

Why Requirements Engineering Fails: A Survey Report from China

Lin Liu Tong Li

School of Software

Tsinghua University

Beijing, China

email: {linliu@, tongli08@mails.}tsinghua.edu.cn

Fei Peng

Corporate Technology

Siemens Ltd. China

Beijing, China

email: fei.peng@siemens.com

Abstract—Requirements engineering has gained growing attention in both academia and industry, as today's software intensive systems are expected to provide highly user-centric functions and qualities. Thus, it is important to understand under what situations existing requirements engineering practice is not working well. Continuing our probe into the industrial practices status quo, this paper reports the results from a recent survey of requirements practices in China in 2009. The web-based survey of requirements engineering practices focuses on requirements elicitation techniques, requirements representation techniques. Although purporting to report on the state-of-the-art of requirements engineering in China, it is likely to portray the state-of-the-art of RE worldwide as well.

Keywords—requirements engineering; survey; practise

I. INTRODUCTION

It is important to develop new techniques, methods, tools and notations for practitioners, and it is equally important, if not more, to see how these techniques, methods, tools and notations are used in reality and how the general practitioners feel about them. Since if we know how they are actually used, we can design better methods in future, and we can target suitable training, automate some part of the adoption, and avoid recurring problems they make when using this methods. To this end, we undertook an extensive survey study to understand how the general software practitioners elicit and represent requirements in organizations in China.

Reviewing the literature, there are many earlier empirical studies on requirements engineering practice. El Emam et al. performed a field study of RE practices in information systems development [3], in which 60 cases were analyzed and 7 technical/non-technical issues influencing the RE processes for information systems are discovered. Sadraei et al. [7] surveyed RE practice from 28 software projects in 16 Australian companies. Aranda et al [2] investigated how small companies conduct RE activity. By and large, our study differs from this earlier work in that our report is based on a large number of practitioners' general experiences and observations across projects.

There are also growing interests in understanding how the globalized software engineering practice

influences RE. Zowghi et al. [10] analyzed a multi-site software development organization in Australia and identified key factors that contribute to the success of requirements management in distributed development structure. Ali Babar et al. [6] surveyed 12 Vietnamese software practitioners and investigated cultural issues in maintaining trust in software outsourcing. Hickey and Davis [7], Sim et al. [8] have conducted surveys to requirements experts. These works focus on a more specific problem than understanding the general status quo of the industry. In our work, we investigate the state-of-practice of RE in Chinese companies.

Section II introduces the research methods of the survey; section III introduces survey data and the findings; section IV discusses related work; and section V concludes the paper.

II. RESEARCH METHOD

In year 2007, 2008 and 2009, we conducted a series of survey investigating the state of RE practice in China. The types of involved organizations include state-owned enterprises, multi-national corporations, domestic private companies and universities. The survey was designed with two major parts: first, we collect data on the general status of the respondents and their associated organizations, then we ask them to fill in an online survey questionnaire on their regular RE practice, in particular, requirements elicitation approaches and requirements representation techniques; then we collect RE related stories and observations from the respondents. We expect that the outcomes of the survey could reflect the industrial practice, and provide useful insights for better understanding the requirements engineering status in China, and to suggest possible improvement in the future.

The survey results from year 2007 and 2008 are reported in [5], where we focused on answering whether the Chinese national culture has significant impact on the RE practices. In this paper, we summarize the survey results in 2009. The sample base of the latest survey includes 377 survey subjects coming from 237 software companies or research organizations. The business areas of the involved companies cover various industry segments including

banking, healthcare, power generation, telecom, retail, electronics, etc. All the survey participants are software professionals whose daily work is closely related with requirements. In particular, we focus on what we have learnt from the RE success and failure stories provided by interviewee.

More than 400 people were contacted, 377 answers have been collected, and among whom more than 200 people have provided their observations and success or failure stories and observations. Subjects have different levels of expertise, most are in the age group of 25-35, and more than 30% have 5-10 years of work experience. Subjects have different roles and perspectives, including: senior managers, general managers, architects.

