This is a post-peer-review, pre-copyedit version of a paper presented at
20th KKIO Software Engineering Conference (September 28-29, 2018, Pułtusk, Poland)
and publication in
"Engineering Software Systems: Research and Praxis", Vol. 830 of the series Advances in Intelligent Systems and Computing, pp. 3-19,
Springer International Publishing,
Final authenticated version is available at: https://doi.org/10.1007/978-3-319-99617-2_1

What is Troubling IT Analysts? A Survey Report from Poland on Requirements-Related Problems

Aleksander Jarzębowicz ✉ [0000-0003-3181-4210] and Wojciech Ślesiński

Department of Software Engineering, Faculty of Electronics, Telecommunications and Informatics, Gdańsk University of Technology, Gdańsk, Poland
olek@eti.pg.edu.pl, slesinski.wojciech@gmail.com

Abstract. Requirements engineering and business analysis are activities considered to be important to software project success but also difficult and challenging. This paper reports on a survey conducted in Polish IT industry, aimed at identifying most widespread problems/challenges related to requirements. The survey was targeted at people performing role of analyst in commercial IT projects. The questionnaire included 64 pre-defined problems gathered from a literature review and a workshop involving a small group of analysts. It was completed by 55 respondents, each of whom assessed the frequency of occurrence for pre-defined problems and optionally could report additional problems based on their work experience. A ranking of most frequent problems is presented in this paper. Additional analyses for more specific contexts: agile projects and smaller/larger development teams are also provided. Final sections of the paper include comparison of our results and results of reported surveys conducted in other countries, followed by a discussion.

Keywords: Requirements Engineering, Business Analysis, Survey, Problems, Challenges, Analyst

1 Introduction

Requirements engineering (RE) is a part of software development process, which focuses on interaction with stakeholders and aims at defining and maintaining system/software requirements [1]. Another commonly used term is business analysis (BA), defined as a practice of enabling change in an enterprise by defining needs and recommending solutions that deliver value to stakeholders [2], which in case of software projects can be considered a wider area that encompasses RE. RE and BA are commonly regarded as important, but also difficult activities. As many software projects end up failed or challenged, causes contributing to such outcome are analyzed. Several analyses [3–6] reveal that problems related to RE/BA e.g. incomplete requirements, lack of user involvement or unrealistic goals/expectations are among main factors leading to project failures and other difficulties.

Dependencies between correctness and efficiency of requirements-related processes and software project outcomes are also confirmed by dedicated empirical research

studies e.g. influence of RE techniques, good practices and resources spent on outcomes such as stakeholders' satisfaction, quality of RE products and predictability of RE process [7], increase in productivity and quality observed as result of introducing improvements to RE processes [8], correlation between RE process maturity and project success factors (scope, schedule, budget and stakeholders' perception) [9].

All of above imply that RE/BA is an important topic which still needs new solutions and evaluation of their effectiveness. However, in order to provide a relevant solution, one needs to correctly identify the problem, which requires knowing the real picture of RE/BA in the IT industry. Such knowledge cannot be established on the basis of theoretical considerations, but has to be gathered from industry professionals involved in real-life software projects. In our case, if we intend our research to be useful to practitioners, then the most likely first recipient is the domestic IT industry.

Our aim was therefore to identify the most widespread and frequent problems affecting RE/BA activities encountered by analysts employed in Polish IT companies. At first glance, such problems are quite well known and can be found in virtually any book or course material on RE/BA. However, problems reported there are usually based on author's experience, rather than collected in systematic, scientific manner through surveys or field studies, which does not allow to generalize such results. When it comes to scientific papers on RE/BA problems, only a few sources can be found and not a single one of them concerns Polish industry. This is the identified research gap we intended to fill.

In this paper we describe a questionnaire-based survey study targeting software project analysts (i.e. people responsible for RE/BA activities). The questionnaire included a list of 64 pre-defined problems collected from a literature review and a workshop involving a small group of analysts. We gathered answers from 55 respondents, who evaluated how frequently they had encountered particular problems in their professional experience and optionally could report additional problems.

The main contributions are: the overall ranking of problems (as reported by all respondents) and separate rankings for agile project and for smaller/larger teams. The additional contributions are: review of problems reported in literature and comparison of survey outcome to similar studies from other countries.

The rest of the paper is structured as follows. In Section 2 we outline related work. Section 3 describes an overview of research process and its particular steps. In Section 4 survey's main results are presented, followed by a comparison to results obtained by others in Section 5. In Section 6 we discuss validity threats before concluding the paper in Section 7.

2 Related Work

We narrow down this related work summary to survey-based papers on gathering and analyzing information about RE/BA problems. Of course, many more research reports on RE/BA state of practice are available, but since they focus on RE/BA practices, techniques, process maturity etc. we consider them not to be directly related.

