Practical Aspects of The Integration of Agile Development and Model-Driven Development: An Exploratory Study

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***Abstract*—The aim of this paper is to investigate and gain insights into the state of practice of integrating Agile development and Model-Driven Development (MDD), understanding their impact and various problems of their applicability. To meet this aim, we conducted seven in-depth, one-to-one interviews with Agile and MDD practitioners to provide insights about their experiences and opinions of integrating Agile and MDD. The study found that although both approaches gained considerable attentions by practitioners, the state of practice is not yet mature. Key challenges relate to the lack of well-defined process, lack of adequate tools and steep learning curve.**

***Index Terms*—agile software development, model-driven development, agile model-driven development, empirical study, interviews**

I. Introduction

The Agile software development principles emerged as a reaction to the bureaucratic traditional methodologies by discarding precise upfront planning [10]. Under the umbrella of Agile principle, there are many methods (such as Scrum and Extreme Programming (XP)) that share the same set of values and principles defined in Agile Manifesto [5]. They are characterised as incremental (small system releases with short cycles), cooperative (developers and customers collaborating constantly through the development process with close communication), straightforward to learn and adaptive to changes in the requirements [1].

Model-Driven Development (MDD) is an alternative software development approach where models are the primary development artifacts and the process becomes model driven where the code and the documentations are generated from models. The MDD vision is to reduce the gap between the problem and implementation domains through increasing the level of abstraction and through automating the transformation process between models [11].

While both Agile development and MDD have received considerable attention from industry and academia, there is little data about their integration [2], [6]. This paper presents details of an exploratory study that was conducted on integrating Agile development and MDD (Agile MDD). The main objectives of this paper are to examine and gain insight into the Agile MDD approaches and practices by answering the following research questions:

(RQ1) What are the reasons that motivate integrating Agile practices and MDD processes?
(RQ2) How are Agile practices and MDD integrated?
(RQ3) What are the benefits of integrating Agile and MDD on development process?
(RQ4) What are the challenges of integrating Agile and MDD?

The structure of the paper is as follows: Section II discusses related work. Section III presents the research methodology while Section IV describes the projects surveyed. Section V presents the results of the study and Section VI discusses and summaries them. Section VII discusses the limitations of this study while Section VIII concludes the paper.

II. Related Work

In this section, we present related work namely empirical studies of Agile MDD. Burden *et al.* [6] have conducted a systematic literature review by proposing two research questions with the goal to investigate the empirical evidence of the state of art of Agile MDD approaches and what is lacking in that area. The study shows that Agile MDD is still in its early stages and there is a need for detailed experience reports. In our previous work [2], we presented a systematic literature review to complement the results of [6] where fifteen primary studies were reviewed. The main characteristics of Agile MDD approaches besides their benefits and problems are highlighted. Both systemic literature review studies provide broader coverage, but they are less in-depth than interview study.

Eliasson and Burden [7] have conducted an exploratory study at Volvo Car Corporation (VCC). At VCC, individual teams adopt Agile practices with MDD while the organisation at large still use plan-driven process. The aim of this exploratory study is to investigate how Agile practices can be extended to the organisation level. In specific, it aims to answer the following question: *Which are the challenges and possibilities for a more Agile software development process on*

a system level?. They interviewed 17 engineers to identify the challenges of the current process at VCC and how to improve it. The results of the interviews revealed two main challenges: first, the developers have to wait long before getting feedback which forced them to make premature assumptions leading to unwanted side-effects and faults; second, the use of MDD tools force developers to employ a waterfall process. The main finding of this study is that there is a need for a more Agile way of working to obtain earlier and faster feedback. They conclude that Agile MDD can be useful in automotive development. However, their study is context specific to VCC to examine its case and limited to automotive domain which is difficult to be generalised.

III. Research Method

We conducted semi-structured interviews with seven practitioners (in person or via Skype) from a variety of countries including the United Kingdom, Germany, Sweden, Brazil, India, Argentina, and Belgium. Our participants were selected based on personal contacts or from our previous literature survey [2]. They have between two and twenty years of experience in Agile and MDD development. The interviews lasted about 45-60 minutes and were conducted by the first author. They began with a question about the participant background and experience; then followed by a series of questions about some practical aspects of Agile MDD such as those relating to the motivation of applying Agile MDD, the strategy of combining Agile and MDD, its benefits and challenges and so on. The interview guide can be found via the link in the footnote [1]. All participants were asked to answer the interview questions based on a self-selected project where they had leading roles in the project. All the interviews were audio recorded after obtaining the participants' consent. After that, the interviews were transcribed in order to facilitate the analysis process. Then, the obtained data was analysed using qualitative content analysis [8].

