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Obstacles to decision making in Agile software development teams

Meghann Drury[a,*], Kieran Conboy[b], Ken Power[c]

[a] Fordham University, The Gabelli School of Business & The Graduate School of Business Administration, 1790 Broadway, Suite 1108, New York, NY 10019, USA
[b] School of Information Systems, Technology and Management, Australian School of Business, The University of New South Wales, Sydney 2052, Australia
[c] Cisco Systems, Inc., Ard Oran, Oranmore Business Park, Oranmore, Galway, Ireland

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ABSTRACT

The obstacles facing decision making in Agile development are critical yet poorly understood. This research examines decisions made across four stages of the iteration cycle: Iteration Planning, Iteration Execution, Iteration Review and Iteration Retrospective. A mixed method approach was employed, whereby a focus group was initially conducted with 43 Agile developers and managers to determine decisions made at different points of the iteration cycle. Subsequently, six illustrative mini cases were purposefully conducted as examples of the six obstacles identified in these focus groups. This included interviews with 18 individuals in Agile projects from five different organizations: a global consulting organization, a multinational communications company, two multinational software development companies, and a large museum organization. This research contributes to Agile software development literature by analyzing decisions made during the iteration cycle and identifying six key obstacles to these decisions. Results indicate the six decision obstacles are unwillingness to commit to decisions; conflicting priorities; unstable resource availability; and lack of: implementation; ownership; empowerment. These six decision obstacles are mapped to descriptive decision making principles to demonstrate where the obstacles affect the decision process. The effects of these obstacles include a lack of longer-term, strategic focus for decisions, an ever-growing backlog of delayed work from previous iterations, and a lack of team engagement.

1. Introduction

Research has concluded that teams, in general, have the potential to make more effective decisions than individuals because teams can pool knowledge and information, which helps them to make a good decision (Russo and Schoemaker, 1989; Schmidt et al., 2001; Wheeler and Valacich, 1996). However, teams face many obstacles when trying to make decisions, for example: lack of information (e.g. difficulty obtaining information); lack of participation and interaction of team members (e.g. due to the pressure to conform, pressure to present themselves in a favourable way, reliance of junior members on more senior members, domination of an individual, shyness and poor team spirit); assigning the wrong person to a task; inability to distinguish between fact and opinion; a pre-disposition for a particular solution; numerous and lengthy meetings (e.g. which may not be productive); miscommunication; insufficient time exploring ideas and generating alternatives (Shen et al., 2004; Wheeler and Valacich, 1996; Whyte, 1993).

Some of these obstacles can cause problems for teams. For example, individuals required to attend what they consider an excessive number of meetings may make a personal decision not to attend (Kraemer and King, 1988). Poor decisions may also be made by individuals who have a personal interest in a project (Bazerman et al., 1984; Whyte, 1993). This can be detrimental, particularly if these individuals dominate or have a large influence on the team (Whyte, 1993).

Agile software development (ASD) teams are involved in critical decisions that underpin ultimate project success or failure (Conboy, 2009). Because ASD teams exhibit characteristics that affect the nature of their team's decision making compared to traditional methods of software development (Conboy et al., 2009), it seems likely that these characteristics would cause other decision obstacles aside from those typically faced by teams using more traditional approaches. For example, ASD teams work under extreme time pressure to deliver working software in short iterations (Fitzgerald et al., 2006; Fowler and Highsmith, 2001) with frequent, short-term decisions, using minimal documentation (Fowler and Highsmith, 2001). The project manager's role as a decision-maker

* Corresponding author. Tel.: +1 847 219 6423.
E-mail addresses: mdrury@fordham.edu (M. Drury), k.conboy@unsw.edu.au (K. Conboy), ken.power@gmail.com (K. Power).

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is greatly reduced (Alleman, 2002; Lindstrom and Jeffries, 2004), developer's roles interchange and blend to such a degree that developers may make decisions outside of their traditional skill areas, and the customer or Product Owner plays a continuous and embedded role, intrinsically involved in many decisions (Beck, 2000). These issues require an analysis of decision making and obstacles in an ASD context as opposed to traditional software development where there is an accountable project manager, clearly defined and specific roles for team members, and documentation used to drive decisions.

However, little is known about the decision obstacles that an ASD team faces. Some research has found that effective decision making depends on the level of ASD team cohesion and empowerment in decision making: ineffective decisions result from team members not expressing views they believe are contrary to other team members' views (McAvoy and Butler, 2009). ASD team members also rely on their experience to determine whether a design decision is necessary (Zannier and Maurer, 2006) and then compare options when making design decisions (Zannier and Maurer, 2007). Related research has found that ASD teams face a number of negative factors preventing them from following a linear decision process (Drury and McHugh, 2011) and that experience is a driving force in ASD project management decisions (Drury et al., 2011). Yet there is no clarity regarding the specific decisions ASD teams make, including both business and software decisions and whether ASD team autonomy means teams are making both strategic and tactical decisions. It is also unclear when decisions are made and what obstacles ASD teams face when making such decisions.

Customers are a major influencer of decisions in Agile teams, as well as being decision makers in their own right (Beck, 2000). However, the scope of this research is specific to the teams and organizations developing products. In particular, customers are not directly included in the data collection. This is intentional. The researchers wanted to explore decision making from the perspective of the teams developing the product, and these teams did not always include a customer or customer proxy.

We adopt descriptive decision making (DDM) as the theoretical lens for this study given its emphasis on "how real people think and behave" (Bell et al., 1988). This is highly suitable for exploring the flexible ASD context because it calls for the researchers to describe the actual decision situations, including what decisions are made when and what decision obstacles ASD teams face. The research objectives of this study are to:

1) Develop an understanding of the tactical and strategic decisions made in ASD teams.
2) Identify the obstacles to these types of decisions in ASD teams.

2. Descriptive decision making

Decision making was traditionally viewed as a rational process: people followed clearly defined, sequential steps to make optimal decisions by weighing options. This process assumed decision makers were fully informed and rational, and problems were well-defined with a variety of informed, alternative solutions (Simon, 1978, 1979). This rational decision making (RDM) method is a normative theory: it describes how decision makers should think and should act based on coherence and rationality. Normative decision theory views decision makers as idealized, rational, extremely intelligent beings who overcome their inner turmoil, shifting values, anxieties, post-decision regrets, fear of ambiguity, inability to perform intricate calculations and limited attention span to make rational, optimum choices (Bell et al., 1988). RDM looked at optimal ways of making decisions between choices of alternatives in well-structured settings (Klein, 2008).

Table 1
Summary of descriptive decision making principles.

1. Uncertainty affects decision maker
2. Information is not collected rationally
3. Behaviors are adapted
4. Complexity of problem and/or internal conflict affect decision making
5. Contextual differences affect decision making

However, researchers admitted that when making decisions in real-life situations, they were not generating multiple options and comparing them on a set of evaluative criteria; they did not generate probability estimates for different options; and when they did compare options, they were not doing so in a systematic way (Lipshitz et al., 2001). As a result, there was an effort to understand decision making in real-world situations because researchers realized that actual choice can differ from prescribed choice (Barron, 1974). Whereas normative decision theory prescribes the choices a rational person should make in a given situation, DDM focuses on the actual choices made in a given situation, on how and why real people think and act in the way they do in given situations (Barron, 1974). DDM is concerned with how people perceive uncertainties, collect information or evidence, learn and adapt behaviors and perceptions, and deal with internal conflicts and complex problems. It does not look for mathematical axioms or ways people should make decisions (see Table 1 for summary of DDM Principles). Rather, DDM looks to explain how people make decisions in a given context (Bell et al., 1988).

Therefore, to understand the decisions of ASD teams, we believe that it is important to study the actual decisions ASD teams make using DDM principles because they focus on defining the actual choices made in a given situation and how and why decision makers make them (Barron, 1974). As team members' roles interchange and they are often involved in decisions outside of their traditional skill areas (Beck, 2000), we will define both the tactical and strategic decisions they make. Tactical decisions are defined as those that refer to the day-to-day activities that maintain efficient and smooth operations (Chandler, 1997) of developing and testing software functionality. Strategic decisions refer to those decisions concerned with the long-term health of the organization (Chandler, 1997). Typically, software development teams would be involved in tactical decisions, and it is unclear whether ASD teams also make strategic decisions, in addition to tactical ones, as these teams involve their members in all decisions (Alleman, 2002; Lindstrom and Jeffries, 2004).