Several works describing research on RE/BA problems, conducted in various countries are available. Hall et al. [10] performed a case study collecting RE problems experiences in 12 UK software companies by assembling employees into focus groups and interviewing them. Solemon et al. [11] surveyed industry practitioners from Malaysia to identify most common RE problems and cross-referenced them with process maturity and good practices applied by IT companies. Liu et al. [12] conducted an industrial survey conducted in China and (among other findings) reported major failure reasons in RE practices. An ongoing research (parallel to our work) known under the name of NaPiRE (Naming the Pain in Requirements Engineering) initiative is conducting a family of replicated surveys on RE problems, their causes and consequences [13]. NaPiRE surveys have already included 10 countries and more are expected in further replications [14].

We provide more information on the abovementioned studies' findings in Section 5, where we compare them to our results. Nevertheless, none of those studies concerned Polish industry, nor even any other country from Central and Eastern Europe (with the exception of Estonia which is included in NaPiRE, but no results have been published yet).

Our main interest was however Polish IT industry and information about RE/BA problems in this context is very scarce. A literature search revealed no directly related work. Some industrial survey reports on software project outcomes and/or problems are available, but RE/BA issues are hardly included within their scopes. For example, a report summarizing a survey based on 80 software projects [15] shows proportions of successful, challenged and failed project. It also lists some contributing factors (e.g. project size, development methodology, risk management), but RE/BA processes and issues were not included in survey questionnaire. Another survey [16] identified several problems plaguing software development in Poland, but it does not distinguish any explicit category of RE/BA problems, only very few such problems are included and assigned to Management category. Papers dealing with particular RE/BA problems e.g. difficulties in understanding and communicating customers' needs [17] or neglecting non-functional requirements [18] can be found, but their purpose is to propose solution to a selected problem, not to analyze the broader scope of problems and their occurrences in the industry.

Also, a previous work of one of us [19, 20] should be mentioned. One part of this work was a survey on RE/BA problems, which was however a small-scale study (8 interviewees from 2 companies) and as such had its limitations. Moreover, during the interviews, only open questions were used, encouraging the respondents to enumerate RE/BA problems affecting their work. The subsequent analysis of results showed a relatively low similarity of reported problems, even in case of interviewees employed by the same company. It can indicate that they had difficulties reminding all relevant problems without any guidance provided. Such observations resulted in the idea for the research described in this paper – to conduct a survey focusing solely on RE/BA problems, involving a significantly larger and more diverse group of respondents and to provide them with a list of pre-defined problems together with the opportunity to report additional ones.

3 Research Process

After identifying the existing research gap and the need for establishing the state of practice in Polish IT, we planned the research process to be followed. We set out to answer he following research questions (RQ):

- RQ1: What are the most common requirements-related problems in Polish IT industry?
- RQ2: What are the differences in reported problems with respect to different software project contexts?

As for RQ2, by context we meant e.g. size of development team or software development approach. We suspected that such factors can make particular problems more or less frequent (e.g. agile projects can cope better with requirements changes, larger teams can have more issues about communicating requirements between developers etc.). No assumptions however were made, we only planned to include context questions in the questionnaire.

The central term used in our research is "problem", which requires some explanation. We consider RE/BA problem to be any requirements-related issue that is perceived difficult or error-prone by people involved in RE/BA processes. Some of such problems can be considered as an inevitable part of analyst's job – it is for example natural that developers and business stakeholders have difficulties understanding each other or that requirements change to reflect business domain dynamics. However, if a given issue is reported as problematic by practitioners, it is something that requires further attention and should be addressed by e.g. dedicated techniques, good practices or tool support. This is the reason we do not exclude any potential problems on the grounds of their origin or responsible party. It is consistent with the notion of "problems" or "challenges" used by others (as outlined in related work summary).

The research process we planned included the following steps (described in the following sections):

1. Literature review aimed at extracting and cross-checking RE/BA problems discussed in reviewed sources.
2. Additional identification of RE/BA problems by organizing a workshop with a group of analysts.
3. Questionnaire design.
4. Conducting the survey and analyzing results.

3.1 Literature Review

The literature search and review was aimed at gathering problems already described in sources of various types. It was not a systematic literature review (SLR), as it was not our intent to identify all possible sources and to list every problem described in the literature. Instead, we wished to cross-reference a number of pre-selected sources and use the subset of most common problems as an input to subsequent steps of our research process.

We selected 9 sources, trying to cover various forms of publications: scientific papers, books and technical reports. It was also different from the usual manner of literature review, where only peer-reviewed sources are included. We deliberately reached for other sources, even those associated with commercial software tools. The reason was to use information originating from industry. Industry professionals are likely to use forms of publications other than scientific papers e.g. informal articles, books or technical reports.

Table 1. Summary of RE/BA problems reported in literature.

