

When Agile Meets Waterfall

Investigating Risks and Problems on the Interface between Agile and Traditional Software Development in a Hybrid Development Organization

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Abstract: This paper aims to map issues (risks and problems) at the interface of agile and traditional development approaches in hybrid organizations which have an impact on coordination and cooperation. Successfully combining agile and traditional development methods appears to be quite a challenge for many hybrid organizations. Both methods have their own strengths and added value but also bring their own culture and conditions. Combining these can lead to problems. If we want to handle such problems, we first need to understand the issues that can cause such problems. This study is aimed at identifying and validating an overview of these issues. Based on an exploration of literature a preliminary overview of issues was derived. These were classified into a coherent set. The result was validated in a case study within a large financial institute in the Netherlands. The resulting list of twenty-four issues can be used as a starting point for handling the problem area.

1 INTRODUCTION

The agile approach towards software development is increasingly being implemented in software development organizations. The advantages, such as productivity, team satisfaction, and fit to user requirements (see e.g. Rigby et.al., 2016) are tempting. This, although drawbacks have also been recognized, such as lack of upfront planning, lack of documentation, and lack of predictability (see e.g. Agrawal et.al., 2016). Within a single organization we can see agile and more traditional approaches being used side by side. A reason might be that this is temporarily, when the organization is in transit from a more traditional towards a more agile approach. Another is that this is deliberate. The organizations might feel that agile is a suitable approach in some cases, but that other situations should be handled more traditionally (see e.g. Rigby et.al., 2016).

In either case a more rigid approach, aimed at retaining control and assuring documentation is being used in conjunction with an approach that features agility. The approaches require a different approach in focus, control, way of working, and culture (see e.g. Lazwanthi et.al., 2016). When the groups do not mingle at either project or program level, this does not

need to lead to problems. But when they do, it is not obvious they can co-exist amicably. Understanding issues that might play would help. In literature we were unable to find an overview of relevant issues.

In this paper we will look at issues that may arise in such a situation. The question to be answered is: “What are the issues (risks and problems) at the interface of agile and traditional development which impact coordination and cooperation?”

In section 2 some related work will be discussed. Section 3 contains the methodology used while section 4 looks at execution and results. The paper ends with conclusions and a discussion of results.

2 RELATED WORK

Traditional development methodologies follow a sequential design process in which progress is seen as a gradual flow of process steps, activities and delivery of documentation to achieve operating software. Key elements are fixed order of main activities and a focus on control and documentation (Royce, 1998).

Agile approaches to software development focus on simplifying and improving software process. Customers, developers and the final product are

central (Agile Manifesto, 2001). This is based on values identified in the Agile Manifesto:

- People and their interactions over processes and tools
- Working software over comprehensive documentation
- Customer collaboration over contract negotiation
- Responding to change over following a plan

Agile development methodologies such as Agile Scrum follow an iterative development process. They define a flexible product development strategy in which a development team works as a unit to achieve a common goal. The team organizes itself and works closely together (preferably) on the same location or otherwise online (Larman and Basili, 2003).

Hybrid development organizations emerge when agile and traditional development approaches are combined. In such an environment, one can determine which approach or combination of approaches fits best. Advantages and drawbacks of the approaches can be balanced (Waardenburg and van Vliet, 2013).

That in such a hybrid environment problems occur that find their origin in the differences between these approaches seems obvious and is confirmed by e.g. Siddique and Hussein (2016). However, as far as we could see, this question has yet to be addressed coherently in literature. We can find structured discussions of similarities and differences between the approaches (see e.g. McAvoy and Butler, 2007). Also literature is available on identifying environments and contexts for which Agile techniques are best suited (Boehm and Turner, 2003; Cockburn and Highsmith, 2001). And extensive research has focused on the change to Agile (see e.g. Boehm and Turner; McMahon, 2004).

Specifically this last field of literature can be considered useful for our research since although our research question is not addressed directly, indirectly in this change relevant issues can be identified. With this as a starting point we decided to conduct our research aimed at identifying a set of issues (risks and problems) at the interface of agile and traditional development approaches in hybrid organizations which impact on coordination and cooperation.

