase the number of expected modifications in favour of a reduction of unexpected modifications (See section 2.4.2)
  - Implementation of procedures and mechanisms for the handling of expected modifications.
- Classification of process steps with respect to permissible modifications
- Development of robust and modular sub-processes
- Design of case-closed sub-processes which can be composed to entire processes that again can be easily modified
- Granting degrees of freedom during process execution
  - Shift decision-making authority to the execution level to accelerate cycle time
- Provision of well-defined access points to adapt processes during run-time
- Gather customers' data only once within processes
- Enable flexible WF-execution by allowing the first point of contact with the customer to tailor the process to the customer's needs

An execution of inter-organisational processes is rather expensive. They should be executed only if an execution is required in accordance with the value chain. In this sense, an organisation should get rid of inter-organisational processes without value creation. In addition, M12 recommends following optimisations to improve interoperability:

- Establishment of an inter-organisational appreciation for the overall process and its objectives
- Avoidance of goal conflicts within participating organisations
- Seize confidence-building measures and establish an enduring climate of mutual trust between contact persons within participating organisations
- Increase communication skills for employees that are involved in inter-organisational processes
- Implementation of procedures for an inter-organisational escalation management
- Assign clear competencies for inter-organisational processes:
  - Reduce to number of decision makers and contact persons
- Definition of a service-level with respect to cycle-time and quality for inter-organisational processes
- Reassign tasks in an inter-organisational environment
  - Avoid redundant work that is executed in both organisations

- Efficient design of process activities at the interface between involved organisations
- Consolidation and review of inter-company business process models
- Conclude agreements on:
  - Process standards
  - Distribution of responsibilities
  - Assignment of duties
  - Granted Rights
  - Fault tolerances
  - Permitted failure rates
  - Specification methodologies
  - Procedures for deviating processes
  - Common test procedures

#### **6.14 M13: Comprehensive System Selection**

This measure refers to the research variable (methodological aspect) A6 (WFMS-Selection) (see Chapter 3). Given the confirmed hypotheses H4 and H34, an impact of M13 was proven on the following objectives (See Chapter 4):

- O1 (early clarity of the feasibility & profitability)
- O5 (technical WFMA-adaptability)

A correlation with O4 (WFMA interoperability) was not proven by the survey.

Chapter 5 revealed that investigated WF-implementation methodologies hardly provide methodological guidance for the selection of WFMS, particularly not for WFMS-selection based on WF-flexibility and WF-interoperability criteria.

The importance of WFMS-selection is represented by a special project phase within the implementation project. M13 and M7 are related measures. In contrast to M13, M7 has already pre-selected potentially applicable WFMS within the feasibility study. Thus, WFMS selection is a two-tier process, as the outcome of M7 is a prerequisite for M13. A final WFMS-selection does not occur before finalisation of the processes' To-Be-design, i.e. after the design- and WF-modelling phases. Executing WFMS-selection after the WF-modelling phase requires an initial design of WFMS-independent WF-models. Nevertheless, relevant selection criteria encompass aspects of WF-flexibility and WF-interoperability. Such a two-tier WFMS selection benefits from the availability of much more detailed findings to do with flexibility and interoperability requirements. This is the main reason why a well-founded WFMS selection is only feasible after finalisation of To-Be-design steps.

A few selection criteria have already been mentioned for the pre-selection measure (M7) (See section 6.8). In addition M13 proposes to apply precise requirements, e.g.:

- Modification approaches for changeable WF-objects according to flexibility facets 3, 4 5, and 6
- Exception handling features according to flexibility facet 7
- Degrees and models of interoperability according to interoperability facets 4 and 5
- Levels and dimension of interoperability according to interoperability facets 6 and 7
- Ability to couple heterogeneous WFMS between business partners

These criteria need to be entirely catalogued in order to gain requirements specifications, which again become the basis of a request for proposal. The bidding process may include vendor workshops which should be based on the requirements specification. Scoring models and sensitivity analysis approaches may be applied to verify different proposals. An application of scoring models again requires an intensive adjustment of weighting coefficients which express the individual importance of WF-flexibility and WF-interoperability.

### **6.15 M14: Prototyping**

This measure is based on the belief that a systematic prototyping of a WFMA's flexibility- and interoperability features leads to valuable feasibility findings. A second aim of M14 is to allow a more requirements-oriented implementation of WF-flexibility and inter-organisational collaboration on a process- and on a system-level. M14 is represented by the research variable (methodological aspects) A8a (prototyping) (see Chapter 3).

Given the confirmed hypotheses H6, H13, H31, H35, and H45, an impact of M14 was proven on the following objectives (See Chapter 4):

- O1 (early clarity of the feasibility & profitability)
- O2 (process flexibility)
- O4 (WFMA interoperability)
- O5 (WFMA-adaptability)
- O7 (clearly structure implementation process)

A correlation with O3 (inter-organisational process control) was not proven by the survey.

Chapter 5 revealed that investigated WF-implementation methodologies hardly provide methodological guidance for WFMA prototyping, and WF-flexibility and WF-interoperability criteria are totally disregarded.

WFMA prototyping may occur in two ways. Firstly, explorative prototyping may be applied to verify user-interfaces and the WFMA's usability. Secondly, experimental prototyping helps to verify exception handling features and the WFMA's ability to modify WFs during run time. Accordingly interoperability features of heterogeneous WFMA may be investigated with prototypes. Respective prototyping scenarios can be derived from flexibility-facets and interoperability-facets in chapter 2.

