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Supporting Information System Integration Decisions in the Post-Merger Context

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Abstract. Consolidation of organizations and assets through Mergers and Acquisitions (M&A) is one of the strategies for organizational growth. However, despite the big popularity, the results of M&A initiatives are questionable. The main idea behind M&A is to create a new organization by combining several existing organizations. This new organization is created through a transformation process often called a post-merger. A significant part of the post-merger process is the integration of information systems. The success of post-merger information systems integration is the result of successful integration decisions. This study focuses on the problem of how a novice organization in post-merger initiatives can handle complexity in the decision-making process of post-merger information systems integration with its internal resources, without involvement of an external expertise, but with a support method to compensate the lack of expertise for informed decision-making. The extended decision-making process can be divided into three phases – identification of necessary decisions, decision-making, and decision implementation. This study focuses on the first two phases. For each of the phases, a specialized sub-method was developed, focused, respectively, on the identification of necessary decisions (AMILI) and decision-making as a choice between possible integration options (AMILP). Supporting tools were also developed for each of the sub-methods.
Keywords: Mergers and Acquisitions, Post-Merger Integration, Information System Integration, Decision-Making.

1 Introduction

Information system (IS) integration is an essential part of a collaboration between organizations, as well as in the functioning of a single organization [1], [2]. It is even more important in mergers and acquisitions (M&A). Consolidation of organizations and assets through M&A is one of the organizational growth strategies [3]. It can help grow faster and on a larger scale. With growing

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competition and market expectations, more and more organizations choose to grow through M&A [4]. The main idea behind M&A is to create a new organization by combining several existing organizations. This new organization is created by a transformation process, often called a post-merger integration (PMI) [5]–[7]. The new organization must be able to achieve the goals stated for M&A, which could not be achieved by each of the merging organizations separately [3], [4]. The outcome of PMI impacts the achievement of M&A objectives [7]. IS integration is a significant step of PMI. In the scope of IS integration, existing IS architectures of merging organizations are combined into one united IS architecture to support the needs of the newly created organization [8]. Successful IS integration is cited as one of the factors contributing to PMI success [9], [10]. IS integration can be perceived as the sequence of integration decisions and decision implementation activities [11]. With the importance of IS integration in PMI, and the importance of PMI for achieving M&A goals, IS integration decision-making has an impact on the achievement of M&A results (Figure 1). But IS integration decision-making is not a trivial task, especially for organizations without prior experience in PMI.

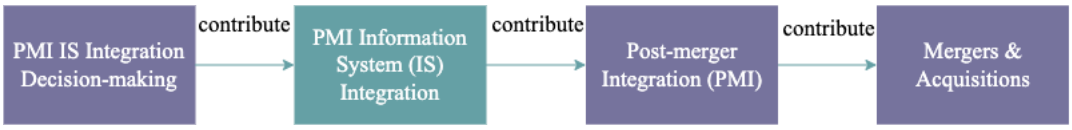

Figure 1. IS integration contribution in the overall M&A success

The research presented in this article is focused on the problem that organizations, without prior experience in PMI, do not have access to methods that would allow organizing the PMI IS integration decision-making process with their own internal resources, without using external expertise, i.e., there are no scientifically based methods to compensate for the lack of expertise in PMI. The goal of the research is to develop the support method for decision-making in the context of PMI IS integration, which can partially compensate for the lack of expertise. This article is the extended version of the research paper exploring managing the complexity of the PMI IS integration decision-making [47] and is explaining how requirements engineering (RE), enterprise architecture (EA), knowledge management (KM), and multi-criteria decision-making (MCDM) are incorporated into the PMI IS integration support method. The method is adjusted for PMI specifics by incorporating approaches for PMI IS integration alignment with other PMI levels and PMI context factors.

The article is organized as follows. In Section 2, the state of the art in the research area and the research motivation are explained, as well as the research method is defined. In Section 3, the proposed concept of the method for supporting first two phases of the extended decision making process is introduced. In Sections 4 and 5, the sub-methods are proposed for decision identification and decision-making. In Section 6, the sub-methods are validated through the use cases, experiments, and usability evaluation. Finally, in Section 7, a research summary and conclusions are provided.

2 Research Approach

2.1 State of the Art

In scientific research, more and more attention is paid to the importance of the IS integration [18]. There are reviews of existing related research results [19]–[21], and conceptual models have been developed [11]. Other research works focus on the procedural aspects of the integration [22]–[28]. Most process-related studies consider the selection between different possible integration options [6]. Recent research examines the impact of different PMI IS integration options on overall PMI outcomes. As one of the reasons for PMI failure, the inconsistency between PMI business and IS levels [29]–[31] and solutions are studied in the enterprise architecture discipline [32]. A separate set of studies is devoted to various success factors of integration [33]–[35]. Organizational expertise [36], [37] and preparedness [38]–[40] are studied as important contributors to the success of integration, and possible solutions for how to accumulate expertise and share it between PMI initiatives are examined in the knowledge management discipline [15], [41]–[46]. However, there are no studies that offer proposals on how to organize the PMI process itself to overcome the lack of expertise in the organization without previous PMI experience.

The research presented in this article complements the following existing research directions: (i) PMI IS integration process and PMI IS integration decision-making—a practically applicable method for the organization of the PMI IS integration decision-making process is proposed and (ii) organizational expertise as a PMI IS integration success factor—the method is oriented to support the lack of decision-making expertise in the PMI IS integration.

Existing research solutions for decision identification and for decision-making used for method design are provided in Section 4 and Section 5 of the article accordingly.

2.2 Research Method

The research process, part of which is the work presented in this article, was based on design science research principles [48], [49]. As prerequisites to start the research process, the research problem was defined, a literature analysis was performed to verify the relevance of the problem, further, the research question was defined, and the treatment of the problem proposed and validated. In this article the research motivation is described in brief and the treatment design presented and discussed.

In the first phase of the treatment design process, the concept of support method was developed, the root research areas were selected to identify existing solutions, and the general requirements for method design were defined prescribing the development of two sub-methods. The following phases of the process were executed separately for each sub-method. The specific context requirements were defined in the second phase of the research. In the third phase of the research, root research areas were inspected, and existing solutions, satisfying specified requirements, were selected. Based on the defined requirements and selected solutions, a sub-method was designed in the fourth research phase, and a sub-method support tool was developed. In the fifth research phase, the use of the sub-method with the help of its support tool was validated through simulation, experiments, and usability evaluation.

2.3 Research Motivation

PMI IS integration decisions depend on several factors in the PMI context; namely: these decisions must be aligned with the determining factors and are impacted by blocking factors (Figure 2).

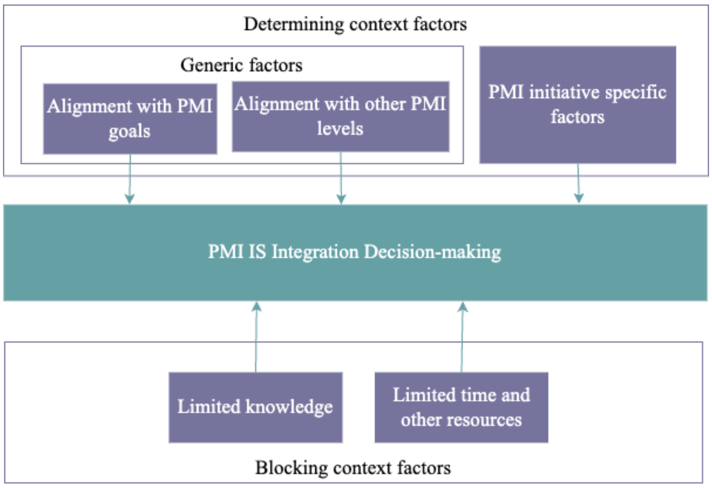

Figure 2. The impact of PMI context factors on the PMI IS integration

Determining factors can be divided into generic factors, applicable to any PMI initiative, and specific factors, applicable to the concrete PMI initiative. Generic determining factors are related to the alignment of made decisions with stated PMI goals and decisions on the other PMI levels [6], [11], [12]. Specific factors emerge in the specific PMI initiative [6], [11]. One of specific factors is related to social aspects – the support of stakeholders and users can play an important role in the IS integration decision-making of the specific PMI initiative. Decisions are based not only on facts, but also on perceptions and personal opinions that can influence the decisions made [6], [13]. Another specific factor is the complexity of the PMI and the implementation of related decisions, as well as the required amount of time and associated costs. PMI complexity is determined by the scope of the PMI, the extent of planned changes, or the degree of structure and interdependence of existing business and system levels [13]. One more specific factor is linked to risks of the concrete PMI initiative – as different decisions can increase or decrease the probability of specific risks [14].

Decision-making is hampered by blocking factors – limited knowledge about PMI, as well as limited time and other resources [12], [15]. Uncertainty makes it harder to make decisions. However, PMI is closely related to the need to make decisions in situations with many unknowns [15]. Acquiring knowledge and expertise is blocked by time and other resource constraints [6], [13]. In addition, in the case of time and other resource limitations, it is more difficult to prepare for a decision, evaluate all available information, and define all options [6], [13].

It is observed that determining factors have a greater coherence and blocking factors have less impact on more experienced organizations, since they can accumulate knowledge and gain expertise through several sequential M&A initiatives [16], [17] (Figure 3).

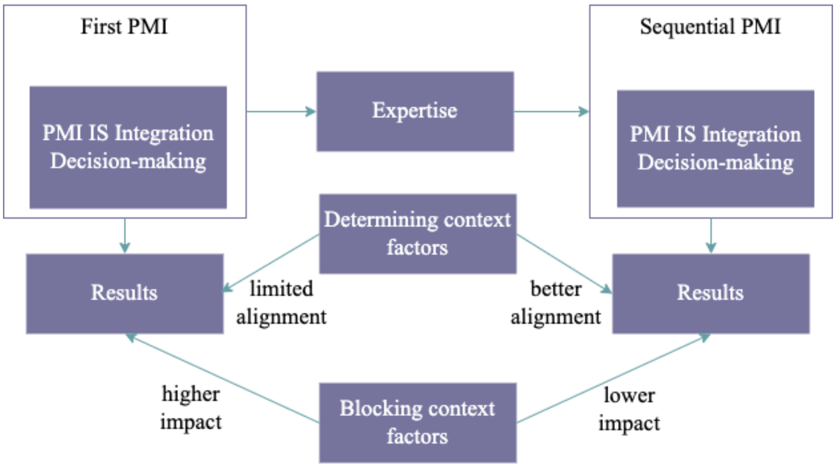

Figure 3. Specifics of the research problem environment

The research aims to answer the following question: "What method can help specialists without expertise in the PMI IS integration to achieve results comparable to the results of experts". Accordingly, the main goal of the research is to develop the method for supporting the information system integration decisions in PMI initiatives.

