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What is Important when Deciding to Include a Software Requirement in a Project or Release?

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Abstract

The requirements on software systems are so many that not all requirements may be included in the next development project or the next release. This means that it is necessary to select a set of requirements to implement in the forthcoming project, and hence to postpone the implementation of other requirements to a later point in time. In this selection process different criteria are used. In many cases, the criteria are not officially stated, but rather implicitly used by the decision-makers. However, to be able to support this decision-making process, it is important to know and understand the underlying reasons for the decisions.

This paper presents an empirical study of the decision criteria. In particular, the paper focuses on how different perspectives have different influence on the decision-making process. It is concluded that business-oriented and management-oriented criteria are more important than technical concerns related to software architecture, impact analysis, dependency between requirements and software evolution.

1. Introduction

The inclusion of software requirements into development should be based on value. The need for a value-based approach to software engineering is emphasized in (Boehm, 2003; Boehm and Huang, 2003). Moreover, (Favaro, 2002) stresses the necessity to include business value into requirements engineering. A value-based approach to requirements engineering is needed to cope with the abundance of requirements being put on software systems today. Many companies have large databases with requirements put on their software products.

To be able to cope with the large number of requirements, it is necessary to carefully select and prioritize which requirements to actually implement in a specific software release. Researchers have developed methods for prioritizing requirements, for example, (Karlsson and Ryan, 1997). They provide a cost-value based approach to prioritizing requirements. Others have worked with methods for release planning and requirement selection, for example, (Greer and Ruhe, 2004) and (Ruhe et al., 2003). However, to the best of our knowledge very little research has looked into the actual criteria used when deciding whether or not to include a specific software requirement into a specific release or development project.

A good understanding is needed of the underlying decision-making process to enable researchers to support it in the best possible way. Thus, it is crucial to understand what governs the decisions, and in particular which perspectives are actually important when these decisions are taken. Who should be supported in the decision-making process? What are the implications if certain perspectives are more important than others in the process?

To increase the understanding of the underlying reasons for the inclusion of certain requirements in a specific release, an empirical study has been conducted. This paper presents the study, which was conducted using a questionnaire. The questionnaire investigates the importance of 13 different criteria that may be used in the decision-making process. The outcome shows that some criteria dominate the process. Moreover, it is clear that business-oriented criteria (customer and market focused criteria) together with management issues related to cost-benefit and timeliness of delivery are more important than technical criteria related to the software architecture and evolution. These findings and its implications are elaborated in the paper together with the presentation of the study.

The paper is structured as follows. Section 2 covers related work. Section 3 describes the method used to con-

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duct the study, whereas Section 4 presents results, which are subsequently analyzed and discussed in Section 5. Finally, conclusions are drawn in Section 6.

2. Related Work

Market-driven (as opposed to customized or bespoke-development) incremental product development and delivery (release) is becoming increasingly commonplace in the software industry (Ruhe and Greer, 2003, Greer and Ruhe, 2004, Carlshamre 2002). Moreover, combinations of market-driven development together with customization are common among the companies participating in the study presented here. This is practiced by having a general product (market-oriented approach) that is customized for different procurers.

Incremental product development is planned and executed with the goal of delivering an optimal subset of requirements in a certain release (version of a product that is distributed to customers). The idea is to select what a release should contain (requirements), when it should be released (time), and at what cost (effort) this should be achieved. Decisions about which customers get which features, at what level of quality and at what point in time, have to be made, making these activities a major determinant of the success of a product. All of these activities are vitally dependent on that product requirements are elicited/captured, analyzed, and specified before any planning and development activity can commence.

The contributions in this area include addressing different aspects of requirements management, such as prioritization (Karlsson and Ryan, 1997; Karlsson et al., 1998; Regnell et al., 2001; Ruhe et al., 2003) and dependencies between requirements (Dahlstedt and Persson, 2003; Carlshamre et al., 2001). Moreover, researchers have worked on connecting the requirements engineering process to decision-making (Regnell et al., 2001; Aurum and Wohlin, 2002; Aurum and Wohlin 2003). Some work has also been done on release planning. In (Ruhe and Greer, 2003; Greer and Ruhe 2004), a genetic algorithm approach has been used to plan for different releases, while the work in (Carlshamre, 2002) is focused on understanding release planning.

