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THE USE OF AGILE PROJECT MANAGEMENT METHODOLOGIES IN NON-IT APPLICATIONS

Abstract. The article presents an analysis of available literature on the application of agile project management methods in the implementation of projects going beyond the field of IT projects, with particular attention given to short series manufacture of machinery and equipment. The definition of agile manufacturing methods as well as the principles of their application and implementation are presented and exemplified by the most popular SCRUM methodology. The results of previous works on the subject are presented, summarizing the use of the methodology and presenting a summary of the results of individual studies. A summary of the available documents is presented and areas for further research are indicated.

Keywords: Agile, Scrum, project management, agile management methodologies.

1. INTRODUCTION

The main aspect of IT projects is their variable and dynamic scope throughout their life cycle. Intensive communication and cooperation of the software producer with the client when creating a new product, evokes the necessity to continually make changes in relation to initial specifications, precluding any detailed planning of activities. The application of traditional project management methodologies, such as PMBOK or PRINCE2, with precisely defined rules of conduct at all stages of the project and the implementation plan determined at the beginning, would require a formal and laborious procedure of changing the scope, involving all project stakeholders. This forced a revision of the project management approach and, as a consequence, the creation of agile methodologies, which allowed to cope the dynamic changes in the scope of the project [1].

According to the results of the 12th Annual State of Agile Report, as many as 97% of IT market organizations have in their structure teams which apply agile principles. Respondents presented a number of benefits resulting from the use of agile management methods, the main ones being: accelerated software delivery, enhanced ability to manage changing priorities and increased productivity. The positive impact of the application of these methods on the operation of companies associated with the IT market leads to the question of whether, if the methodology is used in companies from other branches of the market, similar effects and benefits will be achieved [2].

The AGILE MANIFESTO, developed and published at the beginning of the 21st century, was the starting point for the so-called "agile transformation" of enterprises of the IT

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industry. However, its content presents general principles, not limited in any way to a specific industry [2].

Seeing the effects of the application of these methodologies, examined and documented in IT companies, and the lack of methodological contraindications to use them in other industries, it seems reasonable to verify the effectiveness and effects of their implementation in other industries.

2. AGILE METHODOLOGIES

Agile methodologies is a group of production methods based on iterative and incremental execution of tasks. These methodologies are an alternative to the traditional method of the WATERFALL type, where each stage or part of the project is carried out after completing the previous one.

The concept of agile development was proposed in 2001 and was included in the Agile Manifesto which was a declaration of common principles for agile software development methodologies [3]. The authors of the Manifesto represented new methodologies of software development, such as: Extreme Programming, SCRUM, Dynamic Systems Development Method, Adaptive Software Development, Crystal Clear, Feature Driven Development, Pragmatic Programming. The values established:

- **individuals and interactions** over processes and tools**;**
- **working software** over comprehensive documentation;
- **customer collaboration** over contract negotiation;
- **responding to change** over following a plan**.**

3. SCRUM

For a clear presentation of an example of a management methodology based on the values described, the Scrum methodology will be used. It is a model for developing, delivering and maintaining complex products. Developed by Ken Schwaber and Jeff Sutherland, it is the most popular methodology among Agile methodologies, constituting (along with its modifications) over 70% of all management methodologies used [2].

Scrum is based on the empirical theory of process control. It is shaped according to the principle that knowledge comes from experience, and decision-making should be based on what is known. Scrum uses iterative, incremental approach to optimization, prediction and risk control. The three pillars of the implementation of empirical process control are transparency, inspection and adaptation.

