Product Development Methods for the Agile Transformation

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ABSTRACT

In the recent VUCA (volatile, uncertain, complex and ambiguous) world, where new trends are constantly disrupting the status quo, the agile transformation has become mandatory for companies to survive. The agile mindset provides flexibility and faster reaction time regarding uncertainty and changing market requirements, user needs and competitors solutions. Moreover, it promotes empowerment for the whole team, close collaboration with customers, faster and more accurate results. There are various methods to be applied in the agile environment, such as Scrum for example. However, for the agile transformation be successful, these methods must interact with the product development methods, so they have to transform as well. In this paper, it is presented the main methods applied during the product development phases, such as Requirements Engineering, Focus Area Matrix, FMEA and DRBFM and how they evolved to better meet the needs of the agile transformation. The role of the leadership and team is discussed as well. In the end, and example is presented to demonstrate the proposed approach on a real case application.

INTRODUCTION

Looking back centuries ago, human development has gone through significant changes, coming from the agriculture revolution, with substantial increase in food production and availability, which gave people more time and stability to study and think. At the end of the 19th century, the industrial revolution arose, promoting important changes on the society and people's lifestyle, with big factories and new mass production systems emerging. By the end of the 20th century, the information revolution started, when hardware and software began to change the way we handle information, work and live. Now, in recent decades the business environment has significantly changed, with humanity facing the fourth industrial revolution, where connectivity, internet of things and disruptive technologies quickly change people lives in multiple areas, affecting business and societies in a pretty fast pace [1].

In this VUCA (volatile, uncertain, complex and ambiguous) environment, it is crucial for companies' survival to quickly adapt to these changing customer and business requirements, so new product development and project management methods were created. In order to meet the new demand, the agile mindset started a disruptive change in the way companies run their businesses [2].

In this context, the Auto Parts Industry has decided to transform as well, not only to survive but also to keep growing in a sustainable way, with focus on leading the change instead of just trying to follow a new trend.

In this paper, it is presented the Agile Transformation at an Auto Parts company, the methods for agile project management, the Product Engineering methods and how they interact with the agile mindset. In the end, it is presented an example where the new approach was applied.

AGILE TRANSFORMATION

At the beginning of the 20th century, mastering mass production and achieving outstanding quality at reasonable costs were the main requirements for industries. Companies that followed that strategy successfully grew and expanded to other countries.

Today, companies are facing new challenges. With the consolidation of the fourth Industrial Revolution, big leading companies run the risk of quickly disappear in their own market segments, if they are not able react fast enough when disruptive new technologies radically change the status quo and market needs. That has already happened with many large corporations in the recent past, meaning that no one is safe [3].

Facing those challenges, the Auto Parts industry has identified that agility is crucial, not only to allow it adjusting to the increasing speed of change around it, but also to keep innovating. Big companies need to keep in a market leader position to stay competitive with sustainable profit and growth, so that they can invest in product development and innovation for the future.

The Auto Parts industry has also identified that it is required to remain even closer to customers, associates and suppliers, in order to understand their needs. It is also necessary an agile development mindset, where solutions are delivered iteratively and incrementally, with changes being implemented while the product continues to develop. The agile approach stimulates early user involvement

during product development in a collaborative way, with a strong focus on customer satisfaction [4].

When combining the agile mindset with methods for risk and complexity management, the result is a powerful approach for product development, providing high efficiency and transparency to stakeholders regarding the development progress and product increments, meeting their expectations of the stakeholders.

At next 3 sub-sections it is presented the agile project management methods and mindset, based on the product development at an Auto Parts supplier of components and solutions for the automotive industry.

PROJECT MANAGEMENT - The Project Management (PM) methods have constantly improved over the last decades, due to the increasing demand for complex products and services. As most of company's sales are a consequence of projects, they are constantly seeking for new ways to improve those methods in order to gain efficiency and accuracy [5].

For projects presenting stable technical requirements and known technologies, the traditional project management techniques work pretty well. As many projects still fall into that area, waterfall methods are still widely applied in multiples business units. They have evolved, presenting a simplified and straightforward approach, even allowing tailoring according to the project category and size. Most of company's revenue still depend on that kind of traditional projects [5].