3 METHODOLOGY

The research consisted of three steps:

- A literature search aimed at identification of an initial set of issues;
- A structured classification of the issues;

- Validation of the issues in a case study setting.

3.1 Literature Search

We performed a structured literature survey. For this we used Google Scholar which contains most relevant scientific databases (ACM, Springer, IEEE, etc..). We looked in the title of papers for the combinations “agile hybrid traditional”, “agile hybrid”, “hybrid traditional”, and “agile traditional”. Sources and basic set of keywords used should give a good overview. Completeness of results cannot be guaranteed at this stage given the focus on titles only, and the limited set of keywords used. However for a first exploration this was deemed sufficient.

We did follow up this search with a second one using cross reference search. We looked both backwards, based on the references in the selected papers, and forward at papers that referred to these papers. This second search was more focused since it was based on papers identified in the first round.

During both searches, we first made a selection based on the contents of title and abstract. Remaining papers were downloaded and searched with the keywords ‘problem’, ‘risk’, and ‘challenge’ to determine if relevant issues were discussed. If so, the paper was added. Otherwise it was discarded.

Papers added in the cross-reference step were again used as a basis for a follow-up cross-reference analysis until no new papers could be identified.

3.2 Classification

The resulting set of papers was analysed carefully, extracting potential issues. Each potential issue was extracted and labelled. Since issues were identified from individual papers, the resulting set could well contain overlap, be formulated at differing levels of abstraction and be too big to be manageable. To deal with this, a structured classification was carried out.

Since in an unstructured list the only classification principle available is that of ‘belonging together’, it is essential that such a classification is carried out in a structured way by qualified people.

The participants involved in the classification should have experience in an environment where agile and traditional development methods are used in conjunction. Preferably, the participants can judge this context at the strategic, tactical and operational levels. It is also important that they have gained this experience in an organization of sufficient size, operating with formal structures and a certain degree of professionalism in project and process

management. An organization with a minimum maturity of CMMI level 2 is likely fit this objective.

Literature shows no consensus on the ideal number of participants. A larger number might give a higher degree of certainty about the results. But with a larger group it is also more complex to achieve a good dialogue and to come to conclusions. A minimum of four is sometimes mentioned. In this particular situation we opted for five participants as an uneven number avoids obvious ties.

The process was based on the Metaplan approach. This is a nominal group technology based card sorting technique executed in a group discussion setting (Howard, 1994). An advantage of such an approach is that its group discussion aspect tends to cancel out individual bias. It also directly involves the required expertise.

We obtained the cooperation of the IT department of a large Dutch financial organization. In this organisation agile and traditional development live side by side. The organisation is also of sufficient maturity to enable staff to see beyond the daily emergencies. Five experienced business analysts participated in the research. At this organisation business advisors advise between business and IT on designing and launching projects, and on the potential impact of changes in technology. As a result, they have sufficient knowledge and experience regarding the interplay between different development methods and the risks and problems that may arise there.

The process followed is simple. Each potential issue is noted on a card. The resulting stack of cards is discussed one by one. The first card is put on the table, forming a first group. For each subsequent card the question is: is it in essence identical or to an existing card, sufficiently similar to a group of cards already on the table, or do we need to start a new group of cards? If they are considered to be identical they will be merged into a single issue. After all the cards are processed a number of potential issues will have been merged and a number of groups of cards will have been identified which will subsequently be named. In this way, overlap has been removed resulting in a single list of issues. The group structure identified to allow easier handling of this list.

3.3 Case Study

The result of the research up till now is a list of potential issues. Logical next objectives now are:

- Validation: How valuable and relevant are the elements of this list;
- Enrichment: Can the list be improved?.

Further research will mainly focus on the first question, although options for enrichment will not be ignored when offered. To validate the intermediate results it was decided to do a case study in an organization where the issues might be recognized. Given the preliminary character of the results from literature it was felt a case study would provide richer and more in-depth results than can be expected from a survey. The type of result we are looking for is for each potential issue a confirmation that it played a role in a specific situation. This confirmation should be based on actual and traceable experience, and preferably be confirmed by triangulation. This to avoid too strong a reliance on opinions and strengthen the internal validity of the results. Case studies can provide such information. It allows triangulation and provides in depth situational data that allow a better understanding of the issue and its impact.