IV. Projects Profiles

This section presents a description of the projects which the participants have developed in the context of Agile MDD. Seven projects were involved in this study:

P1: This project is a web-based application which aims to generate domain models and navigations from either written requirements or captured with interface mockups. It can be considered as a medium-sized project (40-50 classes). The development effort is not available.

P2: This project is a web-based application to apply an online auction. It is implemented using J2EE and the development effort is 2 person-year.

P3: This project involves developing electrical component systems in the automotive industry. The accurate scale of this project is not available, while the development effort is 80 person-years.

[1] https://drive.google.com/file/d/0B70Tq3TKSoDQZDhfV2F5RGI1TTA/view?pli=1

P4: This is a component-based approach used to develop policy administration systems for a large insurance company. It is implemented in C++ in nine million lines of code (LOC) and the development effort is 200 person-years.

P5: This project involves the risk evaluation of financial investments in which the process of risk analysis includes intensive computations. It is implemented in C++ in 3000 LOC while the development effort is two person-months.

P6: This project is a web-based application for issue tracking system that manages and maintains a list of reported issues. It is implemented in PHP in 30000 LOC and this required eight person-years of development time.

P7: This project is an online simulation platform in neurorobotics for running and describing experiments. The platform is implemented in C++ and Python. The development effort is 15 person-years.

V. Interview Results

The results are analysed based on the research questions posed in the introduction. For brevity, we provide quotes for only some of the results.

RQ1: Motivations for Integrating Agile Methods and MDD.

Accelerating development process was a frequent motivation given by the interviewees (four out of seven). This can be attained by the two approaches. The automation (producing code and other artifacts from models) of MDD is assumed to accelerate the development process [17]. On the other hand, agility means to minimise the heaviness commonly attributed to traditional development methods to promote rapid response to changes in requirements and accelerate development process [9].

Another motivation for adopting Agile MDD was to involve the customer frequently in the development process. Basically, this can be realised by applying Agile development as active participation of the customers is one of the key principles of agility [13]. Studies show that having the customer as the primary source of information leads to an effective means of requirements gathering especially in the early stages of the development through active participation of concerned stakeholders, and levering changes [13]. Providing early feedback is also valuable within different stages of development as the customer can assess and evaluate frequent deliverables of the system. With regard to MDD, involving the customer or end-user in the development activities is a difficult task since they usually don't understand the concerned technical specification such as Domain Specific Language (DSL) and modelling techniques [18].

One interviewee stated that the motivation of integrating Agile and MDD was to make the MDD process more lightweight. MDD can be considered as a heavyweight process [12] (i.e. it requires a lot of planning, developing the models, and specifying the transformation rules etc.). Therefore, it is assumed that applying Agile into MDD process will result in less rigorous process. By developing the system in an

TABLE I: Agile MDD Processes Overview

Project	Methodology Type	Agile Method	Agile Practices	MDD Practices	Agile MDD Process Definition
P1	Assembly-based	Scrum	Incremental and iterative development, Pair development ,Test-Driven Development	Automatic code generation, Model-based testing, DSL Modelling	None
P2	Agile-based	Scrum	Incremental and iterative development	Automatic code generation, Round-trip engineering, DSL Modelling	None
P3	MDD-based	Scrum	Incremental and iterative development, Stand-up meeting	Automatic code generation, Simulation, DSL Modelling	None
P4	MDD-based	Scrum-like	Incremental and iterative development, Stand-up meeting	Automatic code generation, Model-based testing, UML Modelling	None
P5	MDD-based	Scrum	Incremental and iterative development, Refactoring, Release planning	Automatic code generation, Model-to-model transformation, UML Modelling	None
P6	Assembly-based	General process	Incremental and iterative development, Refactoring	Automatic code generation, UML Modelling	None
P7	Agile-based	Scrum	Incremental and iterative development, Stand-up meeting, Review meeting, Retrospective meeting	Automatic code generation, Round-trip engineering XML Modelling	None

incremental-fashion, developers will be focusing on building only small parts of the system at a time by developing *just barely good enough* models [3] that fulfil their purpose. In this regard, another interviewee stated that he integrated Agile development and MDD because the application domain was unfamiliar to him, so he noted:

> "It was considered to be a more secure kind of development "to develop it in increments" rather than attempting to specify and develop it all in one stage. It was considered to be a more flexible, a more reliable approach to do it up in increments and with certain functionalities in each iteration" (Study participant).

