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Selecting Requirements Documentation Techniques for Software Projects: a Survey Study

Aleksander Jarzębowicz, Katarzyna Połocka
Department of Software Engineering, Faculty of Electronics, Telecommunications and Informatics,
Gdańsk University of Technology, Gdańsk, Poland
Email: olek@eti.pg.gda.pl, k.polocka@gmail.com

***Abstract*—A significant number of techniques dedicated to requirements specification and documentation is described in the available sources. As there is no purpose to use all of them, a selection has to be made, taking into consideration the context of a given software project, for example its size, usage of agile approach or stakeholders' technical competency. This paper is intended to provide guidelines for such selection. We reviewed several sources (mainly industrial standards) to identify the general approach to requirements specification and specific techniques they recommend for this purpose. We also proposed a set of attributes describing project's context. Then, we conducted a survey study involving 42 Polish IT industry professionals, asking them to select techniques applicable to different projects. The survey was followed by two interviews with exerienced business analysts to interpret its results. The main contribution of the paper are selection recommendations based on results of survey and interviews.**

I. Introduction

Requirements Engineering (RE) is a part of the overall development process, which relies on interacting with customer representatives and other stakeholders and results in defining and maintaining system/software requirements. RE comprises of several activities, including discovering, eliciting, developing, analyzing, determining verification methods, validating, communicating, documenting, and managing requirements [1].

In recent years, a term of Business Analysis (BA) emerged, which is defined as the practice of enabling change in an enterprise by defining needs and recommending solutions that deliver value to stakeholders [2]. In case of software projects, it can be said, that RE is a part of BA, as the scope of BA is wider and includes activities focusing on financial and organizational issues affecting the customer.

Regardless of the names and definitions accepted, RE and BA are considered to be among most important areas of any software project, as they provide basis for all further activities and failures/omissions in this area result in serious problems affecting the overall development process and project outcome [3]-[5]. The significance of RE/BA resulted in publishing a significant number of sources describing processes and recommended practices. Such sources include international norms ([1], [6], [7]), industrial standards ([2], [8]-[10]) and books ([4], [11]).

The practices recommended include techniques to be used for particular activities e.g. elicitation or specification of requirements. A notable observation can be made, that despite the fact RE/BA has a long tradition and is considered to be a more disciplined ("heavier") process, the influence of lean and agile approaches is becoming visible. Several titles known for years as established sources of information on RE/BA, in their more recent editions/revisions list techniques adopted from Agile methodologies (e.g. user stories, backlog management, on-site customer representative) [2], [4].

The number of RE/BA techniques listed in the sources mentioned above, as well as others, is very significant. The intent is usually to describe the tools available to business analysts, system analysts or other professionals responsible for RE/BA and to leave the choice up to them. To some extent, several complementary techniques can be used together e.g. different requirements specification techniques cover static, process or user interface aspects of the developed system. In general, however, techniques are usually at least partially redundant and a selection is necessary. Such selection should take into consideration the context of a given software project e.g. team size or development methodology.

In the research reported in this paper we focused on techniques dedicated to requirements specification and documentation, leaving out techniques used in other RE/BA activities (elicitation, validation, management etc.). We intended to provide a guidance on selection of such techniques in various project contexts. We also wished to include (among others) the specifics of agile projects to determine applicable specification techniques. Our general approach was to utilize the experience of business analysts (and other IT professionals working with requirements) for this purpose. The main research method was a Web-based survey study, additionally we interviewed two experienced business analysts to validate the study, as well as to analyze and further interpret the results.

The remainder of the paper is structured as follows: in Section II we describe the related work on applicability of RE/BA techniques and related practices to specific projects, tasks or purposes. Section III provides a background on requirements specification and documentation definitions in the available standards. The next Section IV describes our

preparatory research activities: first a set of requirements documentation techniques is selected for further consideration, next a list of attributes determining project's context is proposed. Section V presents the survey study conducted and its results. In Section VI we describe how the results were validated through follow-up discussions with the interviewed business analysts. Section VII concludes the paper with discussion of the findings and limitations of our study.

II. Related Work

The main group of related research is focused on selection of RE/BA techniques for a particular purpose or evaluation of such techniques with respect to their applicability.

The only work specifically focusing on requirements documentation techniques is reported in [12], where 8 such techniques were evaluated (by the authors) with respect to their potential expressed by inherent characteristics e.g. availability of graphical representation, ability to represent requirements' priorities, independence from a specific development methodology.

A wider study covering techniques from all RE/BA areas (including requirements documentation) is described by Jiang et al. [13]. They propose attributes to assess each technique's potential, a set of characteristics describing software projects and rules for selecting techniques in different contexts. It is a complex and mature approach, however documentation techniques considered by them differ significantly from those recommended in current standards, as they use e.g. formal notations like Z or more general methodologies like object-oriented analysis.

Hickey and Davis [14] conducted interviews with known software engineering experts, about applicability of RE/BA techniques for a number of hypothetical cases of software project contexts. Their study however considered requirements elicitation techniques only.

Also, several other papers on evaluation of RE/BA techniques with respect to their characteristics (e.g. abstraction level, effort, required skills), are available. They however focus on techniques from other areas, mostly requirements elicitation [15]-[17], but also analysis [18] or validation [19].

As we intended to cover some aspects of lean and agile development by e.g. considering projects involving smaller teams, following an agile methodology etc., the other area of related work concerns the application of RE/BA techniques and related practices to agile projects.

