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Business driven method for managing business process changes in the era of digitalization

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doctoral dissertation

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TABLE OF CONTENT

TABLE OF CONTENT 5
LIST OF FIGURES 8
LIST OF TABLES 9
1 INTRODUCTION 11
1.1 RESEARCH OBJECTIVES 11
1.2 THE RESEARCH PROBLEM 11
1.3 RESEARCH QUESTIONS 12
1.4 RESEARCH TYPE AND METHODOLOGY 14
1.4.1 The basics of business informatics research 14
1.4.2 Exploratory research 14
1.4.3 Qualitative and quantitative research 15
1.4.4 Case Study based research 16
1.5 RESEARCH GAP - NOVELTY 18
1.6 CONTEXT AND ANTECEDENT RESEARCH 20
1.7 STRUCTURE OF THE THESIS 22
2 LITERATURE REVIEW 24
2.1 EVOLUTION OF THE BUSINESS PROCESS APPROACH 26
2.2 BUSINESS PROCESS, BUSINESS PROCESS FRAMEWORK 28
2.3 BUSINESS PROCESS MANAGEMENT (BPM) 30
2.4 THE BUSINESS PROCESS MANAGEMENT SYSTEM 31
2.5 CHANGE MANAGEMENT 36
2.5.1 Lewin’s change management model 37
2.5.2 Kübler-Ross “five stages” model 37
2.5.3 Bridges Transition Model 38
2.5.4 Kotter’s change management theory 38

2.5.5 Satir Change Management Methodology 39

2.5.6 McKinsey 7S Model 39

2.5.7 ADKAR Model 40

2.6 PROCESS MODELLING 41

2.6.1 Process modelling methodologies 42

2.6.2 Potential uses of process models 45

2.6.3 Process Modelling Tools 48

2.6.4 Introduction of Adonis process modelling tool 50

2.7 INTRODUCTION OF RELATED SUBJECTS 53

2.7.1 Ontology 53

2.7.2 Process ontology 55

2.7.3 Compliance 56

2.7.4 Enterprise process assessment 60

2.7.5 Text analytics 61

3 PRESENTATION OF THE RESEARCH CASE 64

3.1 OVERVIEW OF THE PRACTICAL SOLUTION 64

3.1.1 Digitalization in the Usability Engineering (UX) process 66

3.1.2 Improving the travel management process 67

3.2 THE CHANGE MANAGEMENT REPORT 68

3.2.1 Structure 69

3.2.2 Required information 74

3.2.3 Intended use 76

3.3 INTRODUCTION OF THE PROCESS MODELS 77

3.3.1 Introduction of the UX process model 78

3.3.2 Presentation of standards related to the UX process 81

3.3.3 The travel management process 84

3.4 EXTRACTING INFORMATION FROM PROCESS MODELS 85

3.4.1 The Adonis process comparison report ... 86
3.4.2 The Adonis business model-comparison functionality ... 87
3.5 PROCESS ONTOLOGY DEVELOPMENT ... 88
3.5.1 Process ontology development from the export of the BPM software ... 89
3.5.2 Building a process ontology from textual process descriptions ... 89
3.6 COMPARATIVE ONTOLOGY ANALYSIS, TRANSLATION TABLE ... 96
3.6.1 Translation Table ... 97
3.6.2 Noise reduction – the text similarity analysis ... 98
3.6.3 Transferring differences to the Recommendation Engine: The Technical Report ... 102
3.7 FROM PROCESS DEVIATIONS TO THE CHANGE MANAGEMENT REPORT ... 104
3.7.1 Additional functions in the Change Management Report ... 105
3.7.2 The Change Management Recommendation Library ... 106
3.7.3 Generating the Change Management Report ... 107
4 SUMMARY ... 110
4.1 RESULTS OF THE STUDY ... 110
4.2 LIMITATIONS AND FURTHER RESEARCH ... 118
LITERATURE AND REFERENCES ... 120

LIST OF FIGURES

Figure 1: Linking The Practical Part Of The Thesis To The Literature Review 22
Figure 2: Structure Of The Process Management System (Scheer Et Al., 2002a) 32
Figure 3: Business Process Management Lifecycle (Von Rosing Et Al., 2015; Guha Et Al., 1993).. 34
Figure 4: Architecture Of The Pmlc Process Management System (Szabó, 2012) 35
Figure 5: Bpmn 1.X (Chinosi Et Al., 2012).. 44
Figure 6: Combined Business Process Modelling Framework (Koliadis Et Al., 2006; Kő Et Al., 2011a) 47
Figure 7: Comparison Between Bizagi, Adonis, Signavio And Semtalk (See Deckert Et Al., 2012).. 49
Figure 8: Graph Of Types Of Models In Adonis (Decker Et. Al., 2000) 51
Figure 9: Architectural Overview Of The Solution 65
Figure 10: Initially Defined Format Of The Change Management Report. Note: Content Is Fictious For Demonstration Purposes 69
Figure 11: Part Of The Ux Process Model In Adonis Software 80
Figure 12: Cover Page Of The Iec 62366-1:2015 Standard... 82
Figure 13: Cover Page Of The Iso 14971:2019 Standard.. 83
Figure 14: Part Of The Travel Management Process In The Adonis Modelling Tool ... 84
Figure 15: Compare Process Models Functionality In Adonis 86
Figure 16: Presentation Of The Process Ontology On The To-Be Ux Process In The Protégé Software 89
Figure 17: Logical Steps Of The Text Mining Activity... 90
Figure 18: Concept And Architectural Context Of The Translation Table 98
Figure 19: Text Similarity Algorithms Investigated (Based On Wang Et Al. 2020).... 100
Figure 20: Transformation Of The Protégé Output Into The Technical Report 102
Figure 21: Transformation Of The Technical Report And The Recommendation Library To The Change Management Report 105
Figure 22: Improvements Made To The Change Management Report 106
Figure 23: The Final Change Management Report.. 108

LIST OF TABLES

Table 1: Challenges And Answers Of The Case Study Research Method (Based On Yin, 1994).. 18
Table 2: Alignment Between The Process Steps Of The Business Process Management Lifecycle And The Shewhart (Pdca) Cycle (Source: Own Work Based On Shewhart, 1986; Tennant, 2001) 28
Table 3: Comparison Of Business Process Frameworks 30
Table 4: Change Management Recommendation Library Used In Our Research.......... 76
Table 5: Example Of The Process Model Comparison Report From Adonis................. 87
Table 6: Result Of The Tagging (Excerpt) 92
Table 7: Naïve Bayes Confusion Matrix On The Full Scope Of Attributes 93
Table 8: Naïve Bayes Confusion Matrix On The Reduced Scope Of Attributes............ 93
Table 9: Findings With The V2 Version Of The Algorithm On The Training Set......... 94
Table 10: Findings With The V2 Version Of The Algorithm On The Validation Set.... 94
Table 11: Findings With The V3 Version Of The Algorithm On The Validation Set.... 95
Table 12: Findings With The V3 Version Of The Algorithm On The New (2020) Standard... 95
Table 13: Hit Rate With The Respective Algorithms 102
Table 14: The Matching Logic Of The Technical Report (Excerpt) 103
Table 15: The Improved Structure Of The Change Management Recommendation Library 106

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1 INTRODUCTION

1.1 RESEARCH OBJECTIVES

My research investigates the novel opportunities to provide support to business change management within the companies. As the digital transformation unfolds, companies need to sustainably transform their way of working to leverage new technology driven opportunities. Successful transformation depends on the mapping and thorough understanding of the multi-faceted gap between the actual and the future operating model. The difference needs to be analyzed and transformed to actionable tasks during change management.

I aim to develop a method and prove the concept of a semi-automated change management ecosystem, capable of extracting process attributes from a company's process models. It then transforms them into process ontology following which it translates the deviations into executable change management action recommendations. Business processes models contain all relevant aspects necessary for execution of a process, which can be structured and analyzed with the aid of process ontology. Comparative analysis can make differences between the process models transparent, enabling the addressing of differences in change management. The dynamic and static components necessary for the performance of the process shall be included in the process model. Identification, extraction and comparison of these components are main tasks to be addressed by this research. In this context the developed solution shall address the field of compliance with the applicable guidelines and standards.

1.2 THE RESEARCH PROBLEM

In my research, I am investigating the opportunities of change management in organizations from the perspective of process management. My aim is to develop a method and a functional proof-of concept that allows the utilization of corporate process architecture for the purpose of change management within to the Business Process Lifecycle.

While managing processes through the Business Process Lifecycle Business, process managers often face the challenge of regulatory compliance. Usefulness, and through that, value proposition is increased if the aimed prototype supports the compliancy aspect as well.

In the case of the proposed solution, the starting points are on one hand the process models, which includes dynamic and static process attributes. On the other hand, expectations towards a process are often expressed in documents such as industry norms, which require the recognition of textual process descriptions as input into the proposed solution. Both inputs need to be converted into a compatible data structure. Once the process models of different versions (e.g. as-is and to-be/must-be) are analyzed, then the solution based on the deviations proposes tailored tasks for change management.

Change management within the Business Process Lifecycle is a recognized step, its functional completeness however needs to be reviewed and enhanced if needed, as only this way the proposed solution can provide the expected level of practicality and pragmatism.

1.3 RESEARCH QUESTIONS

My research connects the process and change management domains, as I aim to explore how information available in Business Process Models and Standards can be utilized for Change Management.

Because of the problem-solving and exploring nature of my research, I do not draw up any hypotheses. My thesis provides a set of tasks to be solved that will enable the objective mentioned in the introduction.

Problems to be addressed, major areas of research:

1. **Business Process, Business Process Models, Business Process Management Lifecycle**: how well is Business Process Management represent an accepted organizing logic in the business? How is process management positioned in different business methodologies? What modelling languages are common? What are the levels of business process modelling? How does Business Process Lifecycle incorporate Change Management? What are the change types? Process management is a common building block, a glue in the domain methodologies that structure and connect business areas. This way enterprise change management built on process change management can be supported by a common approach. Modelling level of the business processes need to be in sync with the purpose of change. The need for change is identified and executed within the Business Process Lifecycle, which is governing the change process itself.
2. **Compliance in the Context of Business Process Change.** Which are the approaches identified for compliance in business processes? What is the most fitting for our context? How can the coded information be extracted from text-based sources? Texts without purposeful preparation present a challenging source to retrieve business process related information from. In case of extracting information from standards, care to be given not to bias the result with the extraction approach.
3. **Examining Change Management.** What Change Management approaches had made inroads into business, what are their commonalities, can these commonalities be supported with information from business process models? As change management focuses on how humans and the organization as living organism process change, there is reason to believe that information extracted from business process models are not directly useful for change management.
4. **Extracting information from process models, data transformation and building a process ontology:** How can stored information be extracted from process models? How does the extracted information become a further processable, structured set of information? Extracted data are transformed and stored and analyzed in a process ontology.
5. **Comparative analysis and presentation of findings:** How can the change element set be compared and used in a goal-oriented way for change management? What information and in what format can best support change management? The information extracted from the above process should be

compared in terms of baseline and target, and the differences should be used to suggest actions to be taken to support the implementation of change management in a target-oriented way.

6. **Review of utilization possibilities:** in what areas can the prototype be useable? Are there any other utilization possibilities in sight? As the prototype matures in our research other potential areas of use could be discovered.

1.4 RESEARCH TYPE AND METHODOLOGY

My research is, as it is often the case in business informatics research, resides on the borderline between information technology and social science. This interdisciplinarity influences the research methodology. The use of the research type and methodology applied in my thesis has been commonplace in the Institute for a considerable amount of time. I take reference to them as well as the guidelines of Gioia (2021) for practice-oriented research.

1.4.1 The basics of business informatics research

It is common for research in the discipline of economic informatics to define a problem to be solved, in which a series of research questions and problems are set and solved. Hypotheses, statistically verifiable assumptions are not formulated in such research. With theoretic as well as practical soundness in focus, these research methods formulate research questions to be explored. Compared to research aimed at proving hypotheses, a binary answer is not possible. The researcher needs to elaborate on the topic and develop and prove an answer to the research questions. Definition of the right research questions is crucial as they first help structuring the research and measure if the research has achieved its set objectives.

1.4.2 Exploratory research

Problem oriented, exploratory approach based on research questions are applicable in the cases where setting an articulated hypothesis or assumption that the researcher seeks to confirm or deny is premature or unrealistic. This is type of research is typically undertaken for four purposes: (a) to provide a better understanding of the topic, (b) to test the feasibility of more in-depth research in the future, (c) to develop applicable methods for further research (Szabó, 2000), and (d) to provide a good chance that the event under investigation will not be repeated (Yin, 1994). In exploratory research theories are developed through analysis of research data, by generalization (Benbasat et al., 1987; Babbie, 2003; Szabó et al., 2014).

A significant number of doctoral theses in the field of business informatics at the Institute of Information Systems do not state hypotheses, but instead the authors define and solve research questions (Klimkó, 2001; Ternai, 2009; Vas, 2007; Szabó et al., 2014). Szabó et al. refers to Klimkó when he notes that "in the thesis I will identify research questions and tasks instead of hypotheses, I will justify the importance of the questions and the importance of my topic through the achievement of the goals they contain" (Szabó et al., 2014)

This research is based on an unsolved industry problem, thus inevitably explorative in nature. Research questions will be formulated based on the problem at hand, keeping both, the theoretical and the practical usefulness of the research in mind. Through answering the research questions the expected answers to the problem should reveal, thus mark the success of this study.

1.4.3 Qualitative and quantitative research

Exploratory research can be of qualitative or quantitative in nature or apply both approaches where applicable. The use of qualitative methods is justified when the aim is to explore or understand deeper relationships in a field, analyzing observations - but not by numerical data. Quantitative methods use mathematical-statistical approaches to data processing and are therefore applicable to research where large amounts of measurable data are available.

To assure that research type is not resulting in unintended bias, triangulation, conscious use multiple types is recommended (Balaton et al., 1991). Types of triangulations:

- using multiple methods within quantitative methods,
- using multiple methods within qualitative methods, or
- a combination of quantitative and qualitative methods.

The present research is multidisciplinary and exploratory in nature using qualitative as well as quantitative methods.

1.4.4 Case Study based research

A case study examines a problem or a phenomenon in their original setting, using a variety of data or information collection focusing on the appropriate type if information, not necessarily on its volume. Solution oriented information technology related research frequently relies on this type (Lee, 1989).

Benbasat et al. (1987) provides an overview on the main features of the case study:

- examines the phenomenon in its natural context
- uses a variety of data collection tools
- applies to one or a few study-units
- exploratory in nature
- does not use experimental controls or manipulation
- does not specify dependent and independent variables in advance
- results are highly dependent on the integrative ability of the investigator
- data collection methods may vary during the study

"In general, case studies are the preferred method when (a) „how and why" questions are being posed, (b) the investigator has little control over the events, and (c) the focus is on a contemporary phenomenon within a real-life context. The case study method allows investigators to retain the holistic and meaningful characteristics of real time events, such as individual life cycles and organizational and managerial processes" (Yin, 1994). The basic strategies for research according to Yin:

- experimental
- based on processing a case study
- questionnaire-based
- analytical, based on secondary or historical analysis

Case studies may relate to a single case or to many cases, and there are countless levels of analysis possible within the research. Case studies usually rely on a combination of data collection methods (archives, interviews, questionnaires, observations) and the results can be both qualitative and quantitative.

To avoid any risk associated with the method, five criteria must be met (Babbie, 2003):

- relatively neutral, neutral objective should be set,
- use known data sources,
- an adequate time span must be considered,
- use known data collection methods, and
- ensure consistency with currently accepted knowledge.

A major advantage of case study research is its flexibility, as it allows interaction between data collection and data analysis. This approach combines the theoretical and practical aspects, should aim to be useful in the theoretic as well as in the practical sphere (Gioia, 2021)

Yin's landmark publication (Yin, 1994) recognizes the main objections towards the case study research type such as the non-existence of binary answers, its questionable reliability and repeatability. It not only describes the most common objections to the case study as an empirical, scientifically accepted research method, but also provides answers and recommendations. These recommendations should be taken into account in the design of my research:

Common objections	Response / Recommendation
Lack of rigor research becomes biased or generalizes individual pieces of evidence	1) a well-defined process should be followed in the research 2) Fair documentation of evidence is necessary
Little basis for scientific generalization (especially when studying a case)	Case studies are not generalizations but refer to specific theoretical recommendations. The aim is analytical and not statistical generalization.
The research period is too long and generates a lot of documents that cannot be processed.	Work without long narratives. The research methodology should not be confused with the data collection methodology - the latter can be

	lengthy; the former does not need to be
Missing validation by "randomized field trials" method.	It restricts the case study to the interpretation used in education, where a similar argument may be valid, but ignores the exploratory nature of the case study.

Table 1: Challenges and answers of the Case Study research method (based on Yin, 1994)

To address well known limitations, and in order to maintain relevance of the case study method for both theory and practice, Gioia (2021) recognizes the characteristics of this method but emphasizes that there is a need to focus on practicability of the processed case, that is stay close to practice. Further, due to the fact that sample size of the case study method is inherently limited, including specific factors and circumstances, conducting research using case study method should aim to assure "transferability", that is applicability of the research and results to similar environments and cases, instead of aiming at the objective of theoretically limitless "generalizability".

The present research is exploratory in nature focusing on an actual industrial problem, using a detailed case study approach, executed with members of industry practitioners. Through the experience gained in solving the tasks, it comes closer to addressing the research questions and objectives outlined.

1.5 RESEARCH GAP - NOVELTY

In my years of practical experience in the field of process and organizational management, I observed that although change management is widely recognized as a distinct step in the lifecycle of process management, there is a lack of full-scale support solutions readily available to the practice, even though all the necessary information for it is available in the process models. Upon familiarizing myself with the previous research in the domains of information extraction and analysis from business process models and textual process descriptions, conducted previously in our Institute, I began on an investigation to see how the problem may be addressed by integrating and advancing these results. Relying on my findings and the literature presented in section 2, I have identified a lack of works suggesting a practice-oriented approach towards the operationalization of Change Management and building a multi-purpose evaluation and recommendation tool relying only on inputs commonly available in enterprises. My study contributes to bridging this research gap.

The significance of the research lies in the comparative analysis of the information found in process models and in descriptive text formats, and in the fact that the results are, through linking in and leveraging the scientific domain of organizational change management, used as a basis for case-specific recommendations for operational business process change management. Given the frequency of invoked significant process and subsequently organizational changes taking place during the digital transformation, a degree of automation is incorporated into the solution to assist the change manager perform their role more efficiently.

While Business Process Lifecycle Management (BPLM) is a broadly studied field, and there is a consensus about the importance of Change Management, BPLM methodologies approach change management from a holistic perspective with the consequence, that practitioners cannot rely purely on these methodologies for execution. Change Management as scientific domain and Change Management methodologies are not sufficiently integrated with the BPLM's Change Management phase from an execution perspective. This results in the lack of methods and tools supporting the operationalization of Process Change Management.

This research combines these areas at a functional and operational level to create a foundation for an efficient change management support concept. It provides a proof of concept in the form of an integrated, semi-automated tool ecosystem designed to assist change managers and business leaders in effectively implementing process changes. Ultimately, the research presents and evaluates a novel approach to the operationalization of business process change management, with the potential of enhancing its quality and efficiency.

On the other hand, practice lacks support from tools to compliance checking which only utilize the information natively available to them on the field: namely the textual description of regulations and norms. Business Process Models are a common input to Compliance Checking methods, yet the other leg of compliance checking, the processing of the descriptions constituting the details of the regulations cannot be used without a preprocessing of the textual descriptions, a step that organizations do not have means and capacity to. As a consequence, compliance checking on business processes remain labor thus cost intensive.

My research dedicates capacities to explore process flow analysis in textual, descriptive format. Expectations from processes, or the process descriptions themselves can be found in textual process descriptions format, yet without formal modelling characteristics, for example in industry norms in pdf format. This fact made it necessary to make advancements in ways of extracting process relevant information from textual formats, thus enabling the inclusion of such information in process comparison and consequently process change management. This study utilizes recent progress in language processing techniques and technologies to advance the extraction of process relevant information from natively available, short, domain specific texts.

My solution utilizes the results of previous research conducted in my research fields at the Institute of Data Analytics and Information Systems. These studies had developed and tested some components which I have relied on, further developed and integrated them into a coherent solution for the business sector. By using process ontology, the outlined system can be used in any field of activity, as process models and textual process descriptions can be "interchangeable", but the comparative analytical function and the structured presentation of results remain equally accessible.

1.6 CONTEXT AND ANTECEDENT RESEARCH

The research fits well into the series of doctoral and European Union research carried out in the last decades at the Institute of Data Analytics and Information Systems, as well as in cooperation with the corporate sector.

The Institute has been teaching and researching process management, information management and change management for many years. Most colleagues are linked to the field of knowledge management with their doctoral dissertation topics. The main research directions range from knowledge mapping tools, competency-based recruitment (Klimkó, 2001; Kismihók, 2012) and the role of knowledge management (Fehér, 2004) to the construction and exploitation of ontologies (Kő, 2004; Vas, 2007), ERP systems and semantic process management, workflow and web services (Ternai, 2009; Kovács, 2010). Further work is done in the area of ontology-based comparison and knowledge discovery (Szabó, 2010; Szabó et al., 2014; Arru, 2018).

In most cases, the above research was generated during a European Union R&D project. In addition to the theoretical results, I consider it important to present the practical results, because they may show the strategic integration of the fields even more clearly.

The eBest project aimed at making process management more dynamic through the development of an ontology-based system development solution that automatically generates a working workflow from a high-level process model (Ternai et al., 2011; Kő et al., 2011b).

The ProKEX project addressed organizational knowledge management in terms of knowledge elicitation, knowledge representation and knowledge sharing through developing a complex methodology and application extracts, organizes, shares and preserves knowledge embedded in organizational processes. Business process management (BPM) approach and knowledge management (KM) approaches were utilized to keep the methodology consistent and structured (Gábor et al., 2013)

Ontology matching, process ontology development and utilization of ontology-based process analytics and text analytics for process analytics have been a focus area for multiple years in the institute (among others Ternai et al., 2017; Szabó et al., 2018; Ternai et al., 2019) The results of those research is being carried forward in my research.

In my research I am building on previous research conducted and knowledge gained in the Institute to organize and complement the results to prove the concept of a practice focused complete solution adapted to the specifics of the practice. The European Union Horizon 2020, later Horizon Europe, program for innovation founding defines Technology Readiness Level 1 to 9 from base research to solution proven in operational environment (European Association of Research & Technology Organizations, 2014). With reference to this scale, I aimed to reach Level 3: “experimental proof of concept”.

1.7 STRUCTURE OF THE THESIS

In the first chapter, I set out the basic aim and topic of the research and identify the main research questions. Here I also describe the background and significance of the research and the research methodology used.

In the second chapter, I review the literature that is significant in this field; I examine process management, process modelling and the mapping of processes into process ontology, and their evaluation. Further, I will review scientific domains related to this study and elementary understanding is necessary. It is legitimate to ask why we rely on process ontology for the analysis, instead of the Business Process Modelling tools' own process-comparing feature, which will also be answered.