Problem	S1	S2	S3	S4	S5	S6	S7	S8	S9	#
Incomplete requirements		X	X	X	X	X	X		X	7
Ambiguous requirements		X		X	X	X	X	X	X	7
Analysts lack adequate training/ competencies	X	X	X	X		X				5
Inadequate requirements management procedures/tools			X	X	X	X			X	5
Lack of stakeholders' commitment		X	X		X	X			X	5
Changing requirements		X	X		X	X		X		5
Inconsistent requirements		X	X	X	X				X	5
Requirements defined in technical jargon rather than customer language	X		X	X					X	4
Requirements lack meta-data (source, priority, status, etc.)				X		X	X	X		4
"Obvious" requirements not reported			X	X		X		X		4
Scope creep				X	X	X		X		4
Lack of quality control of requirements		X		X		X	X			4
Inadequate tool support				X		X	X		X	4
Communication problems between customers and developers	X		X			X			X	4

Sources S1-S4 are scientific papers. S1 [10] and S2 [11] are survey-based studies described in related work summary. The remaining papers use other approaches: S3 [21] is a literature review, which summarizes and categorizes problems found in numerous sources, while S4 [22] is a rather subjective, experience-based discussion of selected problems. Sources S5 [23] and S6 [24] are widely known books on RE, while S7 [25] is a relatively new book item published by Polish authors, which we considered to be closer to Polish IT state of practice. Sources S8 [26] and S9 [27] are technical documents associated with IT tools supporting RE/BA processes.

Table 1 summarizes most essential findings of literature review. It lists problems mentioned by most sources (at least 4 out of 9), For each problem, particular sources mentioning it and total number of them are given. Problem names were unified, as sources use different wordings. Table 1 can also support an argument that RE/BA problems are not well evidenced yet, as sets of problems mentioned by particular sources are only partially overlapping.

3.2 Workshop

The reason of the workshop was to identify additional problems that may be more specific to Polish industry. The workshop was conducted in September 2016 and included 6 active participants: 5 analysts and 1 researcher acting as a moderator. Invited analysts represented different companies and application domains. Also their experience varied – some of them could be considered as beginners, while others quite experienced (about 7 years in RE/BA). The workshop took place in an informal setting and was planned as a moderated discussion. Prior to the workshop, literature research findings were coded by deriving common themes e.g. business goals, cooperation with business stakeholders, requirements quality, requirements prioritization, RE documentation templates etc. About 40 such themes were identified.

During the discussion, all themes were walked through. The moderator asked open questions about problems related to a given theme and participants reported such experienced and/or known problems (or lack of them). The discussion was free-form and informal, participants were also able to refer to each other's statements. The discussion was audio-recorded and later transcribed. Problems reported by participants were extracted. Most of them could be matched to those derived from literature. There were some exceptions though e.g. participants revealed situations where business goals were adjusted to (implemented) requirements, not otherwise (especially in public sector). Moreover, this discussion allowed to identify several sub-variants of already known problems e.g. "Ambiguous requirements" were divided into: "Stakeholders lack sufficient domain knowledge to define requirements", "Software Requirements Specification document is very generic" and "Specified requirements insufficiently detailed/verifiable". Such findings provided an additional input to the next step - questionnaire design.

3.3 Questionnaire-Based Survey

We chose to apply questionnaire-based survey as a method to answer research questions. We also decided to survey solely the practitioners who perform the role of analyst in software projects (i.e. who are responsible or RE/BA activities, regardless of how exactly their job positions are named). The reason was to obtain data based on first-hand experience, from people who are directly involved in RE/BA processes (as opposed to those who are only influenced by it e.g. testers). However, by selecting such profile of respondents we limited the available points of view, which could introduce bias, but it was a trade-off we considered acceptable. The introductory part of the questionnaire included a clear message that it is intended for analysts only. As our survey was targeting analysts from Poland only, the questionnaire was in Polish.

The first part of the questionnaire was supposed to collect background information about respondents. It included questions about: respondent's experience (in RE/BA, as an analyst), size of development team he/she belongs to, software development approach used in projects he/she works on (agile, plan-driven, other). Optionally, respondent could also enter his/her first name and e-mail address to receive a report on survey results afterwards.

The second part was dedicated to RE/BA problems. We included 64 problems on the basis of literature review and workshop. We selected problems that were mentioned by most of reviewed sources or reported by workshop participants. Workshop discussions also motivated us to refine some more generic problems from literature into two or more sub-variants.

We divided problems into 12 groups: business goals; project scope; sources of requirements; elicitation, analysis and specification; RE documents templates; requirements management; glossary; cooperation with stakeholders; cooperation with developers; quality assurance for requirements; analyst's competencies; other problems. The reason was to present respondents with only one group of problems at the time and thus to keep them focused. For each problem in such group, a respondent was asked to assess how frequently he/she encounters it in professional work. To answer a following 5-point Likert scale was used: 0 – "never", 1 – "rarely", 2 – "sometimes", 3 – "often", 4 – "always". For each group, an open question was also included – it was a request to report additional problems not included in pre-defined questions, but relevant to a given group.

Several iterations and reviews of questionnaire were necessary, as we paid attention to proper wording of questions, unambiguity and comprehensibility. After that a pilot study was conducted. It involved 3 people fitting the respondent's profile. All reported issues, doubts and improvement suggestions were addressed in the final version of the questionnaire. As for technical means, we checked on-line survey software services. Initially, two versions of questionnaire were prepared using Google Forms and ankietka.pl services. During the pilot study we asked participants to compare those two versions. They perceived Google Forms version as more readable and intuitive and as such we decided to use it in our survey study.