An initial assessment of RE/BA techniques to agile projects is described in [20]. Empirical analyses on usage of particular agile requirements practices in the industry, as well as related benefits and problems, were reported in [21]-[23]. A literature review based summary of agile requirement approaches (extracted from more general papers on agile practices) is presented in [24]. According to our knowledge, no work dedicated to systematic investigation on application of various requirements documentation techniques in agile development was published.

III. Background

We use the terms of requirements specification and requirements documentation interchangeably and understand them as writing down the requirements using a suitable representation to capture their essentials. The terms however are not so obvious, considering the differences between standards. In this section we summarize how this aspect is described in norms and industrial standards. A summary of terms used by different standards is shown in Table I.

Table I.
Summary of terms used in standards

Term	ISO/ IEEE	BABOK	REQB	IREB	PMI Guide
Documentation				X	X
Analysis	X	X	X		X
Specification	X	X	X		
Modelling		X	X	X	X

The main international norm on requirements engineering is ISO/IEC/IEEE 29148 [1]. It superseded earlier documents [6] and [7], which however are still referenced by current industrial standards (e.g. [8]). These sources recognize the need of unambiguous requirements specification, but do not provide the detailed definition of specifying/documenting requirements activity. Instead, they provide the contents of system/software requirements specification documents.

Business Analysis Body of Knowledge Guide (BABOK) [2] defines a "Specify and Model Requirements" task, included in "Requirements Analysis and Design Definition" (one of six main areas listed in this standard). It therefore does not distinguish between specifying and modelling.

Requirements Engineering Qualifications Board syllabus (REQB) [8] lists "Requirements Specification" as one of main RE sub-processes, which concerns both requirements representation (as diagrams, user stories etc.) and contents of System Requirements Specification document. The available notations and forms of representing requirements are however described more thoroughly in "Solution Modelling" section, being part of "Requirements Analysis" process.

International Requirements Engineering Board syllabus (IREB) [9] introduces "Requirements Documentation" as one of four main RE activities. It also distinguishes "Model-based Documentation of Requirements", where several modelling techniques are listed.

"Business Analysis for Practitioners. A Practice Guide" issued by Project Management Institute (PMI Guide) [10] in turn defines a major activity of "Requirements Elicitation and Analysis", which includes (among others) the documentation-related tasks: "Model and Refine Requirements" and "Document Solution Requirements".

TABLE II.
REQUIREMENTS DOCUMENTATION TECHNIQUES IN BABOK AND PMI GUIDE

#	Technique name (and alternative names)	BABOK	PMI Guide
1	Business Rules Analysis (Business Rules Catalog)	+ (10.9)	+ (4.10.9.1)
2	Data Dictionary	+ (10.12)	+ (4.10.10.3)
3	Data Flow Diagrams	+ (10.13)	+ (4.10.10.2)
4	Data Modelling (Entity Relationship Diagram)	+ (10.15)	+ (4.10.10.1)
5	Decision Modelling (Decision Table, Decision Tree)	+ (10.17)	+ (4.10.9.2)
6	Functional Decomposition (Decomposition Model)	+ (10.22)	+ (3.5.2.2)
7	Interface Analysis (System Interface Table, User Interface Flow)	+ (10.24)	+ (4.10.11.2, 4.10.11.3)
8	Organizational Modelling (Organizational Chart)	+ (10.32)	+ (3.3.1.2)
9	Process Modelling (Process Flow)	+ (10.35)	+ (4.10.8.1)
10	Prototyping (Wireframes, Display Action Response)	+ (10.36)	+ (4.10.11.4)
11	Root Cause Analysis (Fishbone Diagram)	+ (10.40)	+ (2.4.4.2)
12	Scope Modelling (Context Diagram)	+ (10.41)	+ (4.10.7.3)
13	State Modelling (State Table, State Diagram)	+ (10.44)	+ (4.10.10.4)
14	Use Cases and Scenarios (Use Case Diagram, Use Case)	+ (10.47)	+ (4.10.7.5, 4.10.8.2)
15	User Stories	+ (10.48)	+ (4.10.8.3)
16	Acceptance and Evaluation Criteria	+ (10.1)	
17	Business Capability Analysis	+ (10.6)	
18	Business Model Canvas	+ (10.8)	
19	Concept Modelling	+ (10.11)	
20	Glossary	+ (10.23)	
21	Non-Functional Requirements Analysis	+ (10.30)	
22	Roles and Permissions Matrix	+ (10.39)	
23	Sequence Diagrams	+ (10.42)	
24	Stakeholder List, Map or Personas	+ (10.43)	
25	Ecosystem Map		+ (4.10.7.2)
26	Feature Model		+ (4.10.7.4)
27	Goal and Business Objectives Model		+ (4.10.7.1)
28	Interrelationship Diagram		+ (2.4.4.2)
29	Report Table		+ (4.10.11.1)
30	SWOT Diagram		+ (2.4.2)

Also, “Analyze Requirements” task explicitly refers to selecting a suitable requirements representation/model to work with.

IV. PREPARATORY RESEARCH ACTIVITIES

In this section we describe preparatory steps necessary to conduct the survey study. Preparation included two main activities: analyzing the available sources to extract particular requirements documentation techniques and

defining the attributes which characterize the context of software projects.

A. Requirements Documentation Techniques

International norms (ISO/IEC/IEEE 29148, IEEE 830, IEEE 1233) provide guidance on RE/BA processes and contents of system/software requirements specification documents, but not on particular RE/BA techniques (in fact techniques are rarely mentioned and only as examples). We therefore turned to industrial standards mentioned in Section III. Due to limited resources, we decided to use BABOK and PMI Guide to identify state of the art techniques of requirements documentation. REQB and IREB proved to be much more difficult to use. The initial review of their contents revealed that techniques are not explicitly listed (the whole text would have to be carefully scanned) and their descriptions are rather brief (if any at all – many techniques are only mentioned, not described).