Prototyping may occur in connection with WFMS-selection, if different vendors are instructed to exemplarily demonstrate and to prove feasibility for certain interoperability- and flexibility features by means of a WFMA prototype. It needs to be considered that only few well-selected requirements can become prototyping scope. Relevance and efficiency are important factors for determination of the prototyping scope, e.g. exception handling and modification of WF-models.

Vendors are supposed to prove that WFMS are able to cope with the difficult challenges of WF-flexibility and WF-interoperability.

### **6.16 M15: Repeated Analysis of possible Process Exceptions**

This measure relates to the research variable (methodological aspect) A8c (iterative implementation process) (see Chapter 3). It complements the technical analysis as described



by M5 (see section 6.6). For that purpose M15 is based on the analysis- and evaluation framework for WF-exceptions as described by flexibility facet 7 (See section 2.4.7). This measure is based on the belief that an initial analysis of possible process exceptions is not sufficient, but that a complete view emerges during the WF-life-cycle. It is assumed that new findings for process exceptions are gained throughout the project. M15 reveals possible modifications of processes and WFs that particularly arise due to events beyond an organisation's boundaries.

Given the confirmed hypothesis H45, an impact of M15 was proven on the objective O7 (clearly structure implementation process) (See Chapter 4).

Chapter 5 revealed that a highly iterative implementation process is only recommended by one WF implementation approach.

New findings with regard to process exceptions are possible as follows:

- In the Design phase based on To-Be-processes:
  - Process optimisations eliminate or create new process exceptions
- In the WF-modelling phase:
  - Stepwise derivation of WF-models and WF-types are a formal representation of process models and highlight new previously unknown exceptions
- In the WFMS-selection phase:
  - It is possible that WFMS do not provide adequate exception handling features.
  - The selected WFMS might offer features:
    - that only allow to handle process variants instead of process exceptions
    - or the other way round integration of expected exceptions as process variants within WF-models.
- In the Test phase:
  - Test scenarios and test cases uncover unknown exceptions
- In CPI:
  - Operational use leads to new findings concerning exceptions (See also M18; section 6.19).

### **6.17 M16: Comprehensive System Test**

A further measure recommends a WFMA test with test-scenarios that specifically concern WF-flexibility and WF-interoperability. As the research framework does not include a respective research variable (methodological aspect), the empirical study provides no evidence for an impact on any project objective. Yet, it is expected that M16 might have an effect on the objectives O4 (WFMA-interoperability) and O5 (WFMA-adaptability).

Test scenarios need to be derived from To-Be processes. They reflect requirements according to flexibility facets 1 to 7 and interoperability facets 1 to 7. Chapter 2's explanations provide an additional basis for the derivation of test scenarios. For instance, test issues are exception handling strategies, but also modifications of WF-models during run-time. Threshold tests are to be carried out, if necessary. Time constraints are a further issue for tests. Standard WFs, WF-variants and all deviating cases also require test verification.

An integration test of inter-organisational processes requires execution of inter-organisational test cases. However, interfaces need to be tested bilaterally, beforehand. Inter-organisational collaboration also demands verification of functional cohesion, i.e. the distribution and

assignment of tasks to organisations. This also concerns implementation of business functionality within either WFMA.

Test case creation is a joint task for all concerned business partners. Termination criteria need to be defined together. It is also necessary to jointly coordinate, create and generate test data for bidirectional tests. A comprehensive system test should also imply migration procedures, as a possible new functional cohesion might require data migration. If so, data migration and data cleansing are further test issues.

### **6.18 M17: Comprehensive Training**

This measure is derived from the research variable A12 (see Chapter 3). Given the confirmed hypotheses H17 and H25, an impact of M17 was proven on the following objectives (See Chapter 4):

- O2 (process flexibility)
- O3 (inter-organisational collaboration)

Comparison of WF-implementation approaches showed that methodologies hardly provide guidance for the conception and execution of user training (see Chapter 5). Only one approach addresses training to a significant extent. Yet, WF-flexibility and WF-interoperability are disregarded.

M17 intends to explicitly acquaint users with the importance and issues of flexibility and inter-organisational collaboration, respective process designs, and procedures and tools that help to achieve process flexibility and inter-organisational collaboration. The thesis recommends addressing the following training content:

- Execution of reorganised company internal processes
- Training content to improve WF-interoperability:
  - What is the meaning of network organisations?
  - Which processes are executed between organisations by aid of the WFMA?
  - How is the workflow that crosses boundaries of different companies defined?
  - Which are the processes' objectives in an inter-organisational context?
  - How does the inter-organisational process execution contribute to the corporate strategy?
  - What specific activities are required to perform an organisation's interface?
  - What organisational procedures are defined for the handling of exceptions with an inter-organisational impact?
  - Distribution of responsibilities between organisation
  - Assignment of duties between organisations
  - Granted rights and competencies according to the defined inter-organisational task execution
  - Responsible contact persons in partner organisations, e.g. for an exception-handling for inter-company workflows
  - Fault tolerances & permitted failure rates for sub-workflows in each organisation that takes part in inter-company workflow execution
  - Procedures for deviating processes
- Training content to improve WF-flexibility:
  - Importance of process flexibility for the corporate strategic objectives

- Categorisation of WFM-relevant processes according to the wanted degree of flexibility
- Standard processes and process variants
- Procedures, techniques and tools for the handling of process exceptions
- Permitted categories of process-/WF-modifications according to flexibility facets 2 to 7
- Procedures for a flexible division of WF-instances to achieve a homogeneous workload among employees
- Flexible process executions according to changing priorities, responsibilities, competencies, etc.
- Possibilities for the permanent enhancement of processes and WFs by means of the CPI
- Procedures, responsibilities and regulations of the CPI
- Modelling techniques for WF-modifications
- WFMA tools and features for WF-model and WF-type adaptations
- Leeway of flexibility. When is a modification relevant for WF-models?