3 The Concept of the Method for Supporting Decision Making Process

In PMI, the expertise in decision-making, in the broadest sense of the term, includes the use of the following expertise components: *standardized processes* for the automation of repetitive activities, reduction of required cognitive resources, and pattern recognition; *application of previous experience*; and *context awareness* to supplement the decision knowledge [50]. For instance, a standardized process can be used for the steps involved in coordinating a decision-making as such or for the activities of evaluating available decision options. Knowing the context includes obtaining all the information necessary for decision-making, involving stakeholders, as well as the ability to analyze the PMI initiative and adapt the decision-making to its specifics. Personal knowledge, which has been accumulated in previous decision-making cases, or documented knowledge accumulated by other people and organizations, useful for making a specific decision, can form a PMI IS integration decision-making expertise.

To support the decision-making in the PMI IS integration context, the proposed concept of the method provides replacement components for each expertise component for improving the capability of practitioners involved in decision-making, namely: (i) a model of the decision-making process is offered for the standard process, (ii) a model of the decision-making data is offered for perceiving the context, and (iii) for application of experience—both process and data models are extended with elements of knowledge management (Figure 4).

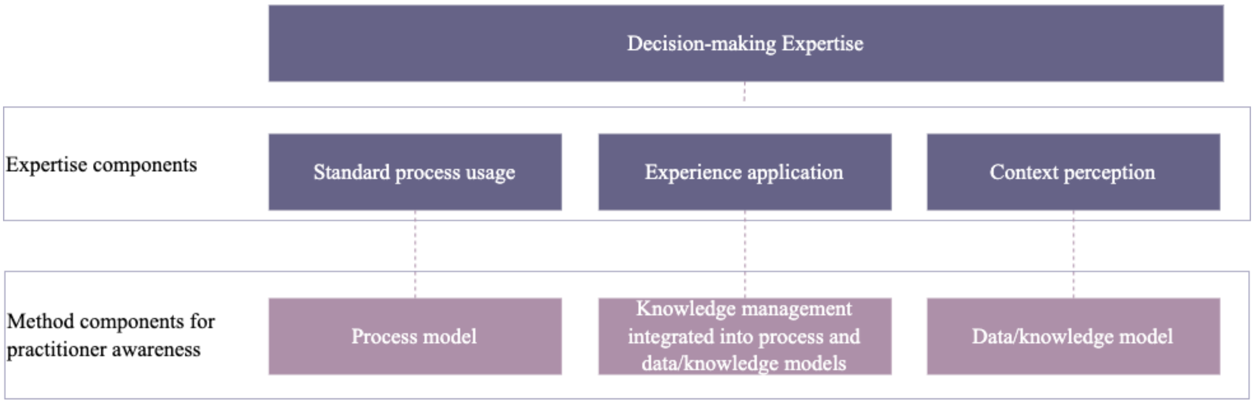

Figure 4. The concept of the method

Based on the opinions of researchers in the field of decision-making, the extended decision-making process can be divided into three phases – *identification* of the necessary decisions to be made, decision-*making*, and decision *implementation* [51], [52]. This research focuses on the first two phases. Each of these two phases of the extended decision-making process has its own objectives [51], [52]. In the context of IS integration, the main achievable result of decision identification (the first phase) is the identified groups of ISs to be integrated [53], [54]. For the second phase, the achievable result of decision-making is the evaluated integration options within an identified ISs group(s) [55]. To compensate for the lack of expertise (Figure 3), it is necessary to improve the capability of employees, i.e., promote the awareness of involved practitioners about the PMI domain and specific PMI initiative, reducing the impact of the blocking factors discussed in the previous section (Figure 5).

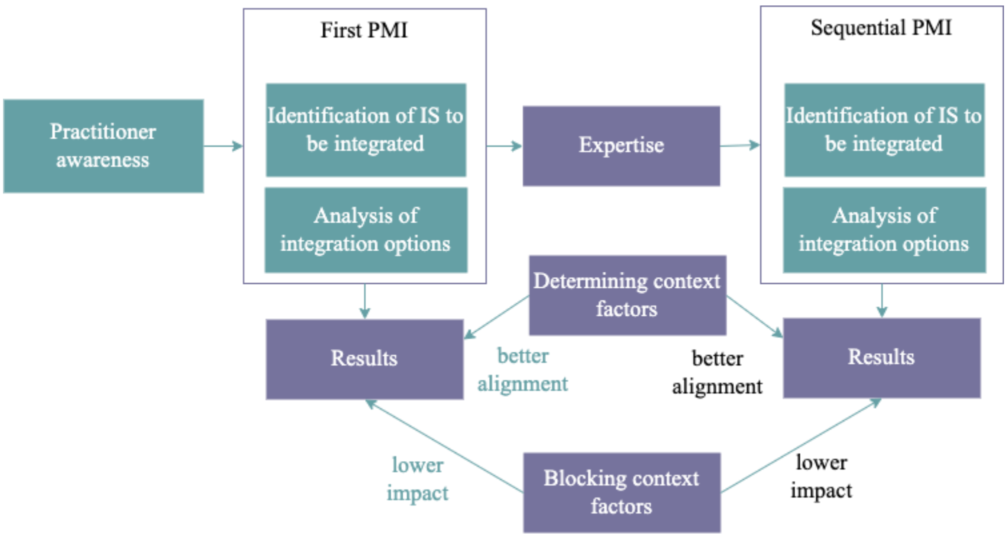

Figure 5. Practitioner awareness for compensation of the lack of expertise

For both (the first and the second) phases of the extended decision-making process included in the research, a sub-method was developed, focused respectively on the identification of necessary decisions (AMILI) and decision-making as a choice between possible integration options (AMILP) (Figure 6). The acronyms AMILI and AMILP are acronyms for the, respectively, "support method for informed decision identification" and "support method for informed decision making" in Latvian language. The original acronyms are used in this article because they have been applied in all stages of the research, including validation, and thus facilitate understanding of the whole scope of developed resources supplementing the article.

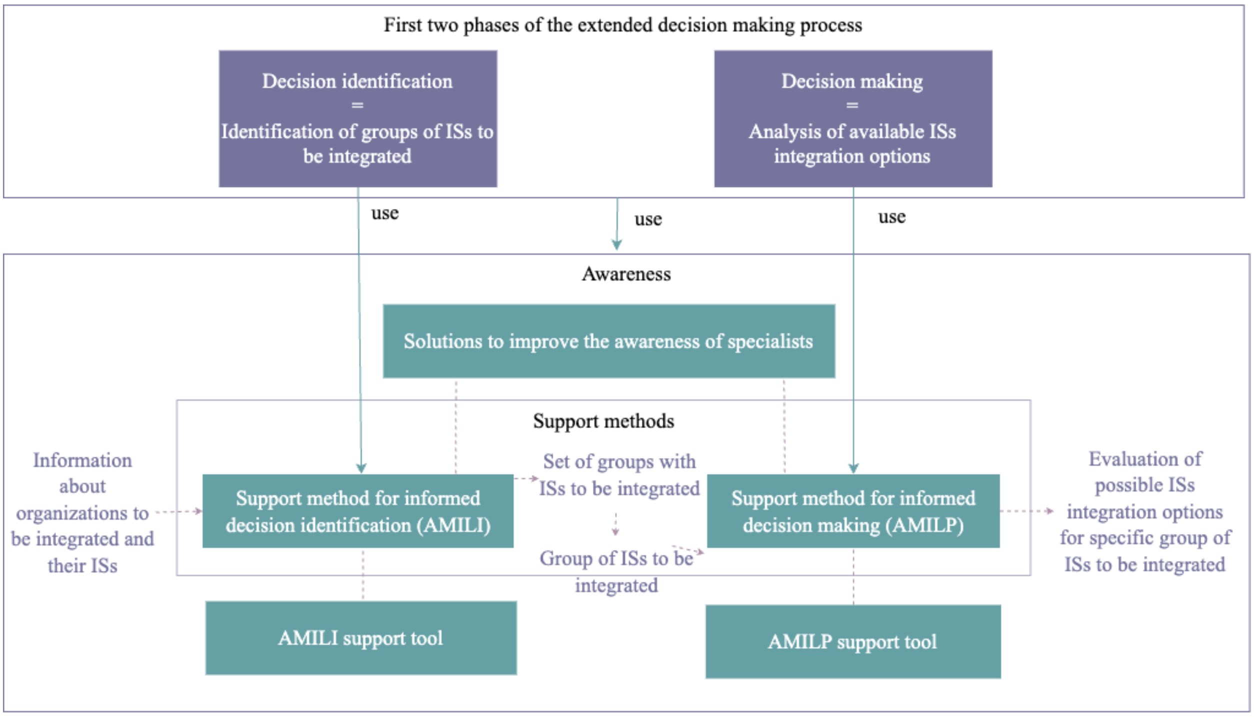

Figure 6. Method's sub-methods for decision identification and decision-making phases

According to the expertise replacement solution, each sub-method consists of a process model and an information model, both containing knowledge management elements (Figure 7). The development of sub-methods is rooted in several research areas. These research areas were selected and explored to identify existing solutions, which can be applied to PMI initiatives. An overview of sub-method components and selected root research areas is provided below.

The process model supports the automation component of expertise and defines the process steps to achieve the result. For the development of the process model, root research areas oriented towards similar achievable results have been selected. The AMILI process model is rooted in requirements engineering to identify groups of IS to be integrated [56], while the AMILP process model is rooted in multi-criteria decision making to analyze available integration options [57], [58].

The information model supports the pattern recognition component of expertise and provides a unified structure for the domain-specific concepts used in the process. For the development of the information model, the root research areas focused on defining the structure of the broader PMI domain have been selected. The AMILI information model is rooted in the enterprise architecture to relate IS changes with other PMI levels [32], [59], [60], while the AMILP information model is rooted in the PMI level synchronization [47], [61] and PMI context influence on different integration options [62] to evaluate available integration options in the specific PMI context.

In addition, the process and information models are also rooted in knowledge management solutions to apply previous experience [15]–[17], [63].

Solutions in the root research areas were selected based on their compliance with the defined PMI context requirements. The following general requirements were defined, which were detailed for each method to represent the specifics of each phase of the extended PMI IS integration decision making: decision identification and decision making:

- Method support for the task to be performed – for decision identification or decision making, respectively.
- Method compliance with the level of specialists' preparation – conformity with existing skills and known concepts, as well as compensation for missing skills.
- Method ability to improve an alignment with the determining context factors.
- Method ability to limit the impact from the blocking context factors.