Building the system incrementally can be a good practice to have a better understanding of the problem domain. Völter *et al* state that developing the MDD system incrementally will be useful in growing the understanding of the domain and hence reducing the complexity associated with the development process [24].

RQ2: Agile and MDD Integration Process

According to Matinnejad [16], Agile MDD process can be developed by: introducing Agile method to a current MDD process which is called *MDD-based*, by applying MDD process to an agile method (i.e. *Agile-based*), or by integrating some fragments from Agile and other from MDD to develop the process (i.e. *Assembly-based*). We found out that three projects have followed MDD-based approach and two other employed Assembly-based approach while two projects develop their Agile MDD process according to Agile-based approach.

Although, both Agile and MDD processes have been introduced for more than a decade, the basic principles on how to integrate them together are not well-known. In this regard, all the interviewees stated that they don't follow a well-defined process or systematic guidelines to guide through development. As a consequence, development teams introduce practices of Agile and MDD in an ad-hoc manner or based on their personal experiences. More interestingly, some interviewees mentioned that they decided on their own way of work at run-time or just before each iteration how to integrate the different practices.

With regard to Agile development, all interviewees utilised the iterative and incremental development as the fundamental Agile practice (with variant length of iterations). In terms of Agile method, six interviewees used Scrum[20] or Scrum-like method while the other used a general Agile method. On the other hand, only few specific Agile practices have been utilised such as pair development in **P1**, refactoring in **P1**,**P5**, and **P6**, stand-up meeting in **P3**, **P4**, and **P7**, review and retrospective meetings in **P7**, Test-Driven Development in **P1**, and release planning in **P5**.

The frequent collaboration with the customer is one of the main value stated by Agile Manifesto [5]. However, the level of customer involvement during the development process varied amongst the projects; in some cases, the customer is extensively involved only during the requirements phase to understand his/her needs and expectations of the system. After that, the communication with the customer is limited until an increment of the system is released and he provides his feedback on the work. This means the customer is not involved during the whole development process. On the contrast, other interviewee stated that the customer is collaborated all the time during the development. Although it is difficult to get the customer physically involved, he is always available (mostly via emails) for discussion and answering questions during the iteration.

Regarding MDD paradigm, we discovered that most projects used models to generate the code automatically. One interviewee evaluated the generated code to be between 80 and 90 percent of the total. Conversely, one interviewee stated that most of the development process is code-centric and the models are used to generate the "glue-code" in order to bind different components of the system. Moreover, models were used for simulation in order to assist decision making process as in **P3** and **P7**. When it comes to modelling approaches, we found DSL has been employed by three projects (**P1**, **P2**, and **P3**) and UML is used by projects **P4**, **P5**, and **P6** while **P7** used XML-based schema to develop the models. Most of the projects supported forward engineering in which the specifications are transformed to the source code. Therefore, when a change to the requirements occurs, the models are changed to reflect the new requirements and then the models are transformed to the source code (by applying model-to-text transformation). However, two interviewees stated that round-trip engineering is provided by their approaches either partially as in **P2** or fully as in **P7**. With regard to verification and validation, only two projects (**P1** and **P4**) used models for generating test cases (i.e. model-based testing). Unit testing, integration testing, acceptance testing were common testing techniques among the rest of projects. Table I presents an overview of the Agile MDD approaches.

RQ3: The Benefits of Integrating Agile Development and MDD Process

Accelerating the development process was the most recurring advantage noticed by the interviewees. By having short iterations, developers managed to build the system incrementally and to verify it early which contribute in saving time. On the other hand, generating code and other artifacts from models automatically helped to speed up development process by reducing efforts in developing code.