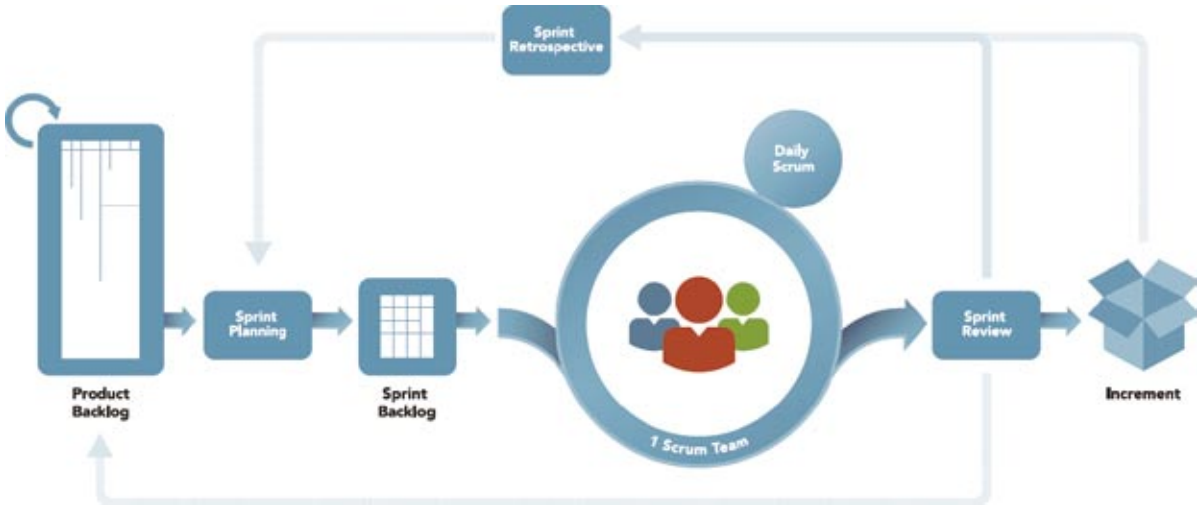

Fig. 1. Scrum framework [4]

3.1. Transparency

All relevant aspects of the process must be accessible and understandable to those responsible for the outcome. Transparency requires those aspects be defined by a common standard so observers share a common understanding of the project status. An example of that may be the establishing of a common and consistent definition of a completed task (Definition of Done) by those performing work and controlling the progress of work.

3.2. Inspection

Scrum users must often inspect their work to detect undesired deviations from the initial specifications. However, inspection can not be carried out in a way that interferes with the work. The purpose is to immediately detect all deviations from the plan and to take further steps as soon as possible.

3.3. Adaptation

If an inspector finds that one or more of the aspects of the process go beyond the limitations allowed, and the resulting product will not meet the set requirements, then the process must be adapted. Corrections must be made as soon as possible to minimize further deviations.

Scrum recommends four formal activities to inspect and adapt actions:

1) Sprint Planning (Sprint is a set, consistent work cycle, usually lasting 1 week to 1 month) – planning tasks for the next Sprint.
2) Daily Scrum – everyday meetings, where each member of the project team says what he did yesterday, what he plans for today and whether he encountered any obstacles or difficulties.

3) Sprint Review – presentation of results of the Sprint.
4) Sprint Retrospective – discussion of the previous Sprint and defining what can be improved.

3.4. Team

A Scrum Team should consist of 5 to 9 members having the following roles:

1. Product Owner, responsible for the final shape and for maximizing the value of the product. He/she presents the customer's point of view.
2. The Development Team consists of professionals who do the work of delivering a potentially releasable Increment of "Done" product at the end of each Sprint. The Development Team is empowered to manage its own work. This optimizes the Team's overall efficiency and effectiveness.
3. The Scrum Master, responsible for promoting and supporting the Team's performance as according to methodology recommendations. The Scrum Master does this by helping everyone understand Scrum theory, practices, rules, and values.

Scrum Teams are self-organizing and cross-functional. They choose how best to accomplish their work, rather than being directed by others outside the team. They have all competences needed to accomplish the work without depending on others not part of the team. The team model in Scrum is designed to optimize flexibility, creativity, and productivity.

4. AGILE IN NON-SOFTWARE APPLICATIONS

Despite the fact that Agile methodologies are used mainly in the IT sector, there is scarce literature available documenting their use in projects related to other industries. They present various ways of using and implementing the methodologies and results achieved.