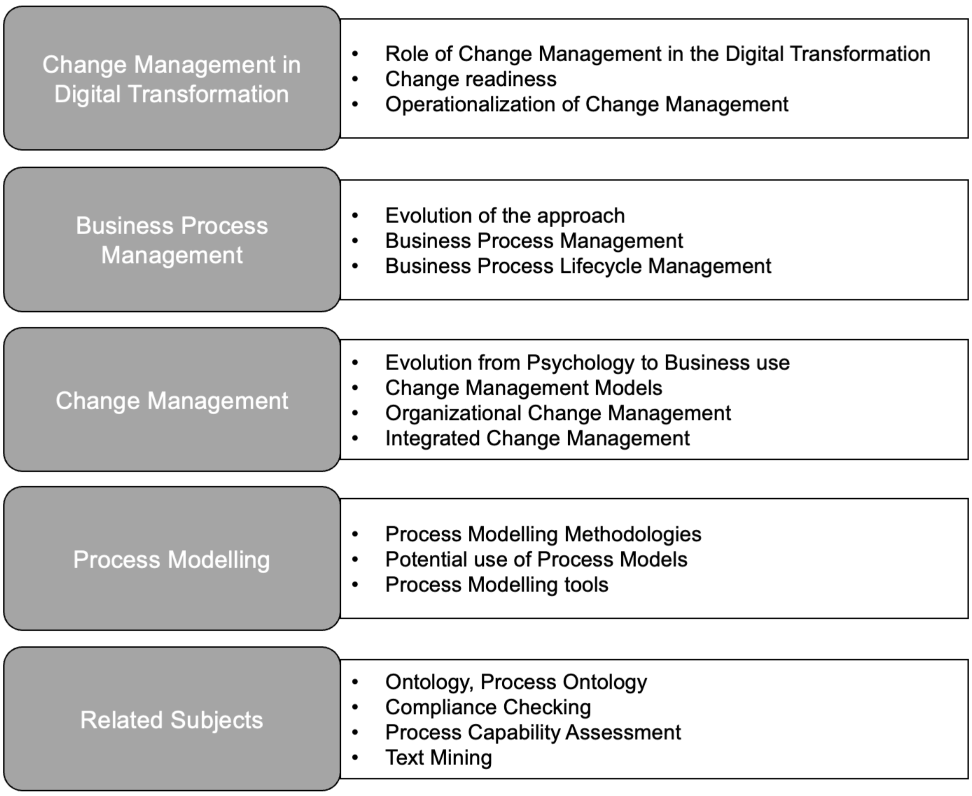

Figure 1: Linking the practical part of the thesis to the literature review

Figure 1 illustrates how the literature review fits into the practical topic of the thesis. The analysis of process management and process modelling is necessary because the proposed solution takes process models as a starting point. Structured text is the common format of regulatory requirements related to a process; thus analysis of this format requires understanding. The aspects that provide the structure for the evaluation of the comparison will be defined in the analysis of the change management topic. It is also the aspects defined in the study of change management that will help us to define the direction of the comparative analysis.

In the third chapter I will focus on the presentation of the practical work. I will describe the details of the solution I have developed and answer the research questions through a demonstration of the solution. I will accept the successful solution of the set tasks as a solution to the research questions, and through these I will also justify the importance of the topic.

In the fourth chapter, I summarize the research, provide an outlook for future work and tasks, and justify the significance of my work.

2 LITERATURE REVIEW

In this section, I provide a literature review on the theoretical background of the research area. The concepts and areas covered are: evolution and embedment of business process based views, process management, business process lifecycle, process modelling methodologies, change management. In the area of business process modelling, I will also discuss the landscape of business process modelling tools, as they are of particular importance in the research.

"Change is typically the discontinuity of the state-of-the-art with a potentially destabilizing and disruptive effect on organizational life" (Trabucci et al., 2022). Therefore, the study of organizational change management is inevitable in digital transformation studies.

Within the literature on digitalization, there is a consensus on the crucial role of change management in effectively carrying out digital transformation (Khamseh et al., 2021; Bellantuono et al., 2021; Komkowski et al., 2023; Govindan et al., 2023). Empirical research further supports this viewpoint (e.g. Luks, 2022; Pronchakov et al. 2022; Amoozad et al., 2020; Kumar et al., 2021; Motzer et al., 2020).

The implementation of change management primarily occurs in two areas: first, in terms of organizational structural change (Motzer et al., 2020), and second, in the personal and psychological element of change management (Pena et al., 2022; Naicker et al., 2021), both having their scientific domain and literature yet to succeed, both areas need to be dealt with in a transformation (Javaid et al., 2023). There is agreement among academics and practitioners that change management is a multi-disciplinary domain where the role of managers is crucial for the successful implementation of change management.

Given the importance of change management, it is essential to note that managers often feel overwhelmed by the practical aspects of implementing the change process, which can undermine the successful execution of the transformation due to its complex and diverse nature. Distinct managerial skills are necessary for success. Despite their best efforts, managers and affected stakeholders frequently disagree on the true efficacy and achievement of organizational change management activities (Budde et al., 2022; Naicker et al., 2021; Muluneh et al., 2018).

Furthermore, organizational change readiness and organizational culture are significant limitations and essential facilitators for transformations. To achieve the desired outcome sustainably, it is crucial to align the implementation of change management with the project plan for the entire scope of the digital transformation project. This integration should not only deal with the execution phase but cover the whole project life cycle and be based on quantitative data (Nordal et al. 2021; Hizam-Hanafiah et al., 2021; Machado et al, 2021; Brown et al., 2021). It is crucial to have mechanisms that consistently provide dependable input from every level of the organization (Naicker et al., 2021). Moreover, the execution of the change management should be consistent throughout the organization, necessitating all managers to work in a coordinated manner (Muluneh et al., 2018).

There is at present no universally accepted approach for effectively handling change during the journey of digital transformation. Researchers and professionals actively seek more efficient techniques and strategies for managing change. Research has also shown that utilizing established and widely adopted methodologies as delivery vehicles of change while making necessary adjustments can lead to favorable outcomes.

- One notable example is the significant role of Business Process Management (BPM) in organizational management, which is critical for achieving lasting change (Zhon et al., 2023; Bagozi et al., 2022; Bazan et al., 2022). Glogovac et al. and Butt both emphasize that for businesses with advanced Business Process Management (BPM) to achieve genuine organizational transformation, they must give significant importance to Change Management as a catalyst for creativity (Glogovac, 2022; Butt, 2020).
- The evidence-based and ongoing improvement approaches advocated by LEAN/SIX-SIGMA can also serve as valuable tools for Change Management, provided that they are modified and tailored to the specific requirements of Change Management (Mosser et al., 2022; Komkowski et al., 2023; Govindan et al., 2023).

- Additionally, there are other approaches that are less commonly recognized but can be utilized to support digitalization efforts.
    - According to Trebucci et al. (2022), using Story Telling / Story Making methodology is recommended to facilitate the processing of change naturally and instinctively at the individual level.
    - Knowledge Management, while it focuses on a specific aspect of change management thinking, can be highly beneficial in achieving evidence-based change management and in identifying and ensuring the acquisition of suitable new skills (Montoya et al., 2022; Pejic-Bach et al., 2020).
    - Muluneh and Gedifew (2018) argue that incorporating impacted stakeholders early is crucial for effectively defining and implementing change. They point out that adaptive leadership can be a practical approach.

The intricate nature of change management has contributed to it being understudied despite its recent significance in studies about digital transformation (Luks, 2022; Jerman et al., 2019; Farina et al., 2021; Nakayama et al., 2020). The lack of research and analysis on implementing change management is particularly noticeable (El Faydy et al., 2023; Muluneh et al., 2018). Although there is much research on the conceptual and methodological aspect of Change Management, such as stages, scope, and responsibilities, there is a substantial lack of study on the issues arising on. the domain of operationalization and actual implementation of Change Management. Despite acknowledging managerial responsibility for the operationalization of Change Management, it does not offer a universally applicable and scalable framework or concepts for executing Change Management measures effectively and coordinated across the entire impacted organisation.

2.1 EVOLUTION OF THE BUSINESS PROCESS APPROACH

The search for the reason of existence of firms on open markets has been an area of intensive research for economists since the beginning of the XXth century. From the multiple firm theories Penrose's seminal work, The Theory of the Growth of the Firm, published in 1959, stands out. Competing theories, such as transaction cost theory and agency theory regard the primary organizational problems as incompatibility of individual goals. Penrose's work marked the first attempt by an economist to view firms as real life "flesh-and-blood" organizations (Pitelis, 2005). On the path opened by Penrose, Grant's knowledge based theory of the firm gained significance in the age of automation and robotization (Grant, 1996). Grant argues that beyond knowledge generation, the primary role of an organization is knowledge application and the fundamental task of an organization is to coordinate the effort of many specialists by creating conditions under which individuals can integrate their specialist knowledge. Knowledge is attributable to people, not organizations and maximization of codified (explicit) knowledge is elementary interest of a firm, since transfer of tacit knowledge between people is slow, costly and uncertain (Kogut et al., 1992).

Corporate culture scholars agree with the importance of the individual, they argue though that human aspects and related corporate cultures are multi-dimensional subjects and they are indispensable for the company`s value creation (Boda et al., 2010; Wien et al., 2014). There is a recent paradigm shift in the ways that organizations balance stability and dynamism: research show that in the past century hierarchy and specialization focused, once highly successful (so called "machine") organizations have been overtaken by quickly mobilizing, agile, nimble and empowered, in short: agile organization which see organization as living organism (Aghina, 2017).

An institution in an ever vibrant environment requires effective focus on continuous improvement, through transformation, so to remain existent and propagate (Black, 2000). Industrial companies have in the 1950s and 1960 developed a number of manufacturing methodologies, from which the model developed by Toyota Motors, called Toyota Production System (TPS) is seminal (Ohno, 1988). Together with LEAN, an evolution of TPS, they are today the industry reference (Womack et al., 1990). A key common point of these approaches is the establishment of the Continuous Improvement (CI) process as operational initiator of changes. The CI process progresses through "incremental" improvement over time or "break-through" improvement all at once. Among the most widely used tools for CI is a four-step quality model – the plan-do-check-act (PDCA) is stands out and it remains inspirational for other approaches (Shewhart, 1986; Tennant, 2001; Moen et al., 2017).

In order to address the imminent need of strategic alignment between IT and other departments, the Business Process Management (BPM) approach was developed (Scheer et al., 2002b). The BPM lifecycle is widely used in IT related projects and it has a potential to be utilized for process improvement as well (Josic, 2016). Its stages can well be put in relation with the PDCA cycle, providing a potential for common denominator in projects approach with industrial stakeholders.

Business Process Management Life Cycle	Shewhart Cycle
Process Documentation	Plan
Process and System Analysis	
Implementation and change management	Do
Process Operation	
Process Controlling and Monitoring	Check
Business Process Strategy	Act

Table 2: Alignment between the process steps of the Business Process Management Lifecycle and the Shewhart (PDCA) Cycle (Source: own work based on Shewhart, 1986; Tennant, 2001)

2.2 BUSINESS PROCESS, BUSINESS PROCESS FRAMEWORK

The definitions of "process" from different authors all agree that a process is a chain of activities that transform inputs into outputs, subject to some value creation objective. A business process is a process that achieves this transformation, in a business context, for business actors.

Wesner and co-authors (Wesner et al., 1994) define outputs as products and services, and users as another person or process, and also highlight the role of the human and other resources involved in the process. In contrast, Hammer and Champy (Hammer et al., 2000) strongly identify the output of the process with the creation of value for the customer, while Davenport (Davenport, 1993) also stresses the importance of the process being structured and measured, and being extended in time and space. Tenner and DeToro (Tenner et al., 1998) describe value creation rather than value enhancement, and emphasize the importance of combining the people, methods and tools that make up the process.

In addition to the above, the processes, and in particular the business processes of a company, form a system; they do not take place in isolation from each other. The large volume of processes require the use of a common set of rules to ensure that the processes can be understood and managed in a consistent manner. These rules constitute process frameworks. A process framework provides

- A checklist for listing processes run in the business or organization;
- A structure for classifying the processes into groups of related processes;
- Rules for assigning process ownership
- A guideline for structuring the process repository
- Wider context of the processes (eg integration)

A business process framework can therefore be created by grouping the many processes of a business into appropriately related groups. However, there is no universally accepted reference for categorizing business processes, and the frameworks often referred to even differ in structure. Different authors group business processes according to different criteria and, in addition to general frameworks, there are also industry-specific ones, such as eTOM, which was designed to structure business processes according to the specificities of the telecommunications industry and has only recently been extended to an industry-independent framework.

As can be seen from the table below, the classification of each process is not straightforward. For my research most applicable is the APQC PCF model, which already includes the areas of Compliance and Human Capital, which play a very important role in my research, at the highest level, among the 13 main processes. (APQC, 2019)

	VRM[1]	APQC-PCF[2]	SCOR[3]	eTOM[4]	Raffai
Structuring logic	Corporate	Functional	Value chain	Corporate	Functional
Process areas	– Activities – Operational – Tactical – Strategic	– Develop Vision& Strategy – Develop Products & Services – Market & Sell – Deliver physical products – Deliver services – Customer Service – Develop & Manage Human Capital – Information Technology – Financial Resources – Manage Assets – Enterprise Risk, Compliance, Resilience – Business Capabilities	– Plan – Source – Make – Deliver – Return	– Strategy, Infrastucture & Product – Operations – Enterprise Management	– Plan – Govern – Execute

[1]VRM = Value Reference Model by Supply Chain Group – based on Wilkiens (Wilkiens et al., 2016)
[2]APQC-PCF = American Productivity & Quality Center – Process Classification Framework – (APQC, 2019)
[3]SCOR = Supply Chain Operation Reference by Supply Chain Council – based on Huan and colleagues (Huan et al., 2004)
[4]eTOM = Business Process Framework (eTOM) – (TM Forum, 2017)

Table 3: Comparison of business process frameworks

2.3 BUSINESS PROCESS MANAGEMENT (BPM)

Management is a form of control, the task of coordinating resources in an optimal way to achieve organizational goals. Management is the set of activities carried out by one or more persons or systems to coordinate and harmonize organizational activities and resources (Boda, 2006).

By applying the definition of management to processes, we arrive at the field of process management. There are also several definitions of this concept in the literature. According to Gartner, process management is a discipline that treats business processes as tools that directly contribute to company performance by creating operational excellence and business agility (Gartner, 2012). Bácsfalvi et al. describe the concept as a subset of process management: the management domain of process design, control, documentation and improvement. They describe the objectives of process management as the design, management and improvement of processes (Bácsfalvi et al., 2001). Szabó defines process management as the knowledge and ability of an organization to design and develop its internal processes with the aim of increasing cost efficiency, simplification and sustained competitive advantage (Szabó, 2010). Németh also emphasises the complex nature of process management, defining it as an integrated, interrelated approach and management task that simultaneously addresses organizational and technological issues (Németh, 2008). Scheer (Scheer et al., 2002b) identify the goal of process management as the achievement of Business Process Excellence, while van der Aals definition already identifies the key tasks of process management through the process life cycle: [the aim of process management is] "to support the design, implementation, control and analysis of business processes using appropriate methodologies, techniques and software, involving people, organizations, applications and documents, as well as other sources of information" (van der Aalst et al., 2003).

Based on the above definitions, business process management it is a kind of management that deals with the business processes of companies throughout their life cycle, using supporting tools and resources and mixed information sources to achieve various positive effects.

2.4 THE BUSINESS PROCESS MANAGEMENT SYSTEM

The number, complexity and interdependence of processes make it difficult to manage them without a proper top-down approach. This difficulty can be overcome by the conscious use of a process management system (or process life cycle), which according to Scheer consists of five main parts (Scheer et al., 2002b), and whose structure is illustrated in Figure 2.

Figure 2: Structure of the Process Management System (Scheer et al., 2002a)

The five elements of the process management lifecycle according to Scheer (Scheer et al., 2002a):

- The basis of the process management system is the **business process strategy**, which covers the definition of process-related objectives. The process strategy is the long-term plan for the organization's processes. It includes the objectives of process management and how they can be achieved. They can be called critical success factors. It also includes an analysis of the opportunities and threats presented by external circumstances.
- Process design involves evaluating existing processes and **design**ing new ones. This phase starts with an analysis of the current processes. After this analysis, the process attributes that will determine how the current process system needs to be adapted are identified. This includes the identification of processes to be deleted, transformed and new processes. In doing so, the links between the processes will of course also become clear. Once the new processes have been identified, the analysis will be repeated.
- During processes **implementation**, the plans that have just been created are put into practice. This is the phase where all the changes that have been identified during the process design are incorporated into day-to-day

operations. It can be very important to monitor the pre-defined indicators, as it is not certain that the plan has taken all possibilities into account. Indicators can predict critical changes that may have a negative or positive impact on processes. In the latter case, there is no role to play other than to look at spill-over effects, but we can intervene in case of potential negative effects.

- **Process controlling** allows for the measurement, evaluation and feedback of results. The results can be useful to store and analyze, as they can be important building blocks for the next planning phase.
- As all this means constant change in the life of the company, it is necessary to support these activities with appropriate **change management**, which means techniques, tools and processes for managing change.

Von Rosing and colleagues (von Rosing et al., 2015), in their work on business process management, break down the business process life cycle into four consecutive cyclical parts and a fifth part that connects the cycles.

- The first phase is to **identify** the process(es) to be improved. The selection of the process to be changed can vary depending on the reason for the change. The motives and methods range from continuous improvement to compliance, to changes required by the new business model.
- The next phase is to explore and reconcile the **current (as-is) process**. Von Rosing emphasizes the great importance of this step, as in practice there is often a discrepancy between the documented processes and the actual processes. The documentation of these discrepancies and other process-relevant data ensures that the starting point of the change is relevant and adequate to the process.
- The definition of the **future process** as a separate phase is self-evident. This is where the old process is analyzed, needs and obligations (compliance) are defined, and the new process is defined on this basis. This phase includes the modelling of the dynamic and static elements of the new process.
- The **implementation** of the modelled to-be process is the fourth phase of the loop and closes the loop. This is when the process is sharpened as the organization moves to using the new process. Von Rosing and colleagues also

recommend testing the process before implementation as a quality assurance measure.

- After the above phases, a fifth element, on a par with them, is **change management**, which is the organization and management of the activities required during the cycle. For change to be successful, in addition to engineering design and implementation, it is necessary to recognize the multi-faceted nature of change and to think about the 'employees who are opposing change' and the organizational culture needed to ensure that the process works properly.

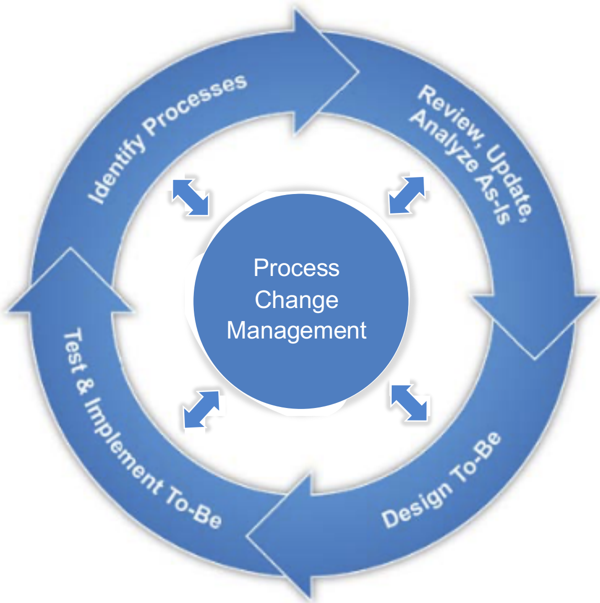

Figure 3: Business Process Management LifeCycle (von Rosing et al., 2015; Guha et al., 1993)

Another presentation of the Process Management Life Cycle (PMLC) as a process management system is given by Szabó (Szabó, 2012), according to which the stages of the PMLC process management system are as follows:

- **Process strategy**: the business process management system starts from the business process strategy. The process strategy contains the process management objectives, which account for the critical success factors.
- **Process documentation**: the core of this phase is the assessment and modelling of the as-is processes.

- **Process optimisation**: After analysing the as-is processes, options should be identified. After designing the new processes, a feasibility study and a cost/benefit analysis are carried out.
- **Process implementation**: In this phase, process improvements are implemented on the basis of the existing plans. During the implementation phase, it is very important to monitor metrics and indicators in order to detect deviations from the target in time. This includes process renewal, restructuring, modification of existing IT systems or introduction of new systems.
- **Process implementation**: the implementation phase is where the processes start to operate. Process control is a prerequisite for proper long-term operation.
- **Process Controlling**: Regular monitoring, measurement and evaluation of processes and results is very important to further improve the effectiveness of the organisation. Key Performance Indicators (KPIs) are a great help in evaluating results.
- **Change management**: the different phases are cyclical, i.e. there is constant change in the life of the company. In the next chapter I will describe in detail the difficulties of change and the tools and techniques used to manage it.

Figure 4: Architecture of the PMLC process management system (Szabó, 2012)

In summary, all process management systems include change management either as an element or as a phase. Change management is therefore an important element of a process management system to keep the process management life cycle in motion. The implementation of the intended changes, and thus the creation of a new change baseline, facilitates this cycle, while the nature of the change is encoded in the process model itself, in the process modeling process, by mapping the static and dynamic elements of the process.

The diversity of process modelling techniques, and the subject of this dissertation, requires a detailed examination of process modelling, which I do in the next chapter.

2.5 CHANGE MANAGEMENT

Digitalization has a big impact on the way companies do business. Not only do they have the opportunity to continuously rethink their operations, to become more efficient, to develop new business models, but the changes in their environment are also forcing them to do so. The transformation of the business environment is putting pressure on organizations to manage these changes efficiently. Because organizations are organic, human-based systems, experiencing organizational change can be difficult for employees. The success of sustainable transformation depends on the people involved in the change and the people charged with implementing it. Since the reaction of human factors to change cannot be programmed, Business Process Change Management needs to approach the human aspects with specific models. Scholars have since over thirty years examined the impact of psychological responses to the success of change implementation (such as Coch et al., 1948; Siegel et al., 1989; Schein, 2004; Armstrong, 2006) and urged to consider works in this domain in the transformation approaches. Change Management models are plenty in the literature, some seminal concepts reveal. The concepts are primarily derived from social behavior studies in private domain, nevertheless many can be applied to in organizational context as well. Beyond models developed by social scientists, some are developed by consulting companies and organisations, although their reliance on one or more of the concepts developed by scientists, cannot be denied. Based on the works of Brisson-Banks (Brisson-Banks, 2010) and Hechanova and colleagues (Hechanova et al., 2013) I provide an overview of the Change Management models.

2.5.1 Lewin's change management model

The model published by Kurt Lewin (Lewin, 1947) has become the reference to many practitioners and other models developed on this basis. Its attractiveness lays in its simplicity: its three steps simply yet insightfully structure the process organizations has to process change. Its critics argue, that while it is simple to understand, it doesn't offer practical guidelines and doesn't deal with the individual as the member of the organization on its personal level.

- Unfreeze
- Change
- Refreeze

Initially one needs to understand the starting point, what needs to change to get the intended results. In this stage, communication to the organization and individuals take place explaining the change process and managing expectations. The next step deals with implementing the changes in the process as well as through communication, this includes providing support to the individuals to perform in the expected way. Once the change is implemented, in the final step, institutionalizing the new way of working, implementing monitoring to assure that gravitation back to the legacy process is detected and counteracted early are the focus points.

2.5.2 Kübler-Ross "five stages" model

Elisabeth Kübler-Ross' (1973) milestone work explores the human side of change processing. It is one of the most influential models for processing change on the personal level. Known as the "five stages" model used to describe the processing of grief. The five steps proven to be very applicable in corporate change management context as well.

- Denial–Refusal
- Anger
- Bargaining
- Depression
- Acceptance

Kübler-Ross' model suggests that initially the person does not want to face the change, following which it develops anger against the uncontrollable force imposing the change. Before settling with the change and seeing the opportunities within often the person ties to minimize the impact of the change and often lets the change pull over the person.

2.5.3 Bridges Transition Model

Created by the change consultant William Bridges (1988), takes Lewin's structure when addressing the emotional journey individuals go through while experiencing and accepting a change. The model recognizes three stages companies should help guide employees through:

- Ending, losing, and letting go
- The neutral zone
- The new beginning

As per Bridges the first reaction to change is a denial based on by anxiety and discomfort. As the change is taking place, employees would be in a neutral state of mind, having let the old go, yet not ready yet to welcome the new. Once the new modus operandi is in place people will acceptance it become ready to follow the new way of working.

2.5.4 Kotter's change management theory

John Kotter's (1996 p. 3-10) presents a highly developed and practice driven methodology centered around the individual and his/her emotional processing to the change. The method has eight steps:

- "Establishing a sense of urgency
- Creating the guiding coalition
- Developing a vision and a strategy
- Communicating the change vision
- Identifying roadblocks and addressing constraints and disturbances
- Empowering employees for broad-based action
- Generating short-term wins

- Consolidating gains and producing more change
- Anchoring new approaches in the culture”

2.5.5 Satir Change Management Methodology

Virginia Satir (1983) presented her model dealing with dynamics in a group responding to change. Although developed through the observation of families, it can be applied to business similarly to Kübler-Ross’ framework.