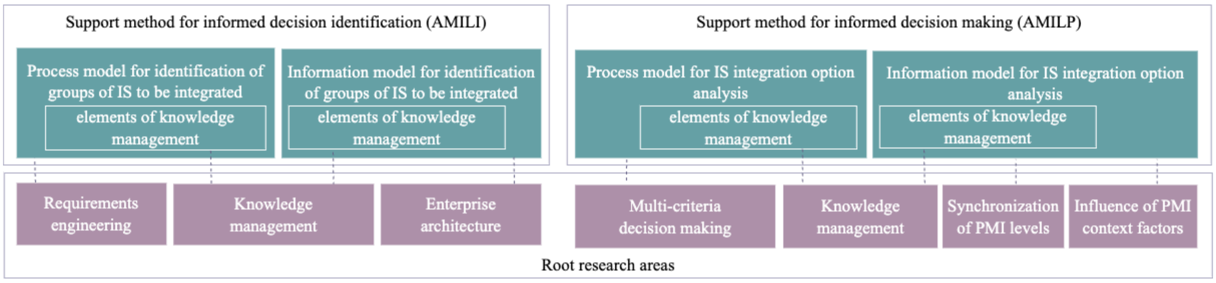

Figure 7. AMILI and AMILP sub-methods

4 AMILI: a Sub-method for Identifying Groups of ISs to be Integrated

Informed decision identification aims at discovering groups of ISs to be integrated. As input data, AMILI uses the business architecture of the newly created organization and the business and IS architectures of the organizations to be integrated, and then, using this information, identifies ISs of similar capabilities and combines them into groups of ISs to be integrated.

In order to select possible solutions in the existing research, previously stated generic context requirements were adjusted for decision identification specifics (Table 1):

- From a task support perspective, PMI IS integration is closely related to software development and is often assigned to IT professionals, so the sub-method should be consistent with the concepts used in IS development [6], [12], [53].
- From the perspective of practitioner preparedness support, the description of the process should be based on concepts familiar to the executors, in order to reduce the learning time and the number of related errors, as well as to increase the engagement of specialists to use the process [64], [65]. The task of PMI IS integration is often assigned to IT professionals, specifically business/systems analysts and requirements engineers [66], [67]. They are used to working on software development projects and using requirements engineering standards.
- According to [69], the sub-method should be consistent with determining factors in the PMI IS integration context. PMI IS integration is part of a larger PMI initiative and the approach should support the business objectives of the PMI as well as, according to [10] and [68], support the alignment between different levels of the PMI initiative.
- The sub-method should minimize the impact of blocking factors in the PMI IS integration context. Commonly cited challenges in the PMI context are the lack of documented knowledge [15], [45], as well as time and resource constraints [6], [13]. The sub-method should be applicable in cases where the knowledge is limited or unavailable. Also, the sub-method should be usable in case of time and other resource constraints.

Table 1. Specific context requirements for decision identification

Generic requirement	Task support	Practitioner preparedness level support	Alignment with determining factors	Minimizing blocking factors impact
Specific requirements	• Software development support	• Support for IT professionals, specifically business analysts and requirements engineers	• Support the business objectives of the PMI • Support the alignment between PMI levels	• Applicability in case of limited documented knowledge • Applicability in case of time and other resource constraints

After specific requirements were defined, existing solutions were analyzed to evaluate their potential to support the requirements (Table 2).

Table 2. Existing research solutions for decision identification

Process model	**Knowledge management in process and information models**	**Information model**
Requirements engineering frameworks: • BABOK [69] Requirements engineering research: • Agile [70] • Business goal orientation [71] • Model-based approach [72]	Knowledge management frameworks: • Nonaka & Takeuchi's [76] • Bukowitz & Wiliams [77] • Choo Sense-making [78]	Enterprise architecture frameworks: • TOGAF [73] Enterprise architecture research: • Agile [74] • Orientation to software development [75]

For AMILI process model existing requirements engineering and business analysis frameworks were analyzed and BABOK framework was selected for business orientation [69]. But BABOK framework is not efficient in the context of not sufficient knowledge and lack of time. Additional requirements engineering research directions were explored to identify potential solutions to address these issues. The basic principles of Agile [70] were integrated into the process for its simplification and economy of resources, as well as orientation towards business goals. Merger objectives and future business architecture [71] were included in the AMILI process to orient them towards business objectives. The modeling principles and modeling notations known in the software development environment [72] were used to describe the AMILI (and, for consistency, also the AMILP) sub-method. Specifically – process and information models were created using notation similar to UML [79].

For AMILI information model, existing enterprise architecture frameworks were analyzed and TOGAF framework was selected as the closest to the software development, as well as the most popular framework [73]. Similarly, as with the BABOK framework, TOGAF is not intended to be used in cases when knowledge is insufficient, and time is limited. Additional research directions were explored to find existing solutions for corresponding information model adjustments. The basic principles of Agile [74] were integrated into the AMILI information model for simplification and resource economy. Orientation to software development [75] was integrated into the AMILI information model as business and IS architecture entities and associations between them to represent business and IS levels.

To integrate knowledge management in both process and information models, existing knowledge management frameworks were analyzed. Nonaka & Takeuchi’s [76] concept of non-documented (tacit) knowledge was applied to the adaptation of knowledge management activities to address the documented knowledge gap through the integration of stakeholders’ non documented knowledge in the AMILI process. Bukowitz & Wiliams [77] framework is focused on the evaluation of information from a business needs perspective and recommends not retaining information without business value. Applying this principle, the information model was inspected to identify which information can remain as non-documented knowledge and does not require transformation into documented knowledge. The knowledge value principle of Choo Sense-making [78] as well can be used to identify the minimally necessary documented knowledge in the AMILI information model and reduce the effort related to documented knowledge creation and maintenance.

More details on how the concepts of RE, EA, and KM were integrated is available in [61].

4.1 Considerations behind the AMILI

Groups of IS to be integrated are identified using information about the set of business units to be integrated, the set of business functions to be integrated, and the set of supporting ISs:

$$ISG = < BV, BF, IS >, \quad (1)$$

where *ISG* – a set of groups of ISs to be integrated;
BU – a set of business units to be integrated;
BF – a set of business functions to be integrated;
IS – a set of supporting ISs to be integrated.

The set of business units to be integrated is determined by identifying all existing business units in the organizations to be integrated that correspond to the future business unit:

$$BU = \{BU_i \mid BU_i \; correspond \; BUF_j\}, \quad (2)$$

where *BU* – the set of business units to be integrated, as a subset of the sets of business units of the organizations to be integrated;
BU_i – specific business unit;
BUF_j – future business unit.

The set of business functions to be integrated is determined by identifying the unique business functions of the business units to be integrated:

$$BF = \{BF_i \mid unique \; BF_i \; of \; BV\}, \quad (3)$$

where *BF* – the set of business functions to be integrated, as a subset of the function sets of the business units of the organizations to be integrated;
BF_i – specific business function;
BU – the set of business units to be integrated.

The set *BIS* of ISs supporting the business function to be integrated is determined by identifying all ISs in both organizations that support the relevant business function (4). It is possible that single business function is supported by several ISs within an organization.

$$BIS = \{IS_i \mid IS_i \; support \; BF\}, \quad (4)$$

where *BIS* – the set of ISs supporting business functions, as a subset of the sets of IS of organizations;
IS_i – specific IS;
BF – a set of business functions.

All identified IS are grouped according to the relevant business functions.

In addition, the IS related to the IS supporting the business functions, which are necessary for the functioning of these systems, are identified:

$$RIS = \{IS_i \mid IS_i \; related \; with \; BIS\}, \quad (5)$$

where *RIS* – a set of additionally related IS, as a subset of the sets of IS of organizations to be integrated;

IS_i – specific IS;

BIS – a set of ISs supporting a business function.

The full set of groups of ISs to be integrated is formed as a combination of the set of ISs supporting the business function and the set of additionally related IS:

$$ISG = RIS \cup BIS, \quad (6)$$

where *ISG* – a set of groups of ISs to be integrated;

BIS – a set of ISs supporting the business function;

RIS – a set of additionally related ISs.

4.2 AMILI Process Model

AMILI process is based on the phases of the requirements engineering process, corresponding to BABOK activities – requirements elicitation, current and future states description, current state analysis, and gap definition between the current and future states. The AMILI process model is represented using a notation similar to the UML activity diagram (Figure 8).

The requirements elicitation phase explores the PMI goals and PMI context. Compared to the wide spectrum of goals in software development projects, PMI is mostly focused on reducing the redundancy of the IS architectures of the organizations being integrated [2], [80]. This requires describing the architecture of the existing IS in both organizations and identifying their overlap. The main task of IS is to support business needs and facilitate the achievement of business goals [10], [68], [81]. In the context of PMI, the overlap of IS architectures is related to the overlap of corresponding business architectures, which also should be addressed in the scope of PMI. Business overlap can be defined by identifying the business architectures in both organizations. For the further execution of the process, the future business architecture is defined as the future business unit(s), the creation of which requires the elimination of overlapping existing business and IS architectures. Summarizing all stated above, in the scope of the current and future state description phase, the following architectures are defined—current business architecture of merging organizations, future business architecture to be created, and current IS architectures in the merging organizations.

In the scope of the current state analysis phase, defined architectures are analyzed. The analysis is based on the considerations defined in the previous section. As a first step, for each of the future business units, the corresponding business units in the current business architectures are identified (Expression 1 in Section 3.1). After that, with a help of corresponding stakeholders, business functions of previously identified business units are identified (Expression 2 in Section 3.1). Then, for each of identified business functions, ISs are identified which are used for supporting this business function (Expression 3 in Section 3.1). And, finally, additional ISs are identified which are not directly used for business functions, but are required for the ISs which support the business functions (Expression 4 in Section 3.1). Also, the relationship type between business functions supporting ISs and additional ISs is defined. It is important to note that during the identification of business functions, one common list of unique business functions is created, which is further used for the identification of ISs supporting the function in both organizations. This list is used later in the phase of gap definition between the current and future states. The same applies to the relationship types defined for additional ISs. If necessary, the process is repeated in several iterations, identifying additional business units, business functions, and ISs to be integrated.

In the scope of the last phase, the gap between current and future states is defined as groups of ISs which are supporting the same business function or provide the same support for ISs supporting business functions.