2.1. Periods of an iteration in which decisions occur

Decision making in any project incorporates a broad range of issues and occurs during many different activities and events. To bound this research, DDM principles in Table 1 are used to determine the actual decisions made during a typical iteration. Although we recognize that decisions may be made outside of the iteration, this study focused only on those decisions made in the iteration. The study participants discuss not only what decisions they make during an iteration, but when and how they make them, particularly when they face new and unclear functionality to develop, which are times of uncertainty. We also try to understand the obstacles during the iteration by using the DDM principles about how behaviors, complexity and context affect decision making in the context of ASD. An iteration is a time-boxed period of fixed length. In Scrum, for example, an iteration is called a Sprint (Schwaber and Beedle, 2002; Svalvay, 2007). For the purposes of this research, we use the more generic term 'iteration' since this research applies equally to any Agile team regardless of which specific method or framework they are using.

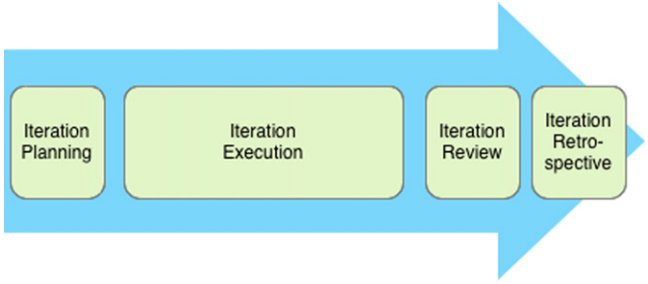


Fig. 1. Decision making periods in a typical iteration.

An iteration starts with an Iteration Planning Meeting and ends with an Iteration Review and Retrospective Meeting (Schwaber and Beedle, 2002). In between the Iteration Planning Meeting and the Iteration Review is the Iteration Execution where the team works on delivering software that meets the iteration goal. For the purposes of analyzing the decisions made in an iteration, we consider these four periods and associated activities described below and visualized in Fig. 1.

Iteration Planning: Iteration Planning is the meeting that marks the start of each development iteration. It consists of a set of activities that will plan the work for the ASD team in the upcoming iteration (Schwaber and Beedle, 2002).

Iteration Execution: Iteration Execution is the period of time between the end of the Iteration Planning meeting and the start of the Iteration Review. Iteration Execution is the time when the team works on developing the actual product to meet the iteration goal. The software, i.e. product, is developed and tested here (Cohn, 2009).

Iteration Review: The Iteration Review is typically a meeting that involves the team plus any invited stakeholders and other interested parties. The Iteration Review focuses on the work the team has completed during the iteration, comparing the commitment at the start of the iteration to the actual delivery at the end of the iteration. An Iteration Review will generally include a demo of the running, tested software that has been developed in the iteration (Schwaber and Beedle, 2002).

Iteration Retrospective: End-of-iteration retrospectives are an opportunity for the team to reflect on how it is working together and actively seek out areas to improve. The Iteration Retrospective is a facilitated session at the end of the iteration (Derby and Larsen, 2006).

3. Research design

To identify the decisions that ASD teams make during a typical iteration, along with the obstacles that impede these decisions, a qualitative approach was employed where the unit of analysis was a focus group comprised of 43 practitioners from 36 different companies, followed by six case studies, one for each of the decision obstacles identified in the focus group.

3.1. Phase 1: focus group

Focus group research emerged from work performed by Paul Lazarsfeld, Robert Merton and colleagues at Columbia University in the early 1940s. It is defined as a "research technique that collects data through group interaction on a topic determined by the researcher" (Morgan, 1997) and involves a group of participants and one or more moderators. The core theoretical elements of focus groups include topical focus, group interactions, in-depth data and a "humanistic" character (Stewart et al., 2007). The focus derives from participants of the group having a "particular concrete situation" in common (Merton and Kendall, 1946), providing a basis for effective communication that is also affected by the moderators' direction of the group's discussions. The researchers guide discussions with suggested topics and probing, open-ended questions.

However, the 'hallmark' of focus groups is the group interaction through which insights and less accessible data can emerge which may not otherwise come to the surface. Researchers (Kidd and Parshall, 2000; Kitzinger, 1997) draw attention to the importance of this differentiator of focus groups from other forms of collective or focused interviews, that is, group interaction and discussion. This group interaction aspect is especially true where participants may not know much about the research topic or require a group discussion to stimulate them to make a contribution (Morgan, 1997). Merton and Kendall (1946) refer to this as "introspective retrospection" while Bloor et al. (2001) refer to the ability of participants to "articulate those normally unarticulated normative assumptions." In drawing out such contributions, Kitzinger (1997) goes so far as to suggest shared tasks and games to encourage group interaction and advocates the analysis of differences and agreements within the group as very valuable. Therefore, in some ways focus groups could be considered to lie between dyadic interviews and direct observation: while allowing the researcher to direct attention to specific topics as allowed by interviews, they also facilitate group discussion as per observation.

As well as the richness of data collected, another significant benefit of focus groups is the ability to obtain much data from a group in a short amount of time (Morgan, 1997; Stewart et al., 2007). It allows participants to probe other participants' reasons for their viewpoints, even challenging others' viewpoints, allowing issues to surface that the researcher might not have asked (Bryman, 2008), which makes them appropriate for exploratory research such as this study. This focus group provided the researchers with an opportunity to explore the varying viewpoints of practitioners who worked on different ASD teams.

The focus group consisted of a group of 43 software industry Agile practitioners. This is a relatively large focus group, but as suggested by Morgan (1997), larger focus groups are recommended for topics where researchers want to collect multiple brief comments and suggestions, whereas smaller focus groups are recommended when researchers want to collect more detailed commentary or discuss complex or controversial topics. As this research was at the early stages of understanding decision making on ASD teams, a larger group was preferred to obtain multiple brief descriptions of the decisions rather than detailed discussion on the complexities. Participants in the focus group were attendees at a professional software development conference with 1400+ attendees. They self-selected to attend this focus group with a choice of 20 other sessions offered at the same time. While this is a limitation of the focus group, it does provide a focus group with participants focused on improving their decision making and thereby a viable group to discuss current ASD decisions and obstacles. As can be seen from Table 2, the participants have a range of experience as some were beginners with Agile methods while others have been working with Agile for up to 10 years. They have diverse backgrounds with varying industry sector experience with Agile development. The focus group was hosted in the USA, but attendees came from the USA, Canada, Sweden, Denmark, Germany and the UK. The focus group participants, because of the nature of the conference, were Agile practitioners, and did not include customers. There were some participants who played the role of Product Owner or customer proxy, but the researchers did not ask the participants to differentiate themselves based on role, or organize by role.

The structure of the focus group was an exercise and open discussion on decisions made during particular periods of an iteration. The discussion loosely followed the DDM principles (e.g. how they make decisions in uncertainty, how they use information, what behaviors affect decision making in the context of ASD, and

Table 2
Profile of focus group attendees.

Criteria	
Number of participants	43
Mean experience with Agile development[a]	2.90 years
Standard deviation of experience with Agile development[a]	2.14
Least experience with Agile development	4 months
Most experience with Agile development	10 years
Industry segments	Communications, Consulting, Entertainment, Finance, Government, Manufacturing, Media, & Software Product Development

[a] The data for experience with Agile distribution is normally distributed with a minimum of 4 months and maximum of 10 years.

how complexity affects decision making) because at this point, the researchers were focused on allowing participants to reveal decisions and obstacles. Specifically, the following topics were covered:

- How decisions are made in the context of ASD teams[3]
- Decisions participants make in the four Agile periods
- Participant perceptions of decision making obstacles to decision making during the four periods of the iteration cycle
- Issues and complexities related to decision making (to flesh out any other obstacles)

After a brief presentation on the importance of decision making for Agile teams, the participants divided into ten teams to conduct the decision making activity in an Agile manner. The goal was for each team to produce a set of decisions that they make at each of the four periods in an iteration cycle discussed earlier. The researchers had previously prepared four blank posters on the wall, one for each iteration period discussed. For an Iteration Planning meeting, for example, participants from each team wrote decisions on Post-It™ notes that arise during Iteration Planning. They organized these decisions to fall into one of each of the four iteration periods. They then had to place their Post-It™ notes with decisions on the correct iteration period poster (see Figs. 2 and 3).

After the participants had completed this activity, the researchers facilitated the focus group discussion on the decisions made in each period and the participants' perceptions of the obstacles for Agile team decision making. Although it was a large group, this resulted in a very lively and engaging discussion. Issues related to decision making were also briefly discussed during this focus group session to discern any other obstacles not already discussed.