Requirements for a case organisation were that:

- Agile and traditional approaches are combined;
- A sufficient level of process maturity is present so systemic effects can be distinguished from emergency situations;
- They are in transition to a hybrid situation, so issues have not yet deteriorated into accepted background noise.

The same Dutch financial organization that participated in the first classification phase met these criteria and was willing to cooperate. We could identify several environments for the research. We choose two of these as subcases, enabling cross-triangulation. Each subcase sat within a programme where both agile and traditional work is required for a common goal, so interactions are mandatory.

For information sources we looked for both documentation and interviews. Documentation presents of events from which relevant issues could be found. Interviews can be used to clarify these and can also validate results from the literature study.

Given the large amount of documentation available we decided to focus on documents related to project phase transitions, problem reports and risk management documentation. It was felt that relevant issues would be likely to be encountered in these.

People to be interviewed were selected such that we would cover the most relevant perspectives in order to provide a sufficiently complete picture. Per subcase we wanted to speak with a person with a higher level overview across the two approaches, who would be able to identify issues from that position. The role of programme manager was used for this. From within each of the approach groups we elected to interview two persons. One interview was with the

person carrying project responsibility. In agile terms that is the scrum master and in traditional terms the project manager. The other interview was with a staff member who maintains contact with the users. In the agile approach that is the product owner. In a traditional setting the business analyst role fit.

To further ensure this, only people were selected with sufficient (> 2 year) experience in the current role, as well as having completed a schooling at bachelor level. We also tried to obtain a mix in gender and age so as to widen perspectives covered. This resulted in 10 planned interviews, five per subcase.

The design of the research process is shown in Figure 1. First an documents were analysed. They were searched using keywords 'risk', 'problem', and 'challenge' so we could identify relevant issues. These were mapped to the results from literature or were labelled as new candidate issues.

After this interviews were planned. Each consisted of four steps. First the results from the document study were discussed and validated. Did the researcher correctly interpret the documents and did the identified issue indeed play a role. This results in a number of validated issues. Some of them based on literature and some of them new.

In step two the interviewee is asked to identify additional issues. For each such issue, additional information was asked to ensure it was based on actual experience. Also the impact of the issue (low - middle - high) was asked to obtain an indication of its degree of severity.

In step three the list of potential issues resulting from literature is discussed. The goal is to see if these issues have been encountered in practice. Questions are primarily aimed at actual experience:

- Have you encountered this issue recently?
 - If yes: Can you describe what happened?
 - If no: Is this a plausible issue?

A solid description after a 'yes' should give us confidence that this answer is indeed based on actual experience, providing strong validation for the issue. The opinion queried after 'no' of course gives a much weaker substantiation since it is an opinion only.

Finally in step four people were again asked for additional issues. This to catch any final thoughts.

The choice was made to conduct the steps one to four in a single session. The benefit was that people remembered the first part and could refer back to that. The discussion of the documents helped in bringing back the actual circumstances of the past. This enabled them to better place e.g. the literature results in this past. It was also done for pragmatic reasons. It was easier to get participation this way. The sequence

between steps one and two can be seen as a drawback. If the interview had started with step two, a more open explorative discussion could have resulted. Discussion of issues identified from documentation might close of the minds of the interviewees. The enrichment objective of the research would have benefitted from that. On the other hand, such an open discussion, might be too open and take (precious) time while leading to inconclusive results. This might endanger the validation objective of the case study. An additional drawback was that issues detected in step two cannot be confirmed in other interviews.

It was decided to do step two before step three, since new insights are unlikely after having been confronted with a large and structured list of issues.