III. DATA COLLECTED AND FINDINGS

We surveyed the requirements engineering related activities that are performed in practice. Question 1 “*In your organization, which kinds of work are performed during requirements engineering?*” The survey results are shown in Figure 1. From the results, we can see that the RE activities that are most widely practiced are requirements acquisition (65%), requirements description and specification (67%), requirements modeling and analysis (47%). The activities such as requirements validation, test case design, and change management receive less attention comparatively. 2008 results are in the short column, 2009 results are the long ones. The difference of the two years is that the 2009 survey has a much larger sample base, and the results is further confirming the results of 2008.

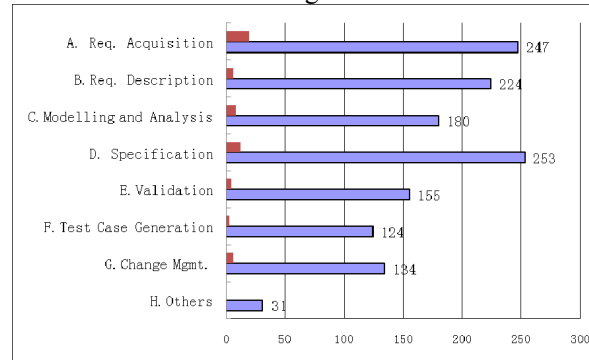


Figure 1. Requirements related work

Question 2 asks about “*How much efforts are spent on RE-related activities in terms of percentage of project time?*”. In 42% of the surveyed organizations, the time spent on RE is more than 10% of their entire project duration, and 25% organizations spend more than 20% of their time on RE, while 21% spend less than 10% project time on RE, and 12% spent little time on RE.

Questions 3 asks “*Are your customers would like to spend time on requirements-related activities?*” 120

out of 377 participants have selected that “*customers are happy to be involved in requirements related activities*”. There are a great portion of participants (185) have chosen “*no, customers are reluctant to work on RE, although they value the importance of requirements and believed that sufficient time should be spent on delivering a high quality document*”. The rest 72 participants select “*neutral*” as an answer to this question.

Then Question 4 asked the subjects’ opinion about “*Do you think there are direct relationships between requirements specification and software quality?*” Most participants (68%) believed that the quality of requirement documents has strong impact on the quality of final software system. Only 3% of them thought that there is no relationship between specification and software quality. The rest 29% reported a moderate impact of specification on software quality. There is a high correlation between this question and the Question 2 – in general, if people do not think requirements specification has large impact on software quality, they will not invest time to develop the specification.

A. Requirements elicitation techniques

Then a set of questions to investigate the usage of requirements elicitation techniques were asked. Question 5 is “*Which requirements elicitation method do you use?*” The survey results are summarized in Fig.2. 333 respondents mentioned that face-to-face meeting is the major approach they use, and 206 respondents mentioned that they always require a prototype in place while eliciting requirements. 203 respondents mentioned that they always refer to similar existing systems for eliciting requirements.

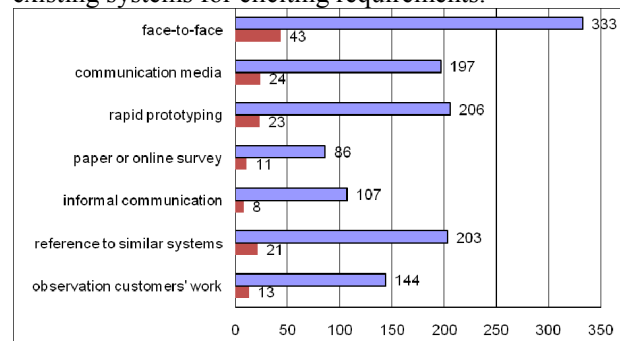


Figure 2. Preferred Elicitation Techniques

Question 6 asks “*what are the roles of the people who perform the requirement elicitation activities?*” The results show that in these surveyed organizations requirements acquisition and management tasks are assumed by project manager (54%), system designer (12%), and requirements engineer (47%), general manager (13%), marketing staff (25%), programmer (21%), others (5%). This indicates that senior staffs

(e.g. project manager and system designer) are often directly involved in requirements engineering process collaboratively. We also surveyed the knowledge and skills background of the people performing requirements engineering tasks. The results show that 45% of the subjects have taken requirements engineering courses in universities, 29% have attended short RE courses as part of their professional training program, 17% have acquired RE knowledge by self-learning, and 9% have not received any training.