Thus, work has been conducted on release planning and, as such, there are investigations into prioritization of requirements and dependencies between them. However, to the best of our knowledge no studies have actually looked into the criteria used in decision-making about whether to incorporate a specific requirement into a software project or release. Moreover, no study has looked at how different perspectives, see the next section, influence the decision-making process. The study presented below is the first step towards filling this gap, and it is needed to understand how value is created for software products. Some preliminary findings based on data from two companies can be found in (Wohlin and Aurum, 2005). However, the different perspectives are not covered in (Wohlin and Aurum, 2005). The main contribution here is the analysis of more companies and the division of the studied criteria into three different perspectives.

3. Method

3.1. Research Questions and Hypotheses

This section provides an overview of the design of the questionnaire used in the study. The overall objective of the questionnaire is to provide insight into the following research question: “Is any perspective more important than others when deciding what requirements to include in a specific project or release and is it likely to change over time?” This question is addressed by having people from industry ranking 13 criteria and their importance in the decision-making process. The criteria were formulated to cover three different perspectives:

- Business (external customers and markets, where external refers to being external from the development project),
- Management (internal related to project issues) and
- System (internal related to technical solutions and the development).

In this paper, the above objective is broken down to two major research questions:

R1. How do different perspectives influence the decision-making process?

R2. Are there significant differences between the importance of the different perspectives when comparing the situation today with the view of how the future ought to look like?

The two questions are closely related to understanding the underlying decision process related to requirements. The results presented are focused on these two research questions, although some results regarding the individual decision criteria are also provided as a step towards answering the two main research questions addressed here.

The research questions are addressed by the following hypotheses:

1. H_{01}: The three perspectives have the same influence on the decision on which requirements to include.
2. H_{02}: There are no significant differences between the importance of different perspectives when comparing the situation for a perspective today with the expected situation in the future.

The first hypothesis aims at addressing the differences between perspectives. The second hypothesis is focused upon changes between the situation today and the expected situation in the future.

The two hypotheses are addressed in the analysis, although some additional data related to the hypotheses are presented when describing the general results from the questionnaire.

3.2. Development Process of Questionnaire

A questionnaire was designed to understand and evaluate the importance of different decision-making criteria when determining whether or not to include a specific requirement in a project or release. Industry representatives were asked to prioritize the importance of the different criteria in their decision-making process. The following procedure was chosen to develop the questionnaire:

- A brainstorming session was held to identify suitable criteria to include in the questionnaire. The session included three researchers involved in requirements engineering research. All three have close industrial contacts.
- Based on the outcome of the brainstorming session, a questionnaire was developed by the main author.
- The questionnaire was reviewed by the participants of the brainstorming session, and one additional independent researcher, to further improve the selection of criteria.
- The questionnaire was updated based on feedback from the reviewers, and then sent to a contact person at different companies.

The brainstorming session and the review process included some in-depth discussion about whether it was possible to identify orthogonal criteria. It was concluded that it would only be possible if the criteria were kept at a high level of abstraction. This would mean that very few criteria would be evaluated and prioritized by the respondents in the study. The discussions led to the removal of some all embracing criteria, such as risk, that are related to basically all other criteria; however it also was decided to retain a number of criteria despite dependencies, since it is basically impossible to avoid all dependencies. The intention was for respondents to prioritize without thinking too much about dependencies, and instead focusing on what they viewed as the main criteria. In summary, the objective was that importance should be judged from the individual importance of the criteria and not as consequences of other criteria.

The design of the questionnaire is further discussed in Section 3.4, where the different parts of the questionnaire are presented.

3.3. Criteria in Questionnaire

After several iterations the questionnaire was narrowed to include 13 criteria for assessment by respondents. Many of the criteria were general in the sense that they were not solely factors relevant for selecting requirements. They were often referred to in literature discussing software success more generally (Wohlin et al., 2000). Moreover, it was also stated clearly that additional criteria could be added by the respondents. These additional criteria are not further discussed here. The possibility to add criteria was provided to avoid respondents feeling that missing criteria hindered their completion of the questionnaire. Moreover, the questionnaire was designed this way to capture any additional criteria that were missed in the brainstorming session. It was agreed among the researchers that the 13 criteria covered three important perspectives, i.e. the three perspectives listed in Section 3.1. The mapping of criteria to perspectives was not communicated to the respondents. The 13 criteria included in the study are as follows. The text is exactly as communicated to the respondents in the questionnaire, including a short explanation and motivation for each criterion.