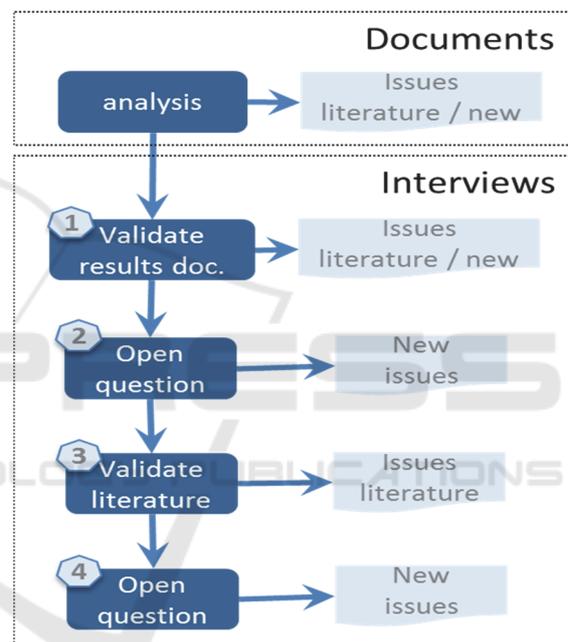


Figure 1: Research process in the case study.

The interviews were recorded to facilitate processing but not transcribed. Since the interviews were well structured, this was not deemed necessary.

Internal validity is fostered by a careful research design. Respondents were carefully selected. Respondents were informed in advance about the purpose of the research. This allowed them to prepare the interview. They were also given the option to check interpretations derived from their interview. This will increase the quality of the information obtained, and thus the validity of the research.

External validity is obtained by the 'factual' context maintained throughout the interviews. Results will show that in the particular organization issues have been encountered. Naturally, this does not

imply relevancy for all organizations. But it does show experienced practitioners have met problems based on the issues, suggesting their relevance.

Reliability is supported by the careful design of document study and interviews. This resulted in the development of an interview guide that allowed to a large degree repeatable interviews. Similarly, the document study process has been well developed.

4 EXECUTION AND RESULTS

4.1 Literature Search

The literature study, using keywords as described resulted in identification of 486 papers. After further consideration of title and abstract 27 of these were selected for a full study. Reading these aimed at identifying specific keywords resulted in a final set of six papers. A cross-reference search led to 12 possibly useful papers, of which six proved useful. Cross-reference search on these papers led to no further findings. The resulting papers are shown in table 1.

A further analyses of the resulting 12 papers showed that seven gave direct evidence for potential issues. From these, in total 20 potential issues were identified. The remaining five papers had no such direct evidence, but provided relevant material from which an additional eight potential issues were derived. This resulted in a list of 28 potential issues.

Table 1: Selected papers.

Bannink, S. (2014); Boehm B. & Turner R. (2005); Gandomani, T.J., et.al. (2013); Khalil, C. & Fernandez, V. (2011); Mahadevan, L., et.al (2015); Mahanti, A. (2006); McMahon, P.E. (2004); Misra, S.C.,et.al (2010); Pechau, J. (2012); Tanner, M. & Willingh, U. von (2014); Vinekar, V.,et.al. (2006); Waardenburg, G. van & Vliet, H. van (2013)

4.2 Classification

This list requires further processing. Different authors might come up with (almost) identical issues. Also, an unstructured list of this size is not easy to handle. So a classification was carried out. For this, five Business Advisors from different domains or product chains were invited for a Metaplan session. During the session a number of issues were merged, resulting in 22 unique potential issues. These were structured into six groups. The resulting structured list with potential issues is presented in table 2.

Table 2: Classification of potential issues.