With multiple innovation projects emerging, companies have started to implement a new approach for dealing with complex projects presenting unstable requirements and unknown technologies. In addition, the pace of innovation in the connected world requires increased agility to deliver reliable solutions to customers even faster, requiring early user involvement during the product development. Some Auto Parts suppliers started introducing an agile approach in 2010. In 2012, a supplier of the automotive industry issued a new agile guideline for trainings, including the Scrum method [5]. A view on PM approaches according to requirements and technologies can be seen in using the Stacey Matrix (Figure 1) [6].

In the Stacey Matrix there is an area called Simple. Those are not easy projects, but they involve known technologies and cause-effect relationships, usually referring to extended applications or variants based on existing products, so a regular waterfall method is recommended.

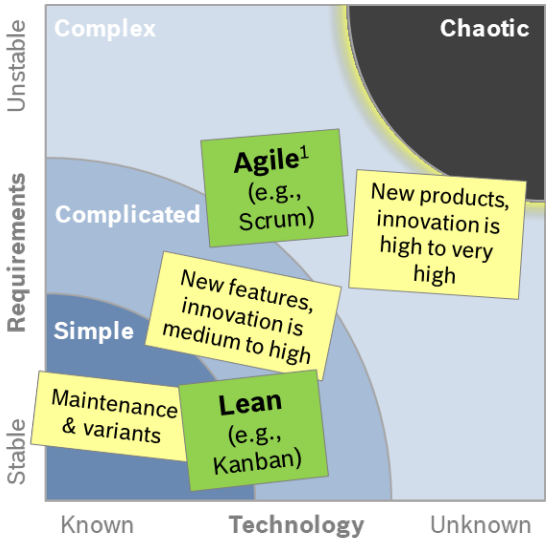

Figure 1. Stacy Matrix

Complicated projects are the ones with innovative features, still based on existing products, but requiring some level of innovation and involving some uncertainty, so an Agile approach is required for part of the project, combining with traditional methods in a hybrid approach. Complex projects are the ones with unstable/variable requirements and unknown solutions. These projects require an iterative and incremental approach for learning requirements and developing new solutions, in order to find the right direction to follow, so a full Agile approach is recommended. Chaotic projects are new business areas or innovations completely unknown, requiring alternative approaches such as Design Thinking for having a starting point and defining the direction to follow according to learnings from early customer involvement during the project [7].

FOUR FLAVORS OF AGILITY - Introducing an Agile approach and mindset is not an easy task. It requires strong cultural change, including not only the top management but also the employees. Empowerment of the team is a key factor, so that the work group can take decisions by themselves and quickly act. Failure acceptance is also an important factor, so that teams do not fear the consequences of their decisions. Failure is seen as an opportunity to learn, especially at the beginning of the project.

It is also important to consider big companies may present different requirements and characteristics for different departments and business areas, so the same approach is not valid for all kind of projects, product segments and customers. For that reason, it was created the "Four Flavors of Agility" model (see figure 2) [8].

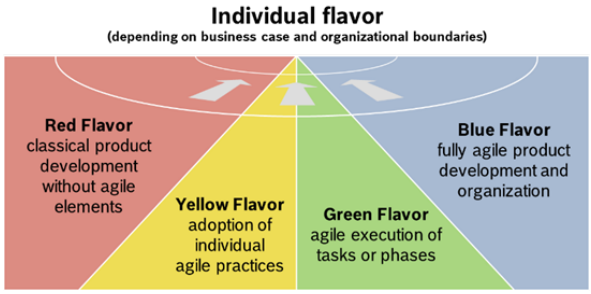

Figure 2. Four Flavors of Agility model

The term flavor was chosen to indicate that no level, type or category is better than the other. The selection of flavor is based on project characteristics and business needs.

The red flavor is the classical approach for projects related to improvements or variants on existing product categories and involving known solutions. For this flavor, the classical waterfall approach is recommended, without any agile element.

The yellow flavor is also considered a classical approach for projects related to existing product, but usually involving some sort of innovative feature or solution. In this area, the classical waterfall approach is also applied, but some elements of agile are included to speed up the process and improve team interaction. These elements may be a daily stand-up meeting for activities follow up and discussion, or a stronger review culture with cross-functional teams.

The green flavor refers to innovation projects involving new technologies and technical solutions, but still in a known business environment. For these projects, the tasks definition may be defined in classical approach, but a strong agile mindset is required to conduct the development activities in multiple control loops (sprints) for iterative learning cycles, in a collaborative environment among teams and users. This approach is also known as hybrid, with quality gates for setting main deliveries and agile approach to conduct the engineering tasks, including Scrum methods.