Business (external customers/markets)

1. Competitors
   Explanation: The status of the competitors with respect to the requirement. In other words, it is taken into account whether a competitor has the implied functionality implemented or not.
   Motivation: We may feel forced to include a requirement if our competitors have the functionality, or we may want to implement something that is considered to be leading edge functionality (functionality competitors do not have).
2. Requirement's issuer
   Explanation: The actual issuer of the requirement is taken into account, i.e. which stakeholder (internal or external) generated the requirement.
   Motivation: We may judge some issuers as more important than others, for example, a very important customer or representative for an important market.
3. Stakeholder priority of requirement
   Explanation: The priority of the requirement is taken into account.
   Motivation: We may want to prioritize the requirements that our customers or markets think are of particular importance.
4. Requirement volatility
   Explanation: This criterion is related to whether the requirement is likely to change or not.
   Motivation: We may want to handle highly volatile requirements differently.

Management (concerns of management)

5. Support for Education/Training
   Explanation: The ability and possibility to provide technical support, education, and training to customers, markets and so forth with respect to the requirement.
   Motivation: We may not want to implement functionality unless we could provide the appropriate technical support, education and training in relation to the requirement.
6. Development cost-benefit
   Explanation: The actual cost-benefit for implementing the requirement.
   Motivation: We may not want to include a requirement if the implementation cost is judged to be high in relation to the expected benefit.
7. Resources/competencies
   Explanation: The availability of resources with the right competencies to implement the requirement.
   Motivation: We may not want to implement a requirement unless we are sure that we have the right people available for the job.
8. Delivery date/Calendar time
   Explanation: The ability to meet the project deadline.
   Motivation: We may not want to introduce a requirement that may affect the deadline of the project negatively.

System (development/maintenance personnel)

9. System impact
   Explanation: The impact of the requirement on the existing system.
   Motivation: We may not want to implement a requirement if we judge that the actual impact in terms of changes to the existing system is too large.
10. Complexity
    Explanation: The estimated complexity of the requirement and the associated challenges in implementing it.
    Motivation: We may not want to include a requirement that is judged to be very complex to implement and as a consequence the risk of failure as too high.
11. Requirements dependencies
    Explanation: The dependencies between this specific requirement and other requirements, either already implemented or other posed requirements.
    Motivation: The dependency to other requirements (already implemented, scheduled to be implemented, or deferred to later release) may affect our decision regarding the current requirement.
12. Evolution
    Explanation: The impact on the future evolution of the system.
    Motivation: We may not want to implement a requirement if it is believed to make long-term evolution of the system more complicated.
13. Maintenance
    Explanation: The impact on the maintenance of the current system.
    Motivation: We may not want to implement a requirement if it is believed that the requirement may cause many problems in terms of maintenance.

3.4. Design of Questionnaire

Based on the identification of the 13 criteria, the questionnaire was designed to include three parts.

First, the respondents were given a short introduction. This included positioning the questionnaire within a larger industry-academia collaborative research project, highlighting the value of participating in the questionnaire, the target audience for the questionnaire (important since the communication was done through a contact person at each company), the main research question, estimated time for the questionnaire, and finally the respondents were also guaranteed anonymity. It was clearly stated both in the questionnaire and in an e-mail that the target audience was personnel included in the decision-making process. It was expected to include the following types of management personnel: product management, project management and line management. This implies that the number of respondents at each company is quite limited, due to that, for example, developers and testers were not expected to respond to the questionnaire.

The second part contained an introduction to the 13 criteria as listed in Section 3.3. The third part included a characterization of the context of respective respondents. This included demographic information such as: company name, unit within company, type of application, whether development was market- or customer-oriented, type of product and the role of the respondent within the organization. Contact details were also asked for to ensure that each respondent could be contacted for clarification purposes, although no data in the analysis will be connected to specific individuals. In addition to the demographic questions, the third part contained the questions related to the actual research. The 13 criteria were listed in a table and the respondents were asked to fill out three columns with respect to the criteria.