### **6.19 M18: Implementation of a CPI- Process**

This measure relates to the research variable (methodological aspect) A9 (CPI-process), but it is necessary to regard M18 in connection with measure M19 and research variable A10 (see Chapter 3). M18 assumes a permanent process for WFMA enhancement and process optimisations during operational use. The BPM-life-cycle provides a standard process for CPI (See section 2.2). Exception handling, process optimisations and WF-modifications are supposed to be executed in accordance with a clearly defined governance process. Given the confirmed hypotheses H14 and H37, an impact of M18 was proven on the following objectives (See Chapter 4):

- O2 (process flexibility)
- O5 (WFMA adaptability)

The comparison of WF-methodologies draws a divergent picture, as some approaches provide significant CPI-guidance, whereas others totally ignore permanent improvements (See Chapter 5).

As mentioned above, a CPI process demands clear and obligatory definitions. They cover guidelines and tolerances for modifications of WF-models and WF-instances. An important part of CPI is a well-defined communication process between users which fosters the exchange of experiences with regard to process executions, weaknesses & potential improvements, and exception handling. Information gathering is aided by WF-monitoring mechanisms and process-mining tools. These tools provide process performance indicators and help to gain insights in possible process amendments, e.g.:

- Available customer service representatives
- Response time to custom orders
- Average time to process special orders as compared to standard orders
- Refusal rate for special orders

Process improvements cause modifications (as described within flexibility facet 3) during run-time, but also further reasons constitute change (See Section 2.4.2). It is necessary to keep in

mind that modifications do not only concern the WFMA, but may also impact the organisational environment, e.g.:

- Redefinition of staff instructions under consideration of:
  - New responsibilities
  - Enriched competencies (wider scope for process executions)
  - New information guidelines and communication channels
- Training of employees

CPI also concerns management of process variant, i.e. validation and abolition of unnecessary WF-variants.

## **6.20 M19: Effective CPI-Stakeholders**

This measure is derived from the research variable (methodological aspect) A10 (Team composition for CPI-process), but it is necessary to regard M19 in connection with measure M18 and research variable A9 (see Chapter 3). M19 implies that an involvement of process owners and technical WFMS-experts leads to a most effective CPI.

Given the confirmed hypotheses H15 and H38, an impact of M19 was proven on the following objectives (See Chapter 4):

- O2 (process flexibility)
- O5 (technical WFMA adaptability)

Chapter 5 revealed that a stakeholder-analysis or an adequate team composition is barely covered by WF-implementation methodologies.

An interdisciplinary team composition is meaningful and should involve process owners as well as technical WFMS experts. It allows analysis of business related modification requests but also verification of exceptions from a technical and business related perspective. General conditions for the utilisations of M19 are:

- Are experts available with appropriate skills and in adequate number?
- Is the company organised in process teams or functional teams?
- Were CPI members also team members within the implementation project?
- Is an adequate communication structure implemented for CPI?

## **6.21 Conclusion**

Nineteen measures have been identified that can improve the achievement of WF-flexibility and WF-interoperability. These measures were assigned to three general steps of the WF-life-cycle, namely:

- Feasibility study
- Implementation project
- CPI-Process

Most measures relate to the research variables. One measure for which an improving effect is expected has also been described. It is intended that the described measures provide methodological guidance on a 'significant' level (See Section 5.2: scale of the Evaluation

framework for WF-methodologies). An ‘extensive’ support would require more comprehensive explanations and ongoing action research (See Section 5.2: scale of the Evaluation framework for WF-methodologies).

## 7 Validation of Methodological Improvements

The intent of this chapter is to validate the previous chapter's methodological improvements in light of the following issues:

- General applicability
- Assumed effectiveness
- Necessity for further enhancements

It is not intended to verify the measure's effectiveness by means of an action research approach. Validation is also not intended to provide conclusions with statistical significance.

All improvements were validated in interviews with workflow-experts and/or within a case-study at the Leuphana University of Lüneburg.

- Structured interviews were carried out with three workflow experts at different companies. In a first step the improvement measures were briefly described. Then the participants were interviewed with respect to the above mentioned three issues. All improvement measures were subject to interviews.
- A case study was carried out with students of the Leuphana University of Lüneburg (see Appendix D). Participants were students of the MSc in Applied Computing. The case study was an assignment of the "Management of Software Projects" –module. Validated improvement measures were M1, M8, M11, M12, and M15. The case study was executed with two groups. One group applied improvement measures, the other group acted as a reference group which applied conventional methodologies. The assignment was a written project report with a reflection on the experiences of the project. Grades were assigned with respect to the academic quality of the discussion made within the report.<sup>49</sup> The intention was to gain findings with respect to the measures' applicability.

The cognitive value of the interview findings is estimated as follows:

- Interviewees are experienced WF-experts who know the challenges of WF-projects. For that reason it is assumed that they are able to validate a measure's potential applicability even if they did not apply the proposed measures in real-life projects.
- A high significance of the assumed effectiveness is expected as the addressees have experienced other methodologies in practice.
- A drawback of the interview methodology is that interviews are merely a snapshot in which participants are only briefly confronted with the proposed improvements. It is necessary to keep in mind that participants have not applied the measures in practice over a longer period.