The questions during this focus group were largely open-ended, allowing respondents freedom to convey their experiences and views (Oppenheim, 1992; Yin, 2003), and expression of the socially complex contexts that typically underpin software development. The focus group was conducted in a responsive (Rubin and Rubin, 2005; Wengraf, 2001), reflexive (Trauth and O'Connor, 1991) manner, allowing the researchers to follow up on insights uncovered mid-session, and adjust the content and schedule of the focus group accordingly. Where participants suggested potential obstacles, they were asked to provide supporting evidence or examples to supplement their point, thus allowing the researchers in the analysis of the data to distinguish between opinions and feelings versus actual practice.

To improve the reliability and repeatability of the research, a traceable 'audit trail' of the research process, from data collection through to the drawing of conclusions, was sought. A focus group protocol was prepared based on the four iteration periods, specifically Iteration Planning, Iteration Execution, Iteration Review and Iteration Retrospective. These provided a list of "intellectual bins" or "seed categories" (Miles and Huberman, 1999) to structure the data collection and the open coding stage of data analysis. While one researcher facilitated the session, another listened, observed and took notes. The researchers then switched roles to account for any variance between their note-taking and questioning. In any cases of ambiguity, clarification was sought from the attendee during the focus group.

In order to aid analysis, the focus group was recorded and transcribed, generating a total of 12 pages of data that were then proof-read, annotated and coded by the researchers using Nvivo software. The data (i.e. decisions and obstacles) were also emailed to all participants for feedback and validation. No participants sent edits or changes to the data, except to comment on the usefulness of having the data for their work at their own organizations. Subsequently, vetting was used, whereby results and interpretations are discussed with professional colleagues to avoid the problem of what Kaplan and Duchon (1988) call multiple realities. In terms of the analysis, the focus group questions and subsequent analysis were based on DDM principles to understand the actual decisions made in a given situation (Lipshitz et al., 2001) and the subsequent obstacles.

3.2. Phase 2: case studies

To provide further illustration of the six obstacles identified in the focus group, and to demonstrate the impact these obstacles may cause, we then conducted six mini case studies, one for each of the obstacles that resulted from the focus group discussion. These vignettes were purposefully drawn from a pool of Agile teams from a range of organizations with which the research team were working with at this time. Each was selected as it was known in advance that it was having significant issues with the obstacle being studied. This case approach was a technique suited for this exploratory research in that it allowed expansive discussions, illuminating factors of importance (Yin, 2003), thereby supporting the focus group discussions in a more focused manner.

The obstacles identified by the focus groups were explored in more detail by conducting face-to-face interviews (Oppenheim, 1992). The questions were largely open-ended, allowing respondents the freedom to convey their experiences and views, and expression of the socially complex contexts (Oppenheim, 1992; Yin, 2003) that underpin ASD decision making. The interviews were conducted in a responsive manner (Rubin and Rubin, 2005; Wengraf, 2001), allowing the researcher to follow up on insights uncovered mid-interview.

Once the obstacles were identified and coded as such from the focus groups, the case studies asked interviewees open-ended questions around the particular obstacle for that case study. These participants were separate to the focus group attendees, and the purpose was to elaborate on the focus group findings and improve the validity of those findings with new research participants. The case studies used the last two DDM principles: how the complexity of a problem and/or internal conflict affect decision making and how contextual differences affect decision making, to guide the understanding of decision obstacles.

Primary data was collected through interviews with 18 individual team members and managers across a range of roles (Table 3). Companies were based in Ireland and the USA. Interviews varied

[3] Note here that the definition of 'team' incorporates the customer. However, some teams of the participants in this study differed in terms of customer. In some cases this was an actual person, in some cases a proxy, and in some cases no customer role existed.

a. Faces have been covered to protect participant confidentiality

Fig. 2. Determining the decisions made in each of the four periods in an iteration.

Fig. 3. Resulting posters of decisions made in each of the four periods in an iteration.

Table 3
Profile of case study participants.

Case	Industry sector	Roles interviewed
LargeSys	Software and Hardware Development	Project Managers (2)
ABC Consulting	Professional Services	Project Managers (2)
MediumSys	Software Development	Developers (2) Quality Assurance (QA) Tester (1) Business Analyst (1) Scrum Master (1)
Museum X	Arts and Entertainment	IT Department Manager (1) Project Manager (1)
SoftDev A	Software Development	Developers (2) QA Tester (1) Scrum Master (1)
SoftDev B	Software Development	Developers (1) Scrum Master (1) Manager (1)

between 60 and 120 min[4] and focused on the obstacles to decision making in the four stages of an iteration. Each interview was audio-recorded and later transcribed. Observation and field notes were also documented during the interviews and clarification was sought after the interviews when required. The data from each case was analysed using standard coding techniques (Miles and Huberman, 1999) according to the obstacle being studied, under codes such 'description of obstacle', 'examples of impact', 'length of impact', and 'range of impact across project tasks'.

[4] It must be noted that these interviews were for multiple purposes across other pieces of research, and so in some cases the component of the interviews related to decision making obstacles was less than the total interview time.

4. Results

4.1. Decisions made in each iteration period

This section states and explains the decisions that participants in the Phase 1 focus groups reported were made at each period in their iteration cycle. This data describes some of the contextual affects on decision making (fifth DDM principle) in an ASD team. It also discusses the first and third DDM principles: how uncertainty affects decision making and how behaviors are adapted. The Iteration Planning Meeting decisions are usually made with high uncertainty, but as the results show, teams acknowledge this uncertainty diminishes during the Iteration Execution because as they develop functionality, their knowledge increases and decisions are more accurate. Thus, the context of the iteration period plays an important role in how decisions are made and impacted by uncertainty. We categorize the decisions they make during the iteration periods as either tactical or strategic decisions to show where these ASD teams focus their decision efforts. Table 4 provides a summary of the decisions that were discussed for each period in the iteration cycle.

4.1.1. Iteration Planning

Participants reported that decisions made during Iteration Planning are forward-looking, though they are made with little information and many unknowns. One participant observed, "*We're making bigger guesses now than we will when we start working. When we estimate a story, there's a lot of unknowns. As we start to work on a story, we learn more and more about it*". This is not surprising as this meeting determines the activities to take place in the subsequent iteration. Therefore, participants quoted such decisions during this period as "*Determine iteration goals*", "*Decide who is the owner of the story*", "*Decide who will work on what*", and "*Determine if user stories require more discovery work*". These quotes indicate tactical

Table 4
Decisions made in Iteration Planning, Execution, Review and Retrospective periods in the iteration cycle.

Decisions made	Tactical	Strategic
Iteration Planning		
Decide iteration goals and scope (user stories and tasks)	X	
Decide priorities within the iteration		X
Decide which people will be available	X	
Decide capacity for team members	X	
Decide who is the owner of a story	X	
Decide who will work on what	X	
Decide task estimates	X	
Decide if user stories require more discovery work	X	
Decide definition of when a story is 'done' (i.e. completed, when to accept/reject story)	X	
Decide to split or combine user stories	X	
Decide the approach to delivering the story	X	
Iteration Execution		
Decide whether iteration scope should be changed (i.e. reprioritize tasks, accept new tasks)		X
Decide definition of when a feature is 'done' (i.e. completed, when to accept/reject feature)	X	
Decide who will pair together for paired programming	X	
Decide the interface design	X	
Decide how to implement functionality	X	
Decide when to commit code	X	
Decide what tests to create	X	
Decide whether to add/remove/change acceptance criteria		X
Decide on the architecture/design for functionality	X	
Iteration Review		
Decide if delivered product meets customer expectations	X	
Decide whether story estimates need to be modified	X	
Decide whether to continue with the project		X
Decide whether to accept the iteration content	X	
Decide what stories and defects be scheduled for next iteration, particularly if not completed		X
Iteration Retrospective		
Decide what to improve during the next iteration	X	
Decide what went well to continue during next iteration	X	
Decide what new things team will try in next iteration	X	
Decide root cause if team did not meet its iteration goal	X	
Decide priorities for things to address in future iterations		X
Decide issues that will most influence team success		X
Decide whether and how to measure team metrics		X

types of decisions to plan what work will be completed during the subsequent iteration and who will do it. The only strategic decision coded during Iteration Planning related to priorities of the iteration (e.g. "*Determine priorities for iteration*") as this decision affects the iteration delivery for this and future iterations, which affects the long-term ability of the organization to deliver to its customers.

Participants also noted that many of the decisions are group decisions, meaning they make them together rather than as individuals. This group decision making requires discussion and agreement from all team members. It seems to be used most for deciding the approach for development. Examples of these group decisions included, "*Decide the approach to delivering the story*" and "*Decide to split or combine user stories*".