Here we have selected a number of materials describing the implementation of the methodologies in various industries, regarding the process of designing and manufacturing machinery and equipment. Each application example is described by presenting the use case and the characteristics of the research done. The results of each implementation and a synthetic description of the documented results of the activities are presented.

Due to the diversity of research done, the description of effects is not uniform. This makes conducting comparison of results difficult, however each research presents a different approach to the issue, allowing for a variety of conclusions.

4.1. WIKISPEED

WIKISPEED was a project aimed at developing a car whose main feature was to achieve fuel efficiency of over 100 mpg (2.8 litres per 100 km). It was implemented in the Open Source formula, it had modular design, and it could be built without using special equipment. The project was run by volunteers and managed using the Agile, Lean and Scrum methods [5].

There are only two articles describing the project execution in terms of organization. According to the authors of the first articles, it is the basis for discussion and does not address the issue of effectiveness or ineffectiveness of the proceedings in accordance with the management methodology described. However, it is a good example of the implementation of agile management methods, due to a comprehensive and complete description of the methodology used [6].

The second article presents the method of project implementation and contains a short analysis of the possibilities of using the methodology in the industry; however, it does not present any measurable effects [7].

Fig. 2. Wikispeed car visualization [8]

The available documents do not in any measurable way describe the effects of project implementation according to the methodology described there. They can be used to analyze the implementation possibilities and be helpful in making decisions about the proposed form of project management. However, it is not possible, despite the favourable attitude of the texts positively assessing the activities in the project, to unambiguously determine whether the described methods are effective. There is no element of comparison referring to traditional project management methods.

4.2. MAREL

Marel is a leading global supplier of advanced equipment and systems for the food industry. The products which Marel creates consist of mechanical units and embedded software modules [9].

The study conducted at Marel does not present any specific product, focusing on the presentation of one of the industrial centres at Marel and two teams - embedded software and mechanical. The study was concentrated on whether Scrum could be used in the development of a mechanical product or whether it required adaptation. The aim of the study was to test the hypothesis as to whether Scrum could be used in mechanical product development teams. The team of designers, while constructing a new product, began using Scrum as a form of a temporary experiment. After its completion, a decision was to be made on the further use of the methodology.

The case study was devoted to a team of mechanics for product development as part of a 7-months experiment. The team in question cooperated with the embedded software development team. During the study, observations, interviews and informal conversations with employees were conducted. The mechanical team used the Scrum scheme with only slight adaptations. It made use of all the main aspects of the methodology; however, there

were some adaptations, i.e. the team was not cross-functional within the full range of competences, and the product or product increment was not created in each iteration.

The main conclusion of the study was the confirmation that Scrum could be used by mechanical teams. It was impossible to state clearly whether the applied methodology was better than other methods of work, but in the employees' opinion the implementation turned out to be helpful and showed the possibilities of improving certain aspects of management. The study has demonstrated that using the methodology could provide the following benefits:

- increased cooperation and coordination;
- increased communication within the team and with external dependent parties;
- better overview of the project among all employees involved;
- prioritizing work, results in a clearer focus and less time spent on redundant work;
- promoting the distribution of technical knowledge within the team and distribution of information on the project to all parties involved, in particular to key dependent parties, e.g. through Sprint Reviews;
- more frequent feedback, both in regards to technical solutions as well as the project plan, as the progress is measured bi-weekly.

When using Scrum in mechanical or hardware issues, the physical nature of the final product should be taken into account and the natural process of developing physical objects should be respected. In view of the above some changes were made to the methodology.

The following adaptations were made at Marel:

- the team was not cross-functional in the sense that not all competences needed to design and manufacture the final product were included in the team;
- the team was not able to deliver a working product increment at the end of every Sprint, although in some specific cases that was possible. Instead the team focused on attaining a defined goal, e.g. a part of product ready to be manufactured.