The frequent interaction with customers has a significant impact on the development process. One interviewee stated that having a continuous interaction with the customer helped to obtain requirement elicitation faster and captured in a formal manner. In addition, it helped to reduce the risk of building incorrect functionalities and the risk of rework in later iterations. Another interviewee agreed that frequent interactions with the customer helped improve the software quality because developers were able to find out what the real requirements are early. On the same note, other interviewee stated that Agile development was a necessary method with unclear expected requirements because it helped to develop distinct requirements incrementally .

Software quality improvement has been realised as an advantage of Agile MDD. Building the system incrementally and breaking its functionalities into smaller chunks of work make it easier to understand the functionalities and more focused to build the right artifacts while generating the code automatically helped to increase the efficiency of the code.

From another perspective, Agile practices helped to relax some of the MDD recommendations and make it more lightweight. In this context, one interviewee noticed that building the system incrementally has helped novice developers improve their knowledge about MDD.

> "MDD by nature is complex [...] but when we introduced for example some ideologies from agile, developers feel more comfortable with it" (Study participant).

TABLE II: The Benefits of Agile MDD Approaches

Case	The Benefits
P1	Improved developers focus, improved developers satisfaction, accelerate development rate
P2	Relax the heaviness of MDD process
P3	Early testing and early feedback
P4	Improved developers focus, improve requirements elicitation and formality
P5	Help promoting the system to the customer, improve the code efficiency and correctness, help reduce the errors, improved development management, improved requirements elicitation
P6	Accelerate development rate, improved developers focus, get early feedback, reduce the cost of changes in requirements
P7	Improve the communication with the customer, improve requirements elicitation

Table II summarises the benefits of integrating Agile development and MDD.

RQ4: The Challenges and Problems of Integrating Agile and MDD

The lack of proper tool support was the most frequent challenge mentioned by the interviewees. Actually, this issue concerns more the MDD paradigm [4] since it is highly dependent on technical functionality of the tools to facilitate models creation and transformations. There are different challenges concerning the tools such as immature tools, poor performance issues, integration issues and insufficient support for the whole development life cycle. This issue resulted in a lot of costly manual activities carried out to accomplish the work during the development process.

The steep learning curve was another recurrent problem mentioned by the interviewees that was an obstacle to adopt Agile MDD. Although both Agile and MDD approaches are subject to steep learning curve [21], [23], some interviewees argued that MDD has a dominant factor regarding this issue.

> "I think that the learning curve is steep, but I also think that's something typical of model-driven and not agile plus model-driven" (Study participant).

This is because MDD requires a substantial amount of knowledge about different technologies and language. Such requirements are huge challenges to developers who are new to the area.

Moreover, the lack of well-defined process and guidelines for combining Agile and MDD approaches was another shared view between many interviewees. Indeed, this contributed to the steep learning curve as well. When they were asked how they overcame the lack of guidelines, one interviewee said

TABLE III: The Challenges of Adopting Agile MDD

Case	The Challenges
P1	Immature tool support, steep learning curve
P2	Immature tool support, steep learning curve, convincing the development team to adopt MDD
P3	Organisational issues
P4	Difficulties with metamodels specifications, convincing the customer to adopt MDD
P5	Lack of customer's availability
P6	Lack of modelling experience
P7	Lack of tool support, the lack of customer's availability

that Agile manifesto was used to guide them while another interviewee answered:

> "We looked for some incompatibilities that could hamper the introduction of MDD to that context [Agile context]. But in fact we have no guidelines to follow. It was entirely adapted ... and this is very bad for the practice because we have no security if our initiative succeeds or fails" (Study participant).

In addition, interviewees highlighted their concerns over the lack of customer availability, convincing the customer and development teams to adopt MDD, difficulties with metamodels specification and the lack of modelling skills. Table III summarises the challenges of integrating Agile development and MDD.

VI. Summary and Discussion

Our study indicates that Agile MDD approach is often used informally (i.e. there is no well-defined process or systematic guidelines for the adoption). Although trial-and error is considered inappropriate technique of developing software [19], most development teams follow a "trial-and-error" or ad-hoc approaches to integrate Agile and MDD. Practically, they employ iterative and incremental development as the main Agile practices in conjunction with some MDD practices such as modelling and code generation. Also, we found that Agile MDD has been adopted in a broad range of domains include web applications, business and financial applications, embedded system, and neurorobotics domain. In addition, Agile MDD has been successfully applied in small to medium sized systems with small development team (4 projects) as well as in larger systems (3 projects). In line with the results of our previous SLR [2], accelerating development process and involving the customer in the development process were seen as the main motivations for adopting Agile and MDD. Accelerating development process was also found as an important motivation for Agile and MDD adoption in the research presented in [17] and [22].