The analysis of the contents of two sources: BABOK and PMI Guide resulted in identifying 30 requirements documentation techniques, together with their definitions/ descriptions. Table II provides a summary of our findings, including references to the relevant sections of sources. Despite the fact that these two sources often use different names and sometimes include different variants of similar techniques, it was possible to match 15 out of 30 techniques as common to both sources. Short descriptions of these 15 techniques are given below, for more details and for definitions of the remaining techniques, the readers of this paper are directed to the source documents.

- Business Rules Analysis – A business rule is a specific, testable directive that serves as a criterion for guiding behaviour, shaping judgments, or making decisions [2]. Business rules analysis is used to identify, express, validate, refine, and organize the rules that shape day-to-day business behaviour and guide operational business decision making [2]. Business rules can be organized into catalogues which describe each rule using e.g. a unique ID, its type/category, description and references to related documents [10].
- Data Dictionary - A data dictionary is used to standardize a definition of a data element and enable a common interpretation of data elements between stakeholders [2]. A data element can be described e.g. by name, aliases, description, allowable values, validation rules [2], [10].
- Data Flow Diagrams - A data flow diagram illustrates the movement and transformation of data between externals (entities) and processes [2]. It identifies data inputs and outputs for processes, but does not specify the timing or sequence of operations [10]. It also includes the temporary or permanent repositories within a system or an organization (named data stores or terminators) [2].
- Data Modelling - A data model describes the entities, classes or data objects relevant to a domain, the attributes that are used to describe them, and the relationships among them [2]. It usually takes the form of a diagram that is supported by textual descriptions [2]. Entity Relationship Diagram can be specifically used for data modelling purposes [10].
- Decision Modelling - Decision models show how data and knowledge are combined to make a specific decision (straightforward or complex) [2]. Straightforward decision models use a single decision table or decision tree to show how a set of business rules that operate on a common set of data elements combine to create a decision, while complex decision models break down decisions into their individual components [2], [10].
- Functional Decomposition - Functional decomposition helps manage complexity and reduce uncertainty by breaking down complex systems and concepts into their simpler constituent parts and allowing each part to be analyzed independently [2]. This technique can be applied to decompose e.g. processes, systems, functional areas, organizational units, work products [2], [10].
- Interface Analysis - Interface analysis is used to identify where, what, why, when, how, and for whom information is exchanged between solution components or across solution boundaries [2]. An interface under consideration can be a user interface for humans interacting with software/hardware but also an interface between IT systems or processes [2]. System interface tables and report tables are more concrete tools for this purpose [10].
- Organizational Modelling - An organizational model is a visual representation which defines how an organization or organizational unit is structured [2]. It should describe the boundaries of the unit, the formal relationships between members (who reports to whom), the functional role for each person, and the interfaces (interaction and dependencies) between the unit and other units or stakeholders [2].
- Process Modelling - Process models describe the sequential flow of work or activities. Models can depict business processes (flow of task and activities within an enterprise) or system processes (control flow within an IT system) [2], [10]. Process models include activities, events, participants and decisions points [2], [10].
- Prototyping – A prototype is a representation of a system used to validate elicited requirements and to identify missing or incorrect requirements [2], [10]. Prototypes can be non-working models, working representations, or digital depictions of a proposed

solution. Various types of prototypes exist e.g. user interface drawings, mock up websites, partially working constructs of the system [2].

- Root Cause Analysis - Root cause analysis is used to identify and evaluate the underlying causes of a problem (or an opportunity) [2], [10]. It applies an iterative analysis approach in order to take into account that there might be more than one root cause contributing to the effects [2]. Specialized approaches like Fishbone Diagram or Five Whys are used to guide such analysis [2], [10].
- Scope Modelling - Scope models define the nature of one or more boundaries and place elements inside or outside those boundaries [2]. Scope models are typically represented as a combination of diagrams, matrices and textual explanations [2]. The name of context diagram is also used instead of scope model [10].
- State Modelling - State modelling is used to describe and analyze the different possible states of an object, allowed transitions from one state to another and internal activities within a given state [2], [10]. State diagrams and state tables are used to express such aspects [2], [10].
- Use Cases and Scenarios – They describe how a person or system (so called actor) interacts with the solution being modelled to achieve a goal [2]. Scenarios are written using a structured text as a series of steps performed by actors or by the solution [2], [10]. A use case usually describes several scenarios [2], [10]. A use case diagram can also be used to visualize relationships between use cases or use cases and actors [2], [10].
- User Stories - A user story represents a small, concise statement of functionality needed to deliver value to a specific stakeholder [2], [10]. A typical format of a user story is “As an <actor>, I want to be able to <function> , so that I can <business reason>” [10].

We made a decision to restrict the survey only to such common techniques (rows 1-15 in Table II). The reason was to keep the scope of the survey realistic. Our earlier experiences clearly indicate that it is difficult to find respondents to a survey with numerous and/or complicated questions and even more difficult to prevent them from dropping out before completion.

B. Attributes of software projects

Our aim was to prepare a list of attributes describing the context/situation of software projects. We intended the list to be short, in order to limit the number of questions in the survey. This approach was different if compared to e.g. [13], where 21 project attributes (each one with several possible values or ranges of values) were defined. Also, we wished to consider software projects from business analyst's point of view and focus on issues essential to RE/BA activities, not software development or project management in general.