Question 7 asks “*who do you communicate with during the phase of requirements elicitation?*” This is a question with check-box answers. The respondents stated they communicate with leaders of related business department (57%) and leaders of IT department (53%), leaders in customer organization (19%), system operators (31%), IT staff (14%), marketing staff (16%), others (5%). Therefore, we interpret it as most people communicate directly with the leaders in order to get exact and confirmed requirements information.

Then we surveyed the attitude of the participants towards changes in requirements. Question 8 is “*The customers keep changing requirements even after the development contract has been signed. How do you deal with this situation?*” Most participants (90%) think that the changes to requirements are normal, 80% people said that they will negotiate with customers for a compromised plan, 7% do what the customer asks, 14% simply follow the contract.

B. Requirements representation techniques

We designed questions to investigate the usage of requirements representation techniques. Question 9 is “*Which representation techniques do you use?*”

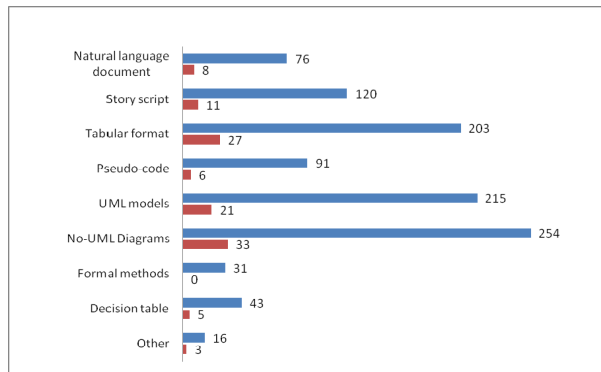


Figure 3. Requirement representation techniques

This is a question with multiple-choice answers provided. The results are shown in Figure 3. Most respondents have selected the sixth choice, using non-UML diagrams in their daily practise, including data-flow diagrams, or ad-hoc diagrams that engineers use.

Question 11 asks “*What are the RE tools that are used in your daily practices?*” 40% participants reported that they use tools such as DOORS. The rest (60%) do not use any RE tools.

Question 12 asks “*what are the actual contents included in the requirement specifications?*” According to the survey results, the contents that are usually included in requirements related document are Project and goal description (78%), Functional requirements description (99%), Overall scheme (74%), Non-functional requirements description (64%), and change log (50%). In requirements documents, project plan and goals and functional requirements description are usually concluded, while information about risk analysis, changes and schedule are included in some projects, but receive less attention comparatively.

C. RE failure and success stories and findings

Following the web-based questionnaire, we also asked the respondents to share with us any stories, observations or opinions related to the requirements engineering practice in their organization. Out of the 373 respondents, 203 have provided information in this column. Here are some example stories.

Story 1: “*In one of our project, we have exchanged information with customers for about a month (the overall duration is 3 months) and collected abundant requirements information, which seems fairly complete at the time. The product was developed in the next three months, during the period, no new requirements or changes were required. However, when we were about to deliver it three months later, the leader refused many earlier confirmed functions, which lead to another three months rework system...*”

Story 2: “*One of our projects is to develop an enterprises annuity management information system, the project duration is 9 months. In the requirements stage, we were not quite familiar with the business requirements of annuity management, the delivered product from the project includes just the current functionalities, which cannot adapt to the fast evolvement of annuity-related business. As a consequence, due to a change of the major business rules six months later, we lost a series of subsequent contract worth 200M RMB.*”

Story 3: “*Once we had a project developing a video stream broadcasting software, the customer expressed the interests of using the same product in an oversea market... However, only later we get to know the fact that the broadcast standard abroad is actually different from the national standard, so the product has to be completely re-implemented to satisfy this requirement...*”

By analyzing these 203 stories, we find that the RE practices are very diversified in China, RE practice differs according to the types of organization developing software, the types of products being developed, and the particular application domain of the product. 15% of the respondents who provided stories and opinions on RE are working with multi-national corporations. 17% are working with government

sponsored enterprises occupying dominant areas of national economy. 53% are with domestic private companies growing rapidly and playing more active roles in the national economy. 8% are from universities and research institutes, 7% have kept their affiliation information confidential. In this investigation, we find that organization culture and values and technical maturity level play a vital role in RE.