However, while participants could list decisions made during Iteration Planning meetings that focused on tasks, task owners and estimations, there was less clarity on the timing of planning decisions for design as to whether they should be planned during the Iteration Planning or allowed to emerge during Iteration Execution: "*Where does the design decision come in? Because we find we take a lot of technical decisions during Iteration Execution and to me that's a little dangerous . . . and I know Agile says design is emergent . . . So how do you get confident because you say "Well, ok, team we've got 2 weeks so let's do this" and then 2 weeks later it's like 'Oops' . . . How do you get past that?*" There is uncertainty as to design decisions, and while the Agile philosophy is for emergent design, certain team members saw value in planning out some tasks related to design to account for team members' time spent on this activity.

4.1.2. Iteration Execution

Participants asserted that Iteration Execution is the tactical period of development and testing compared to Iteration Planning, which plans the activities for the iteration. Participants stated, "*Execution is more about adjustments*" and "*Execution is more tactical*". Thus, decisions during Iteration Execution focus on the actual development of functionality and how to do it as teams: "*Determine how to implement functionality*", "*Decide on the architecture/design for functionality*", "*Define when a feature is 'done'*", "*Decide the interface design*", and "*Decide what tests to create*". These decisions all focus on the practicality of how to develop and test the functionality that teams have planned in Iteration Planning to complete for this iteration.

Decisions made in this period are also generally closest to when those decisions will actually be implemented, so uncertainty is reduced and participants can make more accurate judgments. As discussed during the Iteration Planning, team members make bigger guesses during the planning meeting because they have less information and more uncertainty since they haven't started to develop a piece of functionality yet. But, during Iteration Execution, "*We start to work on a story, we learn more and more about it*". Therefore, some decisions during Iteration Execution are strategic because they address changes to scope as team members gain more information by developing functionality compared to when they were planning the iteration. Examples of these decisions include, "*Decide whether the iteration scope should be changed (i.e. reprioritize tasks, accept new tasks)*", and "*Decide whether to add/remove/or change acceptance criteria*".

4.1.3. Iteration Review

During the Iteration Review meeting, stakeholders have an opportunity to review progress and determine whether it is worth proceeding. Based on customer feedback, the ASD team decides whether the functionality meets customer expectations, whether estimates need to be modified, what stories should be prioritized for the next iteration or whether to stop development. A number of participants reported having worked on projects that were cancelled after 2–4 iterations because it became clear the project could not achieve its goals. This was seen as a positive outcome because the business avoided investing further in an area that was not going to be profitable. Participants said the decision to stop development occurs during Iteration Reviews: "*It [the Iteration Review] shows visibility on the problems we had and the decisions we made. It didn't make sense going forward with more iterations*". Other participants stated, "*It [stopping development] happened twice…it was in the early stages–in the 3rd or 4th iteration*" and "*It happened once in an early iteration where we were trying to figure out how much it would cost us*". The decisions to "*continue the project*" and "*what stories and defects should be scheduled for next iteration*" are strategic because they affect what the overall organization can deliver to customers.

However, it seems not all decisions to stop development occur in the Iteration Review meeting, and some do occur during Iteration Execution when teams gain more information about functionality as they begin to develop as another participant counter-argued: "*We had a little different situation and it wasn't as clean as just being in an Iteration Review meeting. But we were maybe 75% of the way through the project and saw that we couldn't deliver the majority of the value and saw that remaining stories wouldn't really deliver that much for the business so we decided to go to market [with what we had]*". This team recognized that the cost for developing additional stories wasn't worth it because the stories would not add that much more value to the customer, so they made the decision to go with what they had at that time.

4.1.4. Iteration Retrospective

Feedback for the Iteration Retrospective confirmed that teams use this activity to make tactical decisions about process, specifically around short-term improvements. One participant described the Iteration Retrospective as "*Another opportunity at the retrospective to say 'where do we want to improve?'*". Examples of specific tactical decisions include, "*Decide what to improve during the next iteration*" and "*Decide what went well to continue during next iteration*". Yet it is also the iteration period where more strategic decisions are made compared to any other period as team members decide and prioritize improvements for future iterations that could impact the overall organization and its customer relationships. Strategic decisions focus on future priorities and tracking team success. They include: "*Decide priorities for things to address in future iterations*", "*Decide issues that will most influence team success*", and "*Decide whether and how to measure team metrics*". Regardless of being tactical or strategic, all of these decisions indicate the team uses the Retrospective to decide how to better their team's Agile process in future iterations. They even consider the priority of some improvements.

Yet while some participants view the Iteration Retrospective as an opportunity to discuss lessons learned and to improve future performance, not all participants shared a similarly positive experience. Another participant had a less positive experience with retrospectives in their team: "*In my experience it seems to be just a free-for-all of just throwing positives and negatives on a wall and grouping those, you know, if two people say the same thing we talk about it. There's not really a lot of decisions to be made other than, saying, 'alright here's one…*'". Therefore, it seems there is a danger that teams just vent frustrations during the Retrospective rather than make decisions and implement those actions for improvements in future iterations, of which teams should be wary.

4.2. Obstacles to decision making in Agile teams

The focus group participants also discussed a number of obstacles from their experiences across all four periods of the iteration cycle. These obstacles were then explored in greater detail by individual case studies, one for each obstacle. Based on the focus group insights and case studies, each obstacle was mapped to a DDM principle so that the results show which DDM principle to which the obstacle relates (see Table 5 for a summary).

4.2.1. Agile team members are unwilling to commit to a decision and rely on the Scrum Master for decisions

Lack of commitment to a decision was an issue raised by many. In some teams nobody was willing to make a decision and resolution was left to the Scrum Master, coach, or managers who then faced a decision point–either make decisions on behalf of the team, or stand back and allow the team's confidence to emerge. Of the decision list in Table 4, architectural decisions and measurement decisions were often cited as these types of decisions. Lack of commitment regarding the former was typically due to a lack of sufficient expertise, while commitment regarding the latter was due to the diverse metrics that could be applied and the significance of choosing one metric over another, e.g. one metric may be better but have a negative impact on perceived developer or team performance. Evidence of a lack of commitment was varied; in some cases delayed decisions were a clear signal. In one humorous instance developers were often seen to be moving index cards half way between columns on the whiteboard, showing that a story was somewhat complete but that the developers were unwilling to take the decision to declare a story fully complete.

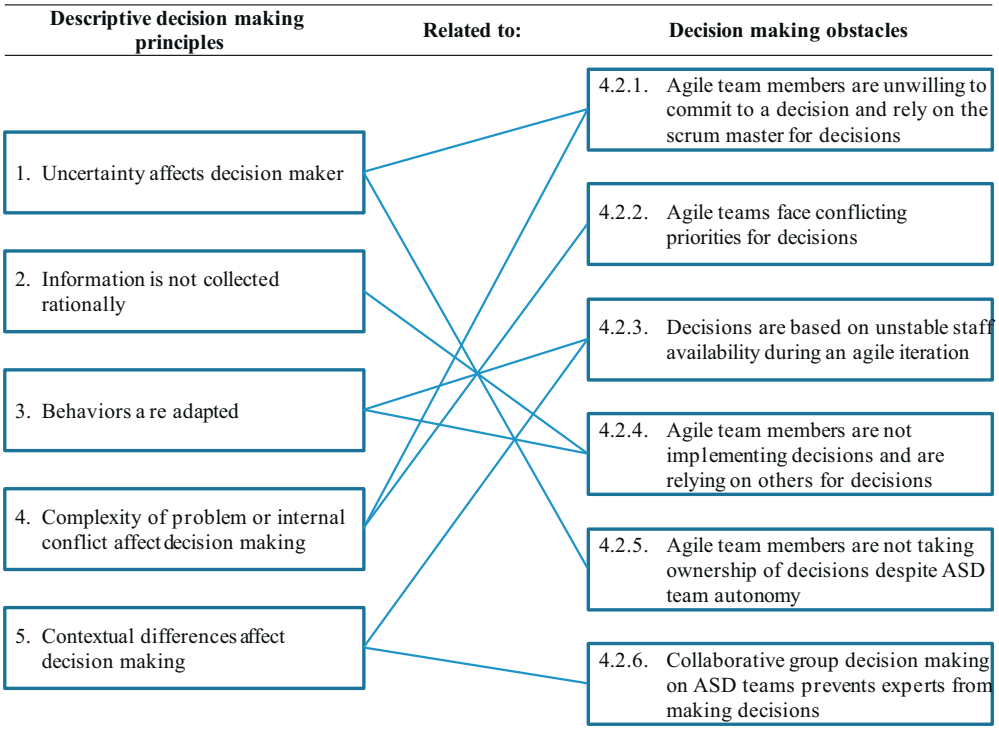
This lack of commitment decision obstacle relates to the 1st DDM principle: uncertainty affects the decision maker, and the 4th: complexity of problem or internal conflict affect decision making. Regarding architectural decisions, a lack of architectural expertise is an example of uncertainty and knowledge, particularly for complex functionality, and resulted in team members not committing to decisions because they weren't sure what to do. Likewise, Case Study 1 illustrates not only how uncertainty relates to an unwillingness to commit to a decision, but also how the complexity (4th DDM principle) of immediately implementing a major decision leads to unwillingness to commit to a decision.