We reviewed several sources which proposed software project attributes or classifications of projects [4], [25]-[27] and used them as ideas to develop our proposals. The resulting list of attributes was:

- Development methodology used in project;
- Time available for RE/BA activities;
- Size of the team responsible for RE/BA;
- Level of quality expectations;
- Technical competence of stakeholders;
- Availability of stakeholders;

Please note that some attributes refer to the general constraints of the project (e.g. development methodology, quality expectations), but the others are narrowed down to RE/BA activities (e.g. time available for RE/BA instead of project's duration time or size of business analysts' team instead of project team size). The reason is that we considered such factors as more important for selection of RE/BA techniques.

V. Survey Study

A. Questionnaire development

Both sets obtained during preparation activities (i.e. the set of documentation techniques and the set of project attributes) were used to design survey questionnaire. In each question respondents were supposed to select documentation techniques, which they regarded as suitable for a given situation. As mentioned before, we intended to avoid complicated questions, so we derived those situations from project attributes by assigning specific values to attributes. For example, considering attribute “Development methodology used in project”, we decided to use two values: “Agile methodology” and “Formal, plan-driven methodology” (which does not have to be waterfall approach, but generally a “heavier” documentation-based process). Consequently, two separate questions about techniques applicable to projects using each of methodologies were included in the questionnaire.

In general, each question was phrased like “Which requirements documentation techniques would you use in the following situation: …?” and referred to 12 situations of software projects:

- A project developed according to an agile methodology (*Agile Meth.*);
- A project developed according to a more formal, plan-driven methodology (*Formal Meth.*);
- Enough time for business analysis in a project (*More Time*);
- Time available for business analysis is short compared to anticipated scope (*Less Time*);
- A larger team (more than 3 persons) of business analysts (*Larger Team*);

- A smaller team (up to 3 persons) of business analysts (*Smaller Team*);
- High level of product quality expectations (with respect to e.g. reliability or ergonomy) (*Quality*);
- Stakeholders with high technical skills/competence (*High Skills*);
- Stakeholders with low technical skills/competence (*Low Skills*);
- Good availability of stakeholders, who can dedicate their time to the project (*Good Avail.*);
- Low availability of stakeholders, who can spare little time to the project (*Low Avail.*);
- Survey participant's free choice - if he/she was able to choose techniques according to his/her own preferences (*Own Pref.*).

Expressions in parentheses are identifiers of questions. They are used in the remainder of this text when referring to questions, especially in tables and figures.

It can easily be spotted that for each of project's attributes two situations were defined. The only exception is "Level of quality expectations" - we only asked about a situation of high expectations (e.g. high integrity systems). An additional question about respondent's preferences regarding documentation techniques was included instead, as we expected that such factor can influence answers to other questions.

Our target group of survey participants were IT professionals from Polish industry (business analysts and others involved in RE/BA activities). We did not decide to expand the study to include professionals from other countries, because of anticipated problems of reaching out to them. The language used in questionnaire was Polish, all questions and answers cited in this paper are translations.

A questionnaire was prepared using a web-based Typeform tool. It was divided into two parts: the first gathered context information about survey participant's background (age, gender, job position, experience in RE/BA), in the second part questions about selection of requirements documentation techniques for various situations were included.

Each question about techniques' selection was a multiple choice question. Survey participant was allowed to choose any number of techniques he/she considered applicable in a given context (including none or all of them). 15 techniques (see Section IV.A) were available as possible answers. The participant was also able to choose "Other techniques" option and enter technique(s) in addition to the ones selected among the predefined ones. The design of the questionnaire ensured that possible answers were displayed in randomized order. The reason was to stimulate more awareness of survey participants and reduce mechanical answers. The survey was anonymous, but optionally a participant could enter his/her e-mail address to receive summary survey results.

The questionnaire was verified in a pilot survey involving 3 test participants of different background (junior analyst, senior analyst, product manager). Their feedback (e.g. concerns about clarity of some questions) was used to improve questionnaire contents. The full scale survey was delayed until all 3 test participants approved the modified questionnaire.

TABLE III.
SURVEY RESULT SUMMARY – SELECTIONS OF DOCUMENTATION TECHNIQUES FOR PARTICULAR PROJECT CONTEXTS

	Agile Meth.	Formal Meth.	More Time	Less Time	Larger Team	Smaller Team	Quality	High Skills	Low Skills	Good Avail.	Low Avail.	Own Pref.
Business Rules Analysis	11	29	36	5	28	12	28	15	13	26	6	12
Data Dictionary	12	26	28	7	23	13	17	18	15	21	8	14
Data Flow Diagrams	4	30	26	4	21	10	16	23	4	17	4	9
Data Modelling	6	25	25	4	25	6	16	25	3	18	3	10
Decision Modelling	3	20	22	1	17	6	13	14	2	20	1	5
Functional Decomposition	12	19	23	7	24	10	14	19	8	23	6	6
Interface Analysis	17	20	28	8	21	11	28	13	13	19	3	15
Organizational Modelling	3	22	25	2	23	5	12	8	6	24	0	6
Process Modelling	24	32	30	6	30	19	26	21	17	30	13	15
Prototyping	30	20	26	20	25	22	27	15	36	22	29	31
Root Cause Analysis	6	15	24	5	20	7	18	9	10	21	6	8
Scope Modelling	11	22	22	4	27	7	14	14	5	19	6	9
State Modelling	8	22	25	1	17	3	15	16	3	14	2	8
Use Cases and Scenarios	30	29	32	28	28	34	29	21	25	29	23	32
User Stories	38	7	18	34	16	29	16	9	35	16	26	4

B. *Survey study and its results*

We started the survey by publishing the questionnaire in the Internet and inviting participants. We invited them using personal contacts, direct mailing and online discussion groups dedicated to business analysis topics.