We published the questionnaire on-line and posted invitations to participate in the survey on websites dedicated to RE/BA topics and social network groups for Polish analysts. No direct invitations to particular individuals were used. The weakness of this approach is that it does not allow to calculate the response rate and it limits our knowledge about respondents' background to the information provided in their questionnaire answers. The survey was open for 7 weeks (April 27th - June 17th 2017) and during this period we obtained 55 responses.

4 Survey Results

Context information about survey responders and their working environments is presented in Fig. 1. It is also worth mentioning that over 75% of them expressed interest in receiving a report on survey results and provided contact e-mail addresses. A complete listing of survey questions and answers (translated to English) can be found in a dataset available on-line [28].

As shown in Fig. 1, 40% of respondents had at least 5 years of experience, while 78% at least 2 years. It indicates that while senior/expert analysts were a minority, most of survey participants had sufficient experience to provide first-hand knowledge about RE/BA problems. As for team sizes, most respondents worked in teams includ-

ing 6-10 members, but smaller and larger teams were represented as well. When answering the question about software development approach, 40% of respondents declared working in projects that apply agile approach, while plan-driven approach was used by only 9%. However, almost half of respondents declared that they had not followed a single approach (agile or plan-driven), but used both in different projects.

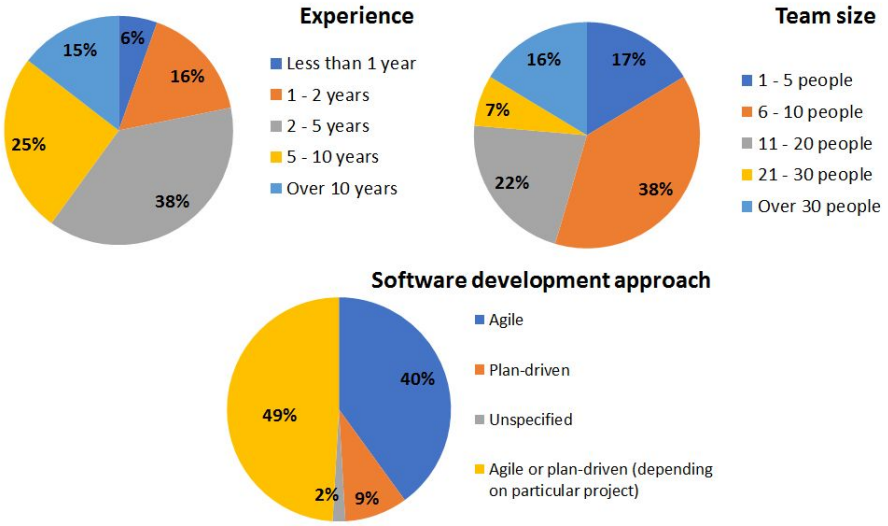

Fig. 1. Context information about respondents.

Answers to the second part of the questionnaire (assessments on frequency of occurrence of particular problems) were processed in order to create a ranking of most frequent problems. Additional (not pre-defined) problems reported by respondents were not further processed because of low similarity (no problem was reported by more than 2 people). We decided to use the mean value of answers (0-4 values, accordingly to the scale specified in Section 3.3) to represent frequency. A median value could be considered more appropriate for ordinal scale, but in case of 5-value scale it is unlikely to note differences.

The resulting ranking based on this metric is given in Table 2. Problem names are shortened for the sake of brevity. In the questionnaire, problems had longer descriptions and sometimes included examples in order to be well understood by respondents. The longer descriptions are available in the associated dataset [28].

Survey results clearly show that most frequent problems are related to cooperation between analysts and stakeholders, as 16 out of 20 top problems fall into such category. Among the remaining ones, P12 and P13 deal with lack of good practices applied by a supplier (software development company or team). P4's origin is not obvious - it can be a result of customer pressure or of supplier's poor planning. P16 is probably responsibility of both sides – stakeholders issue requirements in vague form and analysts (or other development team members) do not ensure such requirements are refined. Other categories of problems e.g. cooperation between analysts and the rest of

development team, analysts' competencies, documents used in RE/BA, quality management hold lower positions in the ranking - outside top 20 presented in Table 2.

Table 2. Twenty most frequent RE/BA problems according to survey results.