- Late Status Quo
- Resistance
- Chaos
- Integration
- New Status Quo

The process starts with the definition of the starting point into the change process followed by the initial reaction to change which is resistance. Subsequently the implementation of change forces employees to let status-quo go, yet a new order is not yet a routine causing a perception of chaos. With the growing benefits of activities carried out according to the new way of working, the acceptance of change grows. Finally, the new way of working becomes the new order, and every employee accepts and respects it.

2.5.6 McKinsey 7S Model

Developed by Strozinski and colleagues (2013) for McKinsey & Company as a commercial consulting model. Critiques insist, that the 7S model, due to its inception is has no scientific foundations, further, the soft aspects make the measurability questionable. Uninfluenced by the doubt of some scholars, the 7S model enjoys widespread acceptance as a Change Management framework. A core statement of the 7-S-Model is: Companies are successful if you adapt all factors in an appropriate way to the changing environment of the company - legal situation, regulations, market requirements - again and again. The seven areas are the following.

- Change strategy
- Structure of your company
- Business systems and processes

- Shared company values and culture
- Style or manner of the work
- Staff involved
- Skills that people need to have

The 7S model is presenting a sequential processing of change, rather lists the aspects of organizational change management, that helps in practice making sure that all areas are covered in a project.

2.5.7 ADKAR Model

The ADKAR model (Hiatt, 2006) is based on the work of Jeff Hiatt who later founded Prosci, the company commercializing the ADKAR model. The phases of the ADKAR model fall into the order of how one person experiences change. The model's name is an acronym from the five phases of the model.

- Awareness
- Desire
- Knowledge
- Ability
- Reinforcement

The five steps of ADKAR made inroad in many organizations due to its practicability and good structure. The model starts with informing individuals and organizations about the change and communicating so that the drivers and the inherent opportunities of the new modus operandi. The interaction with the organization should achieve that the perspective of change is perceived positively, a buy-in and support generated. Building on the success of the previous step, the organization and the individuals will want to learn the new way of working, thus information and tools need to be provided to them to explore the "new world". Ability means the implementation of change: once people are knowledgeable about the new way of working, they will want to put that knowledge into action. Finally, when the change is implemented, the members of the organization need to be confirmed in their actions. The model emphasizes, that progress through the stages is not automatic, in unfortunate situations organisations and be stuck in a stage, putting the successful implementation of change in danger, therefore change leadership is essential.

In conclusion, all theories developed based on psychological research indicate that humans respond to change with resistance or denial. The new situation (post- change) need to be understood and people enablement assured before they can commit themselves to active change. The change needs to be nurtured after change has been introduced to assure new behavior is adopted. There are countless commercialized change management models based on psychological models. Some are also introducing changes to the semantics of Change Management (e.g. McKinsey).

In this research we will use the ADKAR model as the change management framework. ADKAR is a widespread, practice-oriented, methodology optimized for organizational development. The industrial partner of our research also uses this change management methodology; thus, it is well suited for the objectives of our research. Due to the fact that multiple such models exist on psychological basis, it doesn't limit the generalizability of our research. During research we will need to investigate which aspects of the ADKAR model and how can be supported with information out of Business Process Models.

2.6 PROCESS MODELLING

Business process models are essential in structuring organizations' daily operations, as well as to management as they enable focused discussion and communication about activities and the necessary capabilities for executing them (Smith et al., 2003; Hammer et al., 1993).

The model is nothing more than a simplified copy of a part of the real world. A business process model is defined by the Business Dictionary as "A sequential representation of the functions associated with a particular business activity." (WebFinance, 2013). WfMC's definition goes beyond functions, as the process model is interpreted to specify the sequence of activities in the process and all the resources (machine or human) that are required to run the process (WfMC, 1999).

The purpose of modelling is to assess, and then analyze and improve our processes. Process models may carry different information and the receiving party may vary; hence the approach and the level of modelling may vary. A basic grouping of process models is As-Is models, which represent the current situation, and To-Be models, which represent the desired situation.

2.6.1 Process modelling methodologies

During the development and evolution of process modelling, several process modelling methodologies have emerged. These provide appropriate solutions for different purposes.

The different methodologies can be classified into the following broad groups based on their main orientation (Li et al., 2009):

Function-oriented methodologies, such as data flow diagrams and IDEF0. These methodologies attempt to capture the function of the phenomenon being represented, aiming at a high-level representation of the purpose and meaning of a process, and thus its flow. These descriptive models identify the main activities and represent their inputs, outputs and processing steps.

Data-oriented methodologies such as entity-relationship diagrams and IDEF1x models. These diagrams focus on the information processing and data flows of processes. They also take into account the information and communication needs of different actors. They can be used to design properly organized data distribution and information management processes and tools.

Object-oriented methodologies, such as UML and IDEF4. With the spread of the object-oriented approach, these models have also become part of the design and representation techniques. They aim to design and identify abstract models and highly reusable patterns. From the UML toolbox, activity diagrams (OMG, 2010) and behavior diagrams (Bichler et al., 1997) are the most suitable for process modelling.

Process-oriented methodologies such as IDEF3, Event-driven Process Chain (EPC), BPMN. These methodologies were developed with the representation of processes as their basic goal. Yet they are not identical in their approach, they emphasize different parts of the processes and accordingly favor different perspectives.

The literature is abundant on these techniques. The theory and practice of Process-oriented methodologies are dealt with by Reisig in several works (Brauer et al., 1986; Reisig et al., 1998), event-driven process chains by their creator Scheer (Staud, 2001; Scheer et al., 2000). These solutions describe the behavior of a process or the system that is created/created based on it. They thus provide a good basis for choosing between alternative process flow descriptions (Betz et al., 2006). But they are mostly only suitable for creating working programs and services after modifications. For this reason, we consider this as a static use of process management.

In the field of process modelling, there is still no single universally accepted modelling language, and a distinction has to be made between process modelling, or so-called representational languages and implementation languages which are bridging process modelling languages and programming languages so that process models could directly be transformed to programs.

From the notations BPMN is the dominating one for business process modeling with a market share of about 85% (BPMN 1.2 & BPMN 2.0 combined). Nevertheless, Event Driven Process Chain (EPC) and Unified Modeling Language (UML) are two alternatives worth mentioning (Chinosi et al., 2012). In the following chapters I will briefly introduce these languages.

2.6.1.1 Business Process Modelling Notation (BPMN)

"Business processes (BP) can be defined as a series of linked activities, executed in a predefined order which "collectively realize a business objective or policy goal, normally within the context of an organizational structure defining functional roles or relationships" (Chinosi et al., 2012, p. 124). Business process management (BPM) governs the business's process environment and aims for systematic agility and operational performance improvement. However, BPM has no direct relation to a diagram or system architecture. Business process modelling (BPM) can be described as the activity of representing processes of a company and allows a comparison between the current ("as is") to future ("to be") processes. For creating a understandable notation from the business analysts up to the business staff deploying and monitoring a process, Business Process Modeling Notation was developed to provide a notation that primarily focus on simplicity on one hand but include the semantical requirements for picturing processes graphically to show the meaning, properties and execution information on the other (Dijkman et al., 2008). BPMN evolved to a standardized file format as well, which, based on its fixed structure, is widely used in data transformation assuring a high compatibility (lower loss levels) between applications.

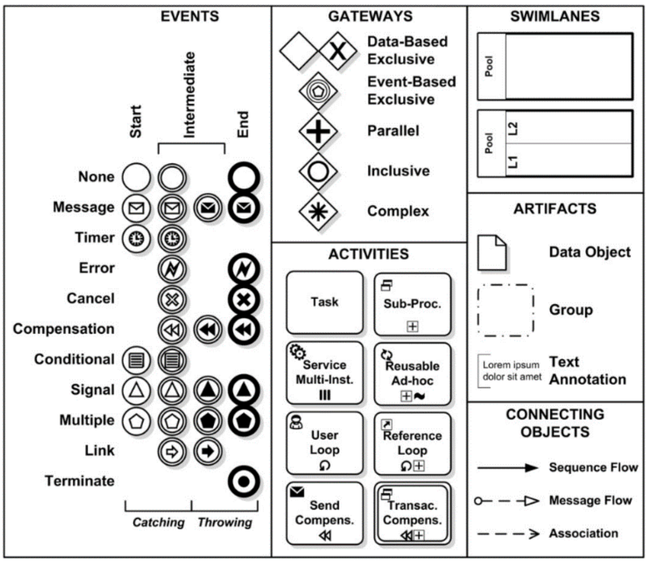

Figure 5: BPMN 1.x (Chinosi et al., 2012)

2.6.1.2 Event Driven Process Chain (EPC)

EPC incorporates role concept and data models like Entity-Relationship-Models and is thus closely linked to an Enterprise Resource Planning system such as SAP (Korherr et al., 2007). The basic idea of EPC is that events trigger functions, or the executed functions cause events. Within the use of connectors, logical relations within a process can be build (Kruczynski, 2010). EPC is based on the concept of stochastic networks and Petri nets but does not "a strong formal framework […] because the notation does not rigidly distinguish between output flows and control flows or between places and transitions, as these often appear in a consolidated manner" (Scheer et al., 2005). The lack of distinguishing functionality, which is not ideally in theory, results in a simplification with some useful applications for EPCs in practice.

Kruczynski concludes (Kruczynski, 2010) that as BPMN was developed after EPC, it incorporates the main drawbacks from EPC and helps to better structuring a process and thus results in a clear layout and better understanding over the EPC notation. However, EPC can especially be the better choice for cross-organizational business processes (Ziemann et al., 2007).

2.6.1.3 Comparison of the modelling methodologies

As earlier mentioned BPMN and EPC are the most common business process modelling languages by the Business Process Management practitioners, thus I will focus on he comparison of these two.

Although both BPMN and EPC can be used to model the same processes, we can never obtain the same diagram, due to the many subtle differences that distinguish the two methodologies, meaning not only the differences in notation.

Events and activities play a significant role in both methodologies. Events in BPMN are the consequences or antecedents of activities, showing what conditions are necessary for an activity to occur and what happens when that activity is performed. In EPC, activities and events follow each other in turn, and events are used to keep track of where the process is, how it is progressing. While EPC uses only one object to display events, in BPMN offers several depending on the type of events. Events are also used at the start of the process, which triggers the start of the process itself. In the case of BPMN, we can use a dedicated object for this purpose, which is the Start Event. In EPC, a completely ordinary event is used as a starting point.

Activities are present in both methodologies, but there is no substantial difference between them.

There are five types of gateways in BPMN and three in EPC. An other important difference between EPC and BPMN is that while in BPMN the choices are shown on the arrows after the branches, in EPC the events after the branches show what the choices are. In BPMN, it is possible to create a Loop Task, which indicates the cyclicity or repetition of an activity.

Roles can be indicated in BPMN as well as in EPC. For the BPMN uses floating bars while EPC signalizes the respective roles on the on the right side of the activity.

2.6.2 Potential uses of process models

Chapter 2.6.1, as a logical next topic in investigating business process modelling, outlined the most common modelling languages and offered a comparison. The other "extreme" is the textual process description: the text-based process descriptions which certainly follows human sense logic, but not a modelling logic or language, and its common areas of use. As to Business Processes Models, they are not necessarily being always described in a formal language. The decision on which modelling form is selected depends on the intended use of the business process model. In this section I will elaborate on this decision.

In my research, I am investigating change management within the Business Process Management Lifecycle, starting from process models and process descriptions to explore the information coded within, then build an ontology from these in order to detect and analyze the differences, this way contributing to change management for business processes.

Process models can be divided into several categories, depending on their use. Harmon (Harmon, 2003), linking the process to the life cycle, divides change into three categories according to its purpose: (1) business process improvement, (2) business process (re-)design, (3) business process automation. In the first two cases, change is preceded by analysis, resulting in process redesign. In (3), the aim is to increase the feasibility of the process by automating an existing process. It also notes that in automation (3), the attempt to improve processes in categories (1) and (2) is also observed. Furthermore, Harmon (Harmon, 2003) distinguishes between (i) changes initiated by the organization directly implementing the process, which are of an improvement nature, and (ii) changes initiated by top management, which are aimed at achieving the strategic goals of the company, according to the motivation for the change. Strategic objectives (ii) include compliance with environmental factors (e.g. standards, "green" operations, etc.). Especially with regard to compliance with environmental factors, a holistic view of change at the holistic level is strategically essential (Burlton, 2001).

By modelling business processes, a link can be created between business strategy and IT systems which can make a big contribution to increasing the value of our business. Modelling can benefit business in many ways: it can provide a common language between users, help document current and future processes, and be used for analysis. The cost and speed of processes can be measured and improved, and flexible workflows created which adapt to future changes. Business process model can be used to improve the output generated by the process and influence how it is produced.

For their intended use, process models can be created with different depths and purposes from an enterprise perspective. There is no general definition of process modelling levels, but it is common to frame process models and to distinguish between conceptual and operational models and the effects between them (Burton, 2003; Koliadis et al., 2006; Kő et al., 2011a).

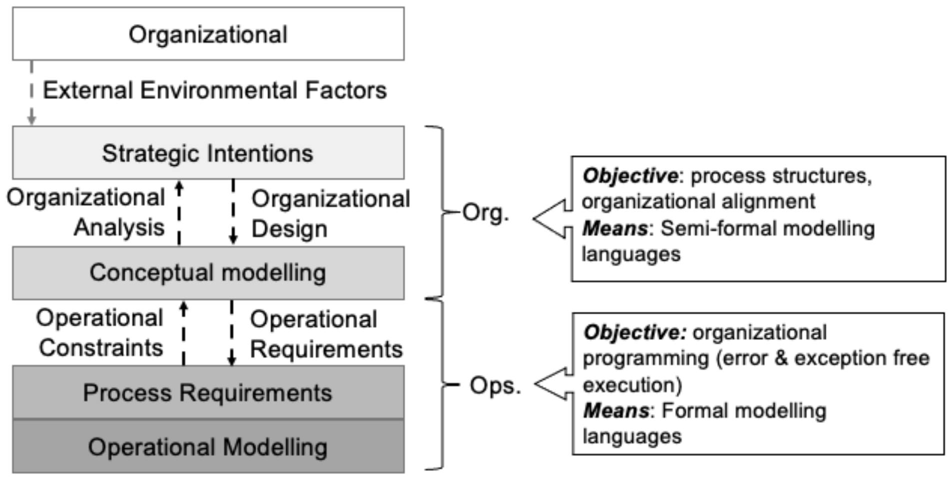

Figure 6: Combined Business Process Modelling Framework (Koliadis et al., 2006; Kő et al., 2011a)

There are several ways to describe processes, and most often a combination of these is used. The format can be text-based or tabular, but the most useful is the graphical, model-oriented description, which allows us to represent the processes in a much clearer and more transparent way.

Recent research in the Institute include semi-automatic transformation of process model to workflow (Ternai, Török 2011) and Knowledge discovery (Arru, 2018, Varga, 2013, Gábor, Kő 2012). Our research includes the extension of the field by the topic of compliance, as suggested by Varga as well.

The present research, within the framework of an industry-partner supported project, aims to provide practical support for Business Process Change Management for the purposes of business process improvements and compliance. Therefore, it uses semi-formal, representational, event-driven process models and structured process descriptions. Our initial export format is the standard BPMN.

2.6.3 Process Modelling Tools

The Business Process Models used in the current research are created by the industry partner by its proprietary Adonis modelling tool. In order to generalize our research, in the following chapter I will process various comparative researches published on BPM tools, including Adonis, and then I will provide a brief overview of the Adonis tool.

Due to the increasing popularity of the BPM, the numbers of tools for modeling processes are available ten a penny. Evaluating all the tools is nearly impossible as there were no comparison including all or a major software available. This is a result of the very different nature of available tools (e.g. industrial vs. academic, open source vs. commercial, few functions vs. software suites, BPMN, EPC…) which can derive from an open-source project to an intelligent business suite, all serving similar but different purposes.

Some of the major tools for BPM modelling which show up in various studies are Bizagi, Bonita, Activiti, ARIS and Signavio (Delgado et al., 2015; Delgado et al., 2016; Wiechetek et al., 2017). Although EPC and much more BPMN determines clear modeling guidelines, most of the tools "clearly lacks support for a significant part of the guidelines" (Snoeck et al., 2015). Snoeck et. al. (Snoeck et al., 2015) tested available tools by reviewing their ability to support the BPMN's notation's guideline. Overall, around 86% of the guidelines are known by tools in total but for single tools, the result is worse: Signavio (57,14%), Bizagi (50%), ARIS Express (30,36%), Visual Paradigm (28,57%) Camunda (25%) and Bonita (19.64%) were the tools with the broadest guideline support (Snoeck et al., 2015). As BPMN models are significantly enhanced in quality the better a model follows the existing BPMN guidelines, the result is rather shocking as only Signavio and Bizagi are supporting half of available BPMN guidelines (Snoeck et al., 2015).

Chinosi & Trombetta (Chinosi et al., 2012) followed a user centric approach when evaluating available tools in a survey with BPM experts and concluded that users preferred Bizagi (30.28%) before TIBCO (18.09%), SparxSystem EA (9.76%) and Intalio (7.55) for non-open source BPMN editors. Rational for users preferring Bizagi is mainly due to the ease of use, compliance completeness with BPMN 2.0 availability of a repository and the validation support. For Open Source Softwares, users mainly choose Bonita (16.67%) over Activiti Modeler (5.56%) and Intalio (5.56%).

Yan, Reijers & Dijkman (Yan et al., 2010) conclude in a study focusing on functional aspects that Orynx and DiaGen might be the best tools for academic purposes while Bizagi Tibco and Intalio might be best for industry purposes.

Deckert, Füllgraf, & Quoos (Deckert et al., 2012) present a very detailed comparison between Bizagi, Adonis, Semtalk and Signavio. In terms of usability, Bizagi and Semtalk received 94/100 points, followed by Signavio and Adonis (84/100). For tools such as versioning, language correction or simulation, Signavio (83.6/100) was places slightly ahead of Adonis (82/100). Semtalk (69.4/100), Bizagi (52/100) could not convince the authors. Import and export capabilities is clearly dominated by Semtalk (71.5/100) before Bizagi (59/100), Adonis (52/100) and Signavio (46.5/100). Bizagi clearly convinced the authors in terms of interfaces (100/100) in comparison to Semtalk (88/100), Signavio (72/100) and Adonis (40/100). For process landscapes Adonis (100/100) and Signavio (100/100) seem to be a clear winner over Semtalk (60/100) and Bizagi (0/0). BPMN support is best in Semtalk (79/100) followed by Adonis (69.6/100), Signavio (54/100) and Biagi (20/100). In total Semtalk (72.9/100) results as the best solution, followed by Signavio (67.3/100), Adonis (67/100) and Bizagi (55/100). (Deckert et al., 2012).

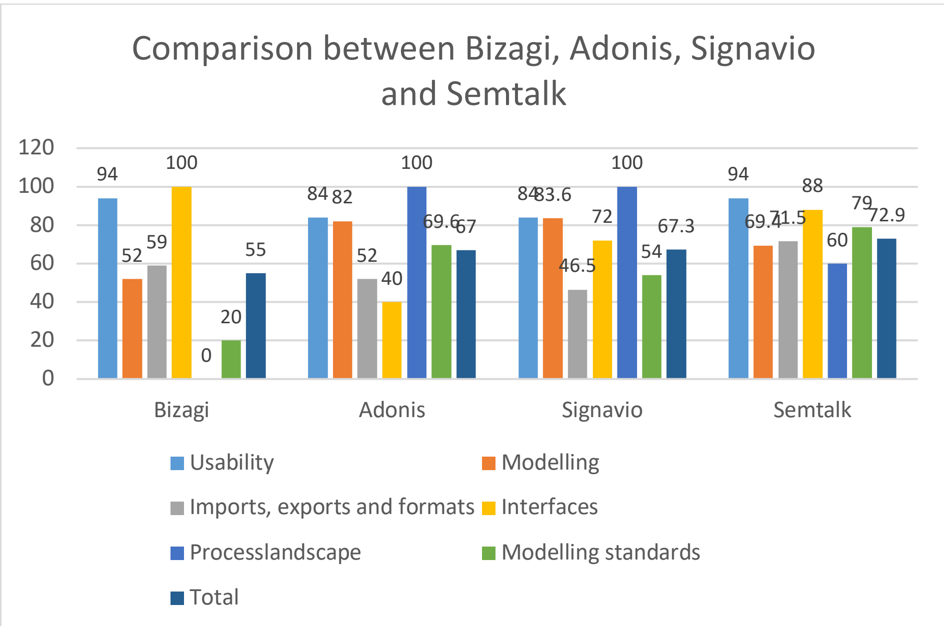

Figure 7: Comparison between Bizagi, Adonis, Signavio and Semtalk (see Deckert et al., 2012)

Sahid, Sinha, Greca & König (Sahid et al., 2015) compare Adonis, Aeneis, Aris, Aris Cloud Basic, BPMN Visio-Modeler, DHC Vision, Innovator, Signavio and Symbio with focus on usability, smartness and readiness for use. Usability describes in this context the ability of the tool to be used by a non-tool-expert as well as support of usability friendly functionalities such as Drag-and-Drop or grouping. Smartness describes the ability of the tool to analyze business processes in real time. Readiness for use describes the complexity of the required IT-infrastructure. In their evaluation, the clear winner is Aris which proofs itself as the smartest tool (by a large margin) while still being one of the best in terms of ease of use, on pair with Signavio. Aeneis (2nd), Adonis (3rd), DHC Vision (4th) and Signavio (5th) are some of the smarter tools. While Adonis and DHC vision are still rated as good in terms of ease of use, Aeneis is rated as being complex to use. Concluding, Aris should definitely be tested as a BPM tool, Adonis, DHC Vision and Sigavio still might be a solution worthwhile considering for any BPM task (Sahid et. al., 2015).

Gartner (2019) evaluated 19 Intelligent Business Process Management Suites on the basis of completeness of vision and ability to execute. Intelligent BPM Suites includes an integrated set of technologies that is of help to coordinate people, machines and things. Accordingly, iBPM Suites include additional functionalities such as content management, human interaction management, analytics or connectivity and a complete CRM suite. Therefore, Gartner's review of iBPM Suites to the before reviewed BPM software solution might seem as a comparison between apples and oranges. However, iBPM Suites often includes an extend range of BPMN functions. According to Gartner, Pegasystems, Appian and IBM are clear leaders for iBPM Suites, challenged by Bizagi, Oracle and K2 (Gartner, 2019).

2.6.4 Introduction of Adonis process modelling tool

2.6.4.1 Architectural design

In our research we used the Adonis BPM tool to model the processes. The Adonis tool has been used in institutional research for a long time (see Varga 2013) and as described above, it is one of the most advanced tools on the market. The choice of tool is also determined by the fact that the industry partner of our research also uses Adonis. In the following, I review the functionality of Adonis relevant for our research.

The architectural design of Adonis is based on a metamodel, ordered in a graph structure, defining types of models based on modelling categories (modeling symbols), types of relationships and views (Junginger et al., 2000). Subcategories of type of models are business modelling, BPMN 2.0, simulation, performance monitoring, GRC (risks and controls) and IT specifications. Part of available model types are but are not limited to company map, business process model, document model, IT system model, product model, working environment model, risk model, control model, use case diagram, business process diagram (BPMN and BPMN 2.0), choreography and conversation diagram. The following illustration possible connections between single types of models including references and attributes:

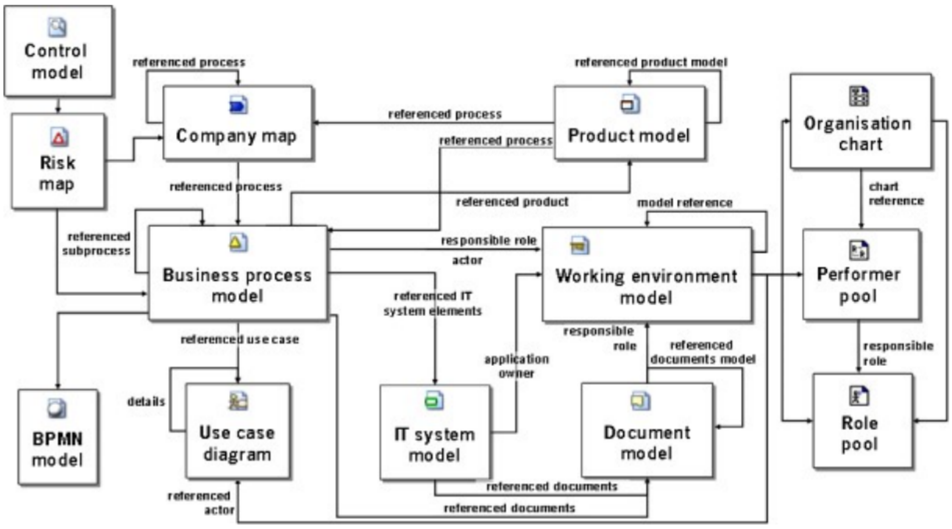

Figure 8: Graph of types of models in ADONIS (Decker et. al., 2000)

2.6.4.2 *Attributes*

For each element within Adonis, a huge number of attributes can be allocated with the objective to add detailed information. Additionally, Adonis allows to set attributes based on type such as numbers, dates, times or formulas. (Deckert et al., 2012) The dynamic notebook of Adonis is a powerful, intuitive repository for managing process- and process related information (Harmon, 2010).