Answers were collected during an approximately two-month period. In total 42 persons participated in the survey. Most of them (25) were employed as analysts (business analyst, system analyst, IT analyst – different names of job positions were declared). Other most frequent job positions included managers, developers, consultants and testers.

Table III presents summary results of the survey. Its rows represent documentation techniques, while columns represent questions about particular situations (using symbols introduced in Section V.A). Numbers in table cells indicate how many survey participants decided to select a given technique in a given context.

As there were very few cases when "Other techniques" were suggested by survey participants (literally 3: Story Maps for *Agile Meth.*, Enterprise Architecture Modelling for *Formal Meth.* and Glossary for *Low Avail.*), we do not present them in Table III nor include in further analysis.

We analyzed the answers for particular questions (table columns) to identify the most and least frequently selected techniques. We used quartiles for this purpose. Techniques from the first quartile (techniques among 25% of least selected) are highlighted using red color, while techniques from the third quartile (25% of most frequently selected) using green color. As the numbers of answers in columns differed (due to multiple choice questions used), the quartile values are significantly different as well.

A number of observations can be made with respect to survey results:

- In general, more techniques were selected for situations where business analysts are not restricted in their work (*More Time*, *Good Avail.*) or a need for a more documented approach is recognized (*Formal Meth.*, *Larger Team*). It is a rather intuitive and not surprising result.
- Quite surprisingly, Use Cases and Scenarios were frequently selected in literally all situations. The reason could be that this technique can be applied on different levels of detail - from structured, scenarios including detailed interaction steps, pre&post conditions, exceptions, alternatives etc. to simpler descriptions of user's goal and brief interaction summaries [28]. Also, such choice can stem from respondents' preferences, as this technique was the most preferred one (*Own. Pref.*).
- User Stories were selected for Agile contexts, both in terms of assumed methodology (*Agile Meth.*) and typical conditions (*Less Time*, *Smaller Team*). However, our participants recognized this technique more applicable in case of low stakeholders' availability (*Low Avail.*), while rather the opposite (*Good Avail.*) is assumed for Agile development (e.g. customer representative on site).
- The second preferable technique (Prototyping) was among the most frequently chosen ones for agile-like situations, but not for other contexts.
- Process Modelling was also declared as applicable in almost all contexts, with a clear exception for the situation of very limited time for BA (*Less Time*). As for high quality demands (*Quality*), it just narrowly did not make to the third quartile.
- Most of other techniques based on models and graphical notations were either not found applicable by survey participants (State Modelling) or found applicable only in limited number of situations (Data Flow Diagrams, Data Modelling, Organizational Modelling).
- Techniques based on causes and consequences analysis (Decision Modelling, Root Causes Analysis) were generally not considered usable by our respondents. A possible explanation is that such techniques are important for specific classes of systems (e.g. the cause and consequence analysis as input for risk estimation in case of high integrity systems), but not necessarily very popular outside such context.

The data from Table III can be processed and used to visualize applicability of techniques to a given situation. Examples are presented in Figures 1-7, the other graphs cannot be included here due to space limitations, but all of them are available in a report published on line [29]. The numbers in each figure indicate how many respondents selected a given technique for the context given in figure caption. Moreover, colors are used to visualize quartiles (1st - gray, 2nd - light blue, 3rd – dark blue).

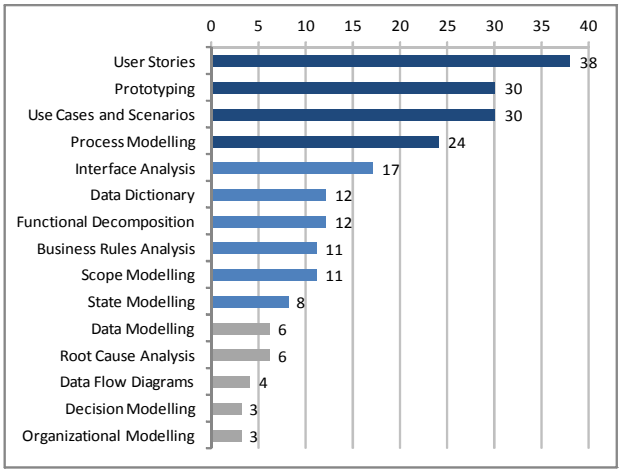

Fig. 1. Selection of techniques for Agile projects (*Agile Meth.*).

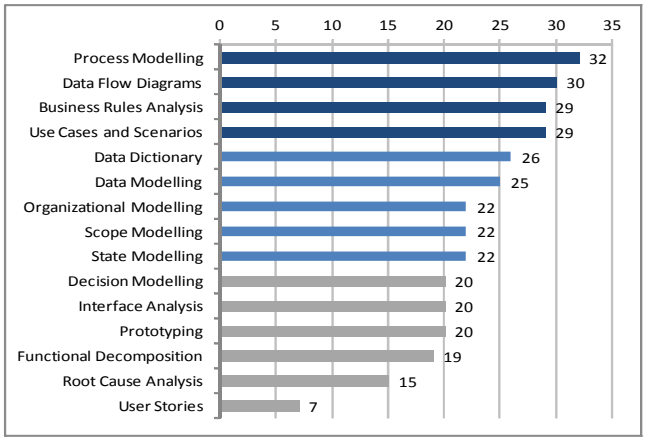

Fig. 2. Selection of techniques for formal, plan-driven projects (*Formal Meth.*).