Organization and structure
C21) Overlap in tasks and responsibilities creates confusion and duplication of work
C22) Lack of joint responsibility for delivering customer value
C25) Overlap in tasks and responsibilities in defining, developing and prioritizing requirements
Business processes and control
C4) Feeling of management they have no control due to lack of reporting
C14) Lack of a high-level planning and understanding of dependencies
C18) Lack of collective goals that result in steering towards individual instead of team contribution
C27) Delay in implementing changes by central quality control
Culture and management style
C9) Lack of a management style focused on leadership and collaboration
C10) Lack of a culture focused on authorizing Agile development teams
C23) Lack of mutual cooperation and trust resulting in reliance on procedures
Development and testing
C2) Lack of linkage of the iterative development process to the test process
C6) Lack of continuous integration testing causing problems be identified too late
C11) Lack of development processes driven by people-oriented iterative development
C16) Lack of a facilitator / coach to remove obstacles
Involvement of stakeholders
C3) Lack of proper client representation in the development team
C8) Lack of continuous customer in determining customer value and priority setting
C28) Lack of executive sponsorship and management commitment
Documentation and communication
C1) Lack of communication and cooperation between and across development teams
C5) Absence of design documentation before the start of the development process
C7) Absence of a fully documented final product which can collide with expectations
C12) Lack of active exchange of knowledge which prevents new insights from arising
C15) Lack of communication aimed at autonomous decision-making and transparency

4.3 Case Study

Next the case study was executed. We identified two subcases within the organization. These were found in clearly distinct environments. Within each subcase, both agile and traditional development were present and interaction indeed took place, thus fulfilling our requirements.

For both subcases the project initiation document and a risk register were used. For subcase I also change requests and exception reports were used. In the analysis for subcase I 20 out of 22 issues were identified. For subcase II, only 8 out of 22 issues were identified. In neither case any issue outside of the already existing list was identified.

These results were used as input for step one of the interview (cf. Figure 1). The data were given to the interviewees beforehand to help them prepare.

Table 3: Results from case study.

Issue	Documentation	Interviews	
	# of cases	Experience	Opinion
Organisation and structure			
C22	2	9	
C21	1	5	1
C25	1	2	3
NC1	0	1	
Business processes and control			
C27	1	7	
C14	2	6	
C4	1	6	2
C18	1	4	3
NC2	0	2	
Culture and management style			
C9	1	6	1
C10	1	6	2
C23	1	5	2
Development and testing			
C6	1	8	
C2	2	7	
C11	1	5	2
C16	0	2	2
Involvement of stakeholders			
C28	2	6	1
C8	2	4	1
C3	2	3	1
Documentation and communication			
C5	2	9	
C1	2	7	
C12	1	4	3
C15	1	4	2
C7	0	2	3

In step one the selection obtained from the documentation was discussed. All identified issues were confirmed in one or more interviews as being real and (potentially) leading to problems.

In step two of the interviews the open question was asked if people could identify any additional issues. Two new issues were identified.

- In the theme organization and structure:
 - NC1) Missing business value by wrong priorities arising from limited visibility on customer value (from one interview).
- In the theme business processes and control:
 - NC2) Lack of pre-funding for development to work together over a longer period (from two interviews).

In step three of the interview, the list of potential issues (table 2) was discussed with all interviewees. All issues were validated in at least one interview.

Finally, in step four of the interview respondents were asked again for any additional issues. This gave no further results. The results are presented in table 3.

5 CONCLUSIONS

In this paper we looked at development organizations where both agile and traditional development meet within programme boundaries. Given the strong differences in approach, culture and terminology, it is to be expected that problems and risks arise when these two worlds meet. The existence of this area of concern is readily shown, both in theory and in practice. However, no current overview of the issues that play a role could be identified in literature.

This gave us the idea to look into this issue. A literature search led to identification of 28 potential issues, based on 12 papers. Overlap between the issues identified was resolved through structured classification, which also added an additional level of structure to facilitate handling of the list.

Classification was done in a workshop where one of the researchers worked with five experienced business analysts who showed the required experience at strategic, tactical and operational level. They provided a sufficient body of experience and knowledge. The workshop process was followed without perceived problems. Members participated voluntarily out of interest resulting in an open and respectful discussion. This gives confidence in the quality of the results.

After merging the overlap, the size of the list went down from 28 to 22 potential issues. In six cases two issues were seen to be sufficiently similar. This is a

relative small shrinkage. Also, no issue was identified in three or more papers. Apparently, there is a fairly small degree of agreement between the results from the different authors. The reason for this is unknown. Maybe the different authors looked from different perspectives, or with different objectives. Whatever the case, from such a result we cannot conclude that the resulting list is complete in the sense that the most relevant issues have been identified. The identified issues seem plausible and are supported by literature. But we take these out of the context in which they were derived. Further validation in the correct context is therefore a mandatory next step.