The cognitive value of the case-study findings is estimated as follows:

- Case study participants are neither WF-experts nor experienced project-managers, but they have attended a number of software-engineering lectures. For that reason students possess a sound theoretical skill that is the basis for validation.
- Students had the ability to sample a few measures to experience the advantages and drawbacks in a simulated project which was carried out over several weeks.























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<sup>49</sup> It was not marked in terms of WF-flexibility and WF-interoperability as project deliverables, as the reference group were not able to apply improvement measures.

- A drawback of the case study approach is that it was not carried out with WF-experts. Yet, the fact that all students possessed a sound SW-engineering skill assured a considered reflection upon the measures' applicability.

### 7.1 Overview: Validated Improvement Measures

The following table provides an overview on the validated improvements and the applied validation approaches.

Improvement Measure		Validation	
No.	Description	Interview	Case-Study
M1	Evaluation of the technical, organisational, and political feasibility. Rough evaluation of the economical profitability		
M2	Definition & Qualification of Project Objectives		
M3	Criteria-based Identification and pre-selection of Business Process candidates		
M4	(Rough) Business Process analysis: Flexibility and Interoperability focussed Business Process Analysis		
M5	(Rough) Technical analysis Systems to be invoked, available interfaces, connection requirements with other WFMS		
M6	Consolidation of Business Process models and technical deliverables		
M7	Pre-Selection of potentially applicable WFMS		
M8	Criteria-based evaluation and repeated review of the processes' "Workflow-Management Capability" (See also measure M3)		
M9	Iterative Implementation Process		
M10	Selection of an adequate Process-Modelling methodology		
M11	Modelling of flexibility- and interoperability-aspects		
M12	Flexibility- and Interoperability focussed Business Process Optimisation		
M13	Comprehensive System Selection		
M14	Prototyping		
M15	Repeated analysis of possible process exceptions (See measure also M5)		
M16	Comprehensive System-test		
M17	Comprehensive Training		

Improvement Measure		Validation	
No.	Description	Interview	Case-Study
M18	Implementation of a CPI-Process		
M19	Efficient CPI-Stakeholders		

**Table 7-1: Overview: Validated Improvement Measures**

## **7.2 M1: Evaluation of the technical, organisational, and political feasibility. Rough evaluation of the economical profitability**

A feasibility study did not form part of the case study. M1 was validated by means of interviews in which the general need for a feasibility study was confirmed for WFMA implementation projects. It was argued that high WFMA-project costs as well as high follow-up costs are a major concern for the execution of feasibility studies. The proof of technical feasibility was regarded as the main matter of a WF-feasibility study. An identification and assessment of political and organisational risks were termed as further issues. Interviewees also approved a cost-benefit analysis as a concern for the feasibility study. Moreover, a complementary risk-analysis was recommended as an extension to M1, M2, and M8.

The measure's view on WF-flexibility and WF-interoperability was confirmed to be meaningful. Particularly inter-company collaboration and resulting opportunities, risks, benefits and costs should be subjects of a feasibility study. Interviewees pointed to possibly emerging problems for the monetary valuation of costs and benefits of WF-flexibility. They stated that necessary assumptions could only be vague. It was recommended amending the investment analysis with the definition and calculation of different scenarios, e.g. high, medium, and low flexibility requirements. A further proposal in this context was the execution of a sensitivity analysis in order to investigate cost- and benefit-drivers with a high impact on financial KPIs.

## **7.3 M2: Definition & Qualification of Project Objectives**

### **7.3.1 Feedback from Interviews**

Interviewees agreed to a goal definition process in which objectives for WFMA projects are to be derived from strategic corporate objectives. For that reason, it was mentioned that a goal-definition process must occur early in the project, ideally as part of a feasibility study. It was also confirmed, that WF-flexibility and WF-interoperability usually have correspondence with corporate objectives. A recommendation was to clarify the contribution of process- / WF-flexibility and –interoperability to strategic corporate objectives. Interviewees conceded assumed difficulties for a monetary quantification, but proposed a qualitative appraisal instead. However, the contribution of WF-technology to corporate flexibility requirements and inter-organisational collaborations was regarded as a crucial information for top-management addressees.

An important suggestion was to regularly review the objectives' relevance, topicality and fulfilment during the CPI-process, as objectives may change over time and possibly new corporate objectives become relevant as a basis for WFMA-amendments.



### 7.3.2 Feedback from Case Study

The case-study's group 1 obtained a general description of project goals whereas a very specific goal definition was provided to group 2. The case study revealed the following results.

- Group 2 reported that the precise goal definition was a helpful means to execute project activities in a goal-oriented way. It was clear that WF-flexibility and an inter-company collaboration scenario were required project objectives. Thus project activities were carried out to fulfil these objectives. Students recommended distinguishing between project-related objectives and process-related objectives to provide more clear instructions for improvement of single processes.
- Group 1 reported that WF-flexibility and WF-interoperability were only two objectives which appeared to be of minor importance compared to other goals such as WFMA implementation and BPR. The lack of a quantified goal definition meant that these objectives were not explicitly pursued. Indeed, inter-company collaboration and a flexible process design were mentioned as required project goals, but a lack of precise goal specification resulted in the students attaching their own prioritisation to project objectives.

### **7.4 M3: Criteria-based Identification and pre-selection of Business Process candidates**

Interviewees referred to their own WF-project experience in which WF-relevant processes have been selected in a more or less systematic way to define the project scope. General aspects such as a process's execution frequency, process structuredness, and the number of weak-points were used as selection criteria by the interview partners' companies. A comprehensive set of criteria was not applied but considered to be meaningful.