2.6.4.3 Simulation

Simulation capabilities are directly integrated into the Adonis tool containing a simulation library with four animations- and playback functions. Their primarily use is to anticipate potential restructuring measurements and to look at their effects from a variety of perspectives: (Deckert et al., 2012)

2.6.4.4 Path analysis

Analyzes paths of business processes without considering the organizational structure. Path analysis allows to calculate costs for resources for a single process, calculate the critical path and analyze every possible path in relation to frequency, execution, cycle time, resource costs and more. Results can help to identify process-flaws. (Deckert et al., 2012)

2.6.4.5 Capacity analysis

Simulates one or more business process(es) by respecting work condition in the organization's environment. Additionally, workload, costs for the workforce and personal capacity is calculated. With the use of a variety of scenarios, effects of various work conditions can be modelled and analyzed. (Deckert et al., 2012)

2.6.4.6 Workload analysis

The workload analysis can simulate one or more business process within a defined work environment and calculates waiting times. Furthermore, activity- and process costs can be calculated, and capacity planning be simulated. As a result, processual bottlenecks can be identified, and resource planning be optimized. (Deckert et al., 2012)

2.6.4.7 Analyzing and reporting

Analyzing and reporting capabilities in Adonis enables simple queries and model comparisons by analyzing the repositories. A variety (standard and custom) of flexible reports can be conducted. Closer analysis of the comparison function revealed, that changes in the processes are mapped by the comparison report. The report has however two major limitations: i) it is presented in an Excel report therefore inclusion of new attributes can not be done, and ii) it doesn't allow extension of correlation between pre-wired attributes. In conclusion although the model comparison report is useful for demonstrating differences between the models, it can not facilitate further analysis. (Deckert et al., 2012)

2.6.4.8 Documentation

Adonis allows to use various forms of documentation such as functional (Activity, Sub-processes), organizational (users, resources), dynamic (sequences, process-flow), content based (artefacts, products) quantitative (time, costs etc.) and context based (versions, variant). (Harmon, 2010)

2.6.4.9 Data export

Adonis has the feature to export process model information. The structure is BPMN which is the widely used XML format, and the export includes all the attributes allocated to the process model. Its limitation is however, that the underlying structures, such as organisation set up, document classification are not exported. Although each data transformation is expected to contain certain information loss, the impact of this limitation on our intended solution needs to be investigated during my research.

In conclusion, Adonis is a tool with a vast range of functions. IT functions are very powerful for any kind of process modeling, but its focus is on business process. As seen in the market overview, Adonis is a widely used BPM tool and its functionalities are a vastly covered by other software tools as well. Nevertheless, Adonis is due to the ability to have different views and hiding objects as well as it’s variety of defining attributes to elements able to be a good tool for technology and data centric purposes as well. While Adonis, as tool, is not limiting generalization of our research, the export and the comparison functionality will be investigated to determine usability for our purposes.

2.7 INTRODUCTION OF RELATED SUBJECTS

The aim of my research is to identify and systematize the properties that can be extracted from process descriptions and process models to support change management. For this reason, I will review some fundamental concepts in this thesis: the ontology that provides the semantic structure of processes and the concept of compliance in business process management.

2.7.1 Ontology

Ontology as a concept is used in many different, often contradictory ways, and the definition of the term is still changing. The word is of Greek origin - it was coined by the compound "being" + "doctrine" and came into common use as a philosophical trend. The different definitions of ontology reveal different perspectives. To date, there have been many definitions of what ontology is, one of the most widely accepted being that of Gruber: “An ontology is an explicit specification of a conceptual model (conceptualization)” (Gruber, 1993).

Some scholars start from the construction of ontology, others from the philosophical concept itself. What is certain, however, is that ontologies can be seen as the pillars of the semantic web.

A frequently cited definition of ontology in the literature is that of Gruber: "An ontology is a clear and detailed description of a conceptual model (conceptualization)." (Gruber, 1993, p. 201), where conceptual model or conceptualization in a broad sense is a kind of worldview; it reflects the way of thinking of a particular discipline.

Ontology represents a mean of storing information. The use of logical propositions, which can be easily algorithmized, or the thesaurus, which describes the relationship between concepts, is a suitable and widespread way of representing knowledge. In addition, there are other solutions, but the speciality of ontology is that it can represent not only the hierarchical relationship between concepts, but also the relations between concepts.

Ontologies are a kind of extended theories about the types, properties and relationships between concepts in a given **domain**. They provide true statements and expressions to capture our knowledge about a given domain. Their aim is to capture knowledge related to a given subject area and provide a widely accepted understanding of that area that can be reused and shared across applications and groups (Davies et al., 2003).

In the case of information systems, the primary goal of using ontologies is to provide a formal description of a domain, task or application. This is why the ontological approach has become popular in the development of knowledge-based systems (Kő, 2004).

An ontology can take several different forms, but it must contain the subject domain's terms, terminology and description of their meaning (semantics). In practice, an ontology is always the representation of a common understanding of a domain, which facilitates communication between different stakeholders. Such a common basis contributes to an accurate and efficient exchange of information, which allows for reusability, sharing and joint operation.

2.7.2 Process ontology

Process ontology has no clear definition in the literature. Herborn and Wimmer simply refer to it as a conceptual descriptive framework for a process (Herborn et al., 2006). In their interpretation, process ontology is abstract and general. In contrast to the former, the so-called task ontologies establish a task order (Benjamins et al., 1996; Tate, 1998; Pease, 1998).

In our interpretation, a process ontology is a structured description, which can be formed from process models, and which contains, in a machine-processable way, the activities, decision points and logical links, their sequence and the resources required to execute the processes. In our understanding, the process ontology includes the knowledge elements needed to execute the process, but they are stored in a structured way in a domain-specific ontology.

In the present research, we rely on existing process ontologies, develop them further and then transform the information extracted from the process models and descriptions into the ontology.

The language used to write the ontology has a rigorous structure, so it can be used for structured description and machine processing. The Resource Description Framework (RDF) (W3C, 2004a), an extension of which is the Web Ontology Language (OWL), was developed to process and store information on the web in a structured way. Two major versions of OWL, OWL 2004 (W3C, 2004b; Guinness et al., 2004) and OWL 2, which has been continuously developed since 2009, have been published (W3C, 2012).

On both versions of OWL, there are three to three different versions, Lite, DL and Full for OWL, which specify the depth of modelling. From Lite to Full, the language becomes more expressive. OWL Full can be considered an extension of RDF. For OWL 2, there are EL, QL and RL versions. EL is for users who want to use a lot of features or classes, QL is for those for whom ***querying*** is critical, and RL is for those for whom speed of ***reasoning*** is important.

The difference between RDF and OWL can be seen as follows:

- The data model of RDF objects and their relationships. The semantic description of the data model is done in RDF, technically using XML syntax.

- RDF Schema is the language used to describe the properties and classes of RDF objects using generalizations and in a hierarchical system.
- OWL, on the other hand, introduces additional language elements for describing properties and classes, such as relationships between classes, handling of numerosities, expressing equality and similarity, an extended property set, and the introduction of set operations.

In summary, OWL has a stronger ability to express meaning in real terms than XML or RDF, and in this way OWL surpasses the other two formats in its suitability for machine interpretation (Jenz, 2003).

2.7.3 Compliance

Regulatory compliance sets new requirements for Business Process Management. Companies are required put in place measures for ensuring compliance to regulations. They must review and enhance their corporate governance processes to assure compliance. Complying to regulations of all sorts is needed for a number of reasons. The range is reaching from ensuring that specific norms are met (e.g. internal or external or industry specific quality standards) to providing correct implementation of internal controls imposed by active legislations.

BPM is an integrated approach bringing together procedural, organizational, documentation and system aspects thus an obvious source for Companies on compliance related analyses. Therefore, ensuring the compliance of Business Processes in companies is a crucial feature for BPM. In their review M. El Kharbili and colleagues (El Kharbili et al., 2008) demonstrate how current approaches within the BPM research are handling compliance checking. They classify related work to two approaches:

2.7.3.1 Backward Compliance Checking (BCC)

Backwards Compliance Checking (BCC) techniques verify if executions of Business Processes are in accordance with regulatory defined rules and constraints.

- **LTL Checker**, the technique introduced by Aalst et al. (van der Aalst et al., 2005) checks whether process instances follow a given linear time logic (LTL) rule. Applying this rule divides the process instances into two groups: regular and non-regular. The disadvantage is that it does not support graphical markup, making it more difficult to use directly by business process change managers.

- **GOSpeL**, introduced by Alberti et al., (Alberti et al., 2007; Chesani et al., 2007) is a graphical modelling language. This language, developed by Alberti, Chestany and colleagues, is used to define models that can then be used in process examples following transposing them to SCIFF.
- **Control flow approach** Rozinat et al. (Rozinat et al., 2008) has developed conformance checking techniques that quantify how exactly the behavior recorded in the process instances of a given history log matches the behavior of the given control-flow process model. If a mismatch is detected, the technique gives an accurate indication of where in the process the mismatch is located. Graphical notation is used to define the models. A criticism of the technique is that the model is only suitable for detecting non-conformities associated with constraints in the control flow process.

Forward compliance checking

Forward compliance checking are such techniques that aim to prevent execution of non-compliant processes. There are two different types recognized: Run-time - and Design Time Compliance Checking. Their objective is to verify the rules during design time, so that non-compliance can be detected before the process is set to operation.

2.7.3.2 Run-Time Compliance Checking (RTCC)

These techniques are focused on the actual Business Process models and consequently depend on the business process execution mechanisms and architecture. They work by annotating business process models with compliance statements. These are subsequently used by the compliance checking engines for compliance checking. In this sense, regulations can either be defined in the Business Process Models (e.g., control flow properties (Vanhatalo et al., 2007) or organizational properties such as separation of duties (SoD)) that aim to achieve better process quality, or they can require runtime information (e.g., information about quality claims during process execution (Rossak et al., 2006)). A methodology that includes the execution aspects of business process conformance was developed by Namiri (Namiri et al., 2007a; Namiri et al., 2007b). His approach ensures the effectiveness of controls during enforcement and provides a response strategy in case of non-compliance.

The approach used by (Cole) describes process models in a declarative way. The authors argue that constraint-based workflow models are more meaningful than process models. Cole’s framework has been extended by Cole and colleagues (Cole et al., 2004), f the extension of technical service level agreements (SLAs) to the enterprise level. The basic idea, similar to the FCL approach, is that the rules are described by using a structured language between the executing departments. Further to these techniques, business rule management systems are broadly in use to ensure predictable compliance with operative specifications, where compliance relevant business rules can be added to Business Process models. Ternai's work (Ternai, 2011) paved the way by presenting a model that transforms BPMs into executable workflows, and BPMs potentially include business rules.

2.7.3.3 Design-Time Compliance Checking (DTCC)

These techniques have a preemptive nature and aim at guaranteeing that processes are regulatory compliant from the inception. Some approaches seek to ensure already at the modelling stage that the Business Process Models created meet the compliance criteria. Some techniques analyze the models that have already been created and ensure that they meet the compliance criteria before they are put into production. Kharbili lists the following approaches (El Kharbili et al., 2008):

- **Compliance Patterns**: Ghose et al. (2007) introduce the so called “compliance-patterns”, a set of pre-defined Business Process models which will become the comparison basis, a kind of benchmark for the newly created processes. “Compliance-patterns” are proven compliant Business Processes. The approach compares the Business Process to the “compliance-pattern” and indicates differences. Upon the differences highlighted, the process signer can undertake corrective action.
- **Control patterns** Namiri et al. (2007a; 2007b; and 2008) developed a semantic layer to BPM in which process steps are interpreted according to a defined set of controls. This semantic layer is made of a set of generic control patterns. These patterns provide solutions to specific compliance

problems. Using the control patterns during the design certain compliance issues can be avoided.

- **Formal Contract Language (FCL)** Business Processes are viewed as a set of social interaction instances by Governatori et al. (2006). The authors present a framework for managing the compliance of regulated relationships in Business Processes. Along this logic, Sadiq et al. (2006; and Governatori et al., 2005) further developed the above logic and link formal contract documents with Business Processes in a way that the constraints included in the documents can be clearly attributable to the Business Process steps. For this purpose, the semantics of business contracts and their violations are described using a specialized logic, the (FCL).
- **Compliance ontology** The work of Schmidt et al. (2007) is of special interest for the research regarding ongoing in our Institution. The authors suggest the development and reference to a "compliance ontology" to which actual domain and process ontologies can be compared to, thus evaluating compliance fit. Ternai and colleagues in multiple works demonstrate practical application of the ontology matching, effectively usable for compliance purposes as well (eg Ternai et al 2015).

Kharbili et al. concludes that at this stage none of the approaches deal with compliance in the whole BPM lifecycle, that is, from the design of the business processes, set-up and run as well as BCC. This observation is imminent when considering that textual process descriptions (eg. Standards, laws, industry norms) are often the carrier of the information.

The current research intends to make advancements on the Design Time Compliance Checking (DTCC) domain. It is exploring a way to process the above-mentioned initial input for regulatory compliance and transform information stored in natural language to a multi-purpose information structure. The developed structure, the process ontology, shall be the anchoring point of a unified framework to support Business Process Change Management by serving both purposes: i) design time compliance checking and ii) for Business Process change mapping.

2.7.4 Enterprise process assessment

Over the years, several works have addressed the improvement of the evaluation process by incorporating different approaches and technologies into one or more evaluation tasks. In this area, two main lines of approach can be identified. Automated outcome calculation and presentation, which include Wen et al (2007), Cater-Steel (2016), Barafort et al (2007) and Alalwan's ontology-based work (2013), and the automated data collection, in which the work of Kivograd et al. (2014), Grambow et al. (2013) and Proença et al. (2019) shall be highlighted.

In the context of our research, two solutions deserve special attention:

- Krivograd et al. (2014) introduce a generic tool where data required for the maturity analysis can be extracted directly from a connected BPM system and can be automatically assessed and recommendations given. The evaluation of the information to determine the maturity level according to the evaluation guidelines of the maturity model can be done automatically by the Intelligent Maturity Model (IMM)-Tool. The introduced IMM tool uses criteria catalogue and/or email surveys to gather input to the analysis, whose result generate recommendations. The introduced tool is in close relationship with the compliance checking aspect of our tool in the sense of automatic BPM output processing and recommendation capability by means of a Best Practice Database. The authors list limitations of the tool which include the capability of providing detailed suggestions to shortcomings.
- Romero et al. (2022) demonstrate a framework that uses raw data gathered through emerging technologies to perform process assessments. The three-layered Smart Assessment Framework (SAF) automates the ratings or weights to organizational aspects by ontologies and text analysis techniques in order to propagate decisions through the assessment workflow and generate assessment results, promising reduction of cost, time, and effort to perform them, as well as achieving more objective and credible results.

This research utilizes test analytics principles for process discovery and process assessments for elaborate on process capability, namely process compliance. Our framework will highlight differences in processes defined versus established through data analysis. We process natural language raw text, standards, as basis, since these are the commonly available sources in enterprises.

2.7.5 Text analytics

The importance of text analytics in the field of process management research is well illustrated by the fact that processes are in most cases presented in an unstructured text format both inside and outside the organization (e.g. rules, best practice, ...). The share of this format in the overall resource is estimated at 80% (Grimes, 2008). Recently, new methods and open-source software have emerged (Aggarwal et al., 2012; Kherva et al., 2020), which allowed the switch of focus of the past 3 decades from closed vocabulary text analytics (Short et al. 2010) to the method that can use any words and/or phrases in text as the unit of analysis, known as open vocabulary text analytics and, more broadly, natural language processing (NLP) (Schwartz et al. 2013; Oswald et al. 2020).

NLP is a subcategory of data mining, which can be further divided into text analysis, processing structured data, and text mining, dealing with semi-structured and non-structured data (Fodor, 2020). The main goal of text analysis is to identify patterns within texts and analyze the results (Ternai et al. 2019). Hashimi defines 5 steps for the general text analysis process: i) corpus preparation, ii) pre-processing of texts, iii) feature generation and selection, iv) data analysis steps, and v) interpretation of results (Hashimi, 2015).

The pre-processing text step is important due to its variability in terms of the quality of the results. It is in this phase that the text is tokenized into individual terms/words, non-alphabetic characters and stop words are removed, root/stem of words are identified, and statistical methods are used for calculating TF-IDF (term frequency-inverse document frequency) to determine the importance words in collections (Vijayarani, 2015). Text analytics is based on the processing of large amounts of documents and complex material, multiple, and sometimes contradictory approaches and criteria set have been developed in the academic space (Hickman et al. 2020). In this context, we consider the suggestions of research on the processing of large documents and small corpus relevant (Kobayashi et al. 2018; Kern et al. 2016):

- Small corpora have less power to utilize fine distinctions in text (e.g., between singular and plural versions of nouns or past and present tense verbs) than large corpora (i.e., those with more documents). As a consequence, a way to increase statistical power in small corpora is, for example, combining semantically related words. Care should be taken that the increase of power remains in balance with reduced validity through the generalization and loss of detailedness of the language.
- The length of documents in the corpus is of importance during preprocessing. More predictive power is available on shorter documents, where content is limited, if the style of speech is retained. Longer documents have more content; therefore, the style of speech is less needed when irrelevant to the research question. Definition of short vary: Kern et al. suggest that documents fewer than 500 words shall be considered short, while Faguo et al. recommends categorizing a document short when contains fewer than two dozen words (Kern et al. 2016), (Faguo et al. 2010).

For data analytics and interpretation of results multiple models are available. It is generally valid though that the models need to be trained on a training dataset and validated (on a validation data) set before the model could be applied to the text to be analyzed. Specialized software can automatically generate the training and validation data set from the provided data stack. Another challenge of NLP is to provide a suitable answer to the semantic key differences. Kalogeraki propose ontology-based process models to address deviations caused by synonyms (Kalogeraki et al., 2016).

In our research we apply the open vocabulary text analytics methodology and its steps on the relevant industrial standards for analysis of process compliance, because in practice these patterns are available in text format and typically only in text format. Text analytics technology and methodology is the contribution of a fellow researcher in the research group. My contribution in the area was the training of the model (tagging) and evaluation of results. For this reason, I will discuss the used text analytics models and findings to the extent necessary for the purpose of this thesis. We use the Native Bayes model, using grammatic and semantic processing of the provided text material Our Institute frequently uses Rapidminer software for data analysis – also our research utilizes this tool.

In the processing, as occur in the business world, no other, supporting elements (e.g. initial process structure) are relied on. The process structure necessary for the processing of the text is also determined based on the information found in the relevant standard. Our text analysis therefore consists of two steps: i) retrieving the process structure as heuristics, ii) search for project attributes based on the retrieved structure. Then we use the analytical methodology developed by Ternai and colleagues (Ternai et al., 2019), complemented with the aforementioned first step. Since industry processes are case specific and relatively exclusive as well as of limited length, we consider the suggestions made by the community regarding small corpora and document length.

In the following I will continue by presenting the research case.

3 PRESENTATION OF THE RESEARCH CASE

In my research, I connect the fields of process management and change management, as my aim is to explore the information needed to support change management and the methods of extracting it from process models and text descriptions, and then to provide a functionable solution to support change management by building process ontology from these. Particular attention will be paid to the investigation of the supportability of the defined changes related to digital transformation.

In subsection 1.3, I identified the research questions that I will address in the practical part. In the following, I will outline the main tasks and expected results of the practical work, in line with the content expectations of the thesis.

3.1 OVERVIEW OF THE PRACTICAL SOLUTION

In the empirical part of the research, I explore the extraction of information from process models and textual descriptions to support organizational change management, with the potential for exploitation.

The solution to be created will consist of several elements based on process models on the one hand and textual descriptions of the contextual flow of processes on the other hand. From these two sources, all the information will be extracted and processed and comparatively analyzed in order to support change management.

The motivation for change in process models can be grouped into two main categories, based on which two scenarios are considered:

- Improvement: this group includes motivations for change that come from within the organization. It is assumed that change will lead to a new process model according to the Business Process Lifecycle phases. In this case, the task is to compare two process models.

- Compliance: in this case, the need for a process change is driven by a need outside the control of the organization. For example, legal compliance, compliance to standards and norms or internal procedures. In these cases, the compliance criteria are typically defined in textual form, so the analysis involves comparing textual information with information extracted from a process model

In my research I will examine these scenarios through two cases. In the first case, I will examine the current (as-is) process and its improved version (best practice). In this case, the output of the comparative analysis will be defined, interpreted and the necessary conventions and constraints will be defined. In the second case, I will compare the current process with the (to-be) process represented in an industry norm using the ecosystem created. In the second cycle, I will examine how the changes required are reflected in the output we define. In this cycle we will also refine the conventions and constraints.

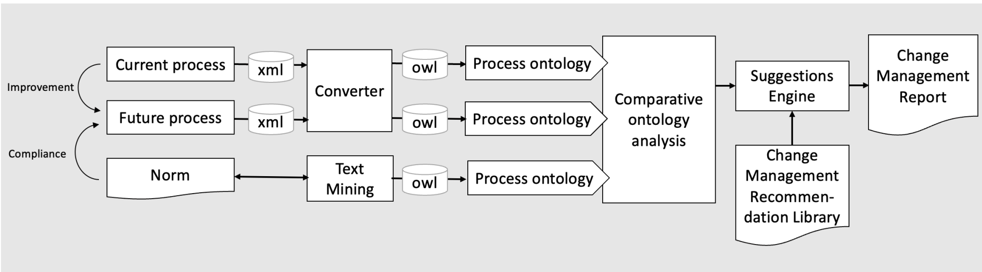

Figure 9: Architectural overview of the solution

Extracting and comparing change elements from process models and text formats is not a trivial task. It is necessary to convert them into a common, structured format. The ontology, with its structure, versatility and good processability, is the right tool to achieve this goal. It is necessary to perform the transformation according to the source of the information.

- Process models should be transformed into a process ontology. A process ontology combines the data content of process models with the structure and good processability of an ontology.
- Information from textual sources should also be converted into a process ontology so that it can be compared with information from processes.

Ontologies provide a common "language" that allows comparative analysis of processes and support for change management. The information extracted from processes or textual process descriptions can be used, for example, to identify changes needed in the process concerned during **digitization** or **compliance** testing.

Identified differences will be processed by the Suggestions Engine. The Suggestion Engine analyses the differences and matches each difference to one or more recommendations stored in the Change Management Recommendation Library, for the organizational change manager. The recommendations are based on the ADKAR change management methodology. Finally, the suggestion engine formats outputs into the predefined structure of the Change Management Report.

The solution outlined in this research will be demonstrated through a pilot project of an international company from the medical device industry.

3.1.1 Digitalization in the Usability Engineering (UX) process

In this chapter, I describe the process our industrial partner wants to change. The process is subject to regulatory stipulations; thus, I will also examine compliance with existing standards through transferring the standards into a process ontology. Ultimately process versions are compared using process ontology and then evaluated.

Digitalization and the development of technology have also had an impact on R&D. One element of laboratory R&D is the investigation and development of what is known as Usability Engineering (UX). UX is not only focused on user comfort and functionality, but also on the detection and management of user-side elements that threaten the functionality and safety of the user.