The main conclusions drawn from the case study were the following:

- the Marel team has benefitted from the use of Scrum. They set milestones and have been able to reach them on set time. The whole team got better overview of the project and product, and knew the status of each team member’s work;
- in the team's opinion Scrum proved to be an effective method of planning and prioritizing;
- team involvement was vital: if the team members did not see the benefits and did not maintain the principles of the methodology, the positive effects of implementation were lost;
- it is important that leaders or product owners be actively involved in the project implementation;
- Scrum Master is vital in the deployment of the framework, as he or she provides support and discipline to the team and helps them stay on track.

The methodology was evaluated using questionnaires and interviews. There was no statistical verification of the implementation of the methodology.

4.3. CUBESAT PROJECT

CUBESAT PROJECT is an example of using agile management methods in systems engineering, indicating them as a source of innovation (at the same time enabling risk management in a disciplined manner) in projects with limited budget and implementation time. It was used in the design of two small satellites in the Applied Physics Laboratory of the John Hopkins University (JHU/APL) as part of the Multi-Mission Bus Demonstrator (MMBD) project [10].

The assumption of the project was that satellite structures did not use existing and available technology, as is the case in the traditional design process. The techniques used for project implementation were similar to those used in the Scrum methodology.

By freezing late in the design cycle, the MMBD project was able to insert innovations throughout the program cycle. The ability to be innovative related to the speed with which the development progressed, including working quickly through all technology choices.
The paper where the project was presented discussed agile systems engineering as applied to both software and hardware. The study has demonstrated how the techniques of agile systems engineering could be adapted to a high technology development program.

The paper describes the philosophy of agile systems engineering technique, an integral part of which are agile management methods. It presents a number of recommendations that positively affect the manufacturing process:

- creating small teams with a direct link to the project sponsor;
- the team that is to carry out project work is responsible for the subsystems, interfaces and interactions with all other subsystems;
- systems engineer, quality assurance manager and program manager spend time each day to review all tasks and problems, including costs and schedule;
- interactive feedback on the project, helps employees to solve problems related to their concepts;
- project analysis and testing should take place as early as possible to alleviate the effects of problems occurring;
- specifications and requirements should be developed throughout the product creation period.

The paper does not include any comparison of the effects of management methods. Only a comparison was made to a product that is different both in terms of initial specifications and requirements as well as the importance of correct operation. For this reason, it cannot be the basis for comparing different production and project management methods.

4.4. ANDRITZ

The study describes organizational changes made at ANDRITZ HYDRO which is a global supplier of electro-mechanical systems and services for hydropower plants. After a merger with Waplans in 2008, the number of projects increased significantly (and consequently problems of increased market requirements and budget overshoots in larger projects) which created serious organizational problems. Therefore, the Swedish offices of Andritz Hydro AB Service and Rehab Division went through changes in their organization built on principles and practices from Scrum and Agile [9].

As part of organizational changes in the company, the effects of implementation were verified. The Product Manager presented the number of engineering hours consumed over time for each project that the pilot team worked on. The results were compared with a project from before the implementation.

The graph below (Fig. 3) presents a comparison of all engineering hours spent on all technical work of the first project on which the pilot team worked after the implementation to the model project from before the implementation. The y-axis represents accumulated hours, and the x-axis represents days passed in real-time. A curve represents the work done by the pilot team for a particular project; that is designing and building their component.