The results of the interviews indicate that the interviewees who have integrated Agile and MDD have recognised advantages such as accelerated development and improvement in developers focus. Agile MDD was also seen to improve the communication with the customers and hence improving the correctness of the requirements. Unlike the findings in our systematic literature survey [2], advantages related to improvement of productivity have not been mentioned by the interviewees. However, these obtained benefits can serve as a hypotheses to be tested in further research.

There are still many challenges such as steep learning curve. Likewise, in our SLR [2], a steep learning curve and models management issues were recurrent problems from integrating Agile and MDD. We can interpret that steep learning curve is due to the fact that the developers need to learn new set of technologies. The lack of well-defined process even makes it more challenging. To overcome this problem, there is a need for a comprehensive framework that includes the best practices of agile and MDD. Also, it is important to know the similarities and the differences between Agile and MDD to facilitate their integrations. Another common challenge was found to be immature tools support. Mohagheghi et al [17] write that immature tools can lead to a productivity loss. In this study, the participants perceived that the success of Agile MDD adoption depends on the availability of MDD tool support.

However, the interviewees seem to be positive about the Agile MDD approach; more satisfied about its encouraging results such as shortening development process and frequent interaction with customers. Our overall interpretation is that integrating Agile development and MDD appears to be promising and the successful adoption of MDD largely depends on how MDD is defined and adopted. In addition, what and how to integrate the different practices of Agile development should be carefully considered.

The following points are considered important for future improvements in the field of Agile MDD:

- **Well-defined Agile MDD method:** A well-defined software development method is one of the key factor for successful adoption of the process by guiding development teams how they should work [15]. To this end, there is a need for a method that facilitates the integration between Agile and MDD. Also, an adequate training for developers is necessary to minimise the high initial investment of adopting Agile MDD.
- **Round-trip engineering (RTE):** Reverse engineering of code to models and vice versa is needed for a quick turnaround of changes applied at code level. One interviewee agreed that supporting round-trip engineering would be of greater value for traditional developers (code-centric developers).
- **Automated test generation:** Testing must be automated to make it cost-effective by reducing the effort needed to generate test cases. Also, it must be repeated to ensure that it meets the requirements expectations. In the principle of MDD, test cases can be generated from the models but it remains a subject of research how to do this in the right way.
- **Proper tool support:** Although Agile manifesto gives priority for individual and interactions over tools and processes, tools are crucial to facilitate fast delivery and

easy modification of prototypes [14]. Having proper tools that provide an adequate support could improve and facilitate the adoption of Agile MDD. These tools should consider configuration and change management features besides modelling, development, and testing.

VII. Limitations

Content analysis approach was used for analysing the interviews. This method does not provide a statistical significance of the results. However, it is well-suited for exploring and discovery and it can provide a subjective understanding of the topic of interest. Another limitation is the relatively low number of interviewees conducted in this study due to the fact of the lack of Agile MDD interviewees and their willingness and interest to participate in the interview. Rather, the interviewees had a good experience in Agile and MDD allowing us to consider many practical perspectives in this study. As this study is the first in its context, this study provides an overview of some practical aspects of integrating Agile and MDD that contribute to improve the understanding of this area.

VIII. Conclusion and Future Work

In this paper, we have presented the results of interview-based study in which we have explored real-life experiences of integrating Agile and MDD in practice. The aim of this study was to complement the findings of our previous study [2] and to provide more in-depth understanding of the practical aspects of integrating Agile and MDD. Our findings suggests that the interviewees found that integrating Agile development processes and MDD is feasible and promising, while there is no clear road map for their integration.

This research may help those who want to adopt Agile MDD as well as researchers to prove these findings. However, more evidence on the benefits of integration Agile development and MDD from research and real experiences is needed. As a future work, we will define a comprehensive method for Agile MDD and systematic guidelines on how to integrate both approaches and then evaluate its feasibility with a case study.