The UX development process typically runs in parallel with technical and technological development. A methodological framework brings together and structures the domain developments running in parallel. During UX development, theoretical and practical tests are carried out to follow the progress of development, often on theoretical (wireframe) models or early prototypes, which are further developed (mock-up) for UX testing.

The development of laboratory tools is strictly regulated. A set of specialized standards govern the development process. As an element of laboratory development, UX development is also subject to standards. These standards are ISO 14971:2019: "Application of risk management to medical devices ", an improvement of the 2013 version, and IEC 62366-1:2015: "Application of usability engineering to medical devices". As can be seen, both standards are international and industry-specific, regulating the development of medical devices (including laboratory devices).

UX developers are often faced with the problem that the device or functionality they want to test is not yet or only incompletely available to other development teams. As a consequence, it is common in UX development to create mock-up models on which usability testing can be performed. Being a human-oriented test, it is necessary not only to prepare the tool to be tested, but also to invite testers selected on the basis of various factors. This is a significant time and cost investment. A further problem is that during development, changes are made to the device which mean that some tests are repeated.

To mitigate this problem, an emerging technology augmented reality (AR) and virtual reality (VR) offers a good opportunity. The basic idea is that time and cost can be saved, and more/frequent measurements can be performed if, wherever possible, mock-ups are replaced by AR/VR images and measurements are performed through them. Full replacement is not possible due to haptic tests on the one hand and user requirements on the other. The goal was to create a process where both tests are possible. At the same time, a general review of the process developed in 2013 was carried out.

The models of the current and to-be processes and the standards mentioned above form the basis of our analysis.

3.1.2 Improving the travel management process

For an internationally active industrial company with R&D, production and sales in more than 100 countries, travel-related expenses represent a significant share of costs. While the COVID pandemic has reduced the amount of travel, it has increased its complexity and cost. Keeping costs under control is possible through processes and strict control of responsibilities. But control is at odds with the need for flexibility and speed. Digitalization has raised the need for more on-line management. The reduction in the number of actors involved promises to speed up the process.

The new process is expected to facilitate and control the process of travel management with fewer actors, faster and more universally usable.

A detailed process design has been prepared to map the changes accurately and to help define the direction of the expected digitalization. The reduction in the number of participants will also reorganize the allocation of responsibilities, which also needs to be mapped out and implemented.

Models of current and future processes modelled in the Adonis BPM tool form the basis of our analysis.

3.2 THE CHANGE MANAGEMENT REPORT

The task of change management support is to provide the person or persons responsible for executing the process change with actionable information about the change.

Process change often requires organizational and personal changes in addition to changes in material assets. As explained in section 2.5, personal and organizational changes need to be managed in a targeted way, using methodologies designed for this purpose.

As outlined in chapter 3.1 when describing the architecture of the solution, the Change Management Report is a tool to support change management and a major product for our industry partner. To this end, a report format has been developed on a practical basis with the industry partner involved in the research to effectively support business process change management. The structure of the report, its use and the information needed to create it are described below.

LOGO

PROCESS CHANGE MANAGEMENT REPORT

Base Process:
Compared Process:

Date of run:

Role filter: applicable for Role Changes section

Process impact

Task	Changed	Removed	New	Name	R	A	C	I	Systems	Documents
				RACI						
Check if document is registered in PAT	X			X						
Deliver requested document(s)	X					X				
Info/Handover document	X					X				
Receive document	X					X		X		
Send order	X			X		X				
Update PAT	X					X				
End Event	X			X						
Ask responsible Department Archivist to pick up document		X								
Ask to order the document		X								
Check document location		X								

Role Changes

Role (make it possible to filter to functional a	Added	Removed	Related Task
External Archivist	Accountable		Deliver requested document(s)
	To Inform		Receive document
Archive Manager	Accountable		Info/Handover document
	Accountable		Receive document
	Accountable		Send order
	Accountable		Update PAT

Suggested Actions
- Validate training need on process
- Check & update job descriptions
- For roles removed from tasks: validate capability to perform remaining activities (appears only if there is value in "Removed" field)

Capability Changes

Systems & Equipment

Task	Added	Removed	Execution A	Execution R
Process XYZ		SAP		External Arcivist
Process ABC	TPM	BBC		
Documents				
Process Step ABC		Risk Log	Role A	Role B

Suggested Actions
- inquire comprehensiveness, where Added capability is empty (and Removed filled) to assure no capability vacuum is created (appear only wh
- Train skills on additional capabilities

« end of report »

Page 1 of 1

Figure 10: Initially defined format of the Change Management report. Note: content is fictious for demonstration purposes

3.2.1 Structure

The report supporting change management of a process should be detailed yet clear, with self-explaining results. Therefore, in addition to the content, the format was also taken into account. As the report is programmed, the format can be changed if required.

Result is a complex report to be developed in collaboration with the industrial partner. The report is divided into two main parts, an overview of the changes and a deeper analysis of the elements to be addressed by the change manager. In the second part, the analysis results in recommendations for the activities to be carried out by the change manager.

The **header section** of the report contains general information to aid clarity. An important element in this section is the identification of the basic process and the processes compared. This will enable the report user to understand the direction of change. I will explain this in more detail in the overview of the first section.

In the **first part**, the changes are listed. This list will help to give an overview of all the changing factors by mapping the changes in the subject, organizational, responsibility and organizational areas.

As the report is analyzed by comparing two models, it is important to note which model forms the basis of the comparison and which one is compared to the baseline. In the following, the report on which the comparison is based is denoted by M_{base}. The compared model is denoted by M_{new}

On the y-axis (**rows**) are the activities where the analysis has detected a change.

The x axis (**columns**) lists the type of change and the relevant attributes:

Section 1: **Type of Change**. In this section the type of change is defined. By marking in the appropriate column. It is understood that a row in this section can only take one value.

- **Changed** - this value is taken by a row if the activity is present in both models (M_{base} and M_{new}) but one of the attributes has changed. In this case, additional information is provided in section 2.
- **Removed** - this value is taken if the activity is found in the M_{base} model but not in the M_{new} model. Since in this case all attributes “disappeared” with the activity, no further analysis is done in section 2. Note that attributes "disappear" but their values can be taken over by other activities. If this happens, the activity that takes over will also appear in the report under the type "Changed" or "New".

- **New** - this value is taken by the row if the activity is not found in the M_{base} model but is found in the M_{new} model. Since in this case the activity is new in all its attributes, no further analysis is done in section 2.

Section 2: a basic analysis of change. If the type of change in the first section is "changed", the report provides additional information to locate the change. The attribute concerned is marked. As the change may affect more than one attribute, several attributes may be marked in this section in one row.

- Change in the name of the activity concerned
- Change in responsibilities
  - Responsible
  - Accountable
  - Consulted
  - Informed
- Technical systems (systems)
- Documents

After the above overview, the **second part** contains the analysis and recommendations relevant to the change manager. These are basically manifested in the area of changed responsibilities and skillset. Changes in these affect the people who have to lead the change. The activities proposed on the basis of this analysis are based on the ADKAR methodology used in the company, which is presented in section 2.5.6.

It should be noted that process models include roles, but neither jobs (groups of roles) nor individuals. This statement is very important when using the evaluation, because the report tells us which roles need to be worked with from a change management perspective, but it is anonymous due to the origin of the analysis: which persons, exactly who, are the ones to be dealt with, has to be added by the change manager from other sources.

1. **Analysis of changes in responsibilities**: the report summarizes the organizational changes associated with each role and shows the type of change and where it is in the process. It provides information grouped by role, filtering by role is also possible.

Filtering by role provides the possibility to view changes by job or organisational unit as the subject of change management. When filtering, the recommended activities are also displayed according to the roles displayed. In this way, the report can recommend targeted change management activities tailored to the person or department.

The analysis of changes in responsibilities is structured as follows:

- On the y axis (**rows**), changes are grouped by role.
- The x axis (**columns**) shows the following values:
  - **Role** - the changed roles are listed, grouped by role. If the report has filtering, only the filtered roles are displayed.
  - **Added** - the row takes this value if the role has been added to an activity (in relation to M_{base} and M_{new}). The value includes the corresponding one of the four RACI responsibility categories (Responsible, Accountable, Consulted, Informed)
  - **Removed** - the row takes this value if the role has been added to an activity (in relation to M_{base} and M_{new}). The value contains the corresponding one of the four RACI responsibility categories (Responsible, Accountable, Consulted, Informed)
  - **Related Task** - this column shows which activity in the process has been changed.
- In the **suggested action** below the table, the report makes suggestions for change management activities based on the analysis of the above changes according to the ADKAR methodology. In this research, the aim is not to use an all-encompassing set of suggestions in the report, but only to test in a basic way whether the report can make suggestions that can be derived from the ADKAR model based on the analysis.

2. The **Analysis of Change in Capabilities** analyses one of the most important elements of personal and organizational change. As in the previous rounds, it analyses the available information in a unified structure, an ontology, and makes recommendations from it. The logic of the analysis is as follows: in relation to M_{base} and M_{new}, it expresses, grouped by attribute (see Structure in 3.2.1), which change occurred at which point in the process, and at which step. From this, the

change in capability can be deduced, which can be used to propose change management activities based on the ADKAR model.

The structure of this part of the report is as follows:

- On the y-axis (**rows**), the steps of the process are listed according to the change of attributes, following the following logic:
    - **Attributes** - These are the process attributes named in the first part, except for the responsibilities. Each attribute type implies a different capability and process understanding. In addition, the creation of attributes and the teaching of the capabilities they require are different and therefore need to be listed separately. Attributes are the main grouping in this part of the process.
    - **Process steps** - under the attributes as the main grouping, the process steps are listed in which the value of the referenced attribute changes.
- On the x-axis (**columns**) the change is evaluated, first by type of change, then by the roles affected by the change.
    - **Direction and value of change** - linked to the process step on the y axis, the value of the attribute is shown. The M_{base} vs M_{new} logic presented in the previous chapter is applied here. If multiple values are added to a process in a given change direction (added or removed), they are displayed in a different row.
    - **Affected roles** - these columns show the affected role. As a general rule, all RACI values are returned, however, in this project the industrial partner focused on the Accountable and Responsible roles. The mapping of roles to attributes and process steps allows the definition of targeted change management activities tailored to the role (person). As the other roles can be easily programmed using the logic of the previous two. Their absence in this case does not affect the generalizability of the report in this respect.

- Underneath the table in the **suggested action**, the report makes suggestions for change management activities based on the analysis of the above changes according to the ADKAR methodology. As stated above, the aim of this research is not to use an all-encompassing set of suggestions in the report, but only to test whether the report can make suggestions that can be derived from the ADKAR model based on the analysis. In the next section, I will present the information required to prepare the report, which includes the illustrative ADKAR-based proposals, which need to be presented according to appropriate criteria at the bottom of the two sections of the second part outlined above.

The page number is shown on each page. The **end of the report** is indicated by the phrase « end of report ».

3.2.2 Required information

3.2.2.1 Process Information

A complete and detailed list of changes to the process models should be available for the report. This detail should include the steps of the process and their sequence. For each process step, the following information is required:

- Process step name
- Previous step - the previous and next images are used to put the process step into context
- Next step
- Responsible
- Accountable
- Consulted
- Informed
- Systems - software and other tools used to implement the step
- Documents - document used to implement the step

The above elements should be extracted from the process models and the text-based description. It must be possible to distinguish the elements per process, otherwise, by definition, the comparison cannot be made. In the comparison, each process must be treated consistently according to the M_{base} vs M_{new} logic mentioned above.

Responsibilities and authorities are very important for change management. These can be clearly defined using the RACI matrix. The RACI matrix is an acronym of four terms representing the role in the activity:

- Responsible, i.e. the Executive role (the one who carries out the activity);
- the Accountable role (the one who approves the execution of the task or who is accountable for its execution);
- the Consulted role (the one who participates in the activity indirectly, with advice or as a peer)
- Informed, the Informed role (the one who is involved in the implementation of the activity or has to be informed about the implementation).

The RACI matrix makes responsibilities and authorities clear in the process models, but at the same time, there can be more than one role associated with an activity. The RACI matrix can be used to map out what work organization changes will occur with the new process. This aspect is an essential element of change management.

The Adonis BPM tool used by the industrial partner also uses the RACI format.

3.2.2.2 Change management recommendations

The proposals that emerge from the analysis can vary depending on the companies and situations. The aim of our research is to formulate indicative proposals which, on the basis of the criteria defined, will be presented in the report at the end of the two sections of the second part. The following table lists the proposals used in our research.

The suggestions can be made more detailed and specific by further programming and by including other information in the analysis. Sophisticated proposal generation was not expected from our prototype, but could be the subject of further research in the future. This approach also allows the report not to make (only) ADKAR-based recommendations.

In the further part of the research the below table will be populated with indicative values worked out with the industry partner. We will accept the report's recommendation functionality if the recommendations appear based on the condition defined.

Recommendation	Condition*
Section: Role Changes	
Validate training need on process step [Task] in process [Process]	If [Role] has value “Added”
Check if [Role] can perform remaining tasks in [Process]	If [Role] has value “Removed”
Section: Capability Changes	
Inqure comprehensiveness around [Task] in [Process] to assure no capability gap is created by removing [IT_system] without substitute	If [IT-system] is “removed” and [Role] and [Task] has relationship [Accountable_for_approving_results] or [Cooperationspartecipation] AND no [IT-system] is "Added” to same [Task]
Inform impacted people about the change and train skills on [IT-system] / [Document] for step [Task]	If [IT_system] / [Document] is “Added” and [Role] and [Task] has relationship [Accountable_for_approving_results] or [Cooperationspartecipation]

* Variables in the conditions, marked with […] are process ontology attributes, detailed in chapter 3.5

Table 4: Change Management Recommendation Library used in our research

3.2.3 Intended use

The report provides ex-ante process control, is of a pre-emptive nature (Design Time Compliance Checking - DTCC) and is designed to be used for both cases presented in chapter 3.1:

In the case of **Process Improvement**, the aim is to compare two process models created in a business process management tool and to map changes based on them. This objective is supported by the first and second parts of the report. The first part provides a structured overview of the changes. The second part deals with the evaluation of the changes and proposes concrete actions. The process manager or the person responsible for the process change can thus use the report at the stage of defining the new process and evaluate the impact of the change, which can be taken into account **at the process design stage**. Once the new process is finalized, the report can be used to help define the activities and tools needed to implement the change.

In the case of a **compliance check**, the process model to be tested is taken from the process management software and used to run a comparison with the information extracted from the standard text for the process. In reality, the aim is not to achieve a process that is identical with the standard, but rather to meet the requirements of the standard. Our industrial partner also intends to use the compliance test as input for the audit of the implemented and future processes. Consequently, the first, comparative part of the report will be given a greater emphasis, where the aim is to show the differences. On this basis, the process manager can decide **at the stage of process design** whether and what needs to be changed in the process.

Improved processes with compliance requirement - in a combined case, a new or improved process with compliance requirements is developed. In this case the above elements should be used in combination **at the process design stage**. For the M_{new} process the comparison should be run and for the M_{new} process the compliance check should be run. Further changes can be made to the process taking into account the results of the two comparisons described above, and then the above comparisons can be run again as required. The report can be used to assist the process manager in implementing the final process as described in Process Improvement.

3.3 INTRODUCTION OF THE PROCESS MODELS

As mentioned, my research aims to systematize and extend the research in the field of process management at the Institute, and therefore I also draw on the results of previous research and the conditions and tools used in it. My research is framed by the joint project with an industrial partner. For this reason, I will use the common process modelling tool Adonis of the BOC Group, semi-structured process models, industry standards in their original format, and XML and owl-based transport formats.

Processes can be modelled at different levels, depending on the purpose of their use. The topics are discussed in detail in section 2.6.3. In the present research, semi-structured process models are the most appropriate for describing organizational structures and are provided by the industrial partner.

Textual process descriptions can be produced for a wide range of purposes and in a wide range of formats. Reviewing and processing all these is beyond the scope of the current research. The compliance references of our industrial partner are the relevant standards and are therefore the subject of the information extraction from the textual process descriptions. The structure of the standards is not structured from a process modelling point of view, yet they generally follow a predictable format. These formats are used to provide a bridge between the requirements described in the standard and their representation in the process ontology. This step is necessary to try to establish a basis for comparison with existing process models. In this way, we can ultimately explore whether the transformation of textual process descriptions into process ontologies using machine algorithms is a viable way to incorporate textual flow descriptions into a change management support system based on process comparison. This will be seen if we can extract from the standards some attributes for process steps and at least indicatively determine the order of the process steps.

In the literature review, I have presented the main process modelling tools and the modelling constraints and freedoms they impose. Particular attention has been paid to the "built-in" process comparison functionality of the tools.

In the following, I review the process models used in the light of the information needed for our purposes:

3.3.1 Introduction of the UX process model

Both versions of the process were documented in Adonis Business Process Modelling software by the industrial partner. These two pieces of information stored in Adonis were obtained for our research. There is no evolutionary relationship between the two processes in the software. This means that the as-is (M_{base}) process was first modelled on paper during the preparation of the relevant Standard Operating Procedure (SOP). Later, this paper-based document was transferred to the Adonis software. The reason for this was that at the time the SOP was developed, the modelling software had not yet been implemented as a standard. The to-be process (M_{new}), which was also functionally revised during the digitization efforts, was also defined outside the modelling software, in workshops, and then uploaded into the Adonis software.

The above process management and modelling is not a unique exercise. From the point of view of our research, we can therefore record that we are looking at information generated in a real situation and that its format is appropriate, since both processes are ultimately modelled in the BPM software, and we work with these models. The necessary attributes are dictated by practice and compliance requirements. The criterion is that the attributes we need, as defined in paragraph 3.2.2.1, are included in both models.

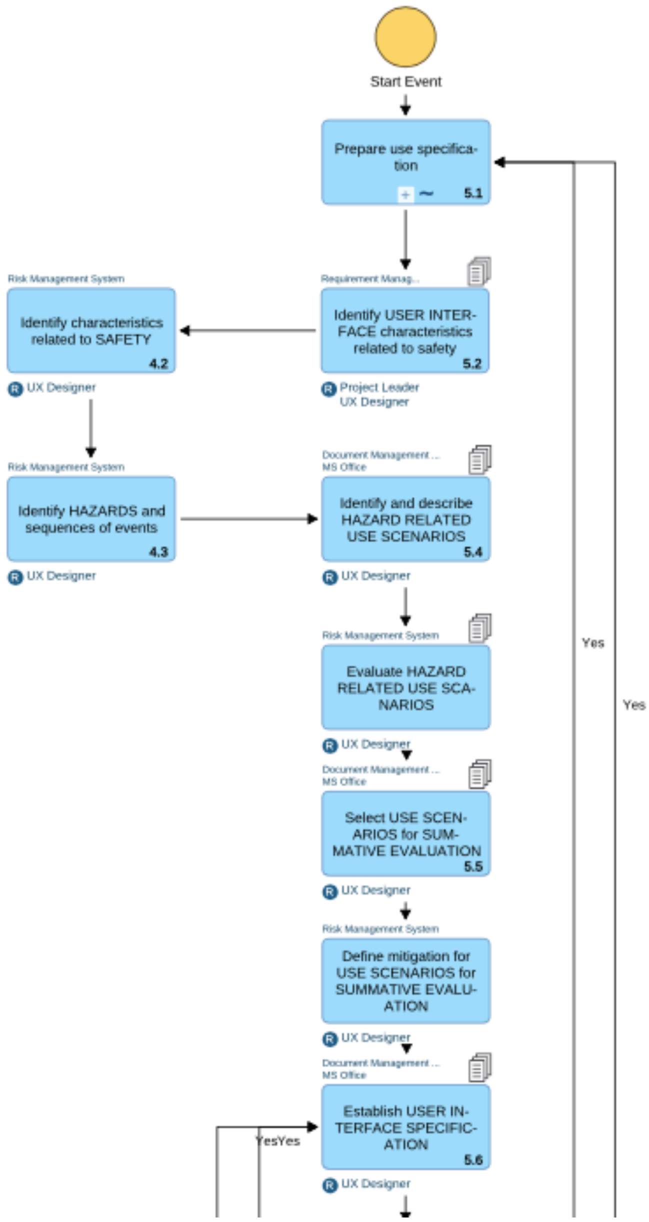

Figure 11: Part of the UX process model in Adonis software

Both models of the UX process include the following information:

- Name of the step
- For each step:
    - Responsibilities structured according to the RACI model
    - Documents
    - Required software and tools
    - Textual notes for each step
- The M_{base} process consists of 13 steps, while the M_{new} process consists of 19 steps

In conclusion, both processes have the attributes defined in section 3.2.2.1. The differentiation of the process steps provides a good opportunity to examine the functionality of the report, how without analysis it can be seen that there will be additional steps that need to be analyzed.

The UX process governed by two standards, which I present in the next point.

3.3.2 Presentation of standards related to the UX process

Both standards presented below are European standards which have been transposed into national law by the Member States. The standard is available in pdf format and can be made machine-readable. The Hungarian editions used by us, due to geographical constraints, are in the original English language and use the original document structure except for a Hungarian introduction.

3.3.2.1 IEC 62366-1:2015 Application of usability engineering to medical devices

This standard provides the framework for the usability engineering (UX) process in a company developing laboratory equipment, such as our research partner. It aims to provide a framework for the logical steps, actors and outputs of the UX process. There are mandatory and optional elements of this framework. From a compliance point of view, the logic of the standard should be followed, but there are no restrictions, for example on naming.

EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 62366-1

April 2015

ICS 11.040

English Version

Medical devices - Part 1: Application of usability engineering to medical devices
(IEC 62366-1:2015)

Dispositifs médicaux - Partie 1: Application de l'ingénierie de l'aptitude à l'utilisation aux dispositifs médicaux
(IEC 62366-1:2015)

Medizinprodukte - Anwendung der Gebrauchstauglichkeit auf Medizinprodukte
(IEC 62366-1:2015)

This European Standard was approved by CENELEC on 2015-03-31. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

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European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
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Ref. No. EN 62366-1:2015 E

Figure 12: Cover page of the IEC 62366-1:2015 standard

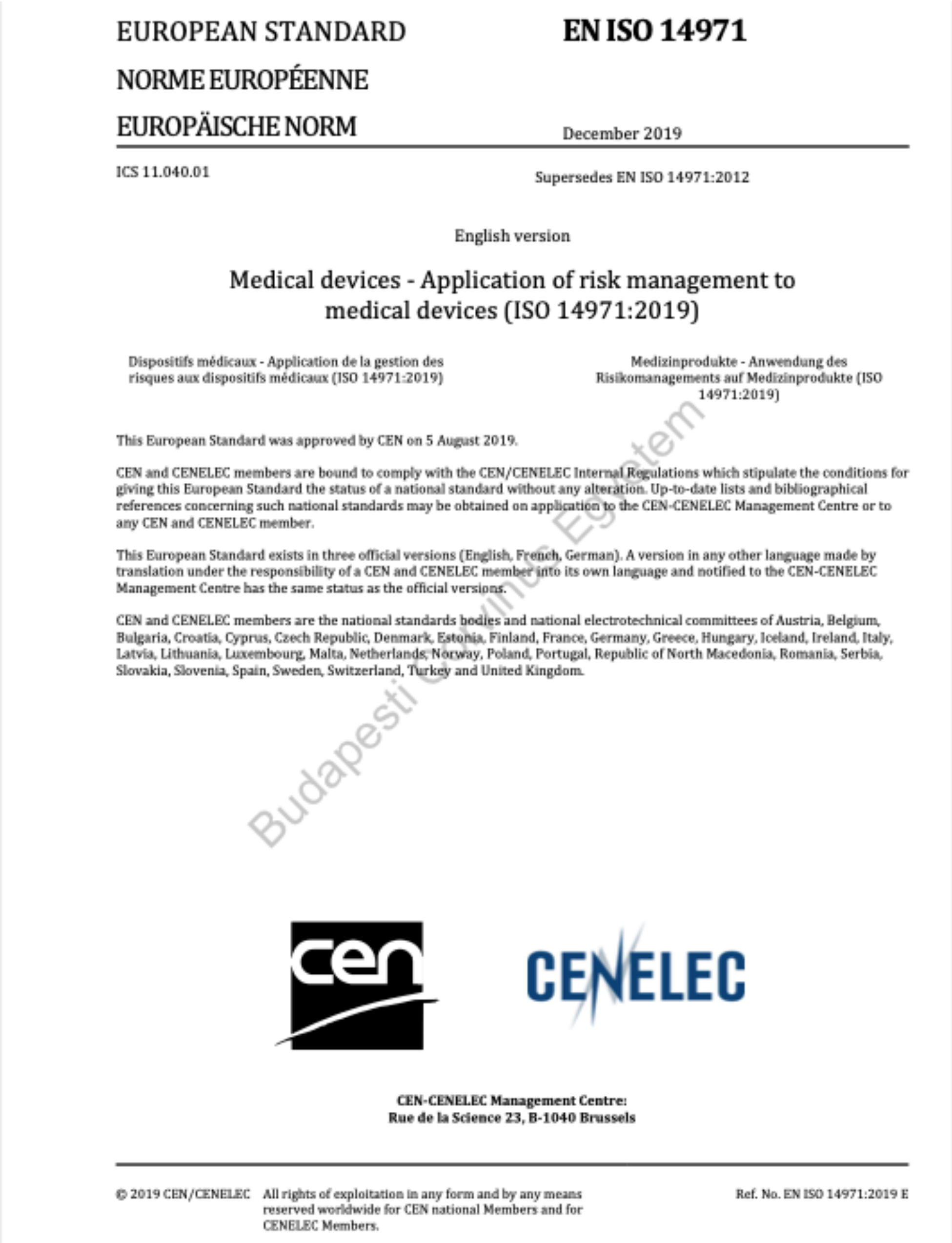
Preliminary tests reveal that the standard includes a table of content and includes the following information:

- Process step names
- Responsibilities
- Responsibilities

The standard makes reference but does not include a software level requirement. Part of the standard is a table, listing the steps in the process.