Validation took place in a case study with two subcases. Each subcase contained a program where both agile and traditional methods are used. The organization scores above CMMI level 2. The case environment is therefore suitable.

Case study design was followed without many deviations. Documentation was made available and participants took time for the 90 minutes interview. This time was found to be sufficient. It is noticeable that some of the criteria, in particular related to the impact on the agile development teams, were recognized to a lesser extent by respondents from a traditional background. However, the impact was not such that it invalidated the results.

Unfortunately, of the ten planned interviews only nine took place. The interview with one business analyst in subcase II could not be held, and no replacement was available. But the project manager of that project was very knowledgeable on customer related issues and so partly compensated for this.

Another point of attention is the large difference between the number of issues identified from documentation in subcase I (20) and those identified in subcase II (8). This might be due to the fact that more documentation was available for subcase I. 8 out of 20 issues identified in subcase I were solely based on the change request or exception report documents that were not available for subcase II. The number of issues identified from common documents (12 versus 8) is not that different.

When we look at the relevance of the potential issues identified in literature it can be stated that all were validated with an explicit reference to specific experience. Table 4 shows an overview of these results. There it can be seen that two issues are validated based on experience in nine interviews. All issues were validated (based on experience) in at least two interviews. Of these, 20 could be identified without prompting from the documentation in subcase I and eight in subcase II, showing a solid basis of proof. In principle a single experience based

validation is enough to give a plausible proof of existence. If we were to require more, then based on a 50% threshold, 14 issues can be accepted. But in principle this list of 22 can in our opinion be accepted as a good basis for further research.

Table 4: Validity of issues.

# of interviews	Frequency based on	
	experience	experience + opinion
2	3	
3	1	
4	4	2
5	3	3
6	5	3
7	3	9
8	1	3
9	2	2

The case study had two objectives, validating the existing list and if possible adding new issues to it. The first objective has been achieved. As to the second, results are less clear. Additional issues could appear during the investigation of the documentation, and in steps two and four of the interview.

No additional issues were identified from the documentation. All issues that were identified, could be related to the existing list. There is a margin for error here, since the analysis of the documentation was done by a researcher involved in the literature study. Some researcher bias is not unimaginable. However, these results were discussed in the interviews with staff members who did not have such a bias, and who agreed both with existence and classification. So the results can be considered reliable. The search based analysis of the documents ensured that any problem, challenge, or risk mentioned in the documentation was found and classified. So the risk of the researcher missing a potential issue because of personal bias is limited.

Step two of the interview gave respondents the opportunity to mention addition issues. However, after having discussed 8 (subcase II) or even 22 (subcase I) issues, there is a good likelihood that this discussion had closed the mind of the respondents to new ideas. Coming up with such issues is difficult at best, and even more so after an extended discussion.

Still, another two issues were identified. One was even offered twice. Both issues were identified by the product owner in subcase II, with one confirmation coming from the product owner from subcase I. Given the setup of the study, no further validation data are available. The fact that a single factor is added independently by two person (both with a

similar role) suggest it is a good candidate issue. But both issues need further validation.

Is this list complete? We have no real reason to claim that. On the other hand, the list by itself could explain all problems, challenges and risks taken from the documentation. Also, only two additional issues were identified, although under unfavorable circumstances. Completeness of such a list can never be guaranteed, but it seems plausible that we have obtained a relevant and significant subset.

Such an overview can be used as the basis for a number of future research activities. Obvious next steps are further validation and enrichment of the list. The current list can also serve as a start to investigate each issue separately so as to provide guidance on handling them. The case organization itself already made a start with this. The interviews have provided insights into possible mitigating measures to avoid problems. These were gathered and reported back to the organization as a basis for improvement. There is also the interesting aspect of the (relative) degree of importance of issues. This is probably very much context dependent although some issues will tend to crop up everywhere. For practical usage, local assessment will be needed to make a “common criteria list” operational for a specific organization.

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