At LargeSys, the uncertainty five teams faced due to so many requirements changes led to a decision to immediately make requirements changes visible to all teams. The complexity resulted because the transition was sudden and team members were not accustomed to looking for changes so quickly so they did not look for them. In 2 days there were 22 new user stories which had also already changed again in those 2 days. The team was not committed to this decision to make requirements immediately visible. As a result, a staged adoption was implemented to increase commitment to the decision.

4.2.2. Agile teams face conflicting priorities for decisions

When faced with multiple customers with multiple, often-competing requirements and priorities, it can be tough to make any decisions on scope, content and priorities. From the Phase 1 focus group, this was felt to be particularly relevant to Agile. As one participant stated, "*With more plan-driven approaches, everybody has a clear role and a clear line of command and so people whose priorities conflict are somewhat separated horizontally or vertically*". In an Agile context, the team hierarchy is flat "*and so all people and all their conflicts are clustered together*", including the customer, which can strain client relationships. This affects the strategic goals as it

Table 5
Summary of DDM principles to which the decision obstacles relate.



becomes unclear as to which priority takes priority, and that comes down to the overall organization's goals.

This obstacle exemplifies the 4th DDM principle where internal conflict affects decision making: the conflicting internal priorities that result from the ASD team nature to flatten a team structure lead to confusion as to which decisions should be made and when for which goals. It becomes more difficult to make prioritized decisions. Case Study 2 further exhibits conflicting priorities between having experienced customer staff on site versus their cost to the budget.

As seen in this case study, decisions were affected due to the conflicting priorities that arose from having customers on site. The software quality improved, but the "invasive" customer presence hurt the client relationship and increased project costs. It is unclear whether the software improvements were worth the sacrifice of the relationship.

4.2.3. Decisions are based on unstable staff availability during an Agile iteration

During an iteration, people can be pulled onto other projects with little or no notice during Iteration Execution. This can happen for a variety of reasons, but the common reason in the focus group was developers being pulled to deal with customer support issues. This was seen as particularly problematic in an Agile context where the scope of the iteration was decided based on team members' task estimations with no allowance for slack. Many noted that the external tasks often take priority over the prioritized list of project requirements: "*When the CTO rings, you cannot tell him or her to wait for the next prioritization to book a developers time*" (participant stating he was a Project Manager). Consequently, when a participant is pulled to external tasks, the iteration cannot be completed on time.

This obstacle relates to the 5th DDM principle: contextual differences affect decision making and 3rd principle: behaviors are adapted. When the availability of resources changes during the iteration, this changes the context of the situation. Scope decisions are therefore impacted because the planned work cannot be completed for the iteration when resources are reduced. Ideally, team member behaviors would adapt to complete these tasks, but estimations are decided so that there is no wiggle room to complete the tasks left behind by team members who have been pulled from the team mid-iteration, which is further illustrated in Case Study 3.

In Case Study 3, the team context often changes mid-iteration when resources are pulled. Behaviors do not adapt to make decisions because the estimates provided during the planning meeting do not leave any spare time. When team members are pulled, there is no additional time left for someone else to cover their work so team member behavior is not able to be modified due to time constraints.

4.2.4. Agile team members are not implementing decisions and are relying on others for decisions

An environment where decisions do not result in implementation can create an atmosphere where people stop making decisions. As one focus group participant noted "*I'm just going to let someone else make the decision for me because whatever I decide to do just didn't go anywhere anyway*". While decisions regarding user stories and their estimates were not typically associated with this, some pointed to Agile as the cause of many decisions "*petering out*". As one developer noted "*we make decisions in the planning meeting but then at the end of the iteration, you find out that somebody rubbed out or changed that item on the whiteboard, based on some chat that we weren't involved in*". There was a sense from quite a few participants that while some decisions in an Agile environment are clearly documented and tracked, the informal, co-located, social nature of Agile can result in subtle changes in decisions, and while this is sometimes positive, some staff take follow-on actions based on decisions that they were unaware had changed.

This characterizes the 2nd DDM principle, information is not collected rationally and 3rd principle, behaviors are adapted. While information is not collected rationally by decision makers, there needs to be a rational, formal way to disseminate information about decision changes so that members' behaviors are adapted to change

Case Study 1: LargeSys—people are unwilling to commit to a decision

LargeSys hired Agile method consultants to assist in a transition from an in-house plan-driven method to a new method which closely resembled an XP/Scrum hybrid. One of the key recommendations from the consulting agency was that, due to an unusually high level of requirement changes, all five teams should allow a change to be instantaneously reflected in any relevant user stories, and the new and updated user stories should replace old or obsolete ones during the current iteration. This advice was followed, and although two projects experienced "*a smooth and enjoyable transition*" (Manager, Project 4), it subsequently "*caused havoc*" (Manager, Project 1), "*fear*" (Manager, Project 2), "*panic and resentment*" (Manager, Project 3) on three projects within 2 days of it being introduced. The common theme across all three managers was that on their project, the transition was too fast. "*We went from a scenario where requirements lists were updated once every six months, and didn't impact developers for a further three, to a scenario where a requirement you started writing code for at 9:00am, had changed or even disappeared completely by 9:15am*" (Manager, Project 3). The teams seemed to cope with minor adjustments to a couple of requirement specifications, but severe problems occurred as, after 2 days for example, Project 2 had 22 new user stories, each of which had changed at least twice. This initiative was abandoned and a staged adoption was introduced over a 7 month period:

Stage 1 (1 month):	Any requirement changes logged but only used for discussion purposes.
Stage 2 (1 month):	All new requirement changes logged and updated user stories introduced into live development after the next monthly release.
Stage 3 (2 months):	All new requirement changes logged and updated user stories introduced into live development after the next fortnightly iteration.
Stage 4 (3 months):	All new requirement changes logged and updated user stories introduced into live development via the product backlog and only brought into current iteration if all planned user stories for that iteration are complete.
Stage 5:	All new requirement changes logged and updated user stories introduced into live development the morning after they are discovered.

Now all 5 teams have completed the transition and, in a formal review, all stakeholders (project manager, developers, customers) voted to retain this practice.

Case Study 2: ABC Consulting—conflicting priorities exist for decisions

Following expert advice and Agile method literature, one business unit in ABC Consulting decided to adopt XP and implemented ten of the 12 XP practices across all 8 of their projects. One of these practices was the "on-site customer", which they implemented rigidly as described by Beck (2000). According to the project managers across the 8 projects, the on-site customer practice contributed to creation of change (creative brainstorming sessions were held with business function experts in focus groups), pro-action (the on-site customer pre-empted user story errors and inconsistencies at the source), and learning (the on-site customer took part in all stand-up meetings and retrospectives and paired with some of the programmers to increase his/her technical knowledge and to disseminate business knowledge). The quality of the software was also considered higher due to the continuous input of domain-specific knowledge from the customers. While the on-site customer practice clearly contributed to many aspects of agility, the impact on economy was "*detrimental*" according to the lead partner on the eight projects: "*We were operating on very tight margins and the cost of paying eight customers to be on-site full-time was highly prohibitive*". Early in the initiative, the on-site customers were relatively junior and had "*extensive knowledge of their own day-to-day job but not of the wider organization*" (Project 4 Manager). Therefore some of these were replaced with highly experienced (>5 years) staff who were much more beneficial but on average 350% more expensive. Also, the customer staff often worked on shift rotas which were inconsistent with the hours worked by the consultants: "*Often we were paying a full day's wages for a customer to sit with us for two hours*" (Project 6 Manager). According to the partner, costs were not purely financial. Prior to a full-time customer being appointed, "*we had a good relationship with the client organization, but because of the invasive nature of the new working system, that relationship became frayed pretty quickly*".

tasks accordingly to align with the desired finished product. Additionally, some decisions are not implemented because neither they nor the changes to the decision are tracked so no one follows up. Case Study 4 highlights an example of a team that decided to have team members anonymously annotate any team document rather than use a rational process to encourage more constructive feedback. As seen in Case Study 4, one team ended up not adapting its behaviors to implement the anonymous annotations process. However, this team did implement a different non-rational data collection process by using a creativity grade ranking that was based on their subjective opinion rather than a rational formula. This adapted behavior resulted in creating business value.