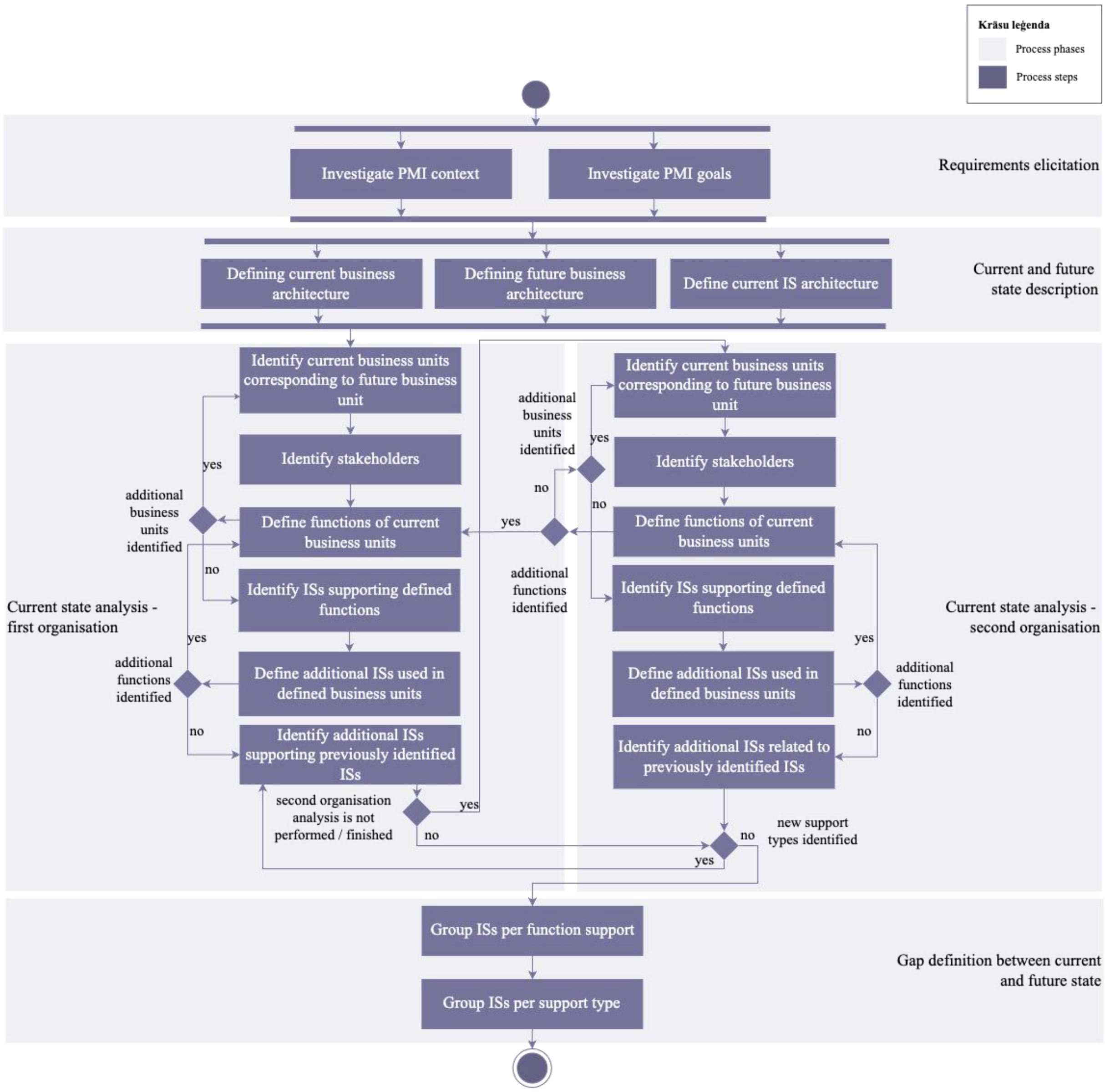

Figure 8. AMILI process model

Requirements engineering standards operate with documented knowledge artifacts that are created as output data in one activity and used as input data in subsequent activities [69]. Due to time and other resource constraints in the PMI IS integration, it is necessary to reduce any additional activities, including activities related to the creation of the documented knowledge artifacts. By reducing the amount of documented knowledge, additional mechanisms are required for the management of implicit knowledge [82], [83]. AMILI incorporates identification of stakeholders and their active involvement in the process (Figure 9). Business representatives are identified for each of the business units; and they help to identify the business functions of the business unit and their supporting ISs from the perspective of the users. In addition to business representatives, IT specialists are also involved to provide additional information about the ISs used in the organization.

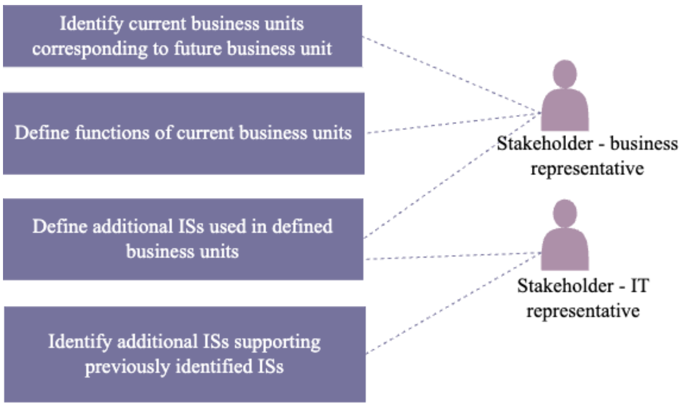

Figure 9. AMILI stakeholder involvement

Using information about business integration and the support of business and IT specialists, the responsible specialists can identify the necessary decisions about the groups of to be integrated ISs.

4.3 AMILI Information Model

The AMILI information model represents the knowledge that is obtained in the scope of identifying ISs to be integrated. The AMILI information model is represented using a notation similar to the UML class diagram (Figure 10). Documented and non documented knowledge highlighted with different colors.

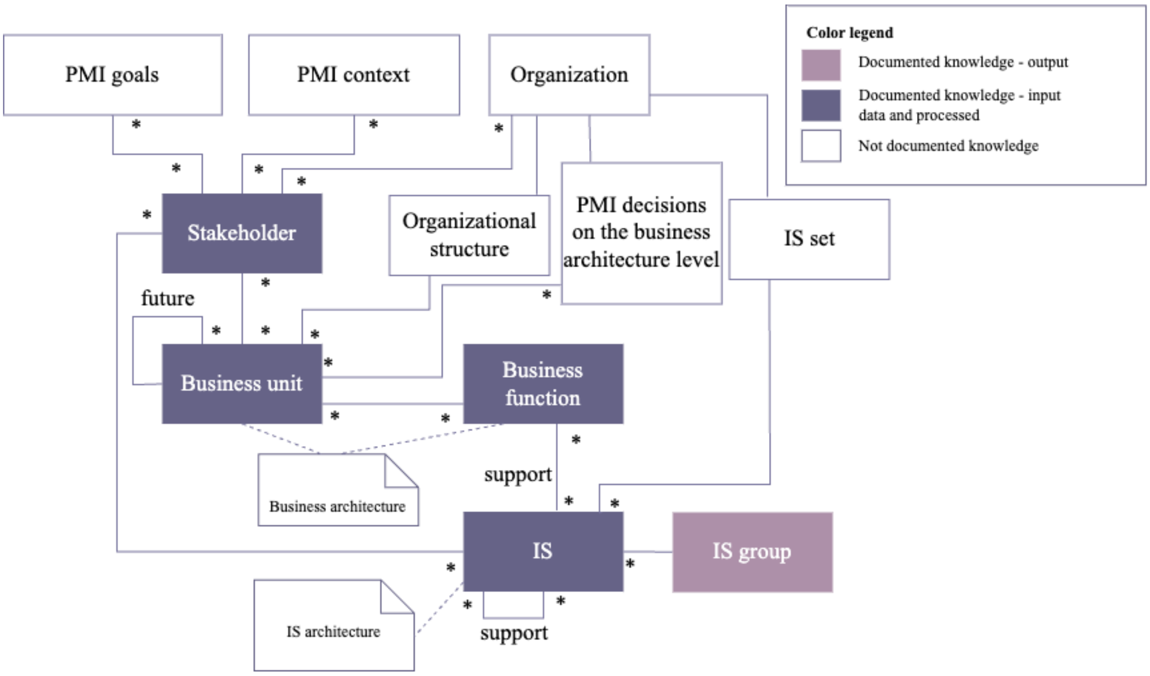

Figure 10. AMILI information model

Given the AMILI context requirements related to the time and other resources constraints, knowledge gathered in the requirements elicitation phase about PMI goals and PMI context is not documented but is replaced with documented knowledge about relevant stakeholders, who have relevant knowledge and can be involved as required. Stakeholders are related to the organization and, additionally, can be related to one or several business units.

To save time and other resources, the following input data about merging organizations is used: for the existing business architecture the organizational structure is used [84], and for the existing

IS architecture the IS set in both organizations is used in any available format. PMI decisions on the business architecture level are used for future business architecture, as they often are applied to existing organizational units [59], [85]. Using information about these decisions, future business units are identified.

For each of the identified future business units, related business units in the current business architecture, are identified (Expression 2 in Section 3.1). With help from the corresponding stakeholders, for each of the current business units, its business functions are related (Expression 3 in Section 3.1). For each business function, supporting ISs are related (Expression 4 in Section 3.1). One IS can be related to several business functions in different business units. Each IS supporting business functions can be related to one or several ISs required for its functioning (Expression 5 in Section 3.1).

Each IS group (Expression 6 in Section 3.1) is related to several ISs which support the same business function, or several ISs that provide the same type of support for other IS.

4.4 AMILI Support Tool

A tool was developed to support the practical use of the sub-method. The tool is implemented as a set of files in the "Google drive" storage. The tool supports the most common case in practice when two organizations are merged. The tool consists of several forms, each of them focused on the specific process step done for one of the merging organizations, or both of them (Figure 11).

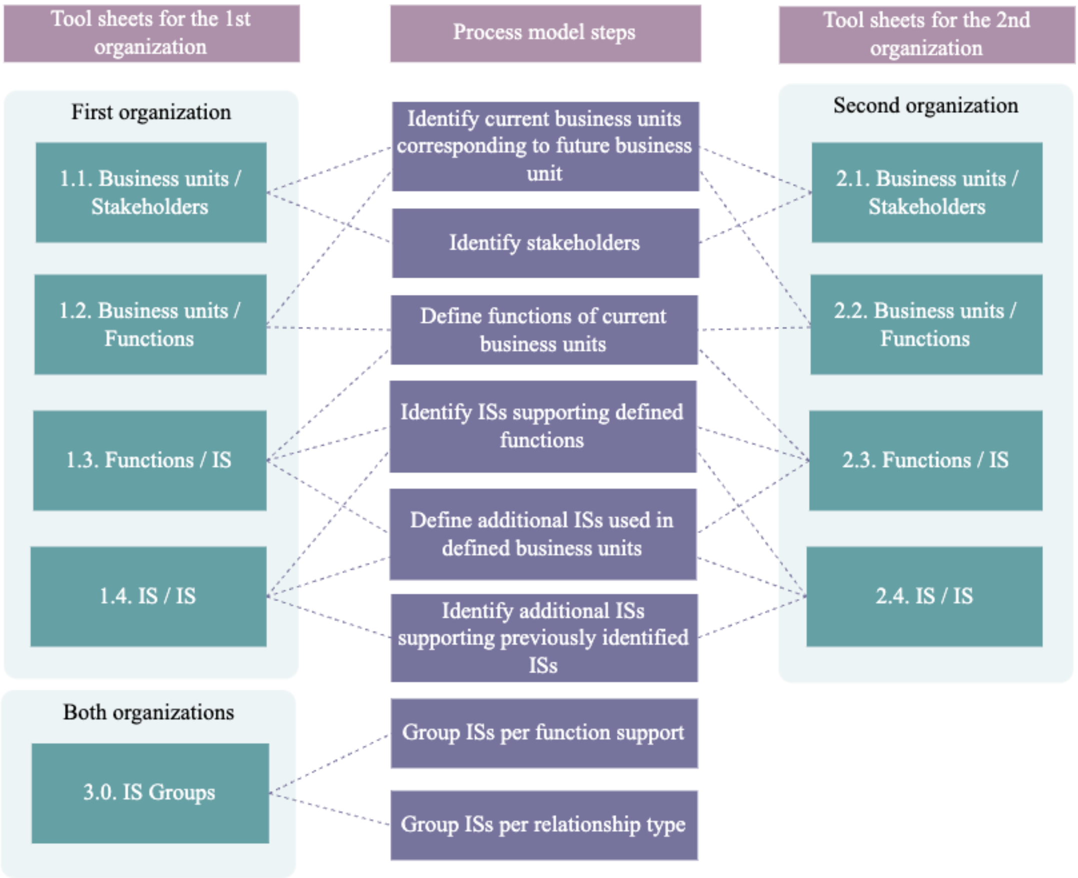

Figure 11. Tool support for AMILI process

All tool components are available using the links provided in the Appendix, Table "AMILI tool's components".