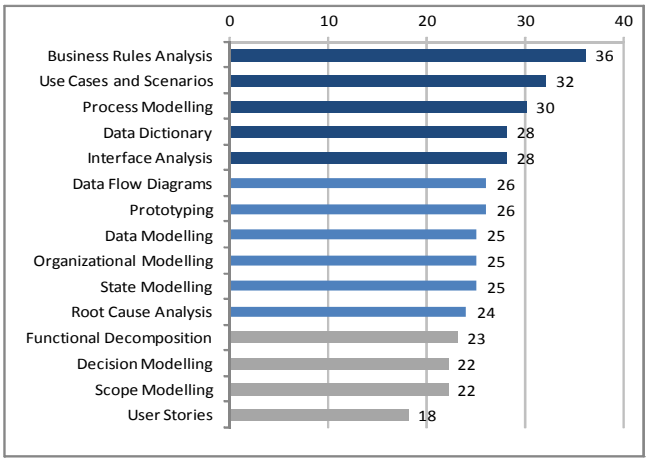

Fig. 3. Selection of techniques for projects with enough time for business analysis (*More time*).

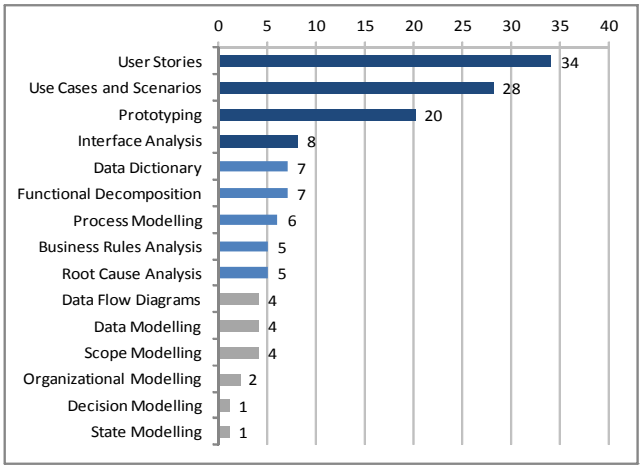

Fig. 4. Selection of techniques for projects with short time for business analysis (*Less Time*).

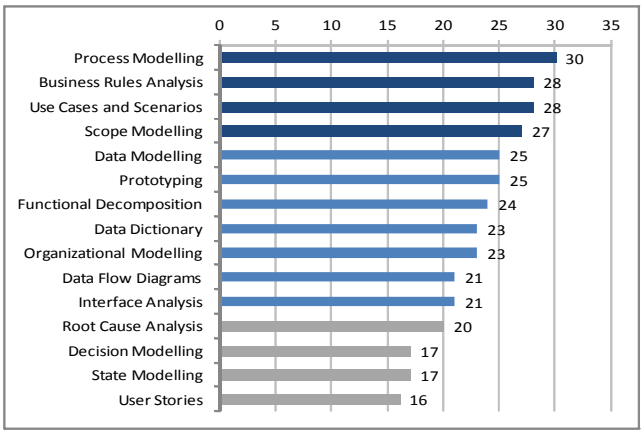

Fig. 5. Selection of techniques for projects with larger team of business analysts (*Larger Team*).

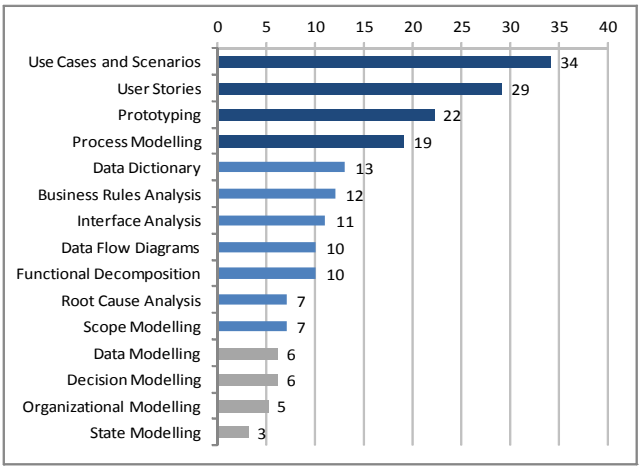

Fig. 6. Selection of techniques for projects with smaller team of business analysts (*Smaller Team*).

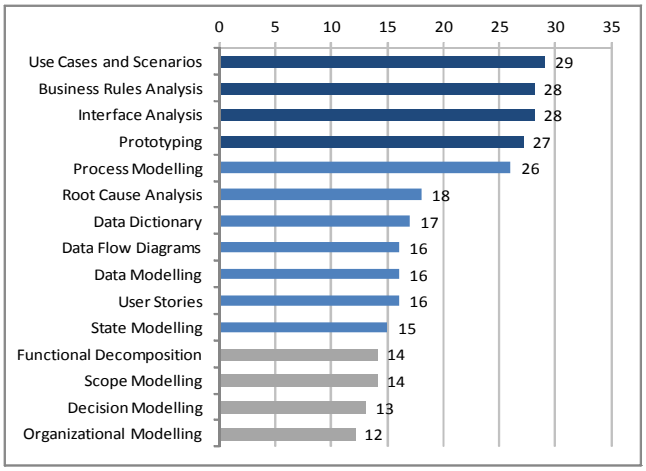

Fig. 7. Selection of techniques for projects with a high level of product quality expectations (*Quality*).