4.2.5. Agile team members are not taking ownership of decisions despite ASD team autonomy

Participants reported cases where the team makes a decision but nobody really took ownership of seeing it through. A few focus group participants in particular spoke of teams with a significant number of "*weaker*" developers, where decisions were very easy to reach, but the implementation of those decisions left a lot to be desired. Interface and implementation decisions were considered particularly susceptible to this, as one participant stated, "*We wouldn't have made that decision if we knew it was going to be executed poorly and nobody was going to stand accountable*".

This obstacle relates to the 1st DDM principle, uncertainty affects the decision maker, because less experienced team members naturally have less certainty about their decisions and this can lead to a lack of ownership and accountability for their decisions. Agile teams have a mix of experience in members, and their flexibility should encourage team members to learn new functionality and take on various tasks. But this can cause uncertainty and therefore lack of decision accountability while members are learning new tasks. Case Study 5 shows how the lack of ownership relates to the DDM principle of uncertainty affecting decision making. In this case, the uncertainty did not result from a lack of experience but rather from a lack of clear accountability. When decisions were made at Iteration Retrospectives, they were not given clear actions or owners, so no one followed up on them and members focused on their assigned tasks. Eventually the team realized this and addressed this issue by making actions and owners clearer, which has started to reduce the lack of ownership for retrospective decisions.

4.2.6. Collaborative group decision making on ASD teams prevents experts from making decisions

This obstacle refers to a lack of empowerment to make decisions and to follow through on executing against those decisions. Ultimately, people like to be involved in the decision making process. Empowerment and involvement in decision making are often seen as core strengths of Agile. However, some focus group participants

Case Study 3: MediumSys—decisions are based on unstable resources

How to address reduced resources occurring mid-iteration was a major decision at MediumSys where team members were regularly pulled from the team mid-iteration to address bug fixes for the client. The team had provided the estimates for tasks during the planning meeting based on who would do the work and how many people in total were working on the current iteration. When someone was pulled from the team mid-iteration, it could happen with less than a day's notice which throws the entire planning askew because the change can be "*indefinite*", causing the team to "*lag behind too much*" (QA Tester 1) and making "*information no longer available*" (Scrum Master) to the team from that member. The team plans tasks based on the resources at the beginning of the iteration so when a resource is suddenly removed from the team, it "*throws your plan out the window*" and requires the team to "*re-evaluate at that point*" (Senior Developer 2) to decide what functionality will not be delivered. Unfortunately, this team had no solution to this obstacle. Regularly, teams were not dedicated entirely to iterations and often were dismantled halfway through projects. Team members felt this was a direct result of poor quality in the past that now affects the critical releases to various clients. New development is halted as resources are "*dragged*" (Business Analyst) to address issues with releases rather than continue with new development. Therefore, new functionality is slow to come to customers and the backlog of delayed work is continuously increasing and hindering future iterations.

Case Study 4: Museum X—decisions are not implemented

During an initiative to implement Agile methods on two mainstream projects, the Museum X IT department placed particular emphasis on enabling creativity in their ISD projects, in line with the obvious overall philosophy of the organization. Many practices were suggested by management; 15% of development time was set aside for 'spikes', which are time boxed periods for research and development of concepts and simple prototypes; resources were allocated to allow multiple stakeholders to spend time on-site to discuss new ideas; higher developer autonomy was facilitated; and team allocation policies ensured that every team had the option of increasing diversity in terms of skills, personality, seniority and background disciplines. A system was established whereby all documents, code, Post-It™ or any other project artefact could be anonymously annotated by any team member or stakeholder, with the rationale that constructive feedback would be more forthcoming without fear of adverse reaction. According to the IT department manager, one team embraced all of these initiatives and used them persistently for the duration of the project, while the other used none. "*No matter what we did that team just did not change anything from the way they did things before- they didn't build in any spikes, they did chat to other stakeholders but didn't really listen, the manager controlled just as tightly as before, and the composition of the team didn't change so diversity wasn't increased*" (IT Department Manager, Museum X). The interesting point in this case is that the latter team produced much more innovative software than the former and outperformed them on every creativity metric used. "*We allocated a crude but effective 'creativity grade' to every piece of code, ranking it as either low, medium or high. The rogue team's sheet was full of medium and high grades, and it wasn't just creativity for the sake of it. Most of these ideas created significant additional business value*" (IT Department Manager, Museum X).

felt that decisions they traditionally had control over disappeared with the transition to Agile: "*While I got advice, I was always the person with the final call on anything architecture related. Now with this democratic environment, I am only one voice among many, and many of those know very little regarding architecture*". Thus, in ASD, people can be involved in decisions that fall outside their remit, thereby potentially lessening the voice of the knowledgeable and expert team members in that particular area.

DDM principle 5 relates to this obstacle. Contextual differences affect decision making and when decision accountability becomes shared by many, the experienced voices can be diminished which can lead to inaccurate or inappropriate decisions made. In this ASD context, the flexible team structure can hinder decisions. However, Case Study 6 shows how a complete lack of empowerment can hinder a team. The experienced members did not empower junior members to select tasks or propose alternative ways to develop functionality. They did not learn new functionality due to time constraints. While this did maintain experts on the team in particular areas, it also prevented the team from self-organizing and working as a team. This becomes an even bigger problem when team members leave the team. Unfortunately, the team in Case Study 6 still maintained a traditional command-and-control style so the benefits of Agile were not seen.

5. Discussion and conclusion

To better understand the actual decisions made in the real-life situation (Barron, 1974) of an Agile environment, this research examined the different decisions made across four periods in an iteration cycle and summarizes them here for each period: Iteration Planning, Iteration Execution, Iteration Review and Iteration Retrospective. Not surprisingly, the results indicate that Agile teams do focus more on tactical rather than strategic decisions. A likely explanation is that working in time-boxed iterations gives the team a short-term focus, usually of 2–4 weeks in duration. Because of this, teams can lose sight of the organization's goals for customer delivery and how their decisions fit into these goals, i.e. strategic decisions, focusing instead on decisions to complete their daily task load, i.e. tactical decisions, which is not surprising. Iteration Planning includes decisions about planning the work for the subsequent iteration. Iteration Execution includes tactical implementation and development decisions, including adjustments needed to the scope of the iteration as teams acquire additional information while they are developing functionality. Iteration Review includes decisions about whether the product satisfies the customer and whether future iterations should continue. However, the data indicate that sometimes the decision to stop development also occurs during Iteration Execution when the value of developed functionality is ascertained. Finally, the Iteration Retrospective includes decisions for improving the team's process in future iterations, although the data also indicate that not all teams implement identified improvement opportunities. To some, the Iteration Retrospective appears a waste of time because people just talk about issues but no one takes them on board to make changes in the process in future iterations, which confirms prior research stating that Iteration Retrospectives do not lead to any real changes for the ASD team (Kwak and Stoddard, 2004).

The goal of DDM is to understand actual choices and why they are made in a given context (Bell et al., 1988), and this research indicates that people make decisions in the context of these four Agile periods based on the goal of each period. Iteration Planning plans the work of the iteration (Schwaber and Beedle, 2002), the development, testing and other work of creating the product happens during Iteration Execution (Cohn, 2009), Iteration Review gives a product demonstration and discusses customer satisfaction (Schwaber and Beedle, 2002), and the end-of-iteration

Case Study 5: SoftDev—lack of ownership of decisions exists

SoftDev has a product team that creates enterprise products for global customers. At the early stages of forming the product team, when they were still learning how to apply Agile principles and practices, they made many decisions at their Retrospectives. These decisions included removing obstacles, e.g. doing something about the number of meetings impacting the team's time. The decisions would also include new things to try, e.g. improve the results of code coverage metrics in a particular component for the next iteration. The team felt good about identifying these areas for improvement. However, as one team member noted, "*The same issues kept coming up iteration after iteration. The problems were not going away. We made a bunch of decisions at the end of the iteration but nobody followed through*". At a future iteration the team decided to address that particular problem, i.e. decisions were made but nobody followed through on them. Everybody agreed there were many problems to fix, but nobody felt they owned the decision. After the retrospective everyone just focused on delivering the committed content. The Scum Master on the team was not a full-time Scrum Master; the Scrum Master was also a team member. So part of the reason for not following up on decisions made during the retrospective was that the Scrum Master just did not have time to do so. The person's work as a contributing team member was taking precedence over his work as Scrum Master. There was nobody to own the decisions made by the team. As the Scrum Master said, "*I just didn't have time to think about it. I felt under pressure to deliver on our user stories and didn't have time to go back and look at what we talked about during the Retrospective. Of course, I felt bad when the same things came up a few Retrospectives in a row. We realized we were feeling good about identifying obstacles and making decisions as a team. But part of the problem was we weren't identifying actions and owners for those decisions*". As a result, problems and obstacles were not addressed. The team was not learning from the insights gained at the Retrospective, and was missing out on the opportunity to make real improvements to how they were working. The team decided to make actions and owners clear in the future. This has started to reduce a lack of ownership for decisions made during Retrospective meetings.