The blue flavor is applied for completely new products or services, including software or a new business model. This approach is fully agile, with strong user interaction since product definition and vision until development of concrete solutions. It applies agile methods for managing activities and conducting the project, such as Design Thinking or Scrum. The features delivery is based on business value.

These flavors provide a guideline for discussion and reflection with the team, regarding best approaches according to specific project characteristics such as targets and business strategy. Inside an organization, it is not expected that all projects will because Blue in the end. For most cases, a hybrid approach will be adopted, or even a Red flavor can remain.

It is important to consider that during an agile transformation period, the transition between flavors is critical. Moving from a Red flavor to a Yellow is easier, because it includes only small “pinches” of agile practices. But moving from Red to a Green flavor can be more painful, because it includes important cultural changes for the team and leadership, including team empowerment and servant leadership, which requires a different team attitude and a strong mindset change.

It is recommended for the team to really choose the right approach and live it completely, even moving directly to a Blue flavor, in order to avoid division within the team with some team members still living the old approach where they feel more comfortable, while others trying to implement the new one. It is also recommended to conduct the change by a certified Agile Master [9].

SCRUM METHOD – Implementing an Agile Transformation requires a structured approach for organizing project activities and team interaction. There are several methods for that, and Scrum is the most common method for agile projects.

The Scrum is an iterative-incremental product development approach for dealing with complex projects (see Stacey Matrix), where requirements and/or technologies are not fully known. It stimulates team interaction, focus and learning through the development process, high transparency, frequent deliveries and continuous improvement [10].

The Scrum process can be seen at figure 3 [11]. There are 3 roles responsible to conduct the Scrum process. They are the Product Owner, Scrum Master and Development Team Members. They will conduct the Scrum events, such as the Sprints, where the team commits to deliver some product increments in a period of 2 to 4 weeks. There deliveries are defined during the Sprint Planning using as a basis a Product Backlog, which is an ordered list of actions needed to gain knowledge and develop a new product. During the Sprint execution, the team conducts daily stand-up meetings in order to discuss status of current activities, what was already done, difficulties and obstacles, including the need for help. At the end of the Sprint, the team performs a Sprint Review, in order to make a retrospective and get lessons learned on product increment deliveries, updating the product backlog and preparing for the next sprint planning.

In contrast with traditional waterfall methods, the Scrum is characterized by these short control loops or Sprints, allowing requirement changes during the product development process, delivering constant product increments and extracting learnings from them, with strong user interaction.

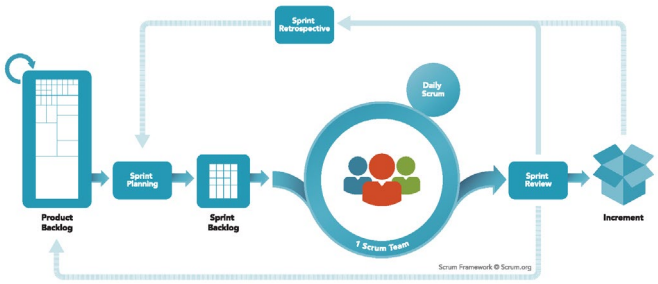

Figure 3. Scrum Framework

In an agile environment using Scrum, failures are seen as an opportunity to learn during the process and consequence of failures are contained within these short periods of spring and small sequential product increments. However, constant failures and improper planning before execution can delay the project, so accuracy and assertiveness is still important. For reaching a good level of accuracy, it is important to add a systematic approach for product development from an engineering standpoint. For these reasons, it is important to combine agile methods with Product Engineering methods, for gaining assertiveness and predicting failures before they happen.

For combining Product Engineering methods with Agile, the traditional Engineering methods have to evolve as well, in order to gain flexibility and the speed required in a Green or Blue flavor environment. The main Product Engineering methods and their improvements for the agile transformation are presented in the next chapter.

PRODUCT ENGINEERING METHODS

The Product Engineering methods have evolved since early stages of the industrial revolution, with significant improvements since the 60's when quality and engineering methods for robust design emerged in the automotive and aerospace industry such as FMEA, Taguchi quality, design and reliability methods, design for six sigma, total quality management, DOE, lean and so on [12].

In this chapter, it is presented the main methods for risk identification and mitigation during product development, and the main improvements it was done on those methods for better attending the needs of the agile transformation.