VI. Interviews

We planned interviews as a way to assess the validity of the survey study and its results. Moreover, we expected discussions leading to interpretation of results (especially more surprising ones). Validation interviews were conducted with two experienced business analysts, of the following background:

- Analyst 1 – 10 years of employment as business analyst in several software companies. Main experience in: business processes improvement and development of customer-tailored systems for various business domains, including: insurance, finances, courts of law, electronics and telemetry. Involved mainly in projects using plan-driven, formalized development methodology.
- Analyst 2 – 8 years as a business analyst, mainly in projects using agile methodologies. Main professional experience in: requirements elicitation, business process modelling and reengineering. Work history in: finances, e-commerce and transportation application domains.

Each interview was conducted in a separate and independent manner. Before each interview, a report summarizing survey results and analyses was sent to the interviewed analyst. The interviewees were asked to consider the following issues:

- Is the report comprehensible or does it contain any ambiguous fragments?
- Was the survey and analysis of its results conducted in correct and valid manner?
- Is the analysis of results complete or should the data be processed in different way?
- What further directions would be recommended in this research on documentation techniques?

It should be noted, that both analysts represented industry practitioner's point of view and provided answers from such perspective, not e.g. research methodologist's perspective. This was however intentional, as we wished to confront our research with the reality of IT industry and its needs.

Analysts 1 and 2 first provided their answers in writing, then face to face meetings with each one took place to discuss their opinions. Both analysts confirmed that they consider survey results as a useful source of information, providing possible support for techniques selection in real-life projects. Both of them however also stressed that survey results cannot be solely used as selection criteria, because there are more factors influencing such selection, which should be taken into consideration.

They had no concerns about survey validity and concluded that in general the results are consistent with their perception of techniques' applicability. There were however some exceptions, the greatest concern was about “Use Cases and Scenarios”, which (according to survey participants) was found applicable to all specified situations.

Analyst 2 suggested, that results could be biased by answers of inexperienced practitioners, who made their choices on the basis of their expectations rather than real experience and job history. To verify such possible explanation, additional analysis was conducted. As the raw data (exported by Typeform tool) included the necessary information (one of the introductory questions was about professional experience in RE/BA), we were able to divide answers into sets according to respondents' declared experience. Then, we used quartiles to identify most frequently selected techniques within each set. No particular differences were found for situations questioned by Analyst 2 between the answers of less (<2 years of experience in RE/BA) and more experienced (2-5 years, >5 years) survey participants.

No other concerns questioning validity were raised, the general feedback was positive and the outcome of the discussion consisted mostly of possible future research. Suggestions about the issues related to requirements documentation techniques that would be interesting to the interviewed analysts were included in our directions of future research (described in concluding Section VII).

VII. Conclusions

We conducted a survey study dedicated to the selection of requirements documentation techniques in different software project contexts and situations. The study was preceded by preparatory activities: we identified a number of techniques recommended by industrial standards and established a set of software project attributes, later used as a basis for defining project context/situations. The survey targeted practitioners from Polish IT industry (mainly business analysts) and was completed by 42 respondents. Its results were processed, analyzed and validated through interviews with two RE/BA experts. These results can be used to support business analysts who face the problem of techniques' selection for a specific project. The results cannot however be treated as the only possible criteria, disregarding any other factors.

The results can be used as guidance or practical tips for business analysts. If such analyst determines the context of his/her software project with respect to the methodology used, time available for analysis and other aspects described in Section IV.B, he/she can refer to Table III and/or more convenient visualizations (Figures 1-7, additional report [29]) to identify a set of techniques most suitable for such project. For example, in case of a plan-driven project with sufficient time and a small team of analysts, “Use cases and Scenarios” and “Process Modelling” would be recommended (1st quartile in each situation). The decision about using one or both techniques would have to be made by the business analyst, also taking into consideration: (1) project needs (e.g. are there complex business processes to understand and describe); (2) how redundant candidate techniques are.

Our study obviously had several limitations. Some of them are simply the effect of decisions made during study's design

– we restricted the number of documentation techniques, the number of project attributes and furthermore the number of situations derived by assigning particular values to such attributes. As result, none of these sets can be considered exhaustive i.e. covering all possible relevant options. The survey used a Web-based questionnaire and was intended to be anonymous (requiring personal data is problematic on legal grounds and a good way to discourage potential respondents), therefore we cannot have absolute certainty that our respondents provided true information about their background. Also, we cannot be sure that the surveyed group is representative in the context of Polish IT industry. As the survey was limited to one country only, its results cannot be simply generalized for European or worldwide software industry (even though IT industry in Poland is not significantly different compared to other European countries.

A number of directions for future research can be considered. A more complete identification of project attributes and their values can be attempted. We are aware that it is rather impossible to list all potential factors influencing business analyst's choices, but an effort can be made towards improving this aspect of our research. It is also possible to expand the set of documentation techniques (by including items 16-30 from Table II and/or techniques recommended by other sources). We do not find this direction very promising though – our survey participants could manually enter additional techniques they considered useful and only 3 such cases were found (for 42 respondents, each answering 12 questions). However, considering variants of already included techniques e.g. particular notations for Process Modelling or distinguishing between brief and detailed Use Cases could provide more insight. Another direction is an attempt to capture not only decisions about techniques selection, but also the rationale behind each such decision. It however would require a different kind of study, based on interviews rather than questionnaires. Moreover, a wider survey study, involving respondents from different countries can be conducted.

REFERENCES

[1] ISO/IEC/IEEE, "Systems and software engineering - Life cycle processes - Requirements engineering" ISO/IEC/IEE, Standard 29148-2011, 2011, https://doi.org/10.1109/ieeestd.2011.6146379

[2] International Institute of Business Analysis, "A guide to the business analysis body of knowledge (BABOK Guide)" ver. 3, 2015.