The recommended selection criteria of M3 were judged to be comprehensible, but should be integrated in an overall framework. It was mentioned that possibly further criteria for flexibility and interoperability should amend such a framework. Altogether it was appreciated that M3 allows assessment of a process's capability for WF-automation. The fact that that M3 comprehends risk- and benefit-related criteria that are derived from WF-flexibility and WF-interoperability was regarded as a further advantage. Apart from the request for further criteria, interviewees also suggested weighting the criteria according to their importance and to assign them to industry specific process-reference-models.

### **7.5 M4: Flexibility and Interoperability focussed Business Process Analysis**

The proposed framework for the analysis of flexibility aspects was appraised to be highly comprehensive and complete. Interviewees referred to the need to integrate the suggested analysis aspects in an appropriate workshop-/interview-methodology. During the interviews, it was explained that M4 and M3 are interwoven project activities. Process selection criteria of M3 are therefore also relevant for process analysis. Interviewees approved this interdependency between M3 and M4.

Utilising the recommended interoperability criteria for process analysis was considered appropriate. Nevertheless, it was mentioned that the provided criteria need further refinement to apply them as a precisely defined analysis-framework within process analysis workshops. Interviewees agreed on the need to analyse technical interoperability aspects within a later

separate project step for a technical analysis, which must not be undertaken in isolation from process related interoperability requirements.

### **7.6 M5: Technical analysis**

Interviewees were surprised that hypotheses 29 and 36 were not confirmed by the survey, as they expected a correlation with WFMA-adaptability and WFMA-interoperability. They might have expected that flexibility and interoperability are not only subject to business process modelling, but would also need sufficient consideration in derived technical specifications. The author assumes that interviewees expected specific measures for the inter-phase transformation of flexibility- and interoperability aspects between different deliverables of the workflow project.

Applicability of the described interoperability criteria was judged to be valuable for technical analysis. The set of interoperability criteria was considered to be extensive, but interview partners mentioned that further issues would probably appear during detailed technical specifications.

Flexibility facet 7 was regarded as a very helpful set of criteria to evaluate exception handling requirements (see section 2.4.7). Particularly their applicability for later WFMS-selection was emphasised.

An important suggestion was that the outcome of technical analysis and technical specification would probably require amendments of business process specifications, so that business process analysis and design and technical analysis and design probably require iterative execution.

### **7.7 M6: Consolidation of Business Process models and technical deliverables**

Interviewees would have expected a correlation with two project objectives, namely the technical WFMA-adaptability and particularly with technical WFMA-interoperability. Yet, contrary to the assumptions, the survey had not confirmed an impact on these project objectives.

Validation also revealed that a consolidation of project deliverables is not consistently executed in practice due to high consolidation efforts. Nevertheless, interviewees conceded related implementation errors that are determined late in the project when test results differ from test case specifications and to-be processes. For that reason, M6 was regarded as a highly relevant and meaningful measure. It was also requested to execute a consolidation in a semi-formal way, i.e. without highly formal methods, as business-staff are involved in early project phases and formal transformation steps are not always comprehensible for that audience.

### **7.8 M7: Pre-Selection of potentially applicable WFMS**

An initial market survey was regarded as a relevant project activity for a feasibility study. Interviewees stressed that flexibility- and interoperability issues are only relevant for a WFMS-related pre-selection, if corresponding project objectives were clearly defined and communicated by means of measure M2. For that reason, clear project objectives with a WFMS-impact should be regarded as general requirements within vendor workshops. It was stated that it is also important not to restrict the number of considered WFMS too early.

Potentially applicable WFMS should not get out of scope in case of doubts. Interviewees mentioned that findings with regard to monetary aspects are an outcome of M7 of particular importance.

### **7.9 M8: Criteria-based evaluation and repeated review of the processes’ “Workflow-Management Capability”**

#### **7.9.1 Feedback from Interviews**

According to the interviewees’ experience, a selection of WFM-relevant processes was carried out only once in a WFMA-project. A repeated review and re-evaluation of the processes did not occur. Nevertheless, they agreed to a revision of the as-is-process based pre-selection after the design of to-be-processes, as to-be-processes might differ from as-is-processes. Yet, interviewees were convinced, that a further review during the WFMS-selection phase would be unnecessary, since WFMS-selection needs to be based on firm process specifications.

#### **7.9.2 Feedback from Case Study**

For the case study, group 1 obtained a framework of evaluation criteria that was rather general, i.e. it did not include criteria that specifically referred to WF-flexibility and WF-interoperability. On the other hand, group 2 applied a set of evaluation criteria that was very specific and which allowed assessment of processes’ WFM-suitability in light of flexibility and interoperability requirements. The case study revealed that both groups gained similar findings. Although group 2 has considered types and numbers of possible process exceptions and regarded the challenges of process coupling with brokers, a WFM-suitability was confirmed by both groups. The case study would have possibly yielded a deviating outcome for other processes with a higher demand on WF-flexibility and WF-interoperability.

### **7.10 M9: Iterative Implementation Process**

Interviewees approved the use of iterations for WFMA-projects. It has been stated that flexibility- and interoperability requirements are often not completely apparent at the beginning of the project. According to the interviewees, it is unlikely that requirements for an inter-company collaboration and process-automation can be completely analysed with business partners in a few workshops on a detailed level. It was also mentioned that an iteration of the WFMS-selection phase would probably not occur in practice. A feasibility study (M1) and possibly prototyping (M14), and a solid final WFMS-selection must ensure fulfilment of all crucial requirements.