First, the respondents were asked to answer yes or no regarding whether each criterion was relevant when deciding to include a requirement in a project or release.

For the other two columns the respondents were asked to provide relative weights regarding the importance of the criteria. The respondents had 1000 points to spend among the 13 criteria. A higher number of points meant that a criterion was relatively more important. For example, a criterion obtaining twice as many points as another criterion was viewed to be twice as important. The respondents were

allowed to distribute the points as they wished, i.e. there were no requirement that each criterion should be allocated a weighting. In other words, a respondent could have given all 1000 points to one criterion.

The second column was concerned with the way different criteria are valued today, and the third column was focused on how the criteria ought to be valued in the future. It should be observed that the respondents had 1000 points to divide in column 2 and 1000 points for column 3. The objective was to capture both the current state of practice and any changes that industry would like to make in the future. The latter may be viewed as a more idealistic situation.

4. Results

The questionnaire was sent to eight companies. However, it resulted in nine data points on a product level. One of the companies provided two responses from different organizational units of the company. The two different units handle different products and have a different customer base. Thus, it seemed reasonable to regard the responses as independent and hence treated as two separate responses. Henceforth, the responses are referred to as coming from nine companies (for reasons of simplicity). All companies develop software for technical products with real time constraints. The companies compete on the global market. The type of systems developed by the companies includes telecommunication systems, hand-held devices, robotics, development tools, resource management systems and automatic guided vehicles.

To summarize, results are available for nine companies, although two responses are from the same organization. In total, 34 responses were provided, although one response was removed from the analysis of the points since that person misinterpreted the assignment of points to the criteria. The removal of one respondent was done after having discussed the response with that person. The responses come from people being involved in the decision-making process whether a requirement should or should not be included in a specific project or release. The roles of the respondents include: product manager, project managers, line manager, user experience engineer and method specialists. The number of responses is actually rather good given the number of people being involved in these types of decisions at the different companies.

However, it should be noted that the companies chose to handle the questionnaire in three different ways:

- Individual responses
- A person representing the company view
- A group of people agreeing on a company response

The intention was to obtain individual response to allow for a more in-depth study of, for example, potential differences in the responses based on the roles. The intention was stated in the e-mail sent to the contact persons at the different companies. However, the companies chose to respond in a way that they found suitable to them. For example, one reason expressed for choosing the third alternative was that it gave the people at the company a good basis for internal discussions regarding their criteria. Previously, the criteria used in their decisions have been quite informal. Each individual participating in the decision-making process applied her or his own criteria and weighting between them. The questionnaire encouraged an internal discussion and hence alignment regarding what was important to them in the decision-making process.

In this section, some general observations from the questionnaire are presented together with the general results. The analysis related to the research questions is presented in Section 5.

4.1. Observations from the Questionnaire

The earlier identified issue, i.e. that the criteria were not fully orthogonal, was also identified by some of the respondents, and mentioned in their e-mail communications when submitting the questionnaire. Two different behaviors with respect to how the criteria were prioritized were observed. Some respondents divided the criteria into subgroups, either based on judged importance or as a way of handling the inevitable dependencies between some of the criteria. They then assigned the criteria in a subgroup the same number of points. A second group approached the criteria without really taking the dependencies into account too much. Basically, they filled out the questionnaire from a “main criteria point of view” as was intended by the research design. In other words, they focused on each criterion’s own value rather than considering its connection to other criteria.

A couple of respondents assigned points where the sum was either below 1000 or above 1000. In these situations, the points were rescaled so that the sum became 1000, and by this it was possible to keep the relative importance assigned.

4.2. Relevant Criteria

The responses provided by the respondents were related to whether the 13 criteria were relevant for this type of decisions or not. Most respondents regarded the criteria as relevant. More precisely, all respondents regarded four of the criteria as relevant. These were:

- Competitors
- Stakeholder priority of requirement

- Development cost/benefit
- Delivery date/Calendar time

In addition, seven criteria were regarded as important by most respondents. These seven criteria are:

- Requirement's issuer
- Resources/competencies
- System impact
- Complexity
- Requirements dependencies
- Evolution
- Maintenance

Only two criteria received less than 30 "votes" out of the total of 34. The two least relevant criteria were:

- Requirement volatility with 29 respondents saying that it is a relevant criterion.
- Support for Education/Training came out clearly as the least relevant criterion with only 25 votes.