5 AMILP: a Sub-method for Making Integration Decisions within the IS Groups

Informed decision-making uses the group of information systems to be integrated as input data and evaluates various possible integration options for arranging them in the order of preference.

In order to select possible solutions in the existing research, previously stated generic context requirements were adjusted for decision-making specifics (Table 3):

- To support the task, the sub-method should support the mutual comparison of integration options [68].
- Specialists involved in decision-making often lack a background in decision-making management, so the sub-method should compensate for the missing expertise and provide decision-making support [6].
- For the alignment with the determining factors (the determining factors are described in Section 1), the integration of PMI IS should be oriented towards achieving the PMI objectives [81], should be coordinated with different levels of the PMI, as well as should be efficient in the specific PMI context [10].
- AMILP sub-method should be developed so that it can be usable in case of insufficient knowledge, as well as with time and other resource constraints [15], [45].

Table 3. Specific context requirements for decision-making

Generic requirement	Task support	Practitioner preparedness level support	Alignment with determining factors	Minimizing blocking factors impact
Specific requirements	IS integration option comparison	Support decision-making for non-experienced professionals	• Support the business objectives of the PMI • Support the alignment between PMI levels • Support specific PMI contextual factors	• Applicability in case of limited documented knowledge • Applicability in case of time and other resource constraints

After specific requirements were defined, existing solutions were analyzed to evaluate their potential to support the requirements (Table 4).

Table 4. Existing research solutions for decision-making

Process model	**Knowledge management in process and information models**	**Information model**	
Multi-criteria decision-making frameworks: • AHP Pairwise comparison [86] • TOPSIS Distance based [87] • ELECTRE Outranking [88] • MAUT Value/utility function [89]	Knowledge management frameworks: • Nonaka & Takeuchi's [76] • Bukowitz & Wiliams [77] • Choo Sense-making [78]	PMI integration levels: • Business unit integration • Information technology integration • Information system integration	Specific PMI contextual factors: • Contribution in PMI goals • Stakeholder support • User satisfaction • Integration cost • Integration time • Integration risks

For AMILP process model, the existing multi-criteria decision-making frameworks were analyzed. None of the frameworks was recognized as fully applicable in the sub-method, as they are based on formal and complicated processes that are not useful in the context of time and other resource limitations. However, the general principles of multi-criteria decision-making process organization can be applied to the organization of the AMILP process. Quantitative evaluation of integration options according to selected criteria allows comparison of options with each other. Option scores can be normalized for easier cross-comparison. Weights can be assigned to the selection criteria to take into account relative importance, thus allowing the sub-method to be tailored to specific PMI initiative priorities.

For AMILP information model, the existing research on the evaluation criteria for IS integration options was analyzed. One part of the evaluation criteria is related to integration option alignment with PMI goals and different PMI levels. Based on the literature research, three PMI levels were identified – business unit integration, information technology integration and information system integration. For each of these levels existing integration options were identified. Based on the identified interconnection between different levels of PMI through the planned amount of changes [10], [17], [68], [90], one unifying classification approach of PMI level integration options was created. The classification is based on the number of current functions to be reused in the future organization (Table 5).

Table 5. Integration options on different PMI levels

Scope of functions to reuse	**Business unit integration options** [91]–[93]	**Information technology integration options** [68], [90], [94]	**Information system integration options** [24], [68], [94]
All functions from merging organizations will continue to be used in the future organization	No changes—separation No changes—holding	Coexistence Synchronization	No changes in IS IS integration
Functions from one merging organization will take over in the future organization, functions from another organization will be discontinued	One company—absorbed	Replacement Replacement with bolt on Replacement with sculpting	IS expansion IS extension IS enhancement
Part of selected functions from both merging organizations will be used to build the solution for future organization	Both companies—mixed	Combination	-
No functions from merging organizations will be used in the future organization – new solution will replace them	Both companies—start new way	Transformation	New IS

Using the results of existing studies and the identified interconnections between different levels of integration through the number of planned changes [10], [17], [68], [81], [90], the degrees of alignment between the PMI levels integration options can be visually represented as a coherence graph (Figure 12). Three different levels of alignment can be identified in the graph – minimum alignment (no arc between options), medium alignment (arc between options represented as a dashed line), and maximum alignment (arc between options represented as a bold line).

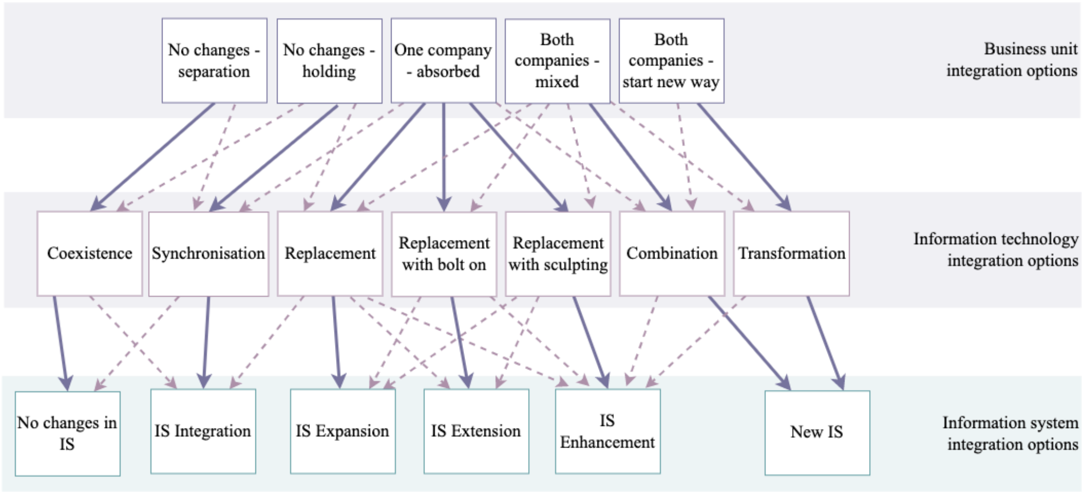

Figure 12. Alignment of the integration options on different PMI levels

Another part of the evaluation criteria is related to the specific PMI contextual factors impacting the choice and effectiveness of the IS integration option. Factors mentioned in the existing research were combined in six groups. Such grouping enables sub-method adjustments for different PMI initiatives specifics, when each group can be expanded with additional criteria without changing the sub-method process (Table 6).

Table 6. PMI IS integration option selection criteria

IS integration option selection criteria	Research papers
Outcome: Contribution in PMI goals	[6], [11], [12], [55], [81], [95], [96]
Outcome: Stakeholder support	[6], [11]–[13], [35], [55], [81], [95]
Outcome: User satisfaction	[6], [13], [95]
Cost: Integration cost	[2], [6], [12], [35], [55], [81], [97]–[99]
Cost: Integration time	[6], [13], [17], [35], [90], [95], [97]
Cost: Integration risks	[35], [55], [90], [100]

Similarly, as for AMILI sub-method, existing knowledge management frameworks were analyzed to integrate knowledge management in both AMILP process and information models. Bukowitz & Wiliams [77] framework information value evaluation concept and Choo's Sense-making [78] concept were used to identify the minimally necessary documented knowledge in the AMILP information model. Nonaka & Takeuchi's [76] concept of non-documented (tacit) knowledge was applied to replace some documented knowledge with stakeholder non documented knowledge.

5.1 Considerations behind the AMILP

The decision on PMI IS integration option selection is determined using information about the set of ISs to be integrated, the set of integration options, the set of options evaluations and the set of expert recommendations for options selection:

$$IOD = < ISG, IO, IOE, ER >, \quad (7)$$

where *IOD* – a decision on the IS group integration;
ISG – a group of ISs to be integrated;

IO – a set of options for IS integration;
IOE – a set of evaluations of IS integration options;
ER – a set of expert recommendations for choosing IS integration option.

The set of ISs to be integrated contains the IS for which integration decision is required in the scope of the PMI initiative. This set of ISs can be obtained as output data of the AMILI sub-method, but the AMILP sub-method can also be used without the AMILI sub-method, in this case, it can be a set of IS to be integrated which is identified using any other way:

$$ISG = \{IIS_i \,|IIS_i\ requires\ integration\ decision\}, \tag{8}$$

where *ISG* – a group of ISs to be integrated as a subset of all ISs used in organizations to be merged;
IIS_i – IS to be integrated.

The set of options for IS integration contains all possible integration options. For each set of ISs to be integrated, it is possible to define its own unique set of possible integration options. However, to simplify decision-making in the PMI context, it is possible to identify a set of standard integration options [2], [55].

$$IO = \{IO_i \,|IO_i\ possible\ integration\ option\ for\ ISG\}, \tag{9}$$

where *IO* – a set of possible IS integration options;
IO_i – IS integration option;
ISG – a group of ISs to be integrated.

The set of expert recommendations for choosing an IS integration option contains the recommendations of invited experts as ordered lists of possible options, where the most recommended option is at the beginning of the list and the least recommended option is at the end of the list. A group of involved experts is created for each set of systems to be integrated. It contains experts from the business, IT, and PMI fields.

$$ER = \{ER_i \,|ER_i\ expert\ recommendation\ as\ an\ ordered\ IO\ set\ for\ specific\ ISG\}, \tag{10}$$

where *ER* – a set of expert recommendations for specific IIS;
ER_i – expert recommendation for specific IIS;
IO – a group of possible IS integration options;
ISG – a group of ISs to be integrated.

The set of evaluations of IS integration options contains the evaluation of each integration option:

$$IOE = \{IOE_i \mid IOE_i\ is\ IO_i\ evaluation\}, \tag{11}$$

where *IOE* – a set of IS integration options evaluations;
IOE_i – IS integration option evaluation;
IO_i – IS integration option.

IS integration option evaluation includes evaluation of option alignment with other PMI levels, and option value in the specific PMI context. Alignment with other PMI levels is evaluated using the previously defined alignment graph (Figure 10). Value in the specific PMI context is expressed as a ratio between option outcome and cost, which was in detail described in a separate research paper [62].