ENGINEERING METHODS OVERVIEW – During the development of a new product, multiple technical risks may cause quality issues, customer dissatisfaction or even safety issues. Depending of the level of innovation, the knowledge and experience of the team members, learnings of previous issues and other sources of know-how, the team is previously aware of some risks since the beginning, but some of them are unknown due to the innovative nature of the project. The risk identification methods aim to uncover and expose not only the obvious risks but also the hidden risks during the product development phase, in order to allow the team take countermeasures on time to avoid them to occur. In summary, these are preventive methods applied to identify and mitigate risks before they happen, making the product more robust.

An important method for risk identification during product development is the Focus Matrix (see figure 4) [13]. It is applied since the beginning of the project, in order to map and classify preliminary risks, as well as mapping knowledge gaps, which will become focus areas for the development team. This analysis is done by crossing all technical requirements, including application, system and product requirements (which are filled in the vertical left columns) with the design proposals (which are filled in the horizontal row), including their functions and solution principles.

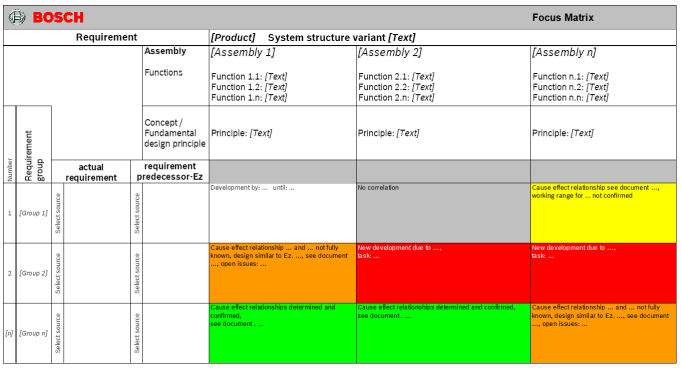

Figure 4. Focus Matrix

The document is filled together in a cross-functional and diverse team, mixing experienced engineers with young ones, with different backgrounds and technical knowledge. They analyze if there is any risk of not meeting those requirements with the proposed design solution. There are some colors codes to communicate the risks:

- Green: The proposed design solution meets the requirement;
- Yellow: There is a low risk of not meeting the requirement;
- Orange: There is a high risk of not meeting the requirement;
- Red: Risk unknown. The team has no technical knowledge to identify the risk.

The color pattern makes it visual and easier for the team and leaders to identify the focus areas. The red items are the first priority because there may be serious risks hidden in that area. The team needs to define a plan for filling that knowledge gap by, for example, consulting an expert or performing an in-depth research on that topic. The orange risks are strong priorities as well, because the team knows that there is a serious risk there. The yellow areas

require some investigation, which must be done at some point during the project, but it is not a strong priority. In addition, the green areas require no further investigation, but it must be proved and documented that it offers no risk [13].

The Focus Matrix is a "live" document during the entire development process, guiding the development team towards the right focus, supporting communication with the experts and providing transparency for the whole organization. It has a strong connection with other methods, and it must be frequently consulted and updated.

Another important engineering method is the FMEA (Failure Mode and Effect Analysis). It was first applied in the 50s by US military engineers, followed by NASA in the 60s. After that, the method quickly spread to other areas and fields. Since the 70s, it is strongly applied in the whole automotive industry worldwide [14].

The FMEA method has the main target to map technical risks and possible failure modes for all system modules, components, design elements and interfaces. It establishes a correlation between technical root causes and effects of failure modes, allowing the team to predict these failures before they happen.

The method allows prioritizing those failures through a risk quantification ranking consisting of Severity, Occurrence and Probability. The Severity refers to how serious the failures consequences are in case it happens. The Occurrence refers to the probability of that failure to happen. And the Detection indicates the chance of detecting that failure before it happens.

There are many types of FMEA including the DFMEA (Design FMEA) and PFMEA (Process FMEA) the most common and used ones. The DFMEA aims to indicate and point out all possible failures that could happen from a proposed design, including all product specifications. The PFMEA analyses the possible failures that could happen in the proposed manufacturing process.

For creating a FMEA, it is important to create a structure consisting of a system structuring tree deploying the system from top level modules to lower level design elements. Based on those elements it is created a function tree and a failure tree, which makes the connection between root causes and effects very clear and visual [15].