It should be noted that it probably is easier to say "yes" than "no". The respondents know that the researchers regard these criteria as relevant since the criteria appear in the list, and hence it is easier to agree that they are relevant than to object. Thus, it is interesting when five or more respondents disagree with the researchers.

The volatility of a requirement is not a relevant criterion according to five of the respondents. This may seem surprising. On the other hand, it may show that requirements are included for other reasons and that volatility has instead to be handled as part of the development project, for example, by postponing the implementation as long as possible until more is known about the requirement.

It is probably not as surprising that the support for education/training is depicted as a criterion that may not be relevant. The inclusion of a requirement is decided based on other criteria and if education/training is needed then this can be provided later.

4.3. Importance of Criteria Today

The assignment of points for the criteria was divided into two parts: "today" and "future". In this section, the outcome regarding the situation "today" is reported. The results are presented as an average for the companies.

The results for each company were aggregated by taking the sum of the points provided by each respondent, where responses were obtained from more than one individual. This refers to the different ways responses were provided as mentioned in the beginning of Section 4. The sum was then normalized to a percentage figure, which makes it possible to, for example, state which criteria contribute to more than X percent to the decision. The average results for the nine companies are shown in Figure 1. The list of the criteria can be found in Section 3.3.

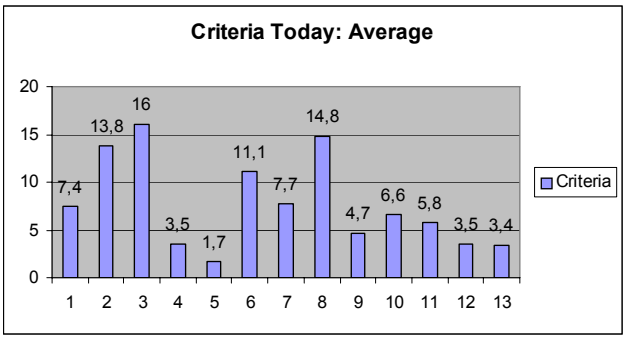

Figure 1. Average percentage values for importance of different criteria.

It is worth noting that four criteria have percentage values above 10% and five criteria have values below 5%. The four most important criteria are (in order): Stakeholder priority of requirement, delivery date/calendar time, requirement's issuer and development cost-benefit. This indicates that issues related to specific customers/markets are important, as are traditional management aspects such as cost-benefit and delivery date. The system or development/maintenance aspects have low influence on the decision. This gives some indications of what can be expected when analyzing the three different perspectives mentioned in relation to the research questions.

In Figure 1, the average for all nine companies is provided. However, it is worth mentioning that the differences between the companies are not large. It is quite clear that the companies have very similar opinions regarding what is important when deciding whether or not to include a specific requirement in the next project or release. This makes the results even more interesting than if the companies had differing opinions, because it points to the possibility of a pattern, or common trend in views, across the software development industry. This could be a first step towards identifying key criteria in the decision-making process with respect to including requirements in software projects or new releases.

4.4. Importance of Criteria in the Future

A similar analysis for the companies was conducted to examine how the respondents wanted to see the use of the criteria in the future. The objective was to capture what the respondents believed would be a better balance between the criteria than the situation today. The average for the companies is presented in Figure 2. From the figure, it can be seen that only two criteria had a percentage value at or above 10%. The two criteria are among the four ranked the

highest in the previous section. The stakeholder priority of a requirement is still regarded as the most important, and development cost-benefit is still viewed as the second most important. The results point to two main conclusions. First, the customers/markets are still the number one criterion and they should have the software on time. Second, the respondents want a more even balance between the criteria than the situation today. There is no major shift in priorities of the criteria. In other words, the order of them in terms of importance is close to the same. The system criteria (criteria 9-13) still have low values, but they are higher than in the previous section. In general, it seems like the patterns of today will remain in the future, although some criteria will be valued slightly more than today.