5.2 AMILP Process Model

AMILP process model is based on multi-criteria decision-making and includes the following phases: (i) context investigation, (ii) selection of experts, options, and criteria, (iii) evaluation of options, and (iv) option recommendation. The process is designed so that it could be easy to understand and executed in the context of time and other resource constraints so that only crucial activities are left in the process. The process is based on the considerations described in the previous section. The process gets as input data a set of ISs, for which the decision on the integration options should be made (Expression 8 in Section 4.1). The AMILP process model is represented using a notation similar to the UML activity diagram (Figure 13).

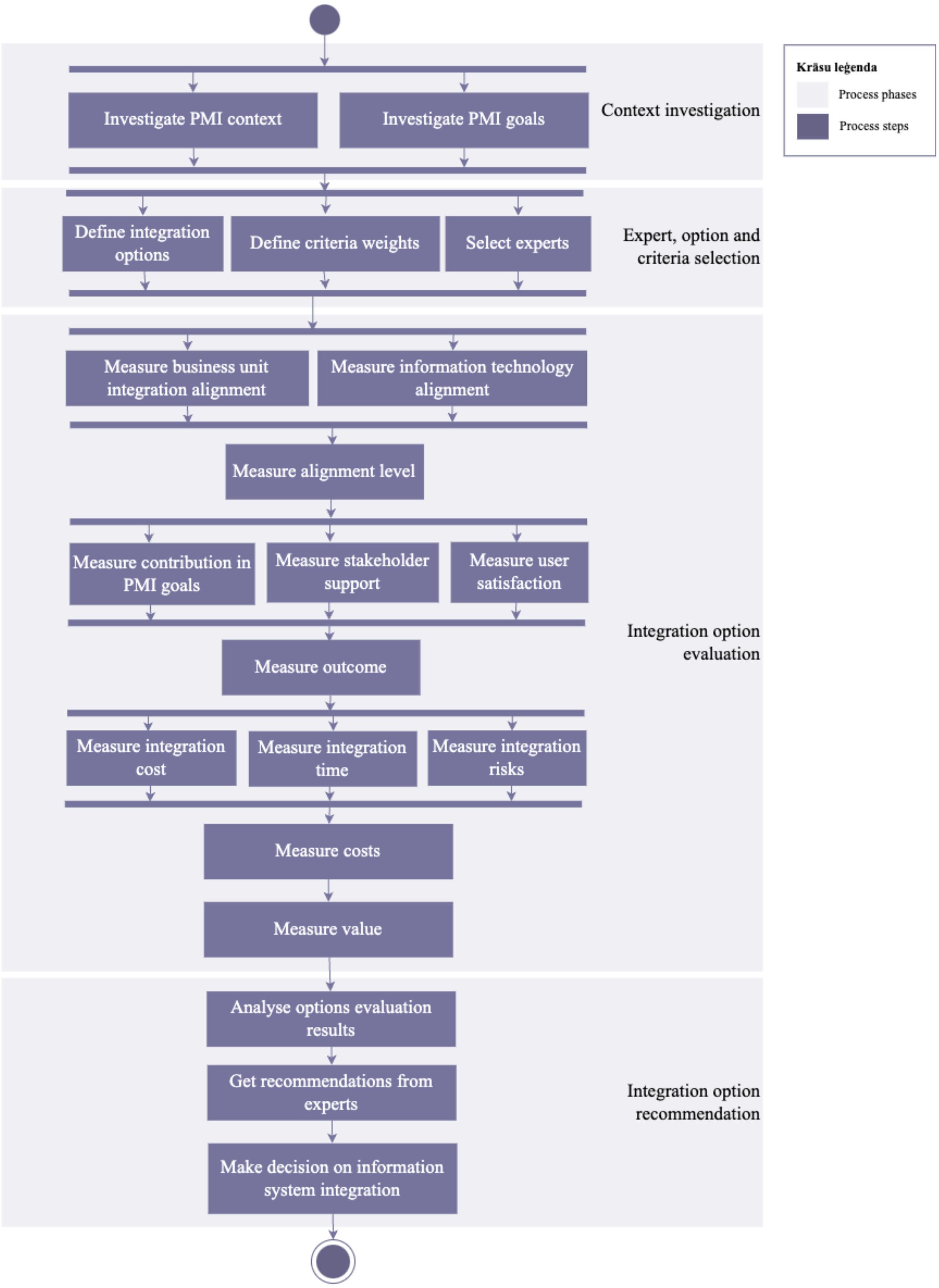

Figure 13. AMILP process model

As part of the context investigation phase, important factors of the PMI context that may impact the value of the integration option are identified. Factor information is later used in the option evaluation phase. Additionally, PMI objectives and decisions made at other PMI levels are identified for evaluating the degree of alignment of the integration option.

In the next phase, the IS integration options to choose from are defined (Expression 9 in Section 4.1). Additionally, the option evaluation criteria are defined. AMILP process, default integration options are used, but the set of options can be adjusted for the specific PMI initiative. In the simplest case, some of the standard options can be immediately excluded if their selection is not possible in the specific case. The sub-method also allows the inclusion of new integration options, but in this case, it is necessary to evaluate the alignment of these options with the options of other PMI levels. Similarly, for evaluation criteria – standard evaluation criteria can be adapted to the specific situation. It is possible to expand the set of criteria with additional criteria on the side of the outcome or cost. When adding criteria, it is necessary to define the formula for calculating the value of these criteria. By default, all criteria have equal importance, but some of the criteria may be assigned a higher degree of importance in each PMI initiative. In this phase experts , who will be providing their recommendations for IS integration option selection, are also selected.

In the option evaluation phase, all options are sequentially evaluated according to their degree of alignment with other PMI levels and their value in the specific PMI. Predefined formulas are used for calculations (the formulas are in detail described in a separate research paper [62]). For easier comparison of options, the calculated values are normalized. As a result of the execution of this phase, for each integration option, a relative assessment of the degree of alignment and value compared to other integration options is defined (Expression 11) in Section 4.1). This assessment is used in the next phase when experts choose options for their recommendation.

In the option recommendation phase, experts from the business, IT, and PMI spheres are invited to recommend the integration option [6], [13] (Figure 14). Each of them, based on the available evaluation results and their own expertise, offers a set of recommended options as a list of options ordered from the most recommended to the least recommended option (Expression 10 in Section 4.1). Based on the evaluation of options and expert recommendations, the responsible specialist can make an informed decision on selecting the integration option for the IS group.

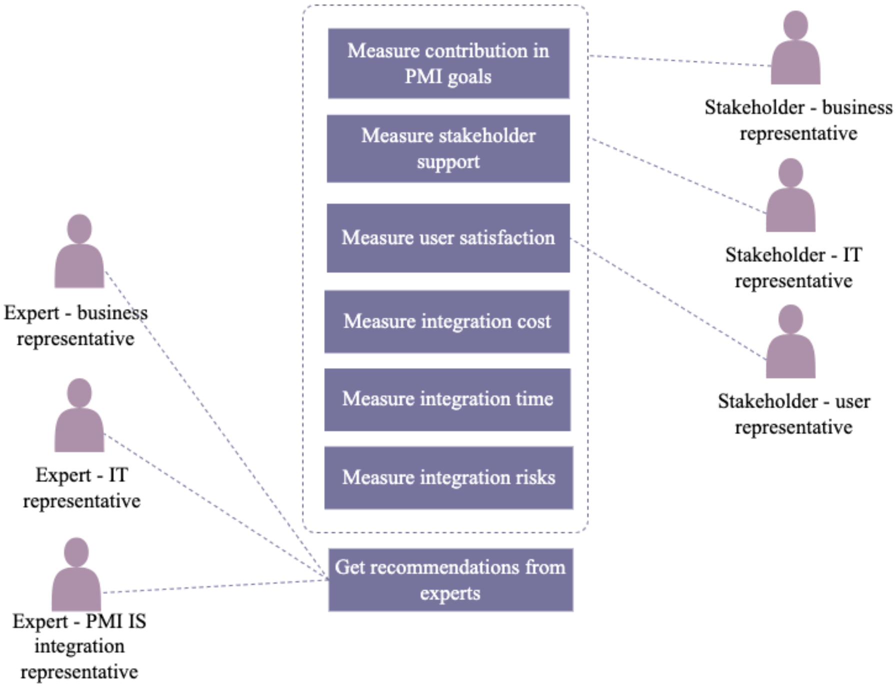

Figure 14. Stakeholder and expert involvement in AMILP process model

5.3 AMILP Information model

The AMILP information model represents the knowledge that is obtained in the scope of analysis of the possible IS integration options. The AMILP information model is represented using a notation similar to the UML class diagram (Figure 15). Documented and non documented knowledge highlighted with different colors.

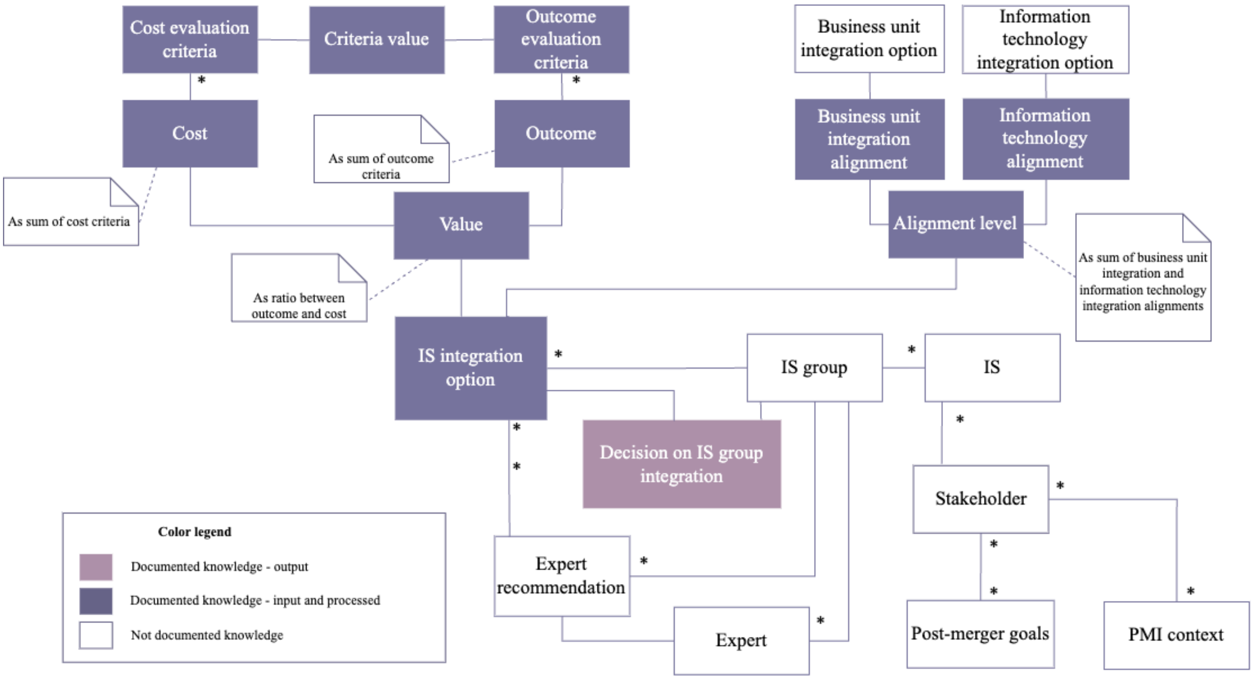

Figure 15. AMILP information model

The method requires input data in the form of IS group, which may contain several ISs requiring a decision about their integration. For the provided IS group, PMI goals and PMI context are explored. Given the AMILP context requirement related to the time and other resources constraints, gathered knowledge is not documented but is replaced with documented knowledge about stakeholders, who have relevant knowledge and can be involved as required.