1) RE status for multi-national corporations: Based on our investigation of interviewees from 33 multi-national organizations, whose headquarters are based in the US, Japan, Sweden, Germany, Finland, and India, the status of requirements engineering practice is usually more advanced, and state-of-the-art technology is adopted. Requirements related principles are understood and tools are more accessible and available to practitioners in general.

- ✧ RE is an explicitly planned and owned task in a software development project.
- ✧ Usually have special teams to handle clients' requirements, could be presales or marketing people, with project manager and service provider involved in the decision making.
- ✧ At present, requirements related activities are conducted and controlled where the head office of the company locates.
- ✧ Multiple elicitation and specification techniques are used in combination in one project: Prototype is used in many companies to facilitate communication; UML models are used to represent requirements and design.
- ✧ Project management tools are used to control and manage requirements processes. Most widely used tool include: DOORS and Team Center.
- ✧ Detailed requirements specification is used to communicate with user and development team, and to obtain their confirmation, iteratively.
- ✧ Functionalities, features, and non-functional requirements such as performance, security varies when it targets at different markets.
- ✧ For some R&D products, when there is no clear requirement in advance, the major focus is to explore whether a design is feasible technically.

2) RE Status for Government Owned Enterprises: Based on the answers from respondents from 31 Government Owned Enterprises covering the industry sector of energy, pharmaceutical, IT and home electronics, we find that the status of requirements engineering practice is affected by the developed level of the geographical areas and the particular industry.

- ✧ There is no dedicated personal for requirements related tasks. Non-professional requirements engineers is likely to use a single technique for requirements related activities, which affects the engineering quality.
- ✧ Awareness of RE needs to be improved among general practitioners. The success of project is still relying on heroic actions rather than standardized management

processes.

- ✧ There are obvious communication gaps between the customer and the development team. Users neither understand nor concern about the efforts required implementing certain functionality. Designers do not always pay enough attention to customers' feedback, but often define the requirements in their own favor.
- ✧ The level of maturity in software engineering practice within the organization has great influence to the efficiency of the requirements activities.
- ✧ Level of business and technical knowledge has great impact to the quality of requirements elicitation and management process. The unavailability (or availability) of rich domain knowledge contributes to the failure (or success) of the project. The mingling of domain experts and software experts is also proven extremely valuable.
- ✧ There is a strict power hierarchy in this kind of organizations. So requirements activities and decisions need support from the higher-management team. In this case, social and political countermeasures for project risk have to be planned. In particular, changes in customer organization often results in radical changes (termination or rework) of software projects.
- ✧ Design solutions become matured only after a project has been deployed for a few times. Customization based on a proven design solution is a good practice to follow. But at the same time, there are reports on disastrous projects caused by inappropriate reuse.
- ✧ Having users participate in the conceptual design of the system, and confirm to detailed design of business functions is essential for the success of the project. However, in many cases, users revoke already confirmed requirements in later stages of projects. So it is a must to predict any possible changes.
- ✧ Rapid prototype method is suitable for the requirement elicitation of any kind of organization. Prototypes should evolve according to requirements changes and the latest available technologies. Questionnaire is often considered less effective.

3) RE Status for Domestic Private Companies: Based on the stories from 32 domestic private companies in telecom and software, we find that in these domestic private companies, engineers usually spend more effort on understanding requirements to engage their customers, especially when facing prominent customers such as the government agencies. In many cases, user requirements are identified from multiple sources using various approaches. On the other hand, customers usually give less trust to small domestic private companies, since they fall short of formal management and quality assurance procedures.

- ✧ Documentation mainly serves the purpose of customer confirmation rather than technical reference. Sometimes it is not passed to the development team.
- ✧ Many SRS documents may not comply with standard template. System requirements may not be traced back to business strategy but are more for the convenience of

design.