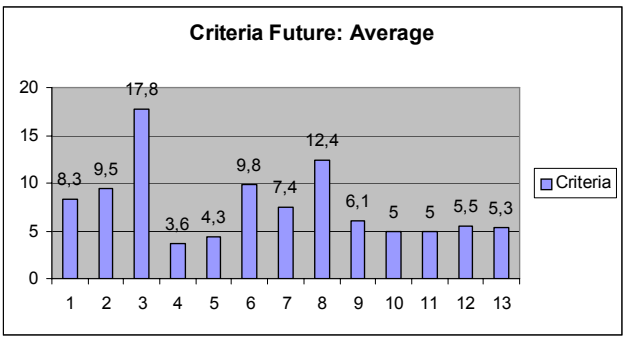

Figure 2. Average percentage values for importance of different criteria.

4.5. Results from the Perspectives

The 13 criteria were divided into the three perspectives in Section 3.1. In relation to the research questions in Section 3.1, it is interesting to see how the balance is between the perspectives and if there are any differences between the situation today and how the respondents say that it ought to be in the future.

In total, 9000 points have been awarded by the nine companies (1000 each) after having averaged over individual responses from the respondents. The division of these points is shown in Table 1. In this case, the main interest is to study how the importance of the different perspectives was judged in relation to each other.

Table 1. Division of points between different perspectives.

	Today	Future
Business	3663	3528
Management	3171	3053
System	2167	2424

The results presented in the table show that the criteria related to the external perspective are and will be most important. The main difference observable from Table 1 is that there is a general opinion that the system-oriented criteria should be valued higher than they are today when it comes to decisions regarding which requirements to include in a project or release.

4.6. Validity Threats

As for any empirical study, there are some threats to the validity of the findings. The first threat is related to what the companies represent in terms of population. The companies have several things in common, such as development of technical systems, although the span across a wide range of different applications. This means that the companies may not be representative of all types of companies, and hence the results must be interpreted with some caution when moving away from the characteristics of the studied companies.

On an individual level, there is a risk that it is easier to agree to the relevance of the criteria than to disagree. However, this is partially taken care of by allowing the respondents to assign zero points to some criteria if they so wish. Moreover, it is easier to stick to the stated criteria than proposing new criteria. This means that important criteria may be missing, for example, one criteria mentioned by some respondents related to strategic importance/alignment.

Another potential threat is related to the questionnaire. It is always difficult to know whether the respondents have understood the questions as intended and in a similar fashion to one another. This threat is somewhat addressed by providing the outcome of the questionnaire to the respondents so that the results can be discussed both at the respective companies and with the researchers. In summary, the threats highlight the need for replication of this type of study.

5. Analysis

A more in-depth analysis is needed to respond to the research questions stated in Section 3.1. The analysis for each question is presented in separate sections below.

5.1. Perspectives Influence

From the plots and the table in Section 4, it seems like there is a small difference between the business perspective and the project perspective, and the system perspective is viewed as being less important in the decision-making process. To shed further light on these differences a statistical analysis has been conducted. The data for the situation today is shown in Table 2. The table shows the three per-

spectives (business, management and system). The first item in each perspective belongs to one company, the second item to one company and so forth. The data shows the importance of the perspective in percentage. Thus, the sum of for each company should be 100, except for some rounding effects.

Table 2. Importance of perspective on a company level.

Perspective	Percentage
Business	36.5
Business	37.8
Business	40.5
Business	44.0
Business	33.0
Business	37.5
Business	51.0
Business	39.7
Business	40.3
Management	46.2
Management	41.4
Management	29.2
Management	50.0
Management	35.0
Management	30.0
Management	31.0
Management	32.2
Management	31.1
System	17.4
System	20.7
System	30.3
System	6.1
System	32.0
System	32.5
System	18.0
System	28.1
System	28.9

From the table it can be seen that most companies view the System perspective as being the least important and no company view the System perspective as the most important perspective.

The data points are not independent and hence this has to be remembered when interpreting the data. The data is not normally distributed and hence a Kruskal-Wallis test is used to identify significant differences between the three perspectives. The Kruskal-Wallis test uses the ranks and given the mostly low ranking of the System perspective, it may be expected that a significant difference emerge. If a significant difference is identified by the Kruskal-Wallis test, then an ANOVA test is applied too. It should be noted that the ANOVA test is mostly rather robust. If the outcome is the same (in terms of being significant) as for the Kruskal-Wallis test then a Fisher PLSD (Protected Least Significant Difference) is applied to identify between which perspectives there are significant differences. A significance level of 0.05 is used in the tests.