References

[1] Pekka Abrahamsson, Outi Salo, Jussi Ronkainen, Juhani Warsta, et al. Agile software development methods: Review and analysis, 2002.

[2] Hessa Alfraihi and Kevin Lano. The integration of agile development and model driven development: A systematic literature review. In *Proceedings of the 5th International Conference on Model-Driven Engineering and Software Development, MODELSWARD*, 2017.

[3] Scott Ambler. *Agile modeling: effective practices for extreme programming and the unified process*. John Wiley & Sons, 2002.

[4] Paul Baker, Shiou Loh, and Frank Weil. Model-driven engineering in a large industrial context-motorola case study. In *International Conference on Model Driven Engineering Languages and Systems*, pages 476–491. Springer, 2005.

[5] Kent Beck. Manifesto for agile software development, 2001.

[6] Håkan Burden, Sebastian Hansson, and Yu Zhao. How MAD are we? Empirical Evidence for Model-driven Agile Development. In *Proceedings of XM 2014, 3rd Extreme Modeling Workshop*, volume 1239, pages 2–11, Valencia, Spain, September 2014. CEUR.

[7] Ulf Eliasson and Håkan Burden. Extending agile practices in automotive mde. In *XM@ MoDELS*, pages 11–19, 2013.

[8] Satu Elo and Helvi Kyngäs. The qualitative content analysis process. *Journal of advanced nursing*, 62(1):107–115, 2008.

[9] John Erickson, Kalle Lyytinen, and Keng Siau. Agile modeling, agile software development, and extreme programming: the state of research. *Journal of database Management*, 16(4):88, 2005.

[10] Martin Fowler. The new methodology. 2005.

[11] Robert France and Bernhard Rumpe. Model-driven development of complex software: A research roadmap. In *2007 Future of Software Engineering*, pages 37–54. IEEE Computer Society, 2007.

[12] David Frankel. *Model Driven Architecture: Applying MDA to Enterprise Computing*. John Wiley & Sons, Inc., New York, NY, USA, 2002.

[13] James A Highsmith. *Agile software development ecosystems*, volume 13. Addison-Wesley Professional, 2002.

[14] Merisalo-Rantanen Hilkka, Tuunanen Tuure, and Matti Rossi. Is extreme programming just old wine in new bottles: A comparison of two cases. *Journal of Database Management*, 16(4):41, 2005.

[15] Watts S Humphrey. *Managing the software process*. Addison-Wesley, 1989.

[16] Reza Matinnejad. Agile model driven development: An intelligent compromise. In *Software Engineering Research, Management and Applications (SERA), 2011 9th International Conference on*, pages 197–202. IEEE, 2011.

[17] Parastoo Mohagheghi and Vegard Dehlen. Where is the proof?-a review of experiences from applying mde in industry. In *European Conference on Model Driven Architecture-Foundations and Applications*, pages 432–443. Springer, 2008.

[18] Francisca Pérez, Pedro Valderas, and Joan Fons. Towards the involvement of end-users within model-driven development. In *International Symposium on End User Development*, pages 258–263. Springer, 2011.

[19] Ruben Picek. Suitability of modern software development methodologies for model driven development. *Journal of Information and Organizational Sciences*, 33(2):285–295, 2009.

[20] Ken Schwaber and Mike Beedle. *Agile Software Development with Scrum*. Agile Software Development. Prentice Hall, 2002.

[21] Bran Selic. Model-driven development: Its essence and opportunities. In *Object and Component-Oriented Real-Time Distributed Computing, 2006. ISORC 2006. Ninth IEEE International Symposium on*, pages 7–pp. IEEE, 2006.

[22] John F Tripp and Deborah J Armstrong. Exploring the relationship between organizational adoption motives and the tailoring of agile methods. In *System Sciences (HICSS), 2014 47th Hawaii International Conference on*, pages 4799–4806. IEEE, 2014.

[23] LEOR Vijayasarathy and Dan Turk. Agile software development: A survey of early adopters. *Journal of Information Technology Management*, 19(2):1–8, 2008.

[24] Markus Völter, Thomas Stahl, Jorn Bettin, Arno Haase, and Simon Helsen. *Model-driven software development: technology, engineering, management*. John Wiley & Sons, 2013.