### **7.11 M10: Selection of an adequate Business Process modelling approach**

Interviewees declared that a process modelling approach is often pre-determined by company-internal modelling standards, so that there is no possibility to select a deviant approach. It was also mentioned that a WF-modelling methodology is often implied by the selected WFMS-product. Interviewees experienced a loss of information during consolidation of models, as process models and WF-models did not have a compatible meta-model. The selection of a specific process-modelling approach would have led to an avoidance of corporate standards. Interestingly, interviewees suggested enhancing corporate process modelling standards by modelling objects for flexibility and interoperability.

## **7.12 M11: Modelling of flexibility- and interoperability-aspects**

### **7.12.1 Feedback from Interviews**

Interviewees agreed to the need for a training of team members in order to impart the importance for adequately modelled processes and WFs. Unfortunately, interviewees had no experience with late-modelling approaches, but it was acknowledged as a valuable approach for the depiction of flexibility. Process variants have been modelled in practice but not consistently transformed into detailed WF-type specifications. Hence, the stringent application of transformation rules was emphasised as a meaningful aspect. It was also suggested that further modelling constructs be used to depict inter-organisational process execution.

### **7.12.2 Feedback from Case Study**

Group 1 did not obtain modelling objects to depict flexibility aspects. On the other hand, group 2 applied simple black-box constructs and objects to depict process variants. The case study revealed the following results.

- Group 1 did not differentiate between standard processes and variants. The students tried to depict all activities of the process, even those for which a process flow could not be anticipated.
- Group 2 provided different process models for the usual process flow and for process variants. Group 2 used black box constructs to simplify the process model, i.e. they decided not to model all special cases, but to provide a black box construct instead.

## **7.13 M12: Flexibility- and Interoperability focussed Business Process Optimisation**

### **7.13.1 Feedback from Interviews**

Interviewees recommended that possibilities for optimisation of a process's flexibility are regarded in light of functional features of a selected WFMS-product and the provided exception handling mechanisms. It was recommended attempting to anticipate as much potential flexibility requirements as early as possible in the project in order to derive respective requirements for the WFMS-product. The simplification and elimination of unimportant process variants was also mentioned as an important issue within process optimisation. It was stated that practice often implements process with poor customer value and a low value creation. An optimisation of inter-company processes was considered in the context of clear inter-organisational agreements for processes, service-level agreements, and an establishment of a trustful business climate.

### **7.13.2 Feedback from Case Study**

Group 1 was provided with rather general guidelines for BPO. On the other hand, group 2 obtained detailed instructions to improve processes' ability for inter-organisational execution. The case study revealed the following results.

- Group 1 only considered company-internal flows for optimisations. Collaboration with brokers was not redesigned or improved.
- Group 2 provided a catalogue of all investigated weak points and process optimisations. These optimisations were related to the elimination of obvious weak points but they also aimed at the improvement of inter-organisational collaboration, as they tried to streamline the cooperation between the insurance company and its brokers. A clear outcome of the

case study was the transfer of As-Is models into To-Be models by means of well-documented optimisations.

#### **7.14 M13: Comprehensive System Selection**

The results for this measure reflected the results for M7 (see section 7.8).

#### **7.15 M14: Prototyping**

Interviewees interpreted the lack of proof of hypotheses H24 (impact of prototyping on process interoperability) as follows. They mentioned that it is hardly possible to prototype inter-organisational collaboration early in the project, as a verification of inter-company processes cannot occur until the test phase. Thus, interviewees were not surprised by the survey's outcome.

Exception handling mechanisms and functionalities for WF-model adaptation were regarded as essential functionalities for prototyping. Prototyping of a technical coupling between heterogeneous WFMS has not been observed in practice. It was mentioned that it would be problematic to utilise a business partner's WFMS for prototyping in practice. Interviewees recommended utilisation of a second WFMS in a lab-situation which could possibly be provided by the WFMS-vendor. Interviewees regarded prototyping within the WFMS-selection phase process as a problematic issue, because a very specific prototyping is a cost-intensive task which will always raise the question of related funding. If prototyping occurs after WFMS-selection, prototyping costs are usually assigned to the implementing company but not to the vendor.

#### **7.16 M15: Repeated analysis of possible process exceptions**

##### **7.16.1 Feedback from Interviews**

Interviewees emphasised that findings with regard to new exceptions can be expected during the operational use. According to the interviewees' project experience a repeated analysis of process exceptions was not executed as a separate project activity.

##### **7.16.2 Feedback from Case Study**

Group 2 identified and catalogued process exceptions, whereas group 1 did not provide a list of investigated exceptions. This is an outcome of the process analysis task (measure M4), as group 2 reported that they did not repeatedly analyse exceptions. Hence, the case study did not contribute to the validation of M15, but showed that a goal directed analysis (M4) helps to identify exceptions.

#### **7.17 M16: Comprehensive System-Test**

Interviewees were surprised that a test-activity was not proposed as a separate research variable. They mentioned that a system-test would also contribute to a clearly structured implementation process (O7) and clarity concerning the project's feasibility (O1). Yet, it was indicated that system-tests would obviously validate feasibility only late in the project. An early clarity as intended by O1 could not be achieved by M16.

A migration test was also suggested, because a changing functional cohesion between applications would probably require data migration. If so, data cleansing and data migration were issues for a migration test.

### **7.18 M17: Comprehensive Training**

The listed training contents were confirmed as a meaningful contribution by the interviewees.