The FMEA is a powerful tool to map all possible failure modes and classify them to enable prioritization, but due to his broad nature of mapping all those risks, it is more generic and not so deep. For in depth analysis of the most serious risks, and even finding additional risks, there is another powerful tool called DRBFM.

The DRBFM (Design Review Based on Failure Mode) was created by Toyota after a series of quality incidents started to happen in the automotive industry as a whole by the end of 90s. The main target is to predict and eliminate failures that could happen from a design change [16]. It is based on the GD3 mindset, which stands for:

- Good Design: A robust design is the result of a thorough analysis of technical risks or concerns that could be caused by a design change, leading the team to work on a design to avoid those failures to happen.

- Good Discussion: An open technical discussion in a multifunctional and diverse team of experts from different areas of expertise, fields and experiences allow the team to find not only obvious risk but also the hidden risks.

- Good Dissection: For a in depth analysis of cause and effect relationships it is necessary to expose the design to the minimum details, considering physical models and technical behavior in different fields, in order to find the root causes for all failures.

The DRBFM (see figure 5) systematic usually starts with a new design proposal. The team identifies changes comparing the new design with a current existing design as a reference, in the Awareness Sheet. These differences are analyzed from a physical behavior standpoint, in order to understand what is physically changing with the new design, and what are the functions affected by the change, in the Changes Comparison and Function Focal Points sheet. With functions and physical behaviors identified, the team quantify them and transfer to a spreadsheet table, in order to identify concerns, in the Concern Points Identification sheet. At the end of the process, the team analyses the most critical concerns, identifying damage mechanisms and possible root causes, in the Worksheet. Then, based on the root causes, the team defines design changes (if necessary) to avoid the concerns to occur and evaluate them to check if the proposed design is really robust [17].

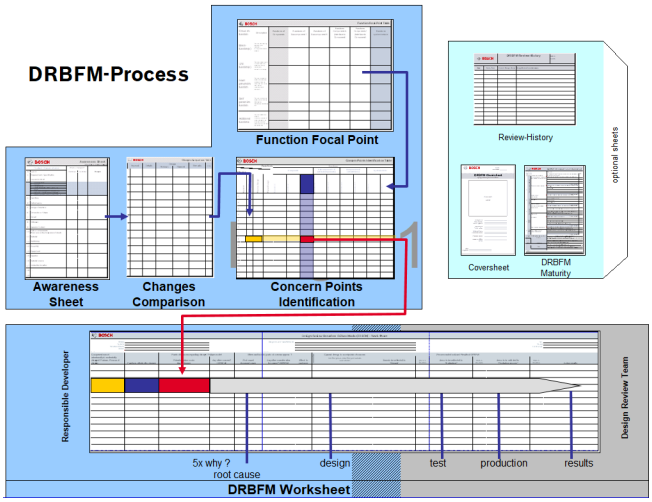

Figure 5. DRBFM Method

There are a few similarities between DRBFM and FMEA. They are both based on risk identification through

cause and effect relationships. However, while the FMEA has the target to map all the risks for all design elements and classify them, the DRBFM focus deeply in the a few important risks to dig into the root causes through physical models and failure mechanism.

There is also a strong interaction between FMEA and DRBFM. The FMEA helps to identify topics for a new DRBFM investigation and the other way around, with the DRBFM feeding the FMEA with new risks that were not included there before. The Focus Matrix is also a good starting point for all of them.

There are other engineering methods such as Design for Six Sigma, QFD, DFMA, Problem Solving and so on. These methods have been applied on multiple projects over decades, and they are still very effective and largely used. The combination between these methods with traditional project management methods have been very good so far, but they consume a reasonable amount of time. With the agile transformation, these methods are still required but they have to transform in order fit into this transformation by becoming more agile as well. This transformation is presented in the next section.

ENGINEERING METHODS FOR THE AGILE TRANSFORMATION

The agile transformation, as presented in chapter 2, requires not only the implementation of new methods for project management but it involves a mindset and cultural change. Included in this cultural change are the empowerment, servant leadership and team/user interaction. Mistakes are accepted as opportunities to learn, however, it is still important to do the right things though a systematic approach, in order to avoid a trial and error approach, improving learnings from mistakes and gaining agility.

According to the classification from the Stacey Matrix (figure 1), for simple (classical) projects, the existing engineering methods fit perfectly in their original state. For complicated projects, some additional methods can be applied such as Problem Solving, but in the area of complex and chaotic, some mindset changes are required.