3.3.2.2 *ISO 14971:2019 Application of risk management to medical devices*

ISO 14971 is the internationally recognized standard for developers of laboratory instruments. Its purpose is to regulate the management of user, product-level and technical risks to the product when developing laboratory instruments. This regulation covers the entire development spectrum, including the UX process. The standard has mandatory and optional elements. Compliance must be ensured during product development and must be able to be demonstrated where necessary. Consequently, the UX process must also comply with this standard.


EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN ISO 14971

December 2019

ICS 11.040.01

Supersedes EN ISO 14971:2012

English version

Medical devices - Application of risk management to medical devices (ISO 14971:2019)

Dispositifs médicaux - Application de la gestion des risques aux dispositifs médicaux (ISO 14971:2019)

Medizinprodukte - Anwendung des Risikomanagements auf Medizinprodukte (ISO 14971:2019)

This European Standard was approved by CEN on 5 August 2019.

CEN and CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CEN and CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN and CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CEN and CENELEC members are the national standards bodies and national electrotechnical committees of Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and United Kingdom.

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Rue de la Science 23, B-1040 Brussels

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Ref. No. EN ISO 14971:2019 E

Figure 13: Cover page of the ISO 14971:2019 standard

Preliminary tests reveal that the standard includes a table of content and includes the following information:

- Process step names
- Responsibilities
- Responsibilities

The standard refers to but does not define a software level requirement. Part of the standard is a table, listing the steps in the process.

3.3.3 The travel management process

Both versions of the process model to be used were developed in the Adonis software. One of the two process models provided by our industrial partner is a direct version of the other, improved directly in Adonis software. The second processes (M_{new}) is an enhanced version of the first one (M_{base}), The process models differ accordingly.

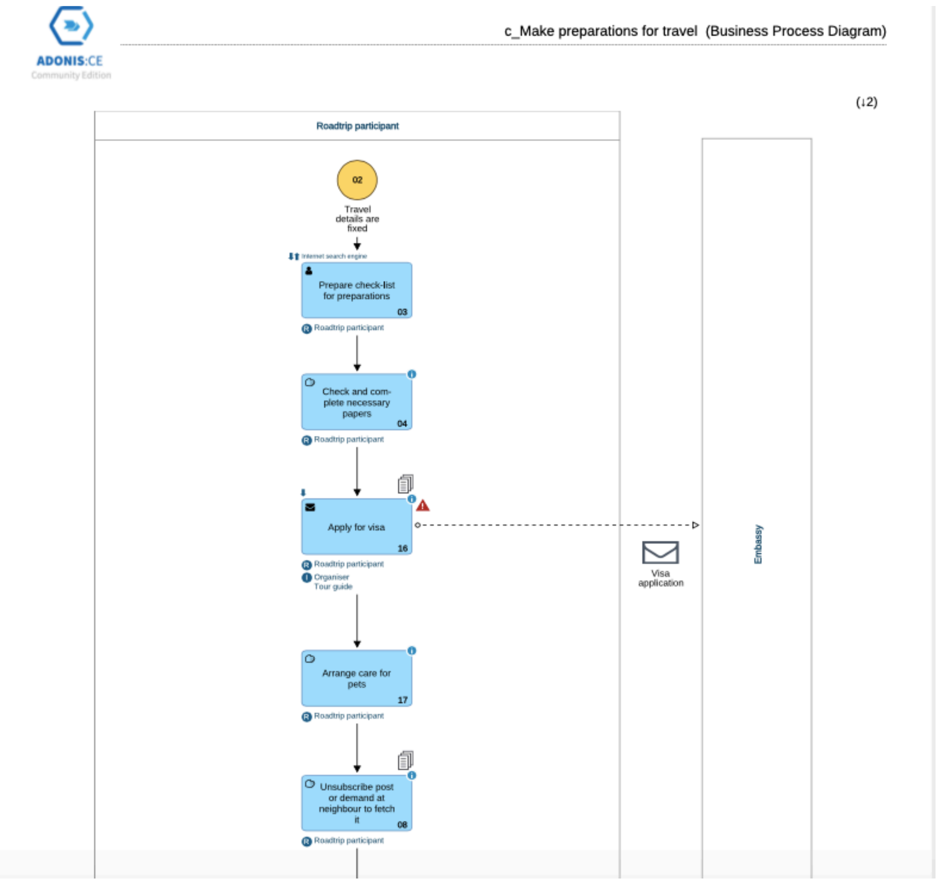


Figure 14: Part of the travel management process in the Adonis modelling tool

Both models of the travel management process include the following information:

- Process Name
- Process version
- Per process step:
  - Responsibilities structured according to the RACI model
  - Documents
  - Required software and tools
  - Textual description of the step
  - Risk associated to the step
- The process consists of 9 steps

In conclusion, the travel management process model contains the necessary information. An advantage of model evolution is that semantic differences only appear where real change has occurred - hence it is possible to examine our model across the full spectrum of the architecture so that semantic differences will likely not unnecessarily make the comparison noisy.

3.4 EXTRACTING INFORMATION FROM PROCESS MODELS

The architecture presented in Section 3.1 is based on the conversion of process models and textual flow descriptions into process ontology. The process ontology is the basis for the analysis of changes. When comparing two processes, the first step is to extract the actual process models, then further process them and ultimately develop a report to support change management.

As shown in chapter 2.6, modern BPM tools have built-in process comparison functionality. The Adonis software includes such a feature. It was therefore important to check whether an element of the architecture used does not provide a solution that is adequate for our purposes.

In this chapter, I will examine the report based on the process comparison function in Adonis from this point of view.

3.4.1 The Adonis process comparison report

Process models that have been modelled with the Adonis software can be compared using a standard function that can be invoked by selecting the two processes to be compared simultaneously and pressing the job mouse button on the list

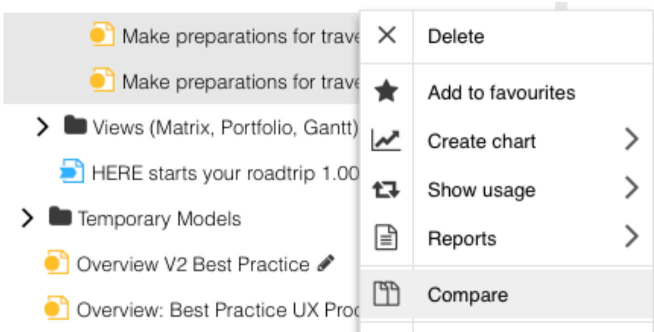


Figure 15: Compare Process Models functionality in Adonis

The result of the comparison is a report, and it is also possible to display the differences graphically in the software itself. For us, the report as output is of interest.

The report is structured as follows:

- State - specifies the type of change with respect to the compared (M_{new}) modeler. This categorization is used in the report of our research.
- Type - indicates the location of the change:
  - Task - a change in an attribute of the process
  - End event - a change at the end of a process.
  - Empty - a change in the order of a process
  - Business Process Diagram - a change in the administrative attributes of the Business Process Model. This type will not be discussed further because the analysis of the information used for the process administration is not in the scope of the exposure.
  - Gateway (exclusive and non-exclusive)
- Name - the value of this field varies according to the type
  - Task and End Event - name of the current step
  - Blank - text description of the change in sequence
- Attribute - for Task and End events, the changed value is taken

- The last two columns record the values of M_{base} and M_{new}, so that the original and new values can be viewed once again

To be noted, that each change instanced will generate a separate row.

State	Type	Name	Attribute	Lend archived records_variant	Lend archived records
added		Sequence flow (Check document location -> Is the document i			added
added		Sequence flow (Is document registed in PAT? -> Check docume			added
added		Sequence flow (Need document -> Is document registed in PAT			added
hanged	Task	Check if document is registered in PAT	Name	Check if document is registered in P.	Check document location
hanged	Task	Deliver requested document(s)	Accountable		External Archivist (Role)
hanged	Task	Info/Handover document	Accountable		Archive Manager (Role)
hanged	Task	Receive document	Accountable		Archive Manager (Role)
hanged	Task	Receive document	To inform		External Archivist (Role)
hanged	Task	Send order	Accountable		Archive Manager (Role)
hanged	Task	Send order	Name	Send order	Order with external archivist
hanged	Task	Update PAT	Accountable		Archive Manager (Role)
hanged	End Event	Documents received	Name	Documents received	Documents lent
hanged	Business Process Diagram	Model properties [Common attributes]	Creation date	18.08.2021 09:07:30	23.07.2021 07:44:29
hanged	Business Process Diagram	Model properties [Common attributes]	has Variants		Lend archived records_variai
hanged	Business Process Diagram	Model properties [Common attributes]	Name	Lend archived records_variant	Lend archived records 7.01
hanged	Business Process Diagram	Model properties [Common attributes]	Process ID	{d9875c1c-e64d-4e2f-9dc6-be1f6e	{d9875c1c-e64d-4e2f-9dc6-
hanged	Business Process Diagram	Model properties [Common attributes]	Version history	[1]	[1]
emoved	Non-exclusive Gateway	Non-exclusive Gateway		removed	
emoved	Non-exclusive Gateway	Non-exclusive Gateway		removed	
emoved	Task	Ask responsible Department Archivist to pick up document		removed	
emoved	Task	Ask to order the document		removed	
emoved	Task	Check document location		removed	
emoved		Sequence flow (Ask responsible Department Archivist to pick u		removed	
emoved		Sequence flow (Ask to order the document -> Send order)		removed	
emoved		Sequence flow (Check document location -> Is the document i		removed	
removed		Sequence flow (Check if document is registered in PAT -> Is doc		removed	

Table 5: Example of the process model comparison report from Adonis

3.4.2 The Adonis business model-comparison functionality

As visible in the table above, the report is not user friendly without further processing. The result of the comparison cannot be examined in the context of the process because the nature of the export is that the information flow is one-way, it cannot "reach back" to the attributes of the process model. This report does not contain additional logic, such as targeted recommendations. Such information is not accessible in Adonis. The contents of the report cannot be configured during export. It is not suitable for compliance checking because it is not possible to integrate any other input than the own process model.

Taking into account the Intended Use of our Change Management Report, presented in chapter 3.2.3, the Adonis process comparison report lacks key features:

- Process Improvement in the case of process differences, the first part of the report can be replaced with it by further formatting and consolidation,
- In the case of Process Improvement, it does not support deeper analysis and recommendations.
- Not suitable to support Compliance check

- It is not suitable as a data extraction format for our purposes due to the lack of completeness of attributes.

In conclusion, the Adonis Process Comparison Report is not an alternative to the Process Ontology Architecture and Process Change Management Report we developed for our purposes.

3.5 PROCESS ONTOLOGY DEVELOPMENT

In this research I use the ontology structure introduced by Kő and Ternai (2011). Information about the ontology structure relevant for my research.

- The possibility of handling multiple processes
- Task: class representing the activities of the process model
- Role: class, which can be related to the Task class with four types of relations according to RACI: responsible_for_execution, accountable_for_execution, approved_by, consulted and informed
- IT_system, class representing the IT systems used for the activities
- Document, class representing the documents used in the activities
- Process, class representing the name of the process
- Accountable_for_approving_results: relationship, linking elements of the Task class to the responsible element within the Role class
- Cooperationpartecipation (note: the typing error is located in the Adonis export attributes): relationship linking elements of the Task class to the consulted within the Role class
- To_inform: relationship, linking elements of the Task class to an informant within the Role class
- followed_by: relationship, interpreted as between elements of the Task class, linking successive activities in the process
- referenced_document: a relationship linking elements of the Task class to a document within the Document class
- referenced_it_system: a relationship linking elements of the Task class to software tools within the IT_system class

3.5.1 Process ontology development from the export of the BPM software

The contents of the process model are extracted from the Business Process Modelling software into an XML export file, which is mapped into a process ontology file with an owl Converter developed earlier in the Institute. As a converter, a dedicated JAVA-based program is created that extracts elements from the XML according to certain rules. The result of the conversion is an OWL file. Since the focus of my research is on the information that can be extracted and its format, I adjust the functionality of the tool, but its development is not part of my research.

The process ontology created in OWL can be viewed using the Protégé software, which is often used in research in our Institute. The necessary classes and subclasses and properties have been created as required. This will allow the further steps necessary to generate the report to be carried out.

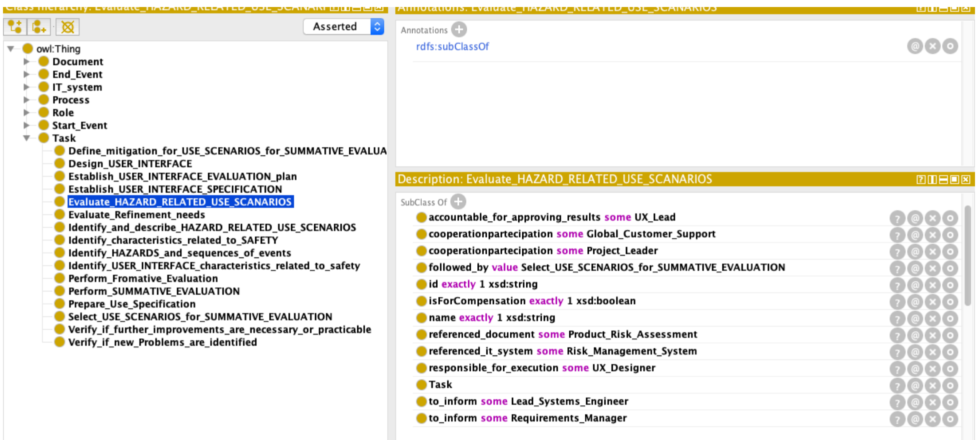


Figure 16: Presentation of the process ontology on the to-be UX process in the Protégé software

3.5.2 Building a process ontology from textual process descriptions

In the following, I will explain the process of extracting information from a written environment, by elaborating on this specific stage of the architecture described in Section 3.1. Our goal is to explore the potential of employing text analytics tools and techniques to identify process information inside textual process descriptions and extract it based on the process structure. The text analytics software relied on was specified and tested by me, development was done by an other member of the research group. As a result, this thesis does not include a technical description of the program. The breadth of our project necessitates a concise overview and evidence of practicality though.

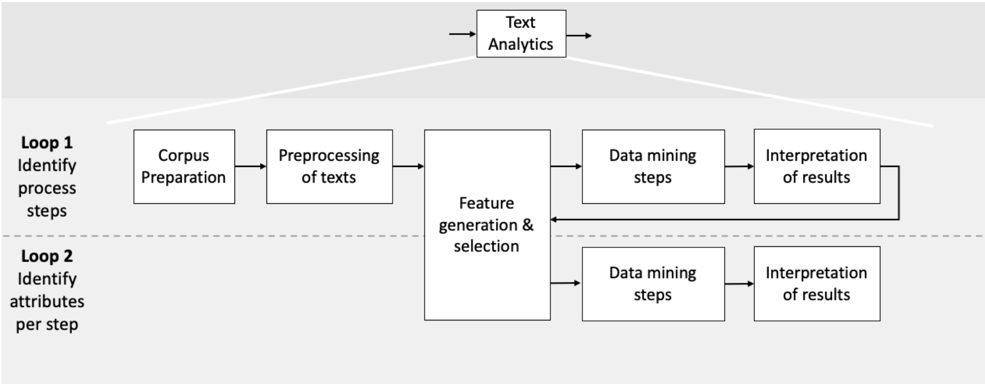


Figure 17: Logical steps of the text analytics activity

We use Hickman's the five steps model in text analytics, and in order to reach our objectives, we implemented two loops:

- **Finding process steps and sequence (Loop 1)** - The initial stage involves identifying the procedural steps outlined in the document and determining their sequential order. This is a fundamental challenge as our objective is to analyze the original compliance document without assuming that the text follows the methods outlined in section 3.7.3.3. We want not to depend on external meta-models. The purpose of this is to guarantee that the data stored in the standard remains unaffected during the process of extraction. Consequently, we are confronted with a new challenge. The solution was discovered in the fact that standards are organized documents that provide a comprehensive table of contents at the start of the text. The table of contents is likely to include the sequential steps of the process. Our objective is to utilize the table of contents to instruct the software on the specific steps to search for and the precise sequence in which to search for them. It is important to consider that the presence and correct organization of the table of contents are limitations that must be considered when evaluating the findings.
- Once the process steps and their order have been determined, the **attributes** of these steps **(Loop 2)** are next examined in the corpus of the standard. The information necessary for us can be found in section 3.2.2.1. We utilized our

own semantic input logic to identify these, while also leveraging publicly available source codes of text similarity available on the Internet. The search algorithm sequentially processes the standard text for each step encountered in Loop 1.

Reducing the noise level of the result was necessary to deliver indicative results for the first part of the report described in section 3.2.1. If at least 2 or 3 steps can be found in and categorized a such and some of the attributes investigated can be extracted from them, it can be said that it makes sense to invest further effort, as further research, in using the text analytics process for compliance purposes.

The initial stage of text analytics was to teach the algorithm. Adequate data set was necessary. While there may not be many standards specifically for the topic at hand, we have devised a method to train and validate our algorithm by utilizing standards from adjacent domains and other sets of instructions. Processed documents should adhere to one of the following: either a table of contents provides a comprehensive outline of the sequential phases involved in the process or the chapters contain specific expressions or words such as procedure. This presents both a limitation and a potential advantage: incorporating work instructions into the algorithm training provides an opportunity, which was not investigated in our research, to verify a process not only against standards, but also against other documents relevant to compliance (such as quality management documentation, laws etc.).

3.5.2.1 Construction of the algorithm

According to the information provided, a total of seven documents have been processed. Later, I will demonstrate that we have successfully extracted a substantial quantity of data from these documents. This data has been used to instruct and verify the algorithm at the TRL3, which reflects the feasibility study stage of the project. Initially, the PDF documents underwent conversion into the DOCX format.

From every sentence in the docx, the algorithm extracted Entity-Relation-Object relations along with their corresponding word forms. The algorithm disregards punctuation. While this adjustment simplifies the algorithm to some extent, it necessitates acknowledging a certain degree of information loss. In addition, it should be noted that our algorithm is currently unable to parse tables. However, we have successfully collected sufficient data for analysis purposes. The outcomes were imported into an Excel spreadsheet.

I manually tagged the complete dataset, which consisted of 1207 lines, according to the attributes specified in our ontology (Document, Role, and IT System). Given that Actor is very probable to be playing the role of Entity, this relationship was likewise tagged. Out of a total of 1207 tagged rows, 593 were identified and tagged as process attribute. The graph below depicts the outcome of tagging in the excel file generated by the algorithm as output.

id	text	entity	entity real Yes	relation	object	remarks			Role
1834:00:00	The manager of administration will fully complete Section Employer Review and Verification with the pertinent information from the employee s documents including document numbers issuing authority and expiration dates if any	manager		will_complete	Section_Employer_Review_ Verification_dates	good finding			Document
1943:00:00	The team will consider procedure guidelines projects and available learning opportunities that may align with the intern s requirements	team		will_consider	guidelines_projects_learnin g_opportunities				(IT) system
2014:00:00	To establish a procedure by which claims files are stored passed along and processed through MACSIS	files		are_stored	passed_along_and_process ed_through_MACSIS				
2609:00:00	Manager of Administration as to loss and Manager of Administration will contact law enforcement authorities or the ADM Board s insurance carrier where appropriate	Manager	Y	will_contact	enforcement_authorities_in surance_carrier				
3229:00:00	approved by the Chief Clinical Officer or Associate Director of Clinical Services before rendered to the provider agency	recommendatio	n	must_be_reviewed	Chief_Clinical_Officer_Asso ciate_Director				
3229:00:00	approved by the Chief Clinical Officer or Associate Director of Clinical Services before rendered to the provider agency	recommendatio	n	approved	Chief_Clinical_Officer_Asso ciate_Director				
2024:00:00	Files must adhere to the MACSIS implementation of the HIPAA format and be named using the following convention Wxxxxxx	Files		must_adhere	using_the_following_conve ntion_ _Wxxxxxx				
2024:00:00	Files must adhere to the MACSIS implementation of the HIPAA format and be named using the following convention Wxxxxxx	Files		be_named	using_the_following_conve ntion_ _Wxxxxxx				
1517:00:00	Examples of absentee patterns include repeatedly reaching the threshold below	Examples		include	repeatedly_reaching_the_t hreshold_below	condition. not collected			
[illegible]	The Kronos Historic Edit form is signed by the Accountant and the Manager of Administration or [illegible]	[illegible]	n	[illegible]	Accountant_Manager_Asso [illegible]				

Table 6: Result of the tagging (excerpt)

The tagging result was imported into Rapidminer, with 60% of the data used as the training set and 40% as the validation set. A Naive Bayes analysis was performed on this dataset. The Naive Bayes algorithm is employed to assess the likelihood of that a relation will be a one of the attributes (Document, IT System or Role) after a word referring to a relation (e.g. provide). The data was analyzed in the confusion matrix that the program produced. An analysis was conducted on the lemmatized version of the text. For the purpose of conducting a precise analysis, any findings over 50% were deemed acceptable since it represents a better hit rate than guesswork, while those that surpassed 80% were regarded good. With the lack of unisono finite acceptable precision value in literature and expert views considerably differing in this domain going as low as 70% and below (Foody, 2023) we have chosen the value from the higher end of the applied range and set our good precision range result at 80%. Conversely, any results that fell below 50% were deemed not acceptable.

Rapidminer generated the confusion matrix for the Naive Bayes model, which yielded the following results in terms of precision (rows):

- Document: 76.15% - good result
- IT system: 24.19% - not acceptable
- Actor (Role): 54.55% - acceptable result.

accuracy: 56.54%

	true Document	true (IT) system	true Role	class precision
pred. Document	83	6	20	76.15%
pred. (IT) system	23	15	24	24.19%
pred. Role	23	7	36	54.55%
class recall	64.34%	53.57%	45.00%	

Table 7: Naïve Bayes confusion matrix on the full scope of attributes

We have then excluded the not acceptable result from further investigation. Without the IT Systems attribute the Naïve Bayes confusion matrix resulted as follows:

- Document: 87.27% - good result
- Actor (Role): 66.67% - acceptable result.

accuracy: 77.51%

	true Document	true Role	class precision
pred. Document	96	14	87.27%
pred. Role	33	66	66.67%
class recall	74.42%	82.50%	

Table 8: Naïve Bayes confusion matrix on the reduced scope of attributes

We could conclude that the class recall value of all attributes were close to each other in both runs, class precision, which is most important for applying the algorithm on an other data set has demonstrated significant improvement with the reduced scope. Documents and Actors defined the scope of our further investigations.