### **7.19 M18: Implementation of a CPI-Process**

The implementation of a CPI was appreciated as sensible recommendation by the interviewees. According to their comments, it is common practice to monitor process performance indicators during operational use, and to utilise them for optimisation purposes. Yet, there was no experience with sophisticated process mining technologies. Regular interviews and workshops with employees were recommended to reveal possibilities for process optimisations. Data migration and data cleansing were raised as further issues for a CPI. These may become relevant, if improvements lead to a modified functional cohesion between applications. It was also mentioned that later integration of further business partners as a consequence of an inter-organisational collaboration might evolve as an issue for CPI. An inter-company process scenario might also trigger a CPI, if business partners provide hints for process improvements.

### **7.20 M19: Effective CPI-Stakeholders**

The involvement of process owners and technical WFMS experts was appreciated as a sensible recommendation.

Furthermore, the interoperability aspect was raised as an issue for team composition especially as an inter-organisational team is required to ensure inter-organisational collaboration. Interviewees mentioned that business experts as well as technical experts of the networking organisations need to be involved to design not only business processes but also technical interfaces between collaborating WFMA.

### **7.21 Conclusion**

Both validation approaches revealed that most improvements were positive and appreciated as an applicable means to better achieve WF-flexibility and WF-interoperability. Furthermore, interviewees confirmed that it is necessary to improve currently available WFMA project methodologies.

None of the measures were rejected by interviewees or case study groups. Further amendments were recommended for some measures especially by the WF-experts. Yet, applicability and effectiveness was generally confirmed. These amendments should be subject to further research projects.

It emerged that the students could mainly provide hints with regard to the measures' applicability, whereas interviewees provided insights into the assumed effectiveness and the possibility to combine the measures with currently available methodologies. Interviews with workflow experts have proved the most valuable approach for validation. Some case study students struggled with the project task and were not able to reflect on the applied methodologies in light of real project experience.

## 8 Summary of Conclusion

The thesis has investigated the contribution of WF-implementation projects to the fulfilment of process-flexibility and the achievement of inter-organisational process automation through WFMA projects. The literature review revealed that both requirements are still a very important concern in the area of business computing. It has also been observed that WFMA's are regarded as an important enabler for automated business processes and a driver for their increased flexibility and inter-organisational coupling. For this reason, the thesis also analysed how adaptability and interoperability of WFMA's could be achieved within WF-projects.

The research design combined several methods of investigation. In a first step the relevance of the overall subject was proven by means of a literature study (see Chapter 1 & 2). Thereupon interviews with WF-experts were carried out to identify three categories of relevant and valid research variables (see Chapter 3):

- Objectives of WF-projects that concern the research scope (WF-flexibility, WF-interoperability and further derived objectives)
- Methodological aspects of WF-projects that help to achieve project objectives
- Environmental conditions of WF-projects that influence the degree of the objectives' fulfilment<sup>50</sup>

These variables formed the research framework. Their relevance was verified by means of a further literature analysis (see Chapter 3). They were surveyed within an empirical study with 79 participants who carried out WF-projects (see Chapter 4). This survey was the key element of the research project. It yielded original material that concerns WF-flexibility and WF-interoperability as objectives of WF-projects and ways to achieve it. Several findings were reported, e.g.:

- Degree of the project objectives' importance
- Degree of the project objectives' achievement
- Impact of the project methodology on the achievement of process flexibility and process interoperability
- Methodological aspects that help to achieve WFMA-adaptability and WFMA-interoperability

A further research step developed the research framework and applied it to the evaluation of five WFM-implementation methodologies (see Chapter 5). This investigation revealed whether the chosen project approaches:

- Strive for the achievement of the identified project objectives that were derived from WF-flexibility & WF-interoperability
- Apply methodological aspects for which an effect on the project methodology was proven by the empirical study

Based on the findings of the empirical study and the methodological evaluation, potential improvements of WFM-implementation methodologies were identified and described (see Chapter 6). These were validated in interviews with WF-experts and within a case study with students of Leuphana University of Lüneburg (see Chapter 7).

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<sup>50</sup> Environmental conditions were later omitted from the empirical study as explained in chapter 4

### **8.1 Summary of Findings / Recommendations**

The research project revealed that WFMA implementation methodologies lack sufficient methodological support to achieve process- and WF-flexibility and –interoperability, as effective methodological aspects are not sufficiently provided. A recommended set of methodological improvements should be adopted by available WF-methodologies. Applicability and effectiveness of these improvements was validated.

A reference to the 8 initially defined research objectives (see section 1.2), allows summarising findings and recommendations as follows:

**Research Objective 1:** Review of the relationship between workflow management and the claim for process flexibility respectively –interoperability

Satisfaction of further increasing requirements on WF-flexibility and an inter-organisational process-automation and –control is still a challenge within workflow projects (see Chapters 1 & 2). These requirements need to be specifically addressed by WFMA implementation methodologies

**Research Objective 2:** Definition of a research-/evaluation framework for workflow projects with all relevant research variables that have been identified for the thesis.

A research framework that consists of 42 variables (7 project objectives, 12 methodological aspects, and 23 environmental project conditions) was defined. 47 research hypotheses were defined to prove the effect that methodological aspects have on the fulfilment of specific WF-project objectives. 41 hypotheses were confirmed; 7 hypotheses were rejected. Confirmed methodological aspects and relevant project objectives establish a valid evaluation framework for the assessment of WF-project methodologies (see Chapter 3 & Appendix C).