ID	Problem	Never	Rarely	Sometimes	Often	Always	Mean	Std. Dev
P1	Unrealistic expectations of stakeholders	0	4	11	24	16	**2.95**	0.89
P2	Stakeholders do not express 'obvious' requirements	1	3	14	25	12	**2.80**	0.85
P3	Scope creep	0	4	14	26	11	**2.80**	0.91
P4	Too short time for analysis available	1	7	12	20	15	**2.75**	1.06
P5	Stakeholders' low availability	0	4	16	26	9	**2.73**	0.83
P6	Stakeholders describe solutions instead of requirements	0	4	17	30	4	**2.62**	0.73
P7	Stakeholders are unable to express requirements other than change requests to working software	0	6	18	25	6	**2.56**	0.83
P8	Conflicting requirements from different stakeholders	1	8	15	23	8	**2.53**	0.98
P9	Stakeholders ignore business goals and focus on requirements only	0	8	16	27	4	**2.49**	0.84
P10	Stakeholders issue requirements clearly outside project's scope	1	6	20	24	4	**2.44**	0.86
P11	Business goals are not measurable/verifiable	1	10	16	26	2	**2.33**	0.88
P12	Interdependencies between requirements are not identified/maintained	7	5	18	18	7	**2.24**	1.19
P13	No defined process for requirement changes	2	11	20	18	4	**2.20**	0.97
P14	A stakeholder believes that all requirements are essential and is unable to prioritize them	4	12	13	23	3	**2.16**	1.07
P15	A stakeholder accepts specified requirements, which he/she had not read or comprehend	3	9	22	18	3	**2.16**	0.96
P16	Specified requirements insufficiently detailed / verifiable	3	7	26	17	2	**2.15**	0.89
P17	Conflicts between stakeholders about requirements' priorities	3	10	23	16	3	**2.11**	0.96
P18	Difficult communication with a remote stakeholder	1	19	14	17	4	**2.07**	1.02
P19	Requirements are not defined by right stakeholders	2	12	22	19	0	**2.07**	1.03
P20	Stakeholders lack sufficient domain knowledge to define requirements	2	12	22	19	0	**2.05**	0.85

To address RQ2, we also processed survey results to find out whether the same problems are reported in various contexts. One factor determining context is software development approach. We were only able to check answers for Agile, as Plan-driven population was too small (5 respondents only). Most of respondents chose answer

"Agile or plan-driven, depending on particular project", which prevented us from further analysis because questionnaire design did not allow to determine which problems were associated to which approach. All other answers other that Agile (Plan-driven, Agile or Plan-driven, Unspecified) were assigned to the group "Other". The other factor examined was development team size. We decided to divide respondents w.r.t. team size (<=10 and >10), which allowed to form two groups (30 and 25 people) and analyze answers separately. For each context (Agile, Other, Teams<=10, Teams>10) Mean values were calculated, using only answers of respondents fitting a given context. A simple comparison of mean values is shown in Fig. 2.

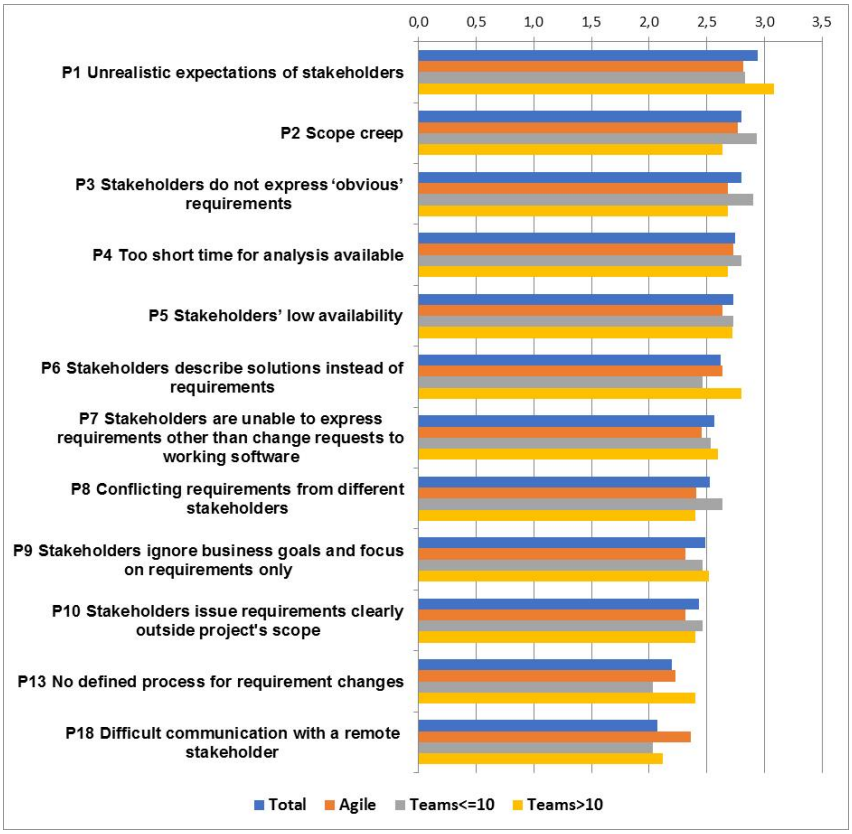

Fig. 2. Frequencies of problems in total and in particular contexts (mean values).

To verify whether differences between groups (Agile/Other and Teams<=10/Teams>10) are statistically significant, we used Mann-Whitney-Wilcoxon Test (suitable for ordinal scale and independent samples). Results are presented in Table 3 and Table 4. Both tables include Mean values for particular groups and p-values of statistical tests for pairs assigned to each problem. Also, relative rankings of problems for each context and a ranking of total answers (from all respondents) are included in both tables (# column).