The starting algorithm has been identified as v1 to signify the algorithm's progressive enhancements. This version contained the building of a dictionary from the Roles and Documents from the tagged dataset as well as the expressions from the Naïve Bayes analysis which identified at least with 1% probability either a Role or a Document. The probability value at 1% is explained by the diversity of the language expression capability, which is demonstrate by the fact, that the exercise resulted from a total of 897 combinations. The expressions were manually reviewed based on our criteria. The investigation only included verbs and there was no overlap among them in the context of Documents and roles. In the remainder of the research, our attention will be on the properties that yield favorable outcomes, namely Document and Actor, in the context of text processing.

3.5.2.2 Progressive enhancements of the algorithm

During the first phase of the algorithm's development, it was observed that the logic fails to distinguish the capitalized words, even though in formal papers, the actor (role) typically begins with a capital letter. After modifying the algorithm, the v2 version was launched on the teaching dataset, where attributes found by the article were compared to the attribute count out of manual processing. It delivered enhanced recall performance regarding the roles in the training set. The implemented improvements led to the roles too achieving close to 80%, thus the classification of "good result":

Attribute	Found attribute	Judgement
Document	78%	Good result
Role	84%	Good result

Table 9: Findings with the v2 version of the algorithm on the training set

Subsequently, we executed the revised iteration of the algorithm on the validation set, yielding a distinct outcome:

Attribute	Found attribute	Judgement
Document	84%	Good result
Role	17%	Not acceptable

Table 10: Findings with the v2 version of the algorithm on the validation set

The quality of the roles did not meet our expectations, primarily due to the quantity of roles mentioned in the text, which is a common limitation when processing standards as corpus. Consequently, we had to analyze tactics to enhance the rate of discovery. Upon manual evaluation, it was discovered that the system did not consistently detect and classify the noun that follows the auxiliary verbs as a Role. Consequently, we made the necessary adjustments to the algorithm, resulting in the creation of version v3.

Attribute	Found attribute	Judgement
Document	84%	Good result
Role	47%	Close to acceptable

Table 11: Findings with the v3 version of the algorithm on the validation set

The roles result was 48%, which is inside the acceptable category barrier and showed a considerable improvement of 30 points. Therefore, we decided to accept the outcome.

The final stage involved the evaluation of the refined v3 algorithm on a previously unprocessed standard, referred to as code-named 2020. The algorithm uses a library that undergoes enrichment as the learning process advances. While it is possible to automate this the improvement process of the library, in our current state it must be done manually. Upon transferring the findings of the v3 algorithm on the validation set, the library was updated and subsequently produced the following results on the standard 2020:

Attribute	Found attribute	Judgement
Document	81%	Good result
Role	63%%	Acceptable result

Table 12: Findings with the v3 version of the algorithm on the new (2020) standard

The outcome of the operation has been positive. Moreover, it is important to emphasize that the percentage of roles that were not found is 3%. Despite noisiness of the result, by any standard, it includes all relevant items. A crucial requirement for the algorithm was that it should not overlook relevant matches. Achieving a 3% outcome is quite commendable.

In summary:

- The refinement of the algorithm has led to a significant improvement in the finding of roles, while the rate of finding documents has remained constant at around 80%.
- The algorithm did not miss any attributes in significant numbers, so that all the expected attributes could be found in the results

The algorithm has undergone major enhancements in two iterations (v2 and v3), resulting in notable improvements. This suggests that the technique we have employed is suitable, and further study may yield even better results.

I have described above, how we have extracted coded information from text-based sources, how we have enabled compliance checking with information out of native textual process description. This at once in detail outlines the answer the technicalities of the problem formulated in our 2. research question.

3.6 COMPARATIVE ONTOLOGY ANALYSIS, TRANSLATION TABLE

The foundation for change analysis lies in comparing process ontologies generated from processes and textual process descriptions. For our research, we employ the Ontology Matching feature of the Protegé software version 5.6.1. To utilize this feature, it is necessary to have the "OWL Difference" plug-in installed within the Protégé software.

The ontology comparison function provides a complete structural analysis of the ontology, using a character-based classification. This technique necessitates addressing two key implications:

- On one hand, it will detect and display any discrepancies at the character level. Therefore, efforts should be made to reduce the occurrence of false positive results. Variations could arise from differences in terminology or from the presence of noise in the dataset. In order to reduce those disruptions, we have incorporated the Translation Table into the architecture. The Translation Table is introduced in section 3.6.2.
- Another outcome of the comprehensive comparison is that the result of the ontology comparison includes data that is not relevant to our objectives. As a result, it is necessary to filter the comparison results and only include the relevant information needed for the generation of the report. The technical report is presented in chapter 3.6.3.

3.6.1 Translation Table

As previously stated, the primary constraint of ontology comparisons is that the existing tools only perform text-based comparisons. Therefore, any slight variation in writing, including spelling, punctuation, or accents, is considered a difference. This limitation emerges in both scenarios:

- When comparing process models to identify modifications, the usage of different language and inconsistent coding might lead to useless and conflicting results.
- When conducting compliance checking by comparing a process model and a standard, the attributes obtained from the raw data could also differ based on terminology and semantics.

The identification and mitigation of the problem have a substantial impact on the outcome of the process ontology analysis and should thus be considered in the ecosystem architecture. The proposed solution in the ontology analysis step is the Translation Table element. The purpose of the Translation Table is to store the similarities between characteristics, ensuring that any irrelevant differences among them do not affect the analysis outcome.

The creation of the Translation Table in our model is done manually. Here, I outline the rationale behind the design of the Translation Table and discuss our investigation on the topic. It should be noted that our objective is to examine the notions of the Translation Table

The Translation Table is a mapping of attributes with the purpose of refining the ontology analyzed. This transformation generates a revised version of the ontology, which serves as the basis for the matching process.

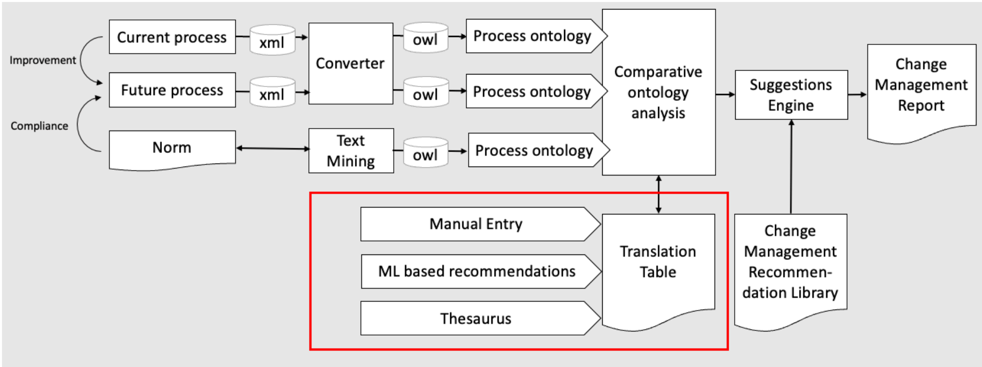


Figure 18: Concept and architectural context of the Translation Table

The Translation Table is generated on the basis of three type of input:

- Inputting the **discovered matches** by the Change Manager into the Translation Table. This input is derived from the established similarities related to the language and the similarities identified after a thorough analysis of the significant discrepancies.
- As mentioned before, the translation database yields a noisy result due to its inherent characteristics. To mitigate this noise, a text **similarity analysis** can be performed. This analysis assists the Change Manager in identifying significant matches in terms of semantics, terminology, or grammar. The analytics identify these valid similarities, and the judgments made by the Change Manager serve as the foundation for include individual positions in the Translation Table.
- By incorporating fundamental semantically related phrases into the Translation Table using a **thesaurus**, it becomes easier to identify similarities at an equivalent level. This, in turn, minimizes the occurrence of incorrect positive matches for key terms.

3.6.2 Noise reduction – the text similarity analysis

Regarding the creation of the Translation Table, our objective was to explore the theoretical feasibility of utilizing text similarity by evaluating multiple techniques. In my literature review, I laid out that NLP is a vast and ever-expanding field of research, encompassing a wide range of algorithms that are constantly evolving. In this study, we have chosen a selection of significant text similarity algorithms in order to gain a deeper knowledge of which group of algorithms is most deserving of further research. Certain groups have been omitted from the test due to their distinct characteristics, such as large text similarity - due to the volume of teaching material required, which our research does not possess.

The text similarity test involves extracting each attribute group from the corresponding ontology and saving it into a file. Upon processing the files, the individual components of the lists are compared with the elements of the other list, and the text similarity algorithm calculates the similarity score. The attribute pairs and their corresponding similarity values are recorded in a newly created file. The Change Manager processes this file and adds the attribute pair to the Translation Table. For our evaluation, we employed the subsequent criteria:

We excluded the similarity level of 1 (100%) from consideration as it represents total similarity, which does not qualify as a deviation in the ontology study.

The similarity criterion is set at 80%. The Change Manager must establish this as a flexible criterion. The optimal solution lies in striking a balance between achieving the best feasible similarity rate (i.e., the most accurate similarity) and using the appropriate dataset size, in order to avoid sorting out all potential matches.

The following algorithms were tested:

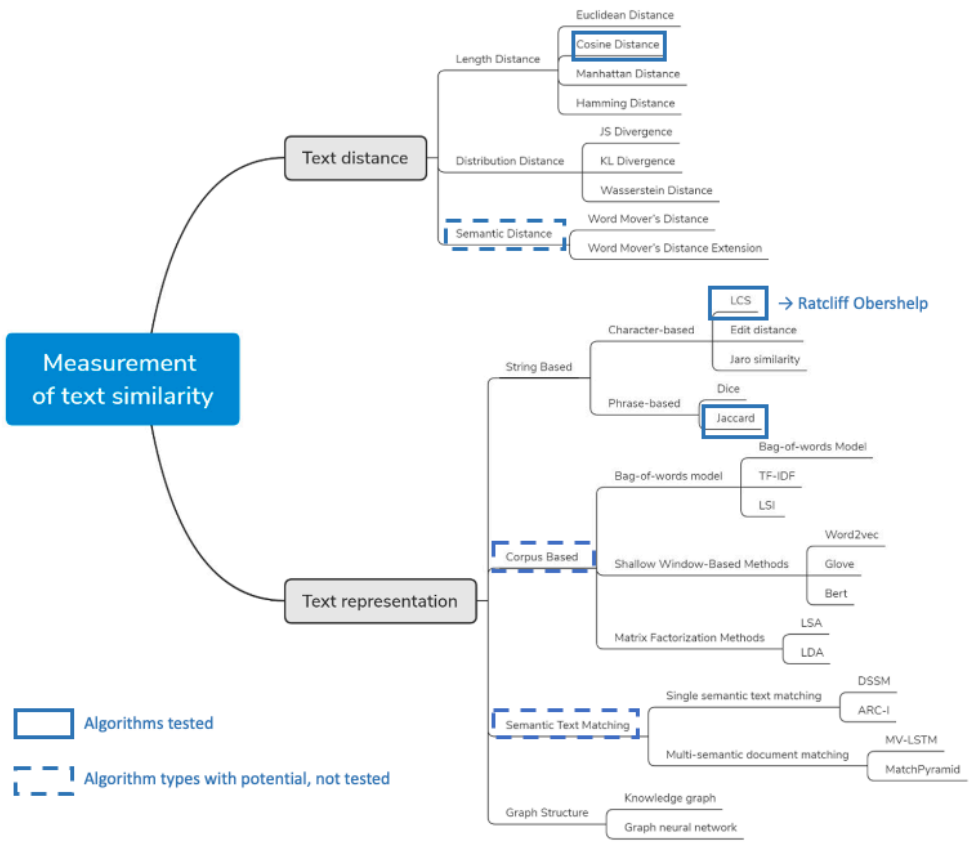


Figure 19: Text similarity algorithms investigated (based on Wang et al. 2020)

- **Cosine**: When measuring the cosine distance, instead of measuring the distance between two points in the vector space, we convert it into an angular problem corresponding to the two points. The similarity is calculated by measuring the cosine of the angle between two vectors. Because of the size of the document, it is preferable to use the cosine distance to measure similarity even if two similar documents are far apart in Euclid. The algorithm can also be used to compare the relevance of a document's perspective (Wang et al. 2020).

$$\mathrm{Sim}(S_a, S_b) = \cos\Theta = \frac{\vec{S_a}\cdot\vec{S_b}}{||S_a||\cdot||S_b||}$$

- Further, under Text Distance, the category **Semantic Distance** suggests an area of interest, however the algorithms estimate the semantic similarity between two sentences based on their distance. Given our objective of analyzing the textual distance between words and expressions, sentence-based evaluation is not suitable for our purposes.

- **Jaccard** similarity is defined as the size of the intersection divided by the size of the union of two sets. Jaccard solves for similarity across the set; if the text is relatively long, the similarity will be smaller.

$$S(S_a, S_b) = \frac{S_a \cap S_b}{S_a \cup S_b}$$

Where S_a and S_b represent the strings.

- The **Ratcliff Obershelp** (also known as Gestalt Pattern Matching) calculates the similarity between two strings by dividing the number of matching characters by the total number of characters in the two strings. Matching characters are the characters in the longest common substring (LCS) and recursively the non-matching characters on either side of the longest common substring (Ilyankou, 2014).

$$D_{ro} = \frac{2K_m}{|S_1| + |S_2|}$$

Where the two strings are S_1 and S_2, and the number of common characters is K_m.

- In addition to text representation, the **Corpus based** and **Semantic Text Matching** categories deserve attention. The corpus-based method uses information from the corpus to calculate text similarity. Semantic similarity determines the similarity between a text and a document based on their meaning, rather than on character-to-character correspondence. Latent Semantic Analysis (LSA) is used to extract the hierarchical semantic structure embedded in the query and document. The characteristic of these algorithms is that they need to be taught. Internal documents, which are not available to us in the present research, can be used for training. The use of these algorithms could be the basis for further research.

We conducted the Text Similarity tests using all three of the aforementioned algorithms and achieved the subsequent results:

Algorithm	Hit rate
Jaccard	75%
Ratcliff Obershelp	69%
Cosine	56%

Table 13: Hit rate with the respective algorithms

Based on the results demonstrated above, it is advisable to enhance the similarity test in the domain of Text Representation > String based > Phrase based techniques by utilizing the Jaccard algorithm, which has proven to yield the most favorable outcomes. The possibility of aiding the building of the Translation Table with text similarity algorithms is evident, and further examination of this topic could be the focus of a future study.

3.6.3 Transferring differences to the Recommendation Engine: The Technical Report

Once the Translation Table is applied and the updated version of the respective ontology is created, the ontologies are compared using the Compare Ontologies function and output structure of the Protégé software. The raw output of the Protégé Software is transformed into a so-called Technical Report (TR) which serves as the input for the Recommendation Engine discussed in the next chapter.

The intermediary Technical Report (TR) is necessary to:

- Achieve an easily processable structure for the data
- Cleanse Protégé's output by removing irrelevant output content
- Format the data back to grammatically correct structure (eg. Remove underscores between words)

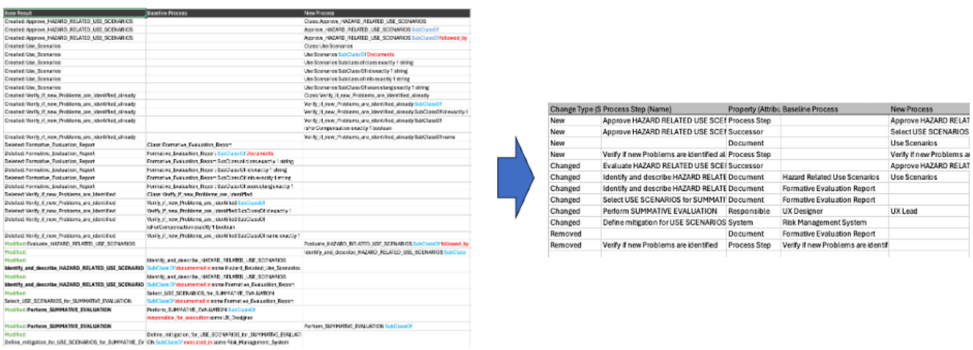


Figure 20: Transformation of the Protégé output into the Technical Report

The Technical Report (TR) consists of the following columns:

- Change type: describes the deviation. Can take the values: “added”; “modified”; “deleted”
- Process Step: identifies the process step to which the properties are related to
- Property: identifies the type of the attribute. Can have the value: “followed by” = Sequence (in the flow); “documented in” = Document; “responsible for execution” = Responsible; “executed in” = IT System
- Baseline Process: the attribute in question in the baseline process. Takes the value behind the property type. Note that an other step can also be Attribute in case the Property is “followed by”
- New Process: the attribute in question in the new process. Takes the respective value behind the property type. Note that an other step can also be Attribute in case the Property is “followed by”

The transformation logic from Protégé output into the Technical Report is based on the following logic:

- The word of the “Base Result” column determines the Change Type in TR
- Information behind the “SubClass Of” (marked blue on Figure 20) determines the content of multiple fields in TR as shown in the table below

after "SubClass Of"	Process Step (Name)	Property (Attribı	Baseline Process	New Process
Documents	[empty]	Document	[Value] (before SubClass Of") in case of Change Type "Deleted" or "Modified"	[Value] (before SubClass Of") in case of Change Type "Created" or "Modified"
Roles	[empty]	Responsible	[Value] (before SubClass Of") in case of Change Type "Deleted" or "Modified"	[Value] (before SubClass Of") in case of Change Type "Created" or "Modified"
IT_system	[empty]	System	[Value] (before SubClass Of") in case of Change Type "Deleted" or "Modified"	[Value] (before SubClass Of") in case of Change Type "Created" or "Modified"
followed_by	[empty]	Successor	[Value] (before SubClass Of") in case of Change Type "Deleted" or "Modified"	[Value] (before SubClass Of") in case of Change Type "Created" or "Modified"
documented_in	[Value] (before SubClass Of")	Document	[Value] (after "documented_in") in case of Change Type "Deleted" or "Modified"	[Value] (after "documented_in") in case of Change Type "Created" or "Modified"
responsible_for_execution	[Value] (before SubClass Of")	Responsible	[Value] (after "responsible_for_execution") in case of Change Type "Deleted" or "Modified"	[Value] (after "responsible_for_execution") in case of Change Type "Created" or "Modified"
executed_in	[Value] (before SubClass Of")	System	[Value] (after "executed_in") in case of Change Type "Deleted" or "Modified"	[Value] (after "executed_in") in case of Change Type "Created" or "Modified"
[empty]	[Value] (before SubClass Of")	Process Step	[Value] (before "SubClass Of") in case of Change Type "Deleted" or "Modified"	[Value] (before "SubClass Of") in case of Change Type "Created" or "Modified"

Table 14: The matching logic of the Technical Report (excerpt)

This chapter has directly dealt with the problem domain of sufficiently cleansed data and the comparative analysis of data sets as formulated in our 5th problem domain and related research questions. In the further section I will outline the specifics of leveraging the results of the comparative analysis and building the Change Management Report – the ultimate goal of this study.

3.7 FROM PROCESS DEVIATIONS TO THE CHANGE MANAGEMENT REPORT

As mentioned in the previous chapter, the output of Ontology Matching is transformed to a Technical Report which is processed in the **Suggestion Engine**. The engine has the following functions:

- Analyze the differences found in the ontology matching results. Both the process steps as well as the attributes of the steps are identifying and analyzed.
- Identify and select applicable recommendations in the Change Management Recommendation Library
- Generate input for and build the Change Management report.

The deviations in processes imply different change management responses. These responses are stored as conditional recommendations in the **Change Management Recommendation Library**, described in section 3.2.2.2. Recent literature recognizes that there is no common approach to change management operationalization. Therefore, it is inevitable for the practical use, that the Recommendation Library is adjustable for every company utilizing the tool.

Once the Suggestion Engine processes its tasks the **Change Management Report** (as described in chapter 3.2.) is generated. The Change Management Report is generated by merging and analyzing two sources, namely the Technical Report and the Change Management Recommendation Library. In the subsequent text, I will explain the logic underlying the creation of the Change Management Report.

The Change Management Report is outlined in Chapter 3.2, the Technical Report in Chapters 3.6.3, and the Change Management Recommendation Library in Chapter 3.2.2.2. Consequently, I will only discuss the structure of these as much as is necessary to illustrate the transformation and the experience gained from the implementation of the research.

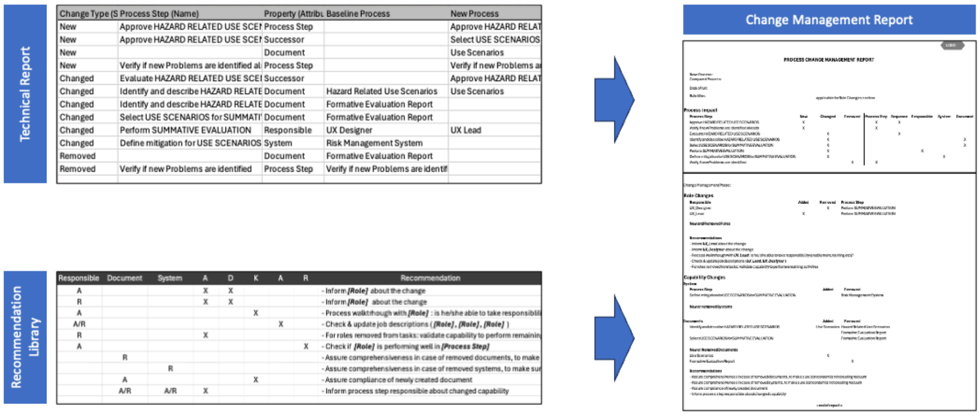


Figure 21: Transformation of the Technical Report and the Recommendation Library to the Change Management Report

3.7.1 Additional functions in the Change Management Report

While conducting the research, I have found two significant insights that allow for further enhancement of the Change Management Report:

- I observed that the outcome of the Ontology matching also includes data on which attribute (Document, System, Responsible) is entirely new or has been entirely eliminated from the process. This information is highly valuable for the Change Manager; hence it was incorporated into the Change Management Report.
- Given that the execution of a process ideally proceeds according to plan, it is more convenient for the Change Manager to exclusively look at the suggestions that pertain to the specific phase(s) of the project. In order to facilitate this, a multiple-choice selection feature has been implemented at the start of the second part. This feature allows the user to choose which ADKAR phase(s) should be included in the Recommendations section. Additionally, it was necessary to modify the Change Management Recommendation Library in order to incorporate this feature. The updated structure will be introduced in the following chapter.

Following the execution of these alterations, the second segment of the Report was updated in the following manner:

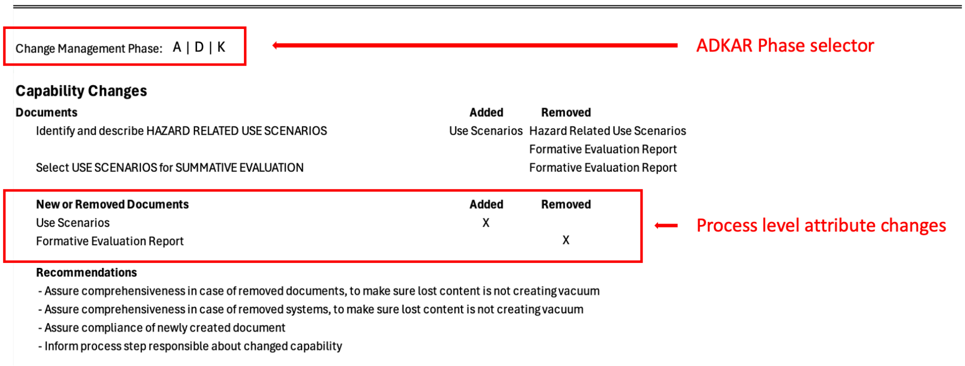


Figure 22: improvements made to the Change Management Report

3.7.2 The Change Management Recommendation Library

To implement the Change Management Recommendation Library, it was essential to enhance the structure that was first suggested in section 3.2.2.2. This was done to ensure efficient report generation and accommodate the functionalities discussed in the preceding section.