The analysis is conducted using Statview version 5. The first analysis is conducted for the situation today. The Kruskal-Wallis test comes out with a very low p-value (0.0007) and hence there is a statistically significant difference between at least two perspectives. To further analyze this, an ANOVA test was used. As can be expected, the results from the ANOVA were also highly significant with a p-value of 0.0003. Based on this, the Fisher PLSD test was applied. The test points to significant differences between the system perspective and the two other perspectives with low p-values (less than 0.0001 and 0.0015 respectively). There is no significant difference between the business and the project perspectives respectively.

A similar analysis was conducted for the data related to the situation in the future. The outcome was similar, although the p-values are higher. The difference between the system perspective and the business perspective is still highly significant. However, the difference between the project perspective and the system perspective is still significant, but the p-value is 0.044, which is closing in on 0.05 as was set as the significance level.

In summary, the outcome is as anticipated from the descriptive statistics, i.e. the System perspective is viewed as being the least important (in relation to the Business and Management perspectives respectively) when it comes to deciding which requirements to include in the next project or release. Thus, the analysis supports the observed differences in Section 4 and shows that the observations are statistically significant.

5.2. Today versus Future

The second research question is concerned with analyzing whether there is any significant difference between the importance of the perspectives when comparing the situation today with the expected situation in the future, or how the respondents would like to see the situation in the future.

The analysis is conducted for the three perspectives separately. The data is not normally distributed and hence the Mann-Whitney test is used to analyze whether there are any significant differences. For none of the perspectives there is a significant difference between the situation today and the expected situation in the future. Thus, the differences observed in Table 1 are not significant.

This also means that it is not with statistical significance possible to say that it is likely that the current situation will

change or that the respondents want the situation to be much different in the future than what it is today.

In summary, this means that the importance of the external perspective today will remain unchanged in the future. Moreover, the project perspective or at least some of the criteria building up the perspective will remain to be important. The internal system or development perspective will continue to be lowest in priority in the decision-making process when to decide what to include in a forthcoming project or release. This does not mean that the perspective is not important. However, it is probably more a matter of that the perspective is not driving the decision-making process. Other criteria are more important when taking the decision and the technical problems should not be a major part of the decision-making; these problems must be handled as part of the development. This is certainly a challenge for the development staff, and it puts requirements on, for example, software architecture and processes to cope with whatever decisions are taking based on non-technical decision-making criteria.

6. Conclusions

The study has shown that there are indeed some criteria that are more important than others in the decision-making process when deciding which requirements to include in a specific project or release. Moreover, the study has shown that the business and management perspectives are more important than the system perspective.

The four most important criteria for making these decisions today are: stakeholder priority of requirement, delivery date, requirement's issuer and development cost-benefit. It is interesting to note that it is not only a matter of priority of requirements. It is also important who states a specific requirement.

With respect to the research questions stated in Section 3.1, it can be concluded:

- R1: It can with high statistical significance be stated that the different perspectives (business, management and system) do not have the same influence on the decision whether or not to include a specific requirement in a specific release or project. Both the business and management perspectives are regarded as important, while the system perspective is of less importance.
- R2: There will be no significant changes in the future in comparison to the situation today. The data indicates a more even distribution between the criteria and a slightly higher influence of the system perspective. However, none of these findings are statistically significant. Thus, it is highly likely that the most important criteria in the future will be the criteria that are important today. Moreover, the relatively low importance of the system perspective will not change dramatically in the future.

These conclusions have some implications. First of all, it is important that the methods developed for selection and prioritization of requirements support the important criteria identified here. Moreover, the methods must support the perspectives identified as the most influential perspectives in the decision-making process.

Second, the relatively low influence of the system perspective should not be interpreted as that it is not an important perspective. On the contrary, it points to the need for better methods, techniques and tools that support the development and evolution of software systems. This is needed due to that the system perspective is not allowed to influence the decision-making process and hence support for whatever is decided must be handled at a later stage. It implies that software development and evolution must be able to cope with the implementation of software requirements independently of, for example, the requirements impact on the software architecture and dependencies between requirements. Thus, all criteria that are not regarded as really important in the decision-making process must be handled within the development and evolution of the software.

The above poses great challenges when it comes to coping with a value-based approach to selection of software requirements. Software value is created based on non-technical criteria, but it is up to the software engineers to deliver the value.