Table 3. Comparison of problems w.r.t. software development approach.

ID	Problem	Total	Agile		Other	p-value
		#	#	Mean	Mean	
P1	Unrealistic expectations of stakeholders	1	1	2.818	3.03	0.5166
P2	Scope creep	2	2	2.773	2.818	0.9047
P3	Stakeholders do not express 'obvious' requirements	2	4	2.682	2.879	0.3501
P4	Too short time for analysis available	4	3	2.727	2.758	0.8799
P5	Stakeholders' low availability	5	5	2.636	2.788	0.7535
P6	Stakeholders describe solutions instead of requirements	6	5	2.636	2.606	0.7308
P7	Stakeholders are unable to express requirements other than change requests to working software	7	7	2.455	2.636	0.5369
P8	Conflicting requirements from different stakeholders	8	8	2.409	2.606	0.6444
P9	Stakeholders ignore business goals and focus on requirements only	9	10	2.318	2.606	0.343
P10	Stakeholders issue requirements clearly outside project's scope	10	10	2.318	2.515	0.5927
P18	Difficult communication with a remote stakeholder	18	9	2.364	1.879	0.0827

Table 4. Comparison of problems w.r.t. team size.

ID	Problem	Total	Teams<=10		Teams>10		p-value
		#	#	Mean	#	Mean	
P1	Unrealistic expectations of stakeholders	1	3	2.833	1	3.08	0.3499
P2	Scope creep	2	1	2.933	6	2.64	0.2388
P3	Stakeholders do not express 'obvious' requirements	2	2	2.9	4	2.68	0.3532
P4	Too short time for analysis available	4	4	2.8	5	2.68	0.6594
P5	Stakeholders' low availability	5	5	2.733	3	2.72	0.8274
P6	Stakeholders describe solutions instead of requirements	6	8	2.467	2	2.8	0.0755
P7	Stakeholders are unable to express requirements other than change requests to working software	7	7	2.533	7	2.6	0.7168
P8	Conflicting requirements from different stakeholders	8	6	2.633	9	2.4	0.3362
P9	Stakeholders ignore business goals and focus on requirements only	9	9	2.467	8	2.52	0.6673
P10	Stakeholders issue requirements clearly outside project's scope	10	9	2.467	10	2.4	0.5614
P13	No defined process for requirement changes	13	19	2.033	10	2.4	0.1586

We intended to list top 10 problems from each context in Table 3 and Table 4 (except "Others" which is not a particular context but a group of various ones). As can be seen, only 12 problems are sufficient do achieve it (P1-P10, P13 and P18), which indicates that similar RE/BA problems are experienced in different contexts. This impression is confirmed by statistical analysis. For this purpose, we used KNIME Analytics 3.3.1 to compute parameters and R 3.5.0 for Mann-Whitney-Wilcoxon tests (using R-Snippets in KNIME). In all cases presented in Table 3 and Table 4, the p-value was greater than 0.05, which does not allow for conclusion that populations are non-identical.

There are of course some differences in mean values and relative rankings, but as they are not significant, it is quite surprising that different contexts do not introduce nor magnify specific problems (e.g. cooperation with development team for larger teams).

The ranking in Table 2 provides answer on RQ1 about the most common requirements-related problems in Polish industry. Table 3 and Table 4 provide answer to RQ2 about differences in reported problems w.r.t. different software project contexts.

5 Comparison with Other Results

Each of sources mentioned in Section 2 (related work) enumerates main problems/challenges identified as result of conducted research study. Direct comparison of our results with those obtained by others is difficult because researched RE/BA problems were defined more or less differently w.r.t. names used but also to assumed abstraction levels and scope (inclusion/exclusion of issues outside RE/BA but potentially affecting that area). Despite this, we would like to compare results to such extent it is possible. When citing problems from related work, in parentheses we give the IDs of (approximately) matching problems from Table 2.

A study by Hall et al. [10] divided problems into two groups: organizational-based and process-based. For the first group there is little similarity, mainly related to "User communication" (P5, P18) and "Inadequate resources" (P4). "Company culture" is a possible match (P13(?)), but other problems ("Developer communication", "Inappropriate skills", "Staff retention" and "Lack of training") have no counterparts in our findings. More similarity can be found for process-based problems: "Vague initial requirements" (P7, P11, P16), "Poor user understanding" (P2, P20), "Requirements growth" (P3, P10), "Undefined requirements process" (P13) and "Inadequate requirements traceability" (P12). Only "Complexity of application" has no match.

Solemon et al. [11] used a similar list of problems (and division into two groups) to the one from [10], but introduced more distinctions between requirement flaws. Here we address only those additional or modified ones: "Incomplete requirements" (P14, P16, P19), "Inconsistent (changing) requirements" (P3, P8, P10), "Ambiguous requirements" (P7, P11, P16) and "Lack of defined responsibility" (P19). It is also worth mentioning that while Hall et al. claim that "our findings suggest that organizational issues exacerbate all types of requirements problems" (referring to lack of skills and staff retention as examples), Solemon et al. conclude "Our results suggest that RE

problems experienced by the companies in our study can be attributed more to factors inherent within the RE process rather than to factors external to the RE process.".