- ✧ Requirements document is usually prepared with MS Word, Excel and Visio. Commercial tools are seldom used. Engineers feel the pressing need for rapid prototype development tools (free, open source RE tools).
- ✧ Engineers also feel the deficiency of a standardized domain requirement/knowledge base, or at least guidelines to frame the design in each recognized application domain.
- ✧ Requirements prioritization is often connected with the availability of developmental man power, and their area of expertise.
- ✧ Project success sometimes relying on the heroic accomplishments of individual engineers and inexpressible experiences of project managers rather than proven techniques and processes in most companies. Requirement elicitation is not purely technical, but often social and political. Sometimes, the success of projects is hindered by potential conflicts of interests, and evasive behaviors (shadowboxing). Requirements decision-making may be intuitive and premature.
- ✧ When eliciting requirements from government agencies/public servants, people are not very open in discussing their own positions and opinions, and being passive and conservative. Thus, it is important to organize group meeting with people at similar ranks, discussions will be more lively and freely.
- ✧ When calling a group meeting for requirements elicitation, a typical scenario is that only one or two people talking and most other people are silent or talk little. But when a requirements document is presented to the procurer, they often make considerable amount of changes.

D. RE status on different product types

Also based on the analysis of these stories, we found that the requirement engineering methods adopted are different according to the different targeted customers. From the answers collected in the first round of questionnaire, 10% of the respondents from the company oriented to out-sourcing products, 16% of the respondents from the company oriented to mass marketed products and 74% of the respondents develop customized products. Market research methods are needed to elicit requirements for mass marketed software, while human relations techniques are more important for customer-specific products. When it comes to outsourcing software development, cross cultural research becomes necessary, especially in high-context cultures such as China.

1) *Mass marketed software products*: Collecting requirements for mass market products is deemed difficult. Here is a summary of the experience shared by the respondents in their stories.

- ✧ Identify representatives of potential user group is an

essential step for requirements elicitation of this type of software.

- ✧ Questionnaire is used more often in requirement elicitation; the quality of answer highly depends on incentives of the participant, customer training.
- ✧ Email with a questionnaire attached was used in some cases. But the result turned out miserable. The returning data can hardly be used for analysis.
- ✧ A relatively successful survey method is to interview customers face-to-face after certain customer training program.
- ✧ When customers are more familiar with the software functionalities, we can invite them to fill out a questionnaire. Thus, the data collected is relatively higher quality.
- ✧ Prototype is always a helpful means for collecting customer feedback. Requirements analysts are often paid less than developers, so in many cases, they don't have enough knowledge and experience in delivering a high quality requirements specification.
- ✧ The requirements collection of such products can be embarrassing when confronting defensive competitors and customers.

2) *Out-sourcing products*: Many outsourcing project requirements are vague, missing detailed information. Here is a summary of the experience shared by the respondents in their stories.

- ✧ Great communication gaps exist between the procurer and contractor.
- ✧ For out-sourcing products, requirement elicitation is often done in the out-sourcing country; engineers consider it problematic to develop certain features based on guesses and "free thinking".
- ✧ Off-shoring projects are in better condition, the usual working mode for off-shoring is that development project are executed in the off-shored office (local contractors are invited in house) and the requirements, development and testing process are under a more rigid and controlled process of the procurer.
- ✧ The development team should be aware of situations where the difference in work, life and thinking leads to different requirements of the system under development, and not adding in details inconsistent with the original required functions.
- ✧ Requirements processes for international project are greatly influenced by language, geographical, and cultural differences and barriers: E.g. multi-currencies, multi-language, etc.
- ✧ More iteration of communication and confirmation has to be executed. Language is a fundamental issue, For instance, in some language, the difference between expressions such as "besides" and "except" should be explicitly noted.
- ✧ Also, people coming from different country often have different preference on non-functional requirements. Chinese customers prefer ease-of-use and fancy user-interface experience, others may prefer stability and reliability.
- ✧ Even for people speak a same language (e.g. China and

Singapore), they still feel the pressing need for face-to-face communication for cognitive purpose.

- ✧ Video-conferencing is preferred than teleconferencing in some cases to achieve shared common understanding.