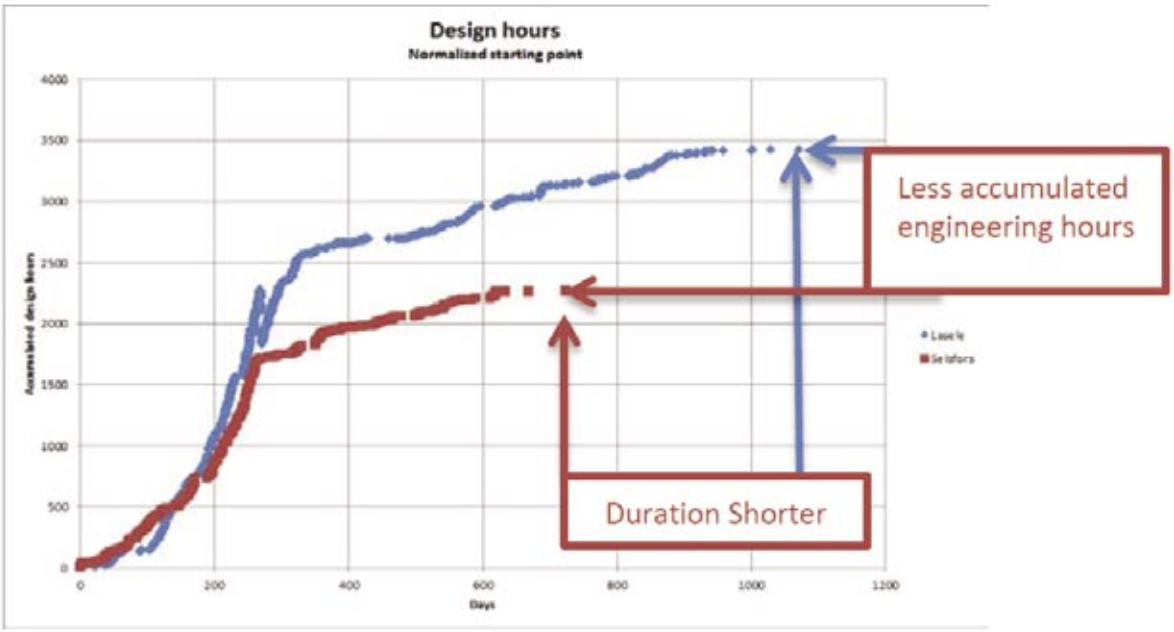

Fig. 3. Comparison of project after implementing the agile management methodology to a reference project [9]

The blue curve represents the reference project and the red curve represents the team's first project after the new method implementation. As can be seen the team delivers the component sooner, using less engineering hours. The second graph (Fig. 4) shows an evident improvement trend both in lead time and engineering hours spent in subsequent projects.