In case of study by Liu et al. [12], more similarities can be found. The most important problem reported by them is "Customers do not have a clear understanding of system requirements themselves, including scope of the system, major functional features and nonfunctional attributes" (P1, P7, P10, P16). For majority of other problems counterparts can also be found: "Users' needs and understanding constantly change" (P3), "Software engineers do not have access to sufficient domain knowledge and expertise" (P20), "Project schedule is too tight to allow sufficient interaction and learning period between customer and development team" (P4), "Requirements decision-makers lack of technical and domain expertise" (P19, P20), "Broken communication links between customer, analyst and developer" (P5). There are no matches for problems: "Reuse existing design in wrong context and environment" and "Lack of standardized domain data definition and system-environment interface".

Mendez Fernandez et al. [13] presented top 10 problems they found. All of them except one can be (more or less) matched to our "top 20 list" items. Below problems from [13] are listed, ordered by frequency descending: "Incomplete and/or hidden requirements" (P2, P7, P9, P14), "Communication flaws between project team and customer" (P1(?), P15), "Moving targets (changing goals, business processes and/or requirements)" (P3), "Underspecified requirements that are too abstract" (P11, P16), "Time boxing/Not enough time in general" (P4), "Communication flaws within the project team" (no match), "Stakeholders with difficulties in separating requirements from known solution designs" (P6), "Insufficient support by customer" (P5, P18, P19), "Inconsistent requirements" (P8, P12, P17) and "Weak access to customer needs and/or business information" (P20). In this case the similarity is quite high, only P10 and P13 have no counterparts and match between P1 and "Communication flaws" is questionable.

6 Validity Discussion

We are aware that our study had several limitations that can pose potential threats to validity. First of all, the study and results presented are based on reasonable but still limited number of participants. Another important issue is participants representativeness – we cannot claim that software projects and companies our respondents work for are consistent with the general picture of Polish IT. For example, plan-driven approach is poorly represented, which may stem from the widespread adoption of agile methods, but may also be a matter of this particular sample. Also, a discrepancy between declared and actual development approach is possible, as e.g. a few respondents declared agile approach and team size of 21-30 or 30+ at the same time.

We deliberately planned to survey analysts only, which has some implications. First, we cannot be sure that only analysts answered the questionnaire as our survey was not based on personal invitations. We explicitly stated target profile in published invitations and in questionnaire introductory text, but that could be ignored (however it is rather not likely that a person not involved in RE/BA would be willing to answer

almost 70 questions about this topic). More important issue is that by asking analysts only, we are likely to introduce bias by limiting survey to one point of view only. An interesting observation is that problems associated with analysts' negligence or lack of competencies were among those with lowest scores. It can be the real picture of RE/BA practices and problems, but can also indicate that analysts are more likely to attribute problems to actions of other parties rather than themselves or fellow analysts.

Another threats typical to surveys are: clarity/unambiguity of questions and honesty of answers. We made a substantial effort to minimize the first threat by several reviews of the questionnaire and a pilot study. The second threat is minimized by the fact that respondents were anonymous (optionally they could provide e-mail address – but any address, not necessarily professional one). As such a respondent had no reason to hide information about problems e.g. in order to make company look better. We are also aware that our results are based on respondents' perception, not "hard data" gathered from software projects, but it is a limitation of almost any survey.

Finally, we cannot claim generalizability of results to other countries, as from start we only intended to research RE/BA problems in IT industry in Poland.

7 Conclusions

This paper identified, on the basis of industrial survey study, most frequent requirements-related problems from the point of view of IT analysts from Poland. The main contribution is the resulting list of problems, together with combined assessment metrics. The conclusion that can be drawn from this list is that the most problematic area in RE/BA is communication with stakeholders. Additional data analysis led to development of problem rankings for particular contexts (Agile development approach, smaller teams, larger teams). Such rankings show some differences, but none of them is statistically significant, thus in general the same problems are present in various contexts. Results obtained in our study were also compared to the findings of similar research studies from other countries.

Results described in this paper can be of potential value for researchers working in RE/BA area, so they can target most frequent problems by analyzing their contributing factors and by proposing and evaluating new solutions. Dedicated methods, tools and/or practices can be introduced to mitigate particular problems. Results can also be used by industry practitioners to raise awareness about problems likely to be expected and consequently to be prepared to deal with them. By practitioners we mean mostly analysts but also others e.g. project managers who are responsible for stakeholders/scope management and for planning all project activities including RE/BA. Finally, knowledge about RE/BA problems in Polish industry can be utilized in BSc/MSc requirements engineering courses and in industrial training programs intended for analysts.

Possible directions of future work include a more thorough analysis of top problems with respect to their root causes as well as identifying effective solutions to address them. Moreover, additional survey studies would be useful, especially studies involving other points of view e.g. those of developers, project managers or stake-

holders representing business domain and customer's side. Also, as our survey focused on problems' frequency only, a study on problems' severity (w.r.t. consequences) would be advisable.