According to the specifics of the IS group and PMI context, possible IS integration options are selected (Expression 9 in Section 4.1), as well as their evaluation criteria. Evaluation criteria can represent the outcome or the cost of the integration option (Table 6). Additionally, experts are selected to provide their recommendations for the integration option.

With the help of involved stakeholders, for each IS integration option, the evaluation of the integration option is performed (Expression 11 in Section 4.1). Using the individual criteria values, for each integration option, the cost and the outcome values are defined. The integration option value is defined as a ratio between the outcome and the cost. For each integration option, the alignment level with other PMI levels is defined, based on the alignment with business unit integration and information technology integration.

Each selected expert creates his expert recommendation, in which each integration option is ranked in relation to the other integration options within the set of ordered integration options (Expression 10 in Section 4.1). A decision on IS group integration is made by taking into account the value and alignment degree of each integration option and the recommendations of all experts involved. As a result, one specific integration option is selected (Expression 8 in Section 4.1).

5.4 AMILP Support Tool

A tool was developed to support the practical use of AMILP. The tool is implemented as a set of files in the "Google drive" storage. The tool supports the most common case in practice when two organizations are merged. The tool consists of several forms, each of them focused on the specific process step (Figure 16). All tool components are available using the links provided in the Appendix, Table "AMILP tool's components".

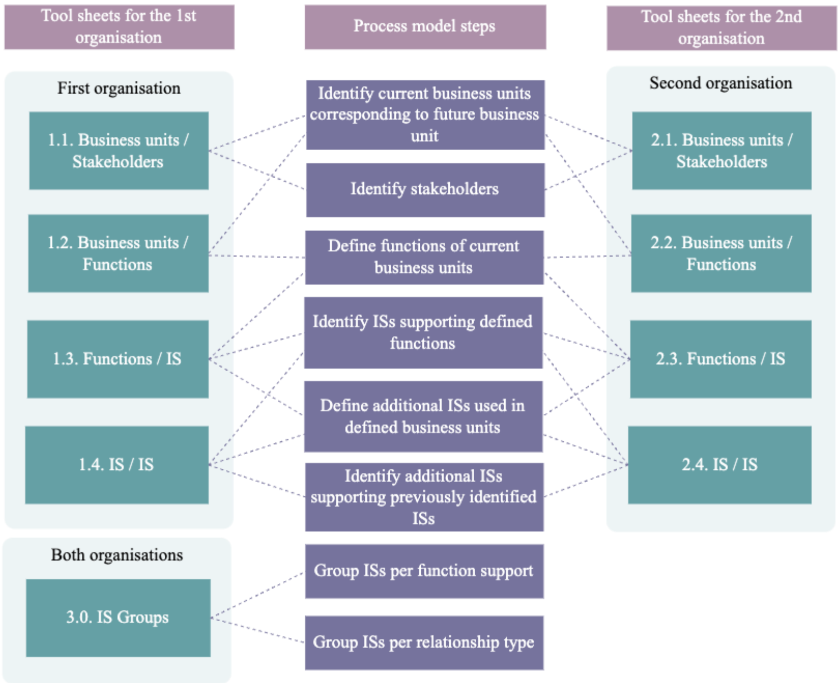

Figure 16. Tool support for AMILI process

6 Method Validation

Both sub-methods with the help of their tools were validated through simulation, experimental evaluation, and usability evaluation. In the first stage of validation, the author of the method simulated the use of sub-methods for a industrial case to get evidence that sub-methods are usable and achieve the expected results. In the second stage of validation with a help of experiments, it was validated whether the specialists without expertise, using the sub-methods, can achieve similar results as experts. In the third stage of validation, the usability of sub-methods and support tools was evaluated through surveys of experiment participants.

6.1 Simulation

AMILI sub-method was simulated in one real-life PMI case. AMILP sub-method was simulated in three different real-life PMI cases to validate if the sub-method can take into account case specifics. All simulation results are available using the links provided in the Appendix, Table "AMILI and AMILP simulation results".

As a result of the simulation of the AMILI sub-method, all expected information systems to be integrated were identified. The AMILI sub-method was able to identify several information systems that were initially missed in the real PMI initiative – access rights management systems and internal communication systems. It was possible to limit the scope of IS integration and divide it into smaller projects with a focus on the integration of the specific business units. This is often useful for resource planning. Orientation to business functions facilitates system grouping, which enables the identification of additional ISs. For the sub-method to be easier to learn, concepts relevant and understandable to stakeholders were used. After the initial training, a large part of the activities could be performed by stakeholders independently. In this way, it is possible to delegate activities related to the identification of ISs. By involving IT representatives, it was possible to identify additional ISs that are not directly used by business representatives, but whose integration was still important. The iterative nature of the sub-method, and returning to the previous steps to add information, made it possible to identify more business units, their functions and their supporting ISs. The IS groups, created as a result of the execution of the sub-method, can be used as input data for further decision-making. However, the manual process itself and the manual copying of data between the tool's forms requires additional effort and can lead to errors. Analyzing large tables can be confusing. The manually created visualization was found to be useful for understanding the linkage of business units, functions and ISs. However, the next step would be to replace the images with analyzable models that could also be used in automated input validation.

As a result of the simulation of the AMILP sub-method, the evaluated degree of alignment with other PMI levels and the value of the integration options matched the expected results from real-life cases. The sub-method allows responsible specialists to find the most suitable integration options in different post-merger contexts. The AMILP sub-method allows to analyze integration options from different perspectives and take into account the specifics of the concrete PMI initiative. However, the evaluation of the risk level criteria did not adapt to the specifics of the context as expected, and gave identical results in all cases, despite the degrees of importance of their individual risks. The risk level assessment formula needs to be reviewed and adjusted for better adaptation to the degree of importance and impact of the risk. The results of evaluations of other criteria should also be checked on a larger number of cases. No criteria weights were used in the sub-method simulation and their effects were not investigated. In addition, the limitation of the simulation was related to the fact that it was simulated by the sub-method author. The author of the sub-method could indirectly influence the results, as he knows the expected results. Introducing default evaluations for standard criteria value improved usability. Basically, it was not necessary to come up with own criteria, values, and evaluations, but just select relevant criteria values for the specific PMI initiative.

6.2 Experimental Evaluation

The results of the sub-methods were tested experimentally by comparing the results of the sub-methods execution for two groups of experiment participants: experts and specialists without expertise in the PMI IS integration. Each group consisted of 10 participants. Two selection criteria were applied to the sample of participants. The expert group included participants with experience in performing similar tasks in at least three PMI initiatives, while the group of specialists without expertise in PMI IS integration included participants without such experience. Participants were asked to rate their knowledge of PMI IS integration theory on a scale of 0 to 10, with 10 being the highest level of knowledge. The expert group included participants whose self-assessment was higher than 7, but the group of specialists without expertise in the PMI IS integration included participants with self-assessment lower than 5.

In order to minimize the influence of external factors, three additional decisions were made. The first decision: in order to remove the influence of knowledge limitations, as input data for the experiment, all participants were given only documented knowledge about the task and the context of the research case. The second decision made is to minimize the involvement of external stakeholders in the execution of the experimental task in order to minimize the possible influence of these persons on the results. The third decision – to minimize the effect of time constraints, all experiment participants were given the same time to complete the task. Based on the known information about how much time the experts needed to complete the task in the real PMI case, the corresponding time limit was set for each experiment.

The results for AMILI were compared using the following error values – identified IS error and grouped IS error. The identified IS error is calculated as the difference between the expected number of identified IS and the number of IS identified. This number includes incorrectly identified systems and unidentified expected systems. The grouped IS error is calculated as the difference between the total number of groups of ISs and the number of correctly grouped ISs. To evaluate this, correctly grouped IS were predefined.

The results of the AMILI experiment (Figure 17 and 18) show that, for specialists without expertise in PMI IS integration and without method support, both error values are greater than for experts. It can also be seen that with the support method, all error values decreased. Comparing the results of group members with each other using T-test, the difference between experts and specialists without expertise in the PMI IS integration without support method was observed only for the identified IS error, but not for the grouped IS error. With the support method, no difference was observed between the expert and the specialist without expertise in the PMI IS integration for both the identified IS error and the grouped IS error.

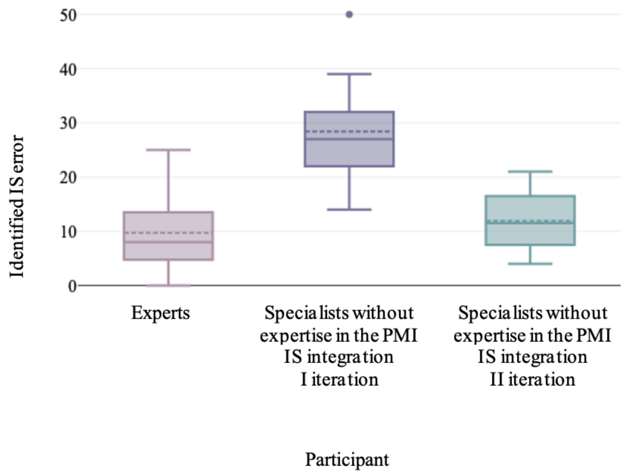

Figure 17. AMILI experiment results – identified IS error (relative)

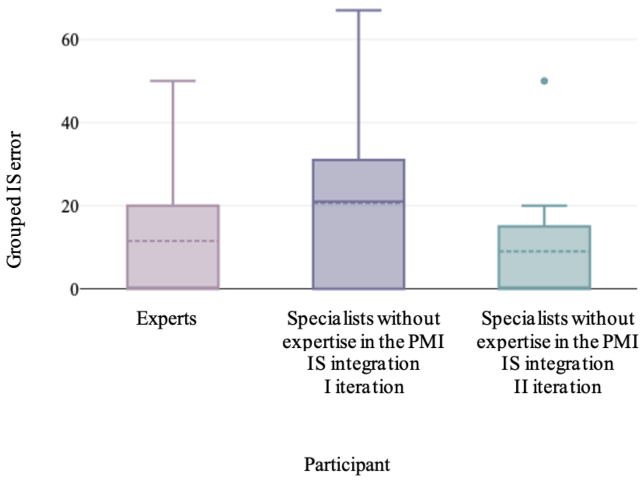

Figure 18. AMILI experiment results – grouped IS error (relative)

The results for AMILP were compared with each other according to IS integration recommendation error, which was defined based on the rank of the expected IS integration option in the recommendation. The results of the AMILP experiment (Figure 19–21) show that specialists without expertise in PMI IS integration and without the method support have higher IS integration recommendation error than experts in all three cases. It can also be seen that with the method support, the error value decreases. Comparing the results of the group members with each other with the help of T-test, without the method support, in two out of three cases, a difference was observed between the expert and the specialist without expertise in the PMI IS integration. However, with the method support in all three cases, the difference between an expert and a specialist without expertise in the PMI IS integration was not observed.