[3] R. N. Charette, "Why software fails", *IEEE Spectrum* vol. 42, no. 9, 2005, pp. 42-49, https://doi.org/10.1109/mspec.2005.1502528

[4] K. Wiegers, J. Beatty, "Software requirements", 3rd ed., Microsoft Press, 2013, ISBN: 978-0735679665.

[5] B. Davey, K. Parker, "Requirements elicitation problems: A literature analysis", *Issues in Informing Science and Information Technology*, vol. 12, 2015, pp. 71-82.

[6] IEEE, "IEEE Recommended Practice for Software Requirements Specifications", IEEE Standard 830-1998, 1998, https://doi.org/10.1109/ieeestd.1998.88286

[7] IEEE, "IEEE Guide for Developing System Requirements Specifications", IEEE Standard 1233-1998, 1998, https://doi.org/10.1109/ieeestd.1998.88826

[8] Requirements Engineering Qualifications Board, "REQB CPRE Foundation Level syllabus", ver 2.1, 2014.

[9] International Requirements Engineering Board, "IREB CPRE Foundation level syllabus", ver. 2.2, 2015.

[10] Project Management Institute, "Business analysis for practitioners. A practice guide", 2015.

[11] K. Pohl, "Requirements engineering: fundamentals, principles, and techniques", Springer Publishing Company, 2010, ISBN: 978-3-642-12577-5.

[12] M. dos Santos Soares, D. Cioquetta, "Analysis of techniques for documenting user requirements", In *Proc. of Computational Science and Its Applications (ICCSA 2012)*, 2012, pp. 16-28, https://doi.org/10.1007/978-3-642-31128-4_2

[13] L. Jiang, A. Eberlein, B. Far, M. Mousavi, "A methodology for the selection of requirements engineering techniques", *Software & Systems Modeling*, vol. 7, no. 3, 2008, pp. 303-328, https://doi.org/10.1007/s10270-007-0055-y

[14] A. M. Hickey, A. M. Davis, "Elicitation technique selection: how do experts do it?" In *Proc. IEEE 11th Requirements Engineering Conf.*, 2003, pp. 169-178, https://doi.org/10.1109/icre.2003.1232748

[15] L. O. Lobo, J. D. Arthur, "An objectives-driven process for selecting methods to support requirements engineering activities", In *Proc. 29th Annual IEEE/NASA Software Engineering Workshop*, 2005, pp. 118-130, https://doi.org/10.1109/sew.2005.18

[16] Z. Zhang, "Effective requirements development - A comparison of requirements elicitation techniques" In: *Software Quality Management XV: Software Quality in the Knowledge Society*, British Computer Society, 2007, pp. 225-240.

[17] S. Wellsandt, K. Hribernik, K. Thoben, "Qualitative comparison of requirements elicitation techniques that are used to collect feedback information about product use", In *Proc. 24th CIRP Design Conf.*, 2014, pp. 212-217, https://doi.org/10.1016/j.procir.2014.03.121

[18] M. Vestola, "A comparison of nine basic techniques for requirements prioritization", Helsinki University of Technology, 2010.

[19] H. Khan, I. Asghar, S. Ghayyur, M. Raza, "An empirical study of software requirements verification and validation techniques along their mitigation strategies" *Asian Journal of Computer and Information Systems*, vol. 3, no. 03, 2015.

[20] F. Paetsch, A. Eberlein, F. Maurer, "Requirements engineering and agile software development", In *Proc. 12th IEEE International Workshops on Enabling Technologies*, 2003, pp. 308-313, https://doi.org/10.1109/enabl.2003.1231428

[21] B. Ramesh, L. Cao, R. Baskerville, "Agile requirements engineering practices and challenges: an empirical study", *Information Systems Journal*, vol. 20, no. 5, 2007, pp. 449-480, https://doi.org/10.1111/j.1365-2575.2007.00259.x

[22] L. Cao, B. Ramesh, "Agile requirements engineering practices: An empirical study", *IEEE Software*, vol. 25, no. 1, 2008, pp. 60-67, https://doi.org/10.1109/ms.2008.1

[23] E. Bjarnason, K. Wnuk, B. Regnell, "A case study on benefits and side-effects of agile practices in large-scale requirements engineering", In *1st Workshop on Agile Requirements Engineering*, 2011, pp. 3:1-3:5, https://doi.org/10.1145/2068783.2068786

[24] I. Inayat, S. S. Salim, S. Marczak, M. Daneva, S. Shamshirband, "A systematic literature review on agile requirements engineering practices and challenges", *Computers in Human Behavior*, vol. 51, 2015, pp. 915-929, https://doi.org/10.1016/j.chb.2014.10.046

[25] D. Dvir, S. Lipovetsky, A. Shenhar, A. Tishler, "In search of project classification: a non-universal approach to project success factors", *Research Policy*, vol. 27, no. 9, 1998, pp. 915-935, https://doi.org/10.1016/s0048-7333(98)00085-7

[26] K. Frączkowski, A. Dabiński, M. Grzesiek, "Raport z Polskiego Badania Projektów IT 2010", 2011. [Online] Available: http://pmresearch.pl/wp-content/downloads/raport_pmresearchpl.pdf, [Accessed: May 9th 2017]

[27] V. Marinelli, P. A. Laplante, "Requirements engineering: the state of the practice revisited", Technical Report, Penn State University, 2008.

[28] A. Cockburn, "Writing effective use cases", Addison Wesley, 2000, ISBN: 978-0201702255.

[29] https://www.researchgate.net/publication/318207441_FedCSIS_LADS_Req_Documentation_Techniques_report (Survey study report)