Acknowledgements. We would like to thank all workshop participants and survey respondents who shared with us with their knowledge and experience. Particular thanks are due to Hanna Tomaszewska from Analizait.pl for disseminating invitations to participate in the survey and to Agnieszka Landowska from Gdańsk University of Technology for advice on data analysis. We are also grateful to anonymous reviewers for their helpful suggestions.

References

1. International Organization for Standardization (ISO): ISO/IEC/IEEE 29148: Systems and software engineering — Life cycle processes — Requirements engineering (2011).
2. International Institute of Business Analysis: A Guide to The Business Analysis Body of Knowledge (BABOK) 3.0 (2015).
3. The Standish Group: Chaos Report (2014).
4. Arras People: Project Management Benchmark Report (2010).
5. McManus, J., Wood-Harper, T.: Understanding the Sources of Information Systems Project Failure - A study in IS project failure. Manag. Serv. 51, 38–43 (2007).
6. Charette, R.N.: Why Software Fails. IEEE Spectr. 42, 42–49 (2005).
7. Hofmann, H.F., Lehner, F.: Requirements engineering as a success factor in software projects. IEEE Softw. 18, 58–66 (2001).
8. Damian, D., Chisan, J.: An empirical study of the complex relationships between requirements engineering processes and other processes that lead to payoffs in productivity, quality, and risk management. IEEE Trans. Softw. Eng. 32, 433–453 (2006).
9. Ellis, K., Berry, D.M.: Quantifying the impact of requirements definition and management process maturity on project outcome in large business application development. Requir. Eng. 18, 223–249 (2013).
10. Hall, T., Beecham, S., Rainer, A.: Requirements problems in twelve software companies: an empirical analysis. IEE Proc. - Softw. 149, 153 - 160 (2002).
11. Solemon, B., Sahibuddin, S., Ghani, A.: Requirements engineering problems and practices in software companies: An industrial survey. Commun. Comput. Inf. Sci. 59 CCIS, pp. 70–77 (2009).
12. Liu, L., Li, T., Peng, F.: Why requirements engineering fails: A survey report from China. Proc. 18th Int. Requir. Eng. Conf. RE2010, pp. 317–322 (2010).
13. Mendez Fernández, D. et al.: Naming the pain in requirements engineering: Contemporary problems, causes, and effects in practice. Empir. Softw. Eng. 22, 2298–2338 DOI 10.1007/s10664-016-9451-7 (2017).
14. Mendez Fernandez, D.: Supporting Requirements-Engineering Research That Industry Needs: The NaPiRE Initiative. IEEE Softw. 35, 112–116 (2018).
15. Frączkowski, K., Dabiński, A., Grzesiek, M.: Raport z Polskiego Badania Projektów IT 2010, available at: http://pmresearch.pl/wp-content/downloads/raport_pmresearchpl.pdf (2011).
16. Pieszczyk, E., Werewka, J.: Analysis of the Reasons for Software Quality Problems Based on Survey of Persons Involved in the Process of Developing of IT Systems. Business Informatics 3(37), 85–102 (2015).

17. Przybyłek, A.: A business-oriented approach to Requirements Elicitation. Proc. of 9th Int. Conf. ENASE 2014, pp. 152–163 (2014).
18. Kopczyńska, S., Nawrocki, J.: Using non-functional requirements templates for elicitation: A case study. Proc. 2014 IEEE 4th Int. Work. Requir. Patterns, RePa 2014, pp. 47–54 (2014).
19. Marciniak, P., Jarzębowicz, A.: An Industrial Survey on Business Analysis Problems and Solutions. In: Software Engineering: Challenges and Solutions, AISC vol. 504, pp. 163–176, Springer International Publishing (2016).
20. Jarzębowicz, A., Marciniak, P.: A Survey on Identifying and Addressing Business Analysis Problems. Foundations of Computing and Decision Sciences 42, 315–337 (2017).
21. Davey, B., Parker, K.R.: Requirements elicitation problems: a literature analysis. Issues Informing Sci. Inf. Technol. 12, 71–82 (2015).
22. Firesmith, D.: Common requirements problems, their negative consequences, and the industry best practices to help solve them. J. Object Technol. 6, 17–33 (2007).
23. Leffingwell, D., Widrig, D.: Managing Software Requirements, Addison-Wesley (2003).
24. Wiegers, K., Beatty, J.: Software Requirements. Microsoft Press (2013).
25. Chrabski, B., Zmitrowicz, K.: Requirements Engineering in Practice (in Polish: Inżynieria Wymagań w Praktyce). Wyd. Naukowe PWN (2015).
26. Rational Software Corporation: Using Rational RequisitePro ® (2000).
27. Blueprint: The Rework Tax : Reducing Software Development Rework by Improving Requirements (2015).
28. Jarzębowicz, A., Ślesiński, W.: Survey dataset, available at: https://www.researchgate.net/publication/324910141_RE_problems_in_Poland_-_survey_dataset