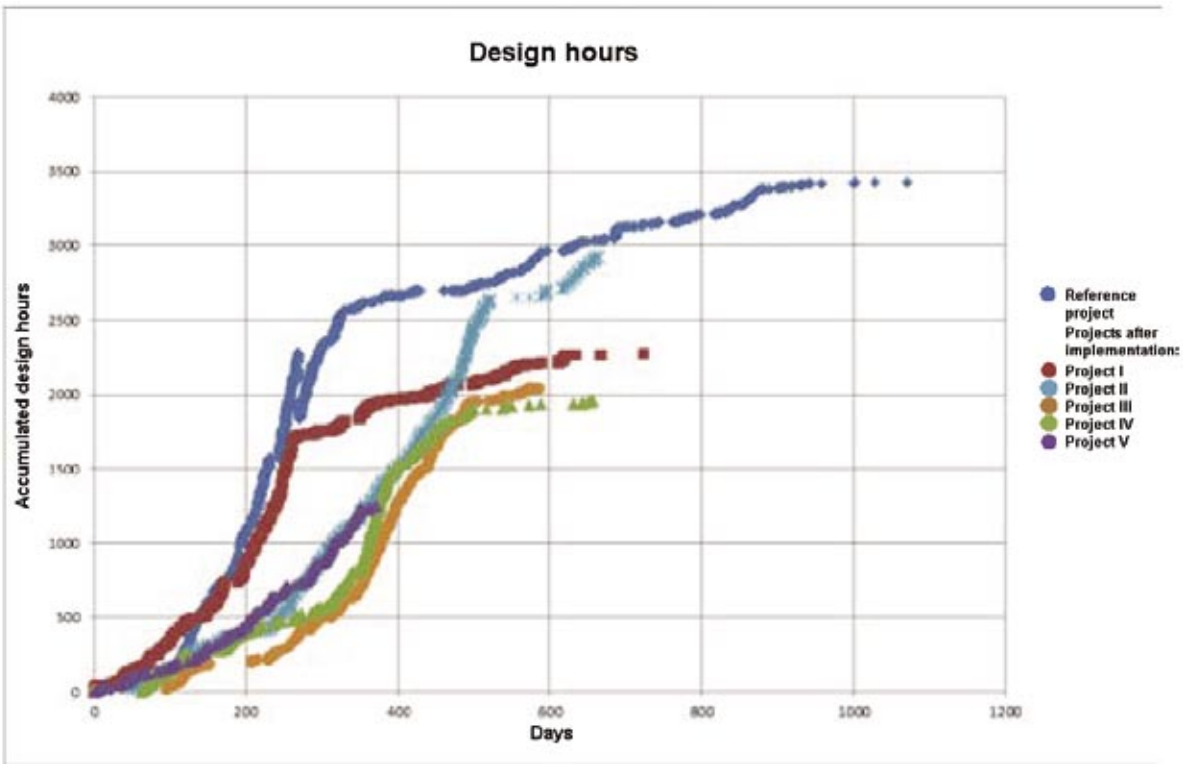

Fig. 4. Engineering hours consumed in various projects [9]

The Product Manager, with whom the process was consulted, noted that the implementation of the projects in the new formula revealed that:

- there was much better quality control, fewer loop-backs from production;
- there was much better control over the early phases in design;
- improvement and self-improvement are an inherent element of agile production methods.

It is also worth noting that:

- the average level of experience in the team was low. There was only one team member with 8 years of experience within the company, the other five had only been for one or two years with the company;
- a new CAD system was implemented during the project;
- there were several new versions of component designs made during the time, and the repeatability between projects was low.

Three months after the main correspondence with the Product Manager, an update of results was made. He stated that the improvements seen previously were to a certain extent lost, as an increased trend of engineering hours spent could be seen.

It was difficult to identify the reason for this, but the Product Manager suggested two: increasing requirements from customers, and shortages in human resources in the organization. The main constraint the new organization structure faces is the reluctance to have enough engineering resources available. That leads to long-term overload with people going between different projects. People start new tasks too often and this results in it being almost impossible to achieve good results and maintain high efficiency.

This was the only study in which the effects of introducing a new management method were measured. The results were very positive, both in terms of measurable effects as well as personal feelings of the employees. The deterioration of the results observed at a later stage should be thoroughly examined, however, there are no indications that this is due to the implemented methodology.

5. ANALYSIS RESULTS

The examples cited do not allow for the analysis of results by comparative methods. Only one study presents statistical results and measurements of project implementation time. However, as the author himself indicates, they were not presented in optimal conditions and should be corrected for a number of factors negatively affecting the course of projects. In none of the projects cited were there any problems with regard to the applicability of the methodology. Some adaptations were necessary, but according to the philosophy of agile project management methodologies, they do not constitute a rigid framework of behaviour, and adaptation to the operation of the organization is a normal and desirable process. In all of the presented cases a positive impact of the methodology on the functioning of the team was observed, based on the employees involved in the projects.

6. SUMMARY

The study and review of the literature indicate that IT methodologies will unceasingly be adapted to applications in non-software sectors. Statistics show that in the coming years these methodologies may become an industry standard, and companies in which they will not be used will be an exception to the rule.

The analysis of the projects implemented under the new formula did not show any contraindications for the adaptation of agile methodologies to non-software applications. There are many indications that, after making appropriate adaptations, it is possible to adopt such a methodology for use in any application. Moreover, in the literature cited there was no evidence that its application in other areas would not produce the same good results as in the IT sector. Currently, however, there is no statistical data on the effects, because the database of published studies is rather modest, and the studies included therein are mainly descriptive and non-quantifiable.

In view to the potential benefits, it would be desirable to carry out studies aimed at large-scale verification of the impact of applying agile methodologies on the execution of projects in various industries. It would be crucial to carry these studies out in a way enabling comparison of projects that are highly similar, both in terms of scope and available resources; with the only difference being the methodology of implementation.

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