In that complex/chaotic area, requirements are not static, so changes are allowed and welcomed during the design process. Additional tools such as User Experience by means of Design Thinking can be used for a strong interaction with users during the product journey lifecycle, in order to understand their pains and extract requirements for developing a proper solution for them.

For design reviews, including Focus Matrix, FMEA or DRBFM, the recommendation is to focus on the mindset and the essence of these engineering methods, going directly to the point without so much emphasis on format or templates. The focus matrix, for example, can be handwritten on a white board in a stand-up meeting mode, with a moderator conducting the process and stimulating participation of team members. The documentation can be printed and attached to the wall, so that participants can write directly on the board by themselves, in oppose to a classical approach where the moderator writes in a computer with all participants sited around a table looking to the screen. In the end, a photo of the wall or board is accepted as documentation, just including the mandatory elements required by internal and external quality norms and audits such as names, identification, date and signatures, and properly storing the file for traceability.

During a DRBFM review, the team focus on physical principles and functions, and the spreadsheets are always printed in a big size attaching to the wall or pin board to allow team interaction and to stimulate discussion between experts.

The DRBFM method have also been transformed to better fit the agile transformation. The previous approach consisted of 5 spreadsheets (Awareness Sheet, Change Comparison, Function Focal Points, Concern Matrix and Worksheet). They were all mandatory and the templates should be printed for the discussion. It was seen as a powerful approach, but also too formal and hard to follow. Based on those feedbacks, a new version was released in 2016. These changes can be seen at figure 6.

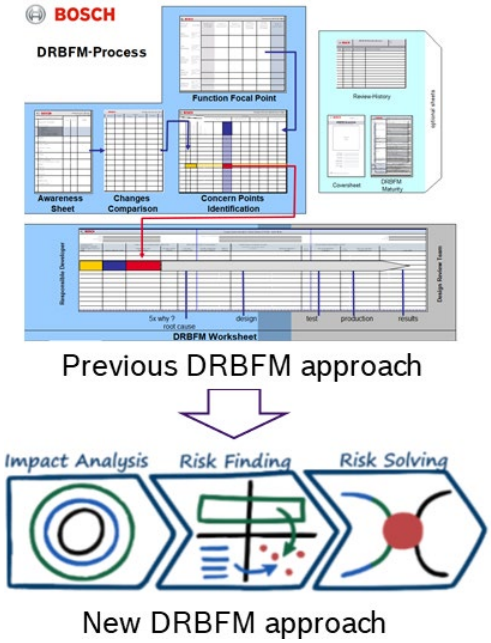

Figure 6. Differences between previous and new DRBFM approach

The new DRBFM version is now consisted of only 3 modules. The first one is the Impact Analysis, with the target of mapping all design changes, physical behaviors and functions, in a qualitative way, with focus on technical breadth. The most relevant findings of the Impact Analysis are transferred to the second module, the Risk Finding, where the team calculates and quantify the most important functions and physical behaviors from the previous module

and identify concerns and risks. The most important concerns from the Risk Finding module are transferred to the third and final module, the Risk Solving, where the team identifies technical root causes and define design changes to avoid the concerns, based on those root causes. In the end, those changes are evaluated and tested to confirm the assumptions and calculations [17].

The new DRBFM approach is very flexible, allowing the team to apply any module independently according to the need of the project at any given time. It is also very focused on mindset, without the need of a formal template. In the next chapter, it is presented an example where the new approach was applied.

EXAMPLE USING PROPOSED APPROACH

The approach applying agile methods in combination with the new Product Engineering methods have been applied on multiple projects, especially the ones involving some innovation. In this paper, it is presented an example related to the development of a new fuel injection pump for small diesel engines.

FROM REQUIREMENTS TO DESIGN SOLUTIONS – In discussion with some customers, it was identified the need for a simple solution to convert small diesel engines equipped with mechanical fuel injection systems into electronic ones. That segment is pretty challenging in terms of requirements, due to the vast range of applications and use cases.

For tackling the challenge, the team decided to apply User Experience methods with Design thinking approach. In a period of weeks, it was performed intensive research on applications, legislation for emissions, potential markets, and it was developed a prototype for preliminary testing and evaluations with customers, including interviews in order to understand their pains and issues. In the end, a list of preliminary requirements was created based on those inputs, and the product development phase got started.