In the new structure, the process characteristics are allocated separate columns, which can be assigned the values A (Added), R (Removed), or empty. Furthermore, a column has been generated for each phase of the ADKAR methodology (Awareness, Desire, Knowledge, Ability, Reinforcement), which may take the values X to indicate that the recommendation is applicable in that phase or left empty if not applicable to the phase. The final column remains unchanged, as it still contains the recommendations as well as the variables to be included in each distinct recommendation.

Responsible	Document	System	A	D	K	A	R	Recommendation
A			X	X				- Inform ***[Role]*** about the change
R			X	X				- Inform ***[Role]*** about the change
A					X			- Process walktrhough with ***[Role]*** : is he/she able to take responsibili
A/R						X		- Check & update job descriptions (***[Role]***, ***[Role]***, ***[Role]***)
R			X					- For roles removed from tasks: validate capability to perform remainin
A							X	- Check if ***[Role]*** is performing well in ***[Process Step]***
	R							- Assure comprehensiveness in case of removed documents, to make
		R						- Assure comprehensiveness in case of removed systems, to make sur
	A				X			- Assure compliance of newly created document
	A/R	A/R	X					- Inform process step responsible about changed capability

Table 15: The improved structure of the Change Management Recommendation Library

3.7.3 Generating the Change Management Report

The aforementioned elements enable the generation of a Change Management Report in the Recommendation Engine by utilizing the Technical Report (TR) and the Change Management Recommendation Library.

The first part of the report generation is based on the Change Type (New-Changed-Removed) and the "Process Step" among the Property values. For each "Process Step" category item, the Change Type is examined. These are the basis for the first half of the list, i.e. the individual steps of the Process are displayed by category. The Recommendation Engine then examines the rest of the process and the corresponding Change Type in the TR. Change Types that contain values for the respective process step are displayed in a consolidated format (one step - one line) on the job page of the first section.

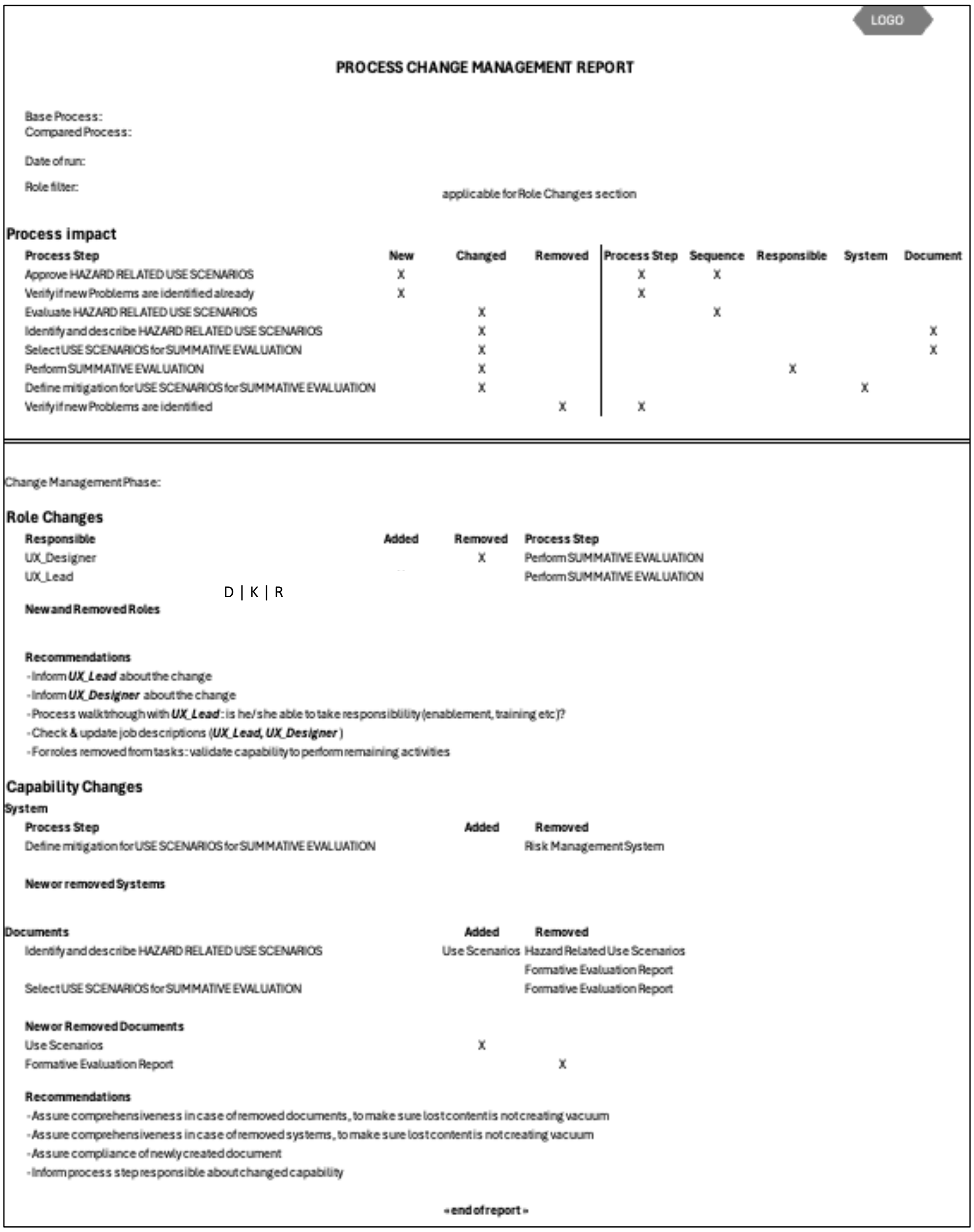
In the second section, the same records of the TR are analyzed. Here, the key values are the process attributes found in the Property field (the "Process Step" values are not taken into account), on the basis of which the values are processed and displayed. In the case of a certain attribute, the following steps are performed:

STEP 1) highlights the Process Step items belonging to the attribute, if not empty, and writes them to the Added and Removed columns of the report based on its respective location in the Baseline Process or in the New Process fields. By default, it consolidates the values, but if there are more than one, it generates as many rows on the report as needed to display all the values

STEP 2) If the Process Step field is empty, it indicates that the status of the attribute is changed in the process as a whole: it is either newly created or it has been removed. In this case, a record is displayed in the second table of the section and the name of the attribute is displayed in the Added or Removed column

STEP 3) Finally, the report compares the values of the Change Management Library with the values of the attribute values marked in the ADKAR Phase selector and the values of the attribute values found in points 1 and 2 are compared with the values of the first column of the Change Management

Library. If a match is detected, the Recommendation is printed in the report (if applicable, it is enhanced with the values defined there)



LOGO

PROCESS CHANGE MANAGEMENT REPORT

Base Process:
Compared Process:

Date of run:

Role filter: applicable for Role Changes section

Process impact

Process Step	New	Changed	Removed	Process Step	Sequence	Responsible	System	Document
Approve HAZARD RELATED USE SCENARIOS	X			X	X			
Verify if new Problems are identified already	X			X				
Evaluate HAZARD RELATED USE SCENARIOS		X			X			
Identify and describe HAZARD RELATED USE SCENARIOS		X						X
Select USE SCENARIOS for SUMMATIVE EVALUATION		X						X
Perform SUMMATIVE EVALUATION		X				X		
Define mitigation for USE SCENARIOS for SUMMATIVE EVALUATION		X					X	
Verify if new Problems are identified			X	X				

Change Management Phase:

Role Changes

Responsible	Added	Removed	Process Step
UX_Designer		X	Perform SUMMATIVE EVALUATION
UX_Lead			Perform SUMMATIVE EVALUATION

D | K | R

New and Removed Roles

Recommendations
- Inform ***UX_Lead*** about the change
- Inform ***UX_Designer*** about the change
- Process walkthrough with ***UX_Lead***: is he/she able to take responsibility (enablement, training etc)?
- Check & update job descriptions (***UX_Lead, UX_Designer***)
- For roles removed from tasks: validate capability to perform remaining activities

Capability Changes

System

Process Step	Added	Removed
Define mitigation for USE SCENARIOS for SUMMATIVE EVALUATION		Risk Management System

New or removed Systems

Documents

	Added	Removed
Identify and describe HAZARD RELATED USE SCENARIOS	Use Scenarios	Hazard Related Use Scenarios Formative Evaluation Report
Select USE SCENARIOS for SUMMATIVE EVALUATION		Formative Evaluation Report

New or Removed Documents

Use Scenarios	X	
Formative Evaluation Report		X

Recommendations
- Assure comprehensiveness in case of removed documents, to make sure lost content is not creating vacuum
- Assure comprehensiveness in case of removed systems, to make sure lost content is not creating vacuum
- Assure compliance of newly created document
- Inform process step responsible about changed capability

« end of report »

Figure 23: The final Change Management Report

When evaluating Process Compliance, there is no requirement to manage the process change, as only the disparity between the process outlined by the standard and the actual process is assessed. Hence, the second half of the Change Management Report, which includes STEP 2 and STEP 3, is inconsequential and should be disregarded.

At its current stage of development, it is feasible to incorporate ChatGPT into the overall report. This may be achieved by including merely the conditions in the Change suggestion Library, and if there is a match, instructing ChatGPT to generate the suggestion. To simplify the creation and maintenance of the Change Management Recommendation Library while boosting multilingual capabilities, the structure of the library needs to be modified. This involves adding a new function under STEP 3 and removing the current one. This could be subject to further research.

4 SUMMARY

This thesis explores new methods and a novel technological support concept for business process change management. Within this interdisciplinary study I examined how information encoded in process models and industry norms can be put at the service of change agents and managers. A concept is utilizing only such inputs which are commonly available in enterprises. The developed concept uses a semi-automatic technology ecosystem that extracts information from business process models and norms. It then compares this information using process ontology and presents the results in a practice-oriented way that managers can easily understand. The solution also provides tailored recommendations for activities related to the results. The research, conducted in collaboration with industry partners, used and further developed the results of preceding research within the Institute and incorporated the latest technologies. The research was carried out in a research team in which my contribution included the conceptual design, definition of the tool architecture, specification of software solutions and the search algorithm, teaching and validating through multiple improvement rounds, linking the disciplines and defining the evaluation of information as well as its presentation.

4.1 RESULTS OF THE STUDY

In the present study, I connected the domains of process management, change management and text analytics, as my aim was to explore the attributes of business processes in process models and textual process descriptions, norms, and the methods of extracting them. And subsequently, to build process ontologies, analyze the deviations and present specific information and recommendations for organizational and individual change management measures. The dissertation defines research questions, through the answering of which the basic research objective was achieved.

The research questions and the research areas investigated were as follows:

1. **Business Process, Business Process Models, Business Process Management Lifecycle**: how well is Business Process Management represent an accepted organizing logic in the business? How is process management positioned in different business methodologies? What modelling languages are common? What are the

levels of business process modelling? How does Business Process Lifecycle incorporate Change Management? What are the change types?

I have answered these questions through the literature review. Process models have been playing a key role in structuring a company's activities. Formalizing processes can be necessary for several reasons, ranging from the complexity of the company to transparency and compliance with external regulations. Such regulations may be industry norms, legal requirements, quality assurance or customer demands. Consequently, there are two basic types of process change, which are also covered by the research: i) **process improvement** and ii) **compliance assurance**. Processes documented in process models consist of steps and to each step **multiple attributes** such as actors, documents, software tools, but also inputs and outputs, and in some cases even justifications. The representation of processes is, in practice, characterized by the optimization of clarity of the process model and the work invested into modelling. Process modelling has **two main levels** of application: one is to facilitate the organizational structuring of the business, breaking down the enterprise-level units of the value chain into understandable smaller units and then into processes to understand and control the operation of the enterprise, typically using semi-formal process descriptions (models). At lower levels, the aim is to standardize the execution of activities, by means of highly detailed specification and programming of the process steps, often through the use of a formal process modelling language. The processes employed in our research fall under the first level, with the objective of demonstrating the operational mechanisms of a company. The process representations stored in the ADONIS software are user-friendly and comprehensible for decision makers and employees, we only had to transform them for machine processing. In companies where processes are referenced on a daily basis, it is essential to have a degree of **business process lifecycle management (BPLM)** to manage the change process of the process itself and to provide administrative support to managing of the versions. Practice recognizes several BPLM models, but all of them include the phase "change management". This refers to phase dedicated to addressing the transition from the old to the new process. Technology provides comprehensive support for process modelling and process lifecycle management. The BPM software market is characterized by numerous contenders, with one of the notable companies being the ADONIS BPM software, which is utilized in our project too.

2. **Compliance in the Context of Business Process Change.** Which are the approaches identified for compliance in business processes? What is the most fitting for our context? How can the coded information be extracted from text-based sources?

Several approaches to Business Process Compliance are recognized by academics and practitioners. I have reviewed these in the literature review. Literature distinguishes between Design Time Compliance Checking (**DTCC**), which checks compliance at the design stage of the process and Run Time Compliance Checking (RTCC) and Backward Compliance Checking (BCC). Both latter two methods are aimed at monitoring the execution of the process on a technical basis to determine whether the execution is or has been done according to the rules. For us, DTCC is the appropriate approach as we aim at the checking the compliance of the new process, while RTCC and BCC are by their own nature not in our scope.

DTCC evaluates a newly developed process versus its applicable regulations prior to the finalization and implementation of the process. Its objective is to detect the disparities so that the process developers can address the variances. In the practice, process compliance evaluation at the design phase is labor-intensive, as it involves the time-consuming task of manually processing and comparing the policy with the process. Various DTCC methods have been developed to automate this task, but due to the fact that automatic processing of text based process descriptions have been technically challenging, they all rely on preconditions such as specifically formatted text, reference ontology or a reference procedure. The field of natural language processing has made significant advancements in recent times, which offers new opportunities to be explored. Our research introduces a novelty: The proof of concept we developed is a practical method as well as a technological framework that specifically handles native inputs, as they appear in enterprises, such as process models in a BPM software and standards in PDF format. Ultimately, automating the task of compliance checking based on natively available inputs contributes to efficiency improvements at the involved human resources as well as it increased the quality and consistency of work done.

Text processing has made significant progress in recent times due to the emergence of advanced technological capabilities, particularly in the fields of automated text interpretation, user-friendly interfaces, and the widespread accessibility of specific program code and algorithms. A major issue with textual process descriptions and standards is constituted by the shortness and simultaneously the specificity of the content, which poses a difficulty for widely used **natural language processing** algorithms. To overcome this challenge, new approaches had to be investigated. We have developed a **specific algorithm** to extract coded process related information in such a context. The process steps and attributes were identified and extracted in two rounds:

- Initially we searched for the steps of the process in the text, building on the assumption that the standards contain a table of contents and the steps of the process are set out in separate chapters.
- during the next round, the attributes (Documents, Responsible, IT system) of the process steps were identified. This activity were executed for each step in a recurring way until the logic reaches the end of the list of the process steps from round one.

Our specific algorithm was then further developed and validated in three iterations based on the findings. Following the three iterations of improvements, we judged the results satisfactory, to move to the next step. In the next step the final validation has been done on one of our industry norms, which we have excluded from the training and validation sets during „teaching" of the algorithm, thus it was completely new to the algorithm. The final validation yielded acceptable results in the case of the Documents and Responsible. The result for IT Systems was not acceptable, but the extraction of this attribute can be solved by using a manually created library, as the diversity of the IT System related expressions is low. The results of this exercise indicate that relevant information can be localized in textual process descriptions, despite the relative brevity of the text, using specific algorithms, but manual work is required to identify them accurately.

The information extracted from textual process descriptions cannot at that stage yet be used for immediate comparisons, because it is inherently noisy, with many linguistic or semantic variations that are irrelevant from our point of view. To reduce the linguistic and semantic differences, we tested text similarity algorithms, where we were able to detect similarities reasonably well with string-based algorithms (Jaccard, Ratcliff-Obershelp). The inverse correlation between the "rigor" and hit rate of the algorithms requires manual testing of the similarity hits before usage.

3. **Examining Change Management**. What Change Management approaches had made inroads to business, what are their commonalities, can these commonalities be supported with information from business process models?

While analyzing the business process life-cycle models, I have discovered that, despite the prominence of change management as a subject in them, they lack the same level of depth in its execution than to the other phases. This poses substantial challenges for our target audience, the key players spearheading the change, and undermines the quality of the change implementation. As a consequence, we could not rely in our concept only on the change management guidelines in the business process life cycle models. At this juncture, it became necessary to study and incorporate change management as a discipline in the research to guarantee the excellence of change implementation, especially given the need to manage change from a process management perspective at both the individual and organizational level.

The processing of change by humans has long been an area of research, initially emerging as a subfield of psychology. Its versions further developed for organizations established change management on the field of business management as well. Several change management models are available, but typically those that effectively handle both the human and organizational components of change have gained recognition in the corporate context. These models aim to provide real assistance to leaders and process managers throughout the implementation of change. In their core, all change management models identify three basic phases: i) preparing for change, ii) leading through change and iii) helping to embed new behaviors. I have provided a comprehensive analysis of the topic in the literature review. One of the widely recognized models is the ADKAR methodology, used by our industry partners, and which I am also referring to in our research when integrating pragmatic change management recommendations in the concept.

Process models support change management in a way that the information stored in their relevant attributes can be extracted, structured and analyzed so that changes can be detected. The information contained in each process model can be utilized for change management, particularly in the later phases of knowledge transfer and reinforcement of the expected new behavior. Full potential of this information is realized when the process models are compared, enabling the identification of differences, so that the extent and nature of change can be detected during process design. This supports the early-stage preparation of the organization and individuals. Acknowledging that a variety of methodologies are in use in the industry, the concept and technology developed is fully flexible in this regard.

4. **Extracting information from process models, data transformation and building a process ontology**: How can stored information be extracted from process models? How does the extracted information become a further processable, structured set of information?

Process models and textual process descriptions provide coded information in distinct formats. To compare them, it is necessary to convert them into a common structure. The use of process ontology offers an appropriate structure for this purpose, as demonstrated by several research projects conducted at our Institute, which I have summarized in the literature review. Process ontology also facilitates the comparison of the content of these sources, which is the primary objective of our concept. Therefore, our study also investigated how the information included in the process models may be transformed into a process ontology for subsequent processing.

Our Institute conducts extensive research on extracting information from process models and converting them into ontologies. I have built on these findings from previous research and further developed them. A previously created Converter was further developed to export the process encoded in the BPM software into a particular XML format and subsequently transform it into our OWL type structure, which can then be processed by Protégé, the ontology software we used. As the Converter itself was available from previous research, it was enhanced for our purpose, according to my specification.

5. **Comparative analysis and presentation of findings:** How can the change element set be compared and used in a goal-oriented way for change management? What information and in what format can best support change management?

Process ontologies provide a structured framework for storing process information and enable the comparison of these in an effective way. There are several software solutions for **comparing ontologies**, of which I used Protégé's add-on in my research. The comparison reveals changes in process steps, their sequence and attributes. This output is optimized for content and not easily understandable, but it may still be processed, analyzed and used to provide a user-friendly report that is readily interpretable by both company leaders and process change managers. The change management report, which compares the baseline process with the new one, was prepared considering the suggestions of the industry partners. In addition to analyzing the changes in the process attributes, two functions are invoked by the tool while generating the **Change Management Report**:

- **Translation Table:** both comparison scenarios, between process models and between a process model and a textual process description comparison can reveal irrelevant differences if the attributes of the baseline and the new process are coded differently, even if they have the same meaning. Company-specific abbreviations and names, linguistic, syntactic and semantic differences can all lead to incorrect results. Therefore, it was necessary to incorporate a mean to consolidate those similar values, which would bring attributes with different but identical meanings to a common denominator before ontology matching, so that they would not appear as differences.
- **Recommendation Library:** in order to provide the report with appropriate change management action recommendations based on the analyses, a register was created in which change management action recommendations were entered for the different attribute constellations as well as for each phase of the organizational change management methodology. From the Recommendation Library, the recommendations determined by these variables are selected when the report is generated, and these are subsequently displayed on the report.

6. **Review of utilization possibilities:** in what areas can the prototype be useable? Are there any other utilization possibilities in sight?

The initial target of my research was to provide support to the process manager and the change agent implementing a process change. This was studied through comparing current and future models of a journey management process provided by one of our industry partners, and through comparing the UX design process within the company with the relevant standard. During the development and validation of the concept, several potential use cases emerged:

- Other conformance needs, not only with standards, can be tested with the architecture created. These may include internal and external instructions or compliance with legal requirements.
- In the context of a larger corporate transformation, the tool can be used in a targeted way to ensure that individual managers manage change in a similar way, in line with each other. For example, when changing a cross-functional process, it is important to ensure that the managers in the affected areas communicate with their teams in a similar way in terms of timing and content, or, when changing several processes at once, that the change management activities are similar for all processes.
- When implementing ERP and other enterprise information systems, integrate change management into the project plan. Considering organizational change management as a methodology allows harmonization with other, more technical project plans. This possibility is particularly interesting in the light of the fact that ERPs are increasingly configured on the basis of the creation of process models in BPM tools (e.g. Signavio-SAP). Process models created for the implementation can also be inputs to our change management support solution.

My research fits well into the series of studies carried out at our Institute. Its main contribution lays in integrating and further developing the products of previous research and linking the Process Management Life Cycle domain with the discipline of Change Management, thus building a unified concept. The process model and the text analytics algorithm are the basis of the system, and through their development the system can evolve. In addition, as the aim is to support the implementation of change management, the utilizing company will be able to implement the organizational changes required during the transformation in a more flexible and efficient way.

The use of process ontology allows that the developed concept and tool ecosystem is applied to any business domain. This is possible since the process model and the domain-specific norm or text can be easily exchanged without affecting the way the system operates. Furthermore, the flexibility of the system allows for utilization of other change management methodologies.

4.2 LIMITATIONS AND FURTHER RESEARCH

The aim of my research was a proof of concept of a new kind of support ecosystem, also known in the practical context as Technology Readiness Level (TRL) 3. The proof of concept the ecosystem operationality has been demonstrated, however, due to its nature, it is with limitations and further improvements are needed to bring it to a higher maturity level.

Adonis xml-type output is transformed by the **Converter** into owl format, which works, but some situations are not handled neatly. In addition, if the ADONIS software's enhanced export function can export other information, such as organizational structures or the coded full-scale RACI responsibility structure, it will be worthwhile to enhance the Converter with these new capabilities.

The feasibility and the potential of the **algorithm** for text analytics has been demonstrated, but to use it in an industrial environment, the development work started in this research should be continued, thus increasing the accuracy of the results. At this point, the algorithm could also be further improved by training and validating it on more technical or domain specific texts.

The need for a **Translation Table** became clear during the research and was therefore included in the concept. We are clear about its function, but at this stage of development, the Translation Table and the new version of the process ontology it would generate were built manually. Further research could be increasing the level of automation around the Translation Table, in particular in the following areas:

- the integration of the thesaurus and text similarity analysis could become more automated.

- Additional research into the text similarity algorithm, specifically focusing on algorithms that need large corpuses.
- Automated generation of the new ontology version to be used in Protégé when the Translation Table is applied

User-friendliness was not in scope of our research. The further development of the solution and its validation in a possibly wider industrial practice will require a certain level of user-friendliness of the tool ecosystem. Further research could cover the development of a GUI with especially to cover the Converter, the manual control of attributes found in the textual process descriptions, the management of the Translation Table and the running of the Report.

The possibility of using the latest **GenAI** models instead of, or in combination with the Recommendation Engine has been raised as an exciting possibility. It is assumed that commonly available GenAI solutions may be able to formulate recommendations well if certain parameters are given to them. Further research could cover its feasibility, namely assessing what kind of input can be transferred from the Recommendation Library to the GenAI application and what results can be expected. It is conceivable that certain situations could be recognized by GenAI on its own and recommendations could be generated based on that input.

A noteworthy limitation of the research is related to the scaling of the solution, to achieve the level of efficiency-gain that offsets the invested effort for maintaining the solution: the need of sufficient amount of domain specific text to train and validate the algorithm, without which the hit rate can remain under acceptable levels. As mentioned earlier, the current method assumes the existence of a Translation Table to reduce the false positive results in the comparison. The extent of the Translation Table, and the related effort to fill and maintain it can be significant, which only justifies invested effort when the solution is used at scale.

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