Case Study 6: SoftDev—lack of empowerment to make decisions exists

For one of the teams at SoftDev that made a decision to adopt Scrum as their Agile development process, the team members' scope of decision making was very limited. Despite the move to Scrum, some managers were still behaving in a command-and-control style. Team members were not empowered to make decisions on certain Agile practices, such as collective code ownership and volunteering for tasks at Iteration Planning. For example, at Iteration Planning meetings, managers were deciding the features and areas of code that developers would work on and team members were not self-selecting tasks. Each developer owned his or her own set of user stories, and the team members were not working together as a team on individual user stories to get them completed. This seemed to stem from a reluctance to let go of the old ways of doing things. One of the developers commented, "*My manager tells me what I'm supposed to be working on. I know we're supposed to be doing Scrum properly, but I still report to my manager*". A development manager noted, "*I need to know what the people on my team are working on, and we also still need experts in different areas. It takes too long to have people ramp up on other areas [of the code base]*". The team members were not encouraged to propose alternative ways of addressing these concerns from management. There was a direct impact to the team's ability to self-organize and to operate effectively as a team. A developer described a consequence of the problem: "*We're not really coming together as a team the way we should be. We're really more a group of people than a team. We're too dependent on managers to make decisions for us*".

Retrospective identifies potential improvements for future iterations (Derby and Larsen, 2006). Throughout the iteration cycle, decisions therefore move from planning the iteration, to tactical implementation, to customer and stakeholder satisfaction, to process improvements. This is not surprising as a project generally requires decisions for planning, tactical work and review of work.

However, what is important to understand is how the six identified decision obstacles can affect Agile development. As Table 5 shows, each of the DDM obstacles faces challenges in Agile development. DDM states that problem complexity affects decision making, and on these Agile teams, the complexity and *conflicting priorities* make it difficult for Agile teams to focus on decisions for planning the 2 week iteration, which is a short period of time particularly for juggling multiple priorities. The short-term focus of iterations puts less emphasis on long-term strategic decisions and more focus on the short-term tactical decisions measured in weeks. As Case Study 2 highlighted, on-site customers not only create conflicting priorities but also increase the cost of the project and can harm client relationships. Also, planning the work requires estimation for tasks for each team member during the iteration. When there is *unstable staff availability during an Agile iteration*, this planning falls apart and the basis of the iteration disappears, which supports the DDM principles that behaviors must be adapted as contextual differences affect the decision making. As Case Study 3 showed, while teams may believe they can recover in future iterations as the incomplete work was just from a 2 week period, these unfinished tasks can build quickly and steadily over time as team members are continuously pulled from Agile teams, thereby delaying future iterations.

The obstacles make Iteration Execution and Iteration Review difficult as well. One of the purposes of an Agile process is to involve team members in all facets of development (Beck, 2000), but when *people are unwilling to commit to a decision*, they often rely on the Scrum Master, or other leadership figure, to make decisions on their behalf. Thus, as DDM states, the decision maker is affected by his or her uncertainty and the problem complexity, and therefore does not make the decision. The decision maker allows another person, namely the scrum master, to make the decision instead. This reduces the autonomy of the team rather than engaging all members. As Case Study 1 showed, the impact of not committing to the decision to regularly update requirements changes led one team to face 22 new user stories in just 2 days which had also already changed again. When *decisions are not implemented as Agile team members rely on others for decisions*, as DDM claims, their lack of information prevents them from empowering their own decision making. They adapt their behaviors as DDM suggests, thereby relying on others to make the decisions. Additionally, there is a *lack of ownership despite ASD autonomy*, so people are making decisions at times but are not following through with quality work. Case Study 4 showed a team not implementing an annotation decision, although this team did implement another annotation method and ended up increasing their creativity and business value as a result. However, Case Study 5 showed that a lack of ownership when clear actions and owners are not given to decisions causes decisions to fall through the cracks and issues to repeat, which exemplifies DDM's principle that uncertainty affects decision making. Additionally, in Case Study 6, *collaborative ASD group decision making prevents*

experts from making decisions, thus hindering the team from self-organizing and providing insight to development. As DDM states, contextual differences affect the decision making, and here, the functional delivery at the end of the iteration suffers and customer satisfaction may be reduced during the Iteration Review as a result.

There are implications of this research for theory. First, we can see the DDM principles at work on these Agile teams. Principle 1, uncertainty affecting the decision maker, is exemplified on these Agile teams when team members are unwilling to commit to decisions and a lack of ownership for decisions exists despite ASD team autonomy. The team members' uncertainty about tasks hinders their decision making. Principle 2, information is not collected rationally, is true for Agile teams who rely on others to make decisions because they lack information. ASD teams exhibit Principle 3, adapting behaviors, when they lose resources mid-iteration, requiring a reshuffling of the work, and when team members are not making decisions and others have to step in to decide. Principle 4, problem complexity affects the decision making, is seen on ASD teams when team members rely on the scrum master for decisions because they do not know how to develop complex functionality and when conflicting priorities prevent an ASD team from making decisions. Finally, ASD teams exhibit Principle 5, contextual differences affecting decision making, as changing of resources mid-iteration requires changes to task owners and decision makers and the collaborative nature of Agile teams prevents experts from making decisions. This contributes to our understanding of the decision making process and obstacles ASD teams face during this process, thus contributing to the coverage of process and technique in Dingsøyr et al.'s roadmap for Agile research (Dingsøyr et al., 2008).

Furthermore, there are many implications of this research for practicing Agile teams. Agile teams should make a discussion on decision making an active part of Retrospectives. Iteration Retrospectives provide a regular opportunity to assess the impacts of short-term tactical decisions, while also providing an opportunity to assess the bigger picture of how the team is doing in relation to longer-term strategic decisions. Providing this context will, in general, help a team's overall decision making ability. Explicitly categorizing decisions into tactical and strategic buckets also helps teams make those links. Understanding the boundaries of decision making in teams is also valuable. Developing this understanding helps to remove confusion about decision making authority, remove confusion over who is responsible for implementing decisions, and provide a better context for teams to exert their autonomy. Things as simple as having owners for decisions, taking actions and making the decisions visible, as highlighted in Case Study 5, can help avoid situations where decisions are not acted upon, or at least provide visibility when these situations occur.

This study examined ASD professionals with various experiences as well as in-depth case studies of the identified six decision obstacles to provide detailed descriptions of them. Whereas this focus group did provide insight by asking team members to describe the decisions and obstacles on their Agile teams and the case study participants provided vivid descriptions of the obstacles, future research should include analysis of solutions to the obstacles to understand how teams are and should go about addressing them. Also, a limitation of this study is that, while running the focus group event at an Agile method conference elicited attendance from a group of experienced, well informed participants, one must be aware that such events are often accompanied by an atmosphere of enthusiasm. The follow up case studies were not limited by any such potential bias but future research should still seek to determine whether the opinions of this group are replicated across more 'neutral' environments.

Also, further in-depth case studies of these obstacles and their impact could be conducted in future research. The main focus of this paper was the identification of the obstacles and so we felt that, given word limit constraints, priority should be given to that phase of the research. The level of detail given to the mini cases was lower as their purpose in this research was simply to illustrate the obstacles and to provide an example of each. Also, while these cases provided illustrative examples of the obstacles 'in action', other factors such as recent adoption, lack of training, and a lack of experience with Agile methods may all play a role. Other forms of data collection such as observation should be included to identify the presence of obstacles, their impact and how ASD teams address decision obstacles to fully conform to the application of DDM by observing people in their actual decision environment. For example, members of this focus group focused on their tactical decisions with little mention of strategic decisions. Observation of ASD teams could reveal whether ASD teams are involved in making strategic decisions or whether these teams remain focused on the day-to-day activities to deliver working functionality each iteration like the focus group stated.