IV. DISCUSSIONS

It is interesting to understand the current status of industrial practices in a rapid growing market such as China and worldwide. In this paper, we present the results of a survey made in 2009 about the RE practices in China. In the first phase of the survey, real project experiences and requirements-related stories in various industry domains are collected and analyzed. The results showed that the status of requirements engineering practice varies from organization to organization. Also the level of technical knowledge and domain expertise determines efficiency of the requirements engineering activities. In summary, the major failure reasons in RE practices are:

- Customers do not have a clear understanding of system requirements themselves, including scope of the system, major functional features and nonfunctional attributes.
- Users' needs and understanding constantly change.
- Software engineers do not have access to sufficient domain knowledge and expertise.
- Project schedule is too tight to allow sufficient interaction and learning period between customer and development team.
- Reuse existing design in wrong context and environment.
- Requirements decision-makers lack of technical and domain expertise.
- Broken communication links between customer, analyst and developer.
- Lack of standardized domain data definition and system-environment interface.

Based on the results, we also come up the following suggested improvements to the current RE practices:

- Improve project management process, to facilitate communication, documentation, and change control and management.
- Domain knowledge and prototypes are necessary conditions of successful RE practice.
- Making the customer feel their ownership and responsibility to the requirements and the future system.
- Be proactive in RE process and predict potential changes and future requirements.
- Link requirements with testing, and adopt a test-driven design process.
- Even when time is tight, still think clear what to develop before developing it.
- Develop RE tools that better fit the real-world needs of the customers and engineers.

In this round of the project, we chose the web-based survey. Different research methods could be chosen for

further study. Although it is simple and effective, the survey-based method may not be able to reflect all what the survey subjects have in mind. Therefore, other research methods, such as face-to-face interview and workshop, may be chosen in follow-up studies to deeply explore actual views of the subjects. While our survey is limited by its scope and scale, we still hope that these results could be useful for industrial practitioners and academic researchers wishing to improve current practices.

Acknowledgments

We thank Eric Yu, Golnaz Elahi for their valuable comments. This work is supported by the Chinese NSF grants no.60873064, and 90818026. National HeGaoJi Key Project No. 2009ZX01045-001-001-02.

References

- [1] M. Ali Babar, J. M. Verner, P. T. Nguyen. *Establishing and maintaining trust in software outsourcing relationships: an empirical investigation*. Journal of Systems and Software, 80(9), Sep 2007, pp.1438-1449.
- [2] Aranda, J., Easterbrook, S., Wilson, G. *Requirements in the Wild: How Small Companies Do It*. 15th IEEE Int'l Requirements Engineering Conf. (RE'07), pp. 39-48.
- [3] K. El Emam and N.H. Madhavji, *A Field Study of Requirements Engineering Practices in Information Systems Development*. In 2nd IEEE Int'l Symp. Requirements Engineering (RE'95), pp. 68-80.
- [4] A. Hickey and A. Davis, *Elicitation Technique Selection: How Do Experts Do It?* In 11th Int'l Requirements Engineering Conference (RE'03), Sept.2003. pp. 169-178.
- [5] L. Liu, H. Zhang, F. Peng, W. Ma, Y. Shan, J. Xu, T. Burda. *Understanding the Chinese Characteristics of Requirements Engineering*, In 17th IEEE International Requirements Engineering Conference (RE'09). 2009. Atlanta, USA. pp. 261-266.
- [6] U. Nikula, J. Sajaniemi, and H. Kalvianen, *A State-of-the-Practice Survey on Requirements Eng. in Small- and Medium-Sized Enterprises*, Tech. Report, Lappeenranta Univ. of Technology, 2000. 26 pages.
- [7] Colin J. Neill and Phillip A. Laplante. *Requirements Engineering: The State of the Practice*, IEEE Software, Vol. 20, No. 6, Nov/Dec. 2003, pp. 40-45.
- [8] E. Sadraei, A. Aurum, G. Beydoun and B. Paech. *A field study of the requirements engineering practice in Australian software industry*. Requirements Engineering Journal, 12(3), July 2007, pp.145-162.
- [9] S.E. Sim, T.A. Alspaugh, B. Al-Ani. *Marginal Notes on Amethodical Requirements Engineering: What experts learned from experience?* In 16th IEEE International Requirements Engineering Conference, (RE'08), pp. 105-114.
- [10] Daniela E. Damian, Didar Zowghi: *The Impact of Stakeholders? Geographical Distribution on Managing Requirements in a Multi-Site Organization*. In 10th IEEE Int'l Requirements Engineering Conference (RE'02), Sept. 2002, Essen, Germany, pp.319-330.