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References

(Aurum and Wohlin, 2002): Aurum, A., Wohlin, C.: Applying decision-making models in requirements engineering. Proceedings of Requirements Engineering for Software Quality, Essen Germany, 9-10 December, (2002)

(Aurum and Wohlin, 2003)**:** Aurum, A., Wohlin, C.: The fundamental nature of requirements engineering activities as a decision-making process. Information and Software Technology, 45(14), 945-954, (2003)

(Boehm, 2003): Boehm, B.W.: Value-based software engineering. ACM SIGSOFT, Software Eng. Notes, 28(2), 1-12, March, (2003)

(Boehm and Huang, 2003): Boehm, B.W., Huang L.G.: Value-based software engineering: A case study. IEEE Computer Society, Computer, pp 33-41, March, (2003)

(Carlshamre, 2002): Carlshamre, P.: Release planning in market-driven software product development: Provoking an understanding. Requirements Engineering 7, 139-151, (2002)

(Carlshamre, Sandahl, Lindvall, Regnell and Natt och Dag, 2001): Carlshamre, P., Sandahl, K., Lindvall, M., Regnell, B., Natt och Dag, J.: An industrial survey of requirements interdependencies in software product release planning. Proceedings Fifth IEEE International Symposium on Requirements Engineering, IEEE, Los Alamitos CA, pp 84-92, (2001)

(Dahlstedt and Persson 2003): Dahlstedt, Å., Persson, A.: Requirements interdependencies - Moulding the state of research into a research agenda. Proceedings Ninth International Workshop on Requirements Engineering (REFSQ'03), Klagenfurt/ Velden, Austria, 71-80, (2003)

(Favaro, 2002): Favaro, J.: Managing requirements for business value. IEEE Software, 19(2), 15-17, March/April, (2002)

(Greer and Ruhe, 2004): Greer, D., Ruhe, G.: Software release planning: An evolutionary and iterative approach. Information and Software Technology 46, 243-253, (2004)

(Karlsson and Ryan, 1997) J. Karlsson, K. Ryan: Prioritizing requirements using a cost-value approach. IEEE Software 14 (5) 67–74 (1997)

(Karlsson, Wohlin, and Regnell, 1997-98): Karlsson, J. Wohlin, C., Regnell, B.: An evaluation of methods for prioritizing software requirements. Information and Software Technology, 39(14-15), 939-947, (1997-98)

(Regnell, Höst, Natt och Dag, and Hjelm, 2001): Regnell, B. Höst, M. Natt och Dag, J., Hjelm, T.: Case study on distributed prioritisation in market-driven requirements engineering for packaged software. Requirements Engineering 6, 51-62, (2001)

(Regnell, Paech, Aurum, Wohlin, Dutoit, and Natt och Dag, 2001): Regnell, B. Paech, B., Aurum, A. Wohlin, C., Dutoit, A., Natt och Dag, J.: Requirements mean decisions! - Research issues for understanding and supporting decision-making in requirements engineering. Proceedings of First Swedish Conference on Software Engineering Research and Practice, Ronneby, Sweden, 49-52, (2001)

(Ruhe, and Greer 2003): Ruhe G., Greer D.: Quantitative studies in software release planning under risk and resource constraints. Proceedings of International Symposium on Empirical Software Engineering (ISESE), IEEE, Los Alamitos CA, 262-271, (2003)

(Ruhe, Eberlein, and Pfahl, 2003): Ruhe, G., Eberlein, A., Pfahl D.: Trade-off analysis for requirements selection. International Journal of Software Engineering and Knowledge Engineering, 13(4), 345-366, (2003)

(Wohlin, von Mayrhauser, Höst and Regnell, 2000): Wohlin, C., von Mayrhauser, A., Höst, M. and Regnell, B.: Subjective evaluation as a tool for learning from software project success. Information and Software Technology, 42(14), 983-992, (2000)

(Wohlin and Aurum, 2005): Wohlin, C. and Aurum, A.: Criteria for selecting software requirements to create product value: An industrial empirical study. In Value-based software engineering, Biffl S., Aurum A., Boehm B., Erdogan H., and Grünbacher P. (editors). Accepted for publication by Springer Verlag, 2005.