The team then defined some solution principles using an existing pump platform as a basis for cost efficiency. The team was using Scrum to manage the activities and the improvements, simplifications and flexibility of the new Focus Matrix approach and DRBFM modularity allowed them to include these methods into quick sprint cycles.

Using first the Focus Matrix, a design review was conducted with a cross-functional team, and some possible concerns were identified, mainly related to lifetime and performance of the pump. For those topics, a DRBFM was defined for an in-depth investigation and search for solutions.

Using the DRBFM, the team could deeply analyze the design proposals, including the concerns identified in the Focus Matrix. A team of engineers from design and production areas worked together to understand the physical behaviors and functions. The main conclusion for the lifetime concern, for example, was that a reduction in hardness at the body material could lead to wear at valve seat, because the valve remained very hard. That could lead to a severe wear above the operational limit during lifetime. The wear calculations and experiments showed that a possible solution was to adjust the tribological pair, reducing the hardness of the valve as well. While the design was being defined, the manufacturing engineers were sitting together in the same room defining the production process in parallel, in a simultaneous engineering environment. The approach can be visualized at figure 7 [18].

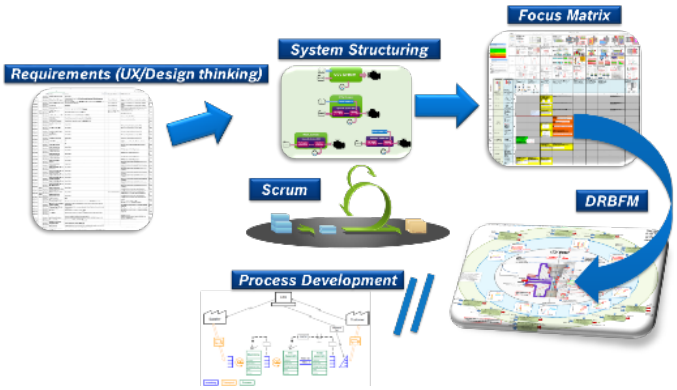

Figure 7. Combination of Agile and Product Engineering Methods

LATE REQUIREMENTS CHANGE – While the team was working on those design solutions, there was a request from the customer to modify important requirements for assembly of the pump in the engine. That request came very late in the project, close to design freeze, something that would not be accepted in a classical project (Red Flavor). However, with a new mindset, the team discussed the change with the customer and welcomed that modification, even though it would cost a project delay.

That requirement change resulted in a significant modification on the pump body design, requiring an update on Focus Matrix and DRBFM. These documents were quickly updated, and new concerns emerged, especially related to mechanical resistance and cracks on the body. New calculations and numerical simulations were done, requiring changes at some corners to reduce stress concentration. Those changes were tested and proved to be robust, so the concern was solved. In the end, the requirement change caused around 2 months delay, but the customer was very satisfied with the result.

CONCLUSIONS

Considering the demands of recent business environment that most companies are facing, with the Fourth Industrial Revolution in place, it is mandatory for companies to become more agile. The agile mindset allows a faster development by the constant delivery of incremental value to the customer, with strong user

interaction. Companies in the automotive sector have identified theses needs and are moving towards that direction.

Performing an agile transformation requires not only the implementation of new methods for dealing with projects and innovation, but also a strong cultural change. The company needs to move from a hierarchical classical structure, with a leadership style based on top down command and control to a more flexible structure with empowered, responsible and independent teams coached by their leaders.

The agile transformation requires also the implementation of new methods, such as scrum, among others. These methods are more flexible than traditional waterfall approaches, but they are not applicable to all types of projects. Some of them still require a classical approach, while some others can adopt a hybrid approach, as discussed in session 2.2.

With the implementation of new methods for agile projects, the Product Engineering Methods had to transform as well. Requirements are obtained with strong user interaction, while the Focus Matrix guide the development team towards main concern areas and knowledge gaps, and a more flexible and modular approach of DRBFM allows the team to deep dive into technical issues faster.

The main conclusion is that a combination of agile techniques with flexible product engineering methods is a powerful tool for a robust and agile development, but that approach requires great team experience and technical knowledge for quick and accurate technical decisions. These experts can be part of the team or can be consulted on demand from an expert network. However, the success of the approach really depends on having the right expertise available during the development, with trained and prepared associates.

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