Nevertheless, this study has contributed to the ASD literature by identifying decisions made and obstacles to decision making during four periods of an iteration cycle using DDM principles. It was an exploratory step to determine when ASD teams make decisions and what obstacles prevent team members from making decisions. Looking at how decisions and solutions to obstacles can improve project performance would help ASD teams improve their iteration delivery which can be explored in the future for impact on project and team performance.

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Additionally, part of this paper was presented as an earlier draft at the annual conference of the Agile Alliance (Agile 2011) in Salt Lake City, UT. That paper, entitled, *Decision making in Agile development: a focus group study of decisions and obstacles*, did not contain all data included in this paper. Specifically, it did not include the mini case studies. It was authored by Meghann Drury, Ken Power and Kieran Conboy and received the Agile 2011 "Best Research Paper" award sponsored by *IEEE Software*.

Appendix A. Interview guide

Company Interview Guide
Start recording.
Read and record instructions: *The purpose of this interview is to understand what group decisions are made on agile teams and the obstacles facing this decision process. Thinking about the agile team on which you currently work and your current role, please answer the following questions. First, there are a few demographics questions to answer, and once you've completed that, we will begin the interview. All of your information will remain confidential at all times.*

1. In what industry does your company operate?_____

2. What is your current role on your agile team? Please tick all that apply and circle your main role.

☐ Customer	☐ Database Architect
☐ Customer Proxy	☐ Technical Architect
☐ Product Owner	☐ Project Manager
☐ Business / Systems Analyst	☐ Scrum Master
☐ Senior Developer	☐ Manager
☐ Junior Developer	☐ Other_____
☐ Tester	

3. Rather than during the iteration, does your team make most decisions ***during*** Iteration Planning Meetings? ☐ Yes ☐ No ☐ Sometimes

   a. Is there a preparatory meeting or one-on-one session prior to the Iteration Planning Meeting where decisions are also made? ☐ Yes ☐ No ☐ Sometimes

   b. If there is a preparatory meeting, can you describe the purpose of this meeting and the purpose of the Iteration Planning Meeting?_____

   _____

   _____

   _____

Now we will move to the actual interview. We will begin with a few general questions before moving to the more specific questions on how your team makes decisions.

General Overview

Q1. Can you describe what happens in your Iteration Planning Meetings (IPM), Iteration Execution, Iteration Review Meetings and Iteration Retrospective Meetings, each in a few short sentences?

Q2. Who is involved in each of these four phases of an iteration cycle?

Q3. In a few short sentences, can you explain how your agile team makes decisions?

RQ1: *What decisions are made **during each of the periods of the Iteration Cycle**?*

Types of Decisions

Q1: What decisions do you make during an IPM? Include specific examples of each. (What decisions can/do you make? Which of these are tactical and strategic?)
   a. Who makes each of these types of decisions?

Q2: What types of decisions do you make during the iteration (i.e. the Iteration Execution period, the interim between IPMs)? Include specific examples of each. (What decisions can/do you make? Which of these are tactical and strategic?)
   a. What are the informal decisions you make (i.e. at coffee, the water cooler, not during a formal meeting)?
   b. Who makes each of these types of decisions?

Q3: What types of decisions do you make during a Story Elaboration Meeting (SEM)? Include specific examples of each. (What decisions can/do you make? Which of these are tactical and strategic?)
   a. Who makes each of these types of decisions?

Q4: What decisions do you make during a Sprint Review Meeting? Include specific examples of each. (What decisions can/do you make? Which of these are tactical and strategic?)
   a. Who makes each of these types of decisions?

Q5: What decisions do you make during a Sprint Retrospective Meeting? Include specific examples of each. (What decisions can/do you make? Which of these are tactical and strategic?)
   a. Who makes each of these types of decisions?

RQ2: *What **obstacles to decisions** do ASD teams face?*

Q1: What factors or issues prevent your team from making decisions during any of the four periods of an iteration?

Q2: What obstacles prevent your team from making decisions during IPMs and how do you overcome them?

Q3: What obstacles prevent your team from making decisions during the Iteration Execution and how do you overcome them?

Q4: What obstacles prevent your team from making decisions during the Iteration Review and how do you overcome them?

Q5: What obstacles prevent your team from making decisions during the Iteration Retrospective and how do you overcome them?

Anything Else

Q1: Are there any other meetings where decisions are made? What meetings?

Q2: Are there any other decisions made informally?

Q3: Is there anything we haven't covered that you feel is important to know about how your team makes decisions or what obstacles they face in making decisions?

Please do not discuss the details of these questions with others on your team. We do not want to bias their responses when they answer in their interview.

Appendix B. Agenda for the focus group meeting

Read and record instructions: In an Agile environment, the development team is empowered to make most decisions, creating a "pluralist decision making environment" due to diverse backgrounds, attitudes, and goals of the team members. Team members are faced with decision tasks on a daily basis in a dynamic environment with rapidly changing requirements, expectations and underlying data.

Therefore, this focus group and its participants will discuss the key decisions an Agile team has to make, share best practices for decision strategies to support high quality decision making in Agile information system projects, and discuss obstacles preventing high quality decisions.

Participants should be those currently working on Agile teams, or who will be working on an Agile development team in the near future.

Session Outline (90 min)

- Introduce the topic of decision making strategies and decision obstacles, including why decision making and team behavior is important for Agile teams (10 min)

- Facilitate activity where participants list the key decisions and corresponding data used to make those decisions on Agile teams (30 min)
  - On the Post-It™ pads provided, take 5 min to write down the decisions you make in your planning meetings and during the iteration (a separate Post-It™ for each decision)
  - Once you have written your decisions, post them on the whiteboard at the front of the room under the correct group:
    - Iteration Planning Meeting
    - Iteration Execution
    - Iteration Review Meeting
    - Iteration Retrospective
- Present key decision strategies that have helped other Agile teams make high quality decisions (10 min)
- Facilitate discussion on problems or obstacles that negatively impact decision making on Agile teams (35 min)
  - What obstacles to decision making do your Agile team(s) face during the four iteration cycle periods?
    - Iteration Planning Meeting
    - Iteration Execution
    - Iteration Review Meeting
    - Iteration Retrospective
  - How do your Agile teams overcome those obstacles?
- Provide conclusions and contact details for participants who would like more detail on how to improve their team's decision making (5 min)

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Meghann L. Drury, Ph.D., M.A., H. Dip. B.S., is an Assistant Professor of Communication and Media Management in The Gabelli School of Business and The Graduate School of Business Administration at Fordham University. Her Ph.D. is from Northwestern University. Her research interests include decision making, decision quality, change management, and organizational communication. She has received numerous academic and industry awards, recently earning the Agile 2011 "Best Research Paper" award sponsored by IEEE Software and *SIG IT Project Management* "Best Paper Award" in 2011. She reviews for prestigious outlets such as the *European Journal of Information Systems*, *Journal of Applied Communication Research*, the *International Conference in Information Systems* (*ICIS*) and the *European Conference in Information Systems* (*ECIS*). Prior to Fordham, she managed a research project on Agile team decision making at the Centre for Innovation and Structural Change at the National University of Ireland, Galway, and worked for Deloitte Consulting LLP as an organization and change management consultant.

Kieran Conboy, Ph.D., is an associate professor at the University of New South Wales and Lero research centre in Ireland. His research focuses on Agile systems development approaches as well as agility across other disciplines, and he is currently involved in numerous national and international projects in this area. His research has been published in leading journals and conferences such as *Information Systems Research*, the *European Journal of Information Systems*, *Information & Software*

Technology, the *International Conference in Information Systems* (*ICIS*), and the *European Conference in Information Systems* (*ECIS*). He is also associate editor of the *European Journal of Information Systems*, and has been a guest editor on special issues of top journals on the topics such as qualitative IS research and agility.

Ken Power is an internal Agile-lean coach/consultant and co-founder of the Agile Office at Cisco Systems' Unified Communications Business Unit. He works with global product teams and the organization's leadership, navigating a path through their Agile journey. Working with Agile methods since the late 1990s, he has wide experience introducing and applying Agile development at all levels in organizations, and across a variety of industries and domains. His interests include architecture, Agile processes, lean development, patterns, systems design, test driven development, and design of organizations to support productive and effective teams.