**Research Objective 3:** Empirical survey of relevant workflow-project objectives and their priority in the context of process flexibility and –interoperability

The survey revealed that process-/WF-flexibility and process-interoperability are desired objectives in workflow projects together with further related objectives (see Chapter 4), e.g.:

- Early clarity concerning the feasibility and profitability of the WFMA project and the achievement of WF-flexibility and WF-interoperability
- Process-flexibility
- Inter-organisational process automation / -execution
- WFMA-adaptability
- Expressive process- and WF-models that clearly depict flexibility- and interoperability-aspects
- A clear implementation process that helps to achieve WF-flexibility and WF-interoperability

The empirical study could not prove the relevance of technical WFMA-interoperability as a major concern, which was a surprising outcome of the survey



**Research Objective 4:** Empirical survey of the project objectives' achievement

The survey indicated that process-/WF-flexibility and process-interoperability were achieved by companies who applied adequate project methodologies. Companies who did not apply specific methodological aspects have not achieved or have hardly achieved these objectives. An achievement of these objectives determines if companies regard a WFMA implementation as a successful project (see Chapter 4).

**Research Objective 5:** Empirical survey of methodological aspects (project activities) that have been applied within workflow projects.

The survey revealed a set of effective measures that can be applied within WFM-projects to particularly achieve WF-flexibility and WF-interoperability. Effectiveness of these measures was empirically verified. Only a few of the investigated measures were not proven to be effective (see Chapter 4).

**Research Objective 6:** Verification of the project methodologies' effectiveness in terms of the impact that applied project activities had on project objectives.

See: research objective 5

**Research Objective 7:** Evaluation of existing workflow life-cycle models in accordance with the research-/evaluation framework.

The evaluation revealed that investigated methodologies regard WF-interoperability actually not at all, whereas WF-flexibility is addressed only to a limited extent (see Chapter 5).

**Research Objective 8:** Identification of basic improvements for workflow implementation processes with respect to the achievement of flexible and interoperable business processes.

The recommended measures do not represent a holistic implementation methodology, but are rather considered as singular improvements that can be applied by existing methodologies. For that reason they were assigned to a generic phase approach for WFM-projects. The reason for this approach is that analysis revealed a considerable number of WFM-methodologies, which usually possess different pivotal intentions. An analysis of five popular methodologies has shown that WF-flexibility and WF-interoperability are not a major concern of existing available methodologies (see research objective 7 & Chapter 5).

Identified measures are relevant to all phases of the WFM-life-cycle. They are refined by a framework of WF-flexibility- & WF-interoperability-facets (see Chapter 2). This framework provides an encompassing set of categorised WF-flexibility- & WF-interoperability criteria. For instance, recommended measures are intended to improve the following aspects of the WFM-life-cycle (see Chapter 6):

- Feasibility of an inter-organisational collaboration and the achievement of the required degree of process- and WF-flexibility needs to be verified in an early preliminary study. Such a preliminary study also has to investigate costs and benefits.
- High requirements on flexibility and inter-organisational collaboration became a detailed concern for the selection of WFM-relevant business processes to precise the project scope
- Analysis of business processes in light of flexibility- & interoperability requirements

- Selection and application of a process modelling approach that allows to depict flexibility aspects and that clearly describes an inter-organisational process execution
- Improvement of the business processes in a way that allows coping with flexibility- and interoperability requirements
- WFMS-product selection occurs relatively late in the project, namely after the design of to-be processes and if so after WF-modelling. In either case, it needs to be verified, if potentially applicable WFMS-products fulfil requirements of WF-flexibility and WF-interoperability. Workshops with WFMS-vendors are one instrument for investigation.
- Well defined exception-handling- and CPI-processes contribute to process flexibility and WFMA-adaptability

An investigation of characteristics that establish an ideal implementation process for WFMA-projects led to following recommendations:

- Prototyping helps to experimentally approve flexibility requirements
- Project activities should be carried out iteratively as far as possible
- A systematic stepwise consolidation & refinement of project deliverables such as process- and WF-models but also test-case, WF-type- and other technical specifications needs to consider flexibility- and interoperability aspects.

A high degree of user involvement results from business-oriented methods of process analysis, -optimisation, and prototyping. Furthermore, the thesis recommends specific user training for an inter-organisational process execution, and which also acquaints users with a WFMA's adaptation mechanisms. An ideal CPI process involves process owners and technical WFMS-experts.

The improvements were validated in interviews with workflow-experts and within a case study as appropriate.

## **8.2 Potential for further Research**

Recommendations for future research can be made in 3 areas.

### **8.2.1 Enhancement of the research framework**

It would be interesting to see how a company's environmental conditions and a project's conditions influence the achievement of WF-project objectives. A further empirical study could survey these research variables. Appendix C describes relevant conditions; appendix B includes already prepared questionnaires which were omitted from this study as described in chapter 4. For the sake of further investigation, conditions would need to become part of the research framework as described in chapter 3.

### **8.2.2 Enhancement of improvement measures**

Improvement measures could be enhanced by further details in relation to the proposed methodological recommendations

- Precise transformation rules for the stepwise refinement and precision of flexibility- & interoperability-aspects throughout the WF-implementation project
- Precise specification of the process- and workflow-modelling approaches for interoperability- and flexibility-purposes. These issues are subject to current research. New findings with respect to enhanced meta-models could be directly adopted.
- Extension of the CPI by new findings gained within the area of process-mining research. Novel process mining tools could be applied and verified with respect to their applicability for WF-monitoring within a closed-loop CPI-process. Especially the gathering of key performance indicators (KPIs) in the context of inter-organisational process execution and the examination of KPIs for flexible process execution might be of particular interest. .

### **8.2.3 Further Validation of improvement measures**

Improvement measures could be further validated by investigating applicability and effectiveness in large WFMA-implementation projects. Such validation might be undertaken in conjunction with a consulting organisation where experienced practitioners would be on hand to ensure appropriate (and flexible) implementation. Appropriate metrics would have to be developed to provide meaningful feedback.

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