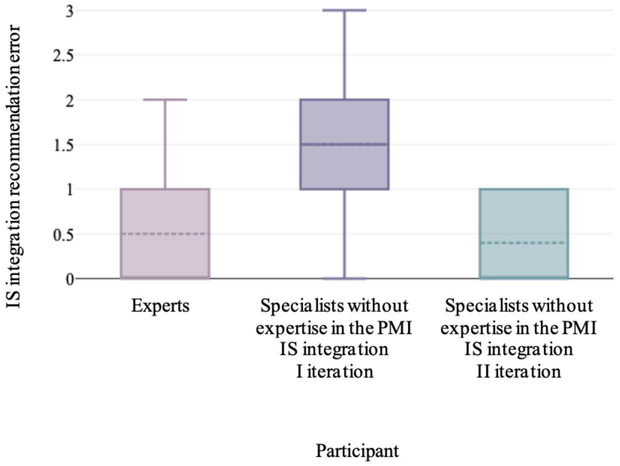

Figure 19. AMILP experiment results – IS integration recommendation error (I case)

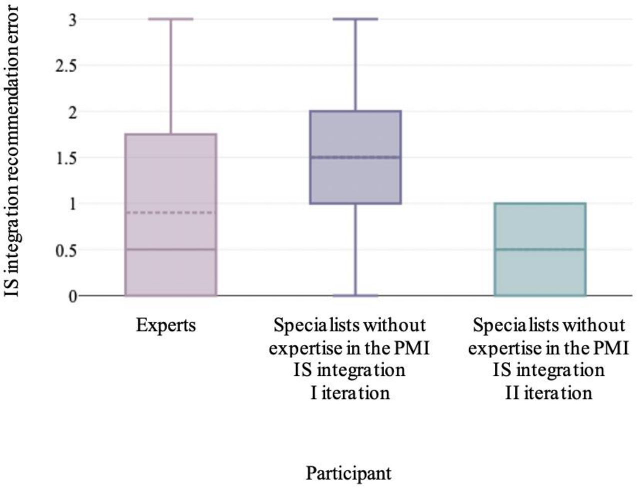

Figure 20. AMILP experiment results – IS integration recommendation error (II case)

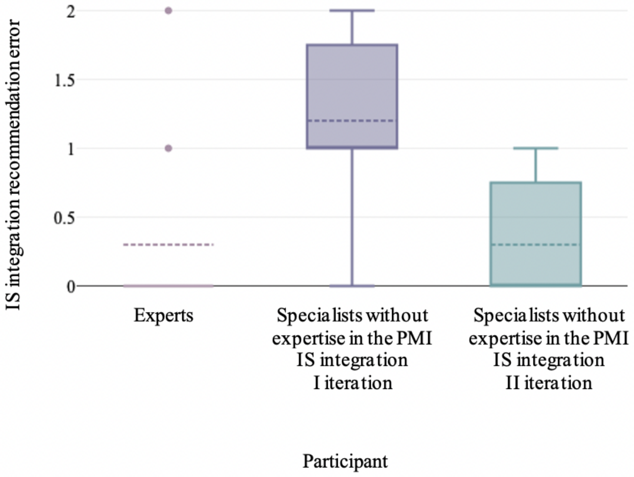

Figure 21. AMILP experiment results – IS integration recommendation error (III case)

6.3 Usability Evaluation

In addition to testing the results of sub-method usage, its usability was also evaluated. The usability of the sub-methods was evaluated according to three aspects—ease of learning, ease of use, and benefit from using a sub-method. The experiment participants were invited to evaluate the usability of the sub-methods immediately after using the sub-method and its tool within the experiment. The evaluations were given as the individual opinions of the participants in the survey questionnaire, evaluating each of the aspects on a scale from 1 to 5, where 5 is the highest positive value. In addition, participants were invited to provide suggestions for improvements to the sub-method in free text form.

For the AMILI sub-method, the benefit of using the sub-method is rated as 4.5 out of 5. This confirms that professionals value the sub-method's support for the task. Ease of use is rated 3.6 out of 5, and ease of learning is rated 3 out of 5. Overall, the rating is above average, but there is a room for improvement. Among the recommendations for improving the sub-method, the part of easier learning was mostly mentioned—long instructions and processes described in the text format with several steps are difficult to understand. Before using the sub-method in real projects, it would be useful to simulate the sub-method for test cases in order to learn the sub-method in practice. For the AMILP sub-method, the benefit of using the sub-method is rated as 4.5 out of 5. The support of this sub-method is also appreciated by specialists. Ease of use is rated 3.1 out of 5, but the ease of learning is only 2 out of 5. Ease of learning and use definitely need improvement. Identical to the AMILI sub-method, many of the recommendations were related to minimizing the reading of long and complex instructional texts, as well as adding more illustrative examples. The specificity of the experiment was related to the non-involvement of stakeholders in the process, which is why several comments were related to the context of the experiment - the difficulties to provide required information without the involvement of stakeholders. Several comments were also related to the terminology used in the sub-method and the need to explain it more, including reminding the importance of different integration options during the execution of the sub-method.

7 Conclusions

In this article, the problem of managing the complexity of the PMI IS integration decision-making is explored and the concept of a support method for decision-making in PMI IS integration is proposed which prescribes several components for compensating common lack of expertise in PMI projects. The following expertise compensation components are discussed and elaborated:

- a decision-making process model is proposed for the standard decision-making process,
- a decision-making information model is proposed for investigating the context,
- for the application of experience, it is proposed to extend both process and information models with knowledge management elements.

Two sub-methods were implemented, focused respectively on the identification of necessary decisions (AMILI sub-method) and decision-making as a choice between possible integration options (AMILP sub-method). These sub-methods use existing research results in RE, EA, MCDM and KM adjusted and applied to the context of PMI IS integration. The support tool has been developed for each of the sub-methods. Both sub-methods and support tools can be used in practice to provide help to specialists without expertise in the context of PMI IS integration. Sub-methods and tools can be used to compensate for the lack of expertise of specialists involved in both the organization's first and regular M&A initiatives.

The obtained results allow us to state that with the support method, specialists without expertise can achieve results comparable to the results of experts in the identification of groups of IS to be integrated (identification of decisions) and analysis of integration options (decision-making). Experiments showed that the method can have a positive effect not only on the results of professionals who are inexperienced in M&A, but also on the results of experts. The effect of the method on the results of the experts is a prospective question for further research.

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Appendix – Links to Additional Resources

Table: AMILI tool's components

Tool component	Link
Tool file storage	https://drive.google.com/drive/folders/17wWOZe9NRfYiG3HnteACt0HEhBQtXJQU?usp=share_link
Tool template	https://docs.google.com/spreadsheets/d/1wyXP_35mVAAgyJcwORgoNR_Zw9-N36jn1SeAkvPzOH4/edit?usp=share_link
Tool usage example (filled in template)	https://docs.google.com/spreadsheets/d/1Ys3OHfSlvnF7XY5dJMMppSZQDlO3kBWbXRFWGHp0wvk/edit?usp=share_link
Tool training materials	https://drive.google.com/drive/folders/1iAdLOovrg5_4u1CDCB6x8y7UjQ1eG5aL?usp=share_link

Table: AMILP tool's components

Tool component	Link
Tool file storage	https://drive.google.com/drive/folders/17wWOZe9NRfYiG3HnteACt0HEhBQtXJQU?usp=share_link
Tool template	https://docs.google.com/spreadsheets/d/19B-xoY_wGyi9fVirgtngs4bPrS8VnFpNzrb74x_D_Sg/edit?usp=share_link
Tool usage example (filled in template)	https://docs.google.com/spreadsheets/d/14aBtqQNJqb3QbzxxVEG2c1OBvrP9VsHB7TbuXxldvSA/edit?usp=share_link
Tool training materials	https://drive.google.com/drive/folders/1gtq_83taihN9y3_43Ezywvo4MVWJ5aUF?usp=share_link

Table: AMILI and AMILP simulation results

Simulation subject	Link
AMILI	https://docs.google.com/spreadsheets/d/1y0wQbmqRpYLTEd429-LRAKK2cT7BzPpkhsOb5xlLTy8/edit?usp=share_link
AMILP - I case	https://docs.google.com/spreadsheets/d/1rehroPhcreOQR4a2-IHuN07R3Ur0nDMUcSOli2cetDs/edit?usp=share_link
AMILP - II case	https://docs.google.com/spreadsheets/d/1lKNNQ8gDzxL78e_mw64_nwmYKzTpE3DzY6fNWpfv_LA/edit?usp=share_link
AMILP - III case	https://docs.google.com/spreadsheets/d/1rQvfWUtOWCwU8KfHNeoAeOA1Oh4KEJLasRonuB_ei0E/edit?usp=share_link

Table: AMILI experiment materials

Experiment phase	Artefact	Link
I	Task description	Part of case and survey
I un II	Case description	https://docs.google.com/document/d/11FYBaRdWieg-gfyzpJOjb4AxFpK20UC-/edit?usp=share_link&ouid=101257216006971850556&rtpof=true&sd=true
I	Survey	Survey: https://userbit.com/external/pzXRcIVkWHiY6BPmUMlu/cardsort/APe8u7NlcXyiUkDLThIf
II	Task description	Part of case and survey
II	Tool template for each participant	Tool template: https://docs.google.com/spreadsheets/d/1itDkUCAk5pHs3at0LKlRqce5gC_0p5hMe7ksIabqO0w/edit?usp=share_link

Table: AMILP experiment materials

Experiment phase	Artefact	Link
I	Task description	Part of survey
I un II	Survey	Survey: https://forms.office.com/r/tz4ixCkPuD
II	Task description	Part of tool template and survey:
II	Tool template for each participant	Tool template for I case: https://docs.google.com/spreadsheets/d/1h4aJlauTHvv56Ocw8p1Sv6955HBfsCt_Jl7nryYWGfs/edit?usp=share_link Tool template for II case: https://docs.google.com/spreadsheets/d/1dz94n0jIkbZ_laekbO6SgHHllAuB2BzlFegVPpJOK3k/edit?usp=share_link Tool template for III case: https://docs.google.com/spreadsheets/d/1dz94n0jIkbZ_laekbO6SgHHllAuB2BzlFegVPpJOK3k/edit?usp=share_link