Leadership approach towards Agile, Waterfall and Iterative implementation of the software development products

O Popa[1], C. Mihele[1], C Făgărășan[1]and A. Pîslă[1]

[1] Design engineering & Robotics Department, Machine Building Faculty, Technical University of Cluj-Napoca, 103-105 Muncii Avenue, Cluj-Napoca, Romania

[1]ou.popa@gmail.com

Abstract. The automotive industry is one of the most dynamic markets, gathering around many different sectors from material extractions to robotics and cloud computing. The current research analyses the influences and particularities of leadership and identifies the challenges and advantages of the two principal methodologies in software development projects within the automotive industry, Agile and Waterfall. Some aspects of reducing methodological disadvantages are suggested and presented. The aim is to arrive at a sustainable solution that can ensure the delivery of reliable and flexible software products. The impact of these methodologies on the quality standards and project documentation is analyzed, which is a vital part of automotive software development. By influencing the product development lifecycle, there is an opportunity to develop a structured framework that can be adopted to build software products in a more flexible and agile way.

1. Introduction

It is impossible to ignore the global value of the automotive industry that employs directly around five million people and indirectly many times more. Only in South Korea, this industry employs over 1.4 million people. Besides that, the automotive sector is one of the most dynamic fields reporting continuous and sustainable growth. It gathers around different other industries from raw materials extraction, materials development, design, machine-tools and robotics, manufacturing process, technologies development, cabling, testing, maintenance, ensuring, dealership, planning, programming, AI and cloud computing, bringing to the market more than 60 million cars and trucks in a single year.

The automotive industry contribution to technology and value creation acts as a pillar of the global economy and the central driver of macroeconomic growth and stability using innovation and technological advancement in developed and developing countries, with a high percentage in the national GDP, representing 3% of the global GDP. It is known that governments can have a direct impact on automotive manufacturers through the regulations introduced. As an effect, the production costs may be increased, and limitations may be added to the way cars are sold and marketed. Therefore, the governments and the industry's key stakeholders must closely collaborate to build a shared strategy.

Car manufacturing implies many engineering specializations. At the end of the XX century, the automotive industry was dominated by the physical suggested disciplines, directly contributing to automotive manufacturing, the so-called "conventional engineering". The XXI century is greatly influenced by the fourth industrial revolution, which promotes the automation of traditional

manufacturing and industrial practices, going fully digital towards building an automotive "brain" and "sensorial" system.

The boost for innovation needs substantial Research and Development investment by automakers, driven by the consumer demands for more product variety, better performance, improved safety and higher emission standards, all together at lower costs. Automobile companies are in third place on the list with the most significant investments in Research and Development. In the first place is the pharmaceuticals companies with $120 billion (as reference 100%), then the technology companies with $111 billion (92.5%) and the automotive industry with $108 billion (90%). The essential automotive investing countries that cover 71% of the automotive Research and Development investment are Germany (33%), Japan (20%) and South Korea (18%). Furthermore, the automotive industry's Research and Development and innovation can benefit other sectors, such as insurance or automotive telematics, the communication technology for the automobile industry based on information flowing from vehicles via wireless networks.

The core automotive industry, the vehicle manufacturers and parts makers, will continue to support a wide range of upstream and downstream business segments with adjacent sectors. This will continue to lead to a multiplier effect for growth and economic development. The automotive industry remains at the forefront of cutting-edge manufacturing technology that spread to other sectors. Leading and production processes within automotive (lean manufacturing, assembly lines, supply chain integration and modular sourcing) are standard for many different industries. This sector was a pioneer in using robots and other automation solutions, and now the Robotics business is an over $25 billion industry.

Recognizing it as a forefront means that learning from the global automobile industry is more than beneficial, especially for the fact that project management is a vital component as is also defined in DIN 699901 [1] by the core characteristics: novelty, unicity, complexity, and nevertheless interdisciplinary, interlacing different resources from different fields that depend on one another. By focusing on kernel processes, automakers have improved profitability and served niche markets more efficiently. Therefore, the interdisciplinary projects involving hardware and software development for the automotive industry face three significant challenges.

1.1 The organization leadership best implementations strategy

By definition, the Agile methodology can be considered a product of successful leadership. The Agile methodology's implementation in any organization automatically determines an increase in the leadership quality level [2]. The fusion of core values, concepts, and behaviour promotes highly-rated products that consistently exceed customer expectations and increase the project team's potential. As a result, it can be affirmed that efficient leadership and agile methodology can be considered interdependent components of the organization strategy in project management [3].

In this complex equation, other critical factors can lead to project success when Agile or Waterfall methodologies are applied. They include a brief definition of scope and objectives, increasingly focused on adding value to the organization, implementing a functional management structure, pushing its members to adopt a new mindset that can lead to determination, proactive and efficient communication. In the Agile context, the project attributes tend to be amplified, and their impact extrapolated.

The transition from Waterfall to Agile needs to be evaluated as a complete change inside the organization because of the significant impact on the project management methodology that grants success. During waterfall project applicability, the project's constraints are high, and the software development lifecycle is sequential; a phase needs to be finalized and accepted before the next one can be started. Regarding the scope, it is defined at the beginning of the project, and once it is approved, there are rigorous processes to follow to change the agreed scope baseline. The Agile methodology was introduced to promote change and welcome early feedback in the software development life cycle to respond to customer requests continually. The budget and time may remain fixed, depending on the existing agreement.

The Agile transformation should start with understanding the organization's desire to change the standard approach by adopting Agile, as each organization might have a different one. The most apparent

reasons are improving delivery, increasing the quality of the products and improving the time to market. For situations where no development delivery method was officially instated, the Agile methodology represents a suitable solution.

The agile framework offers the possibility of fragmented product increments delivered in short periods through development iterations. Decoupling big projects in fragments represents a solution for blocking stops in the cascade approach. In the automotive industry, the quality of final delivered products may not correspond to customer expectation because it might have changed between the project's start-up till the end of the project. Still, the Agile methodology is preventing such situations by constant reviews with customers and continually adapting the product according to their vision.

The approach toward Agile strategy needs to address the organizational culture and management style, on top of their critical constraints [4]. Culture is one of the foundation pylons for the business strategy, and the most popular culture constraints are the management style, trust, acceptance of change and intense process focus. Therefore, awareness about the existing organizational structure is crucial as long as that will reflect the adopted business strategies.

The automotive industry has more cascade-type organizational structures as a typology that helps in the tasks and responsibilities distribution in an organized way. The delegation is transparent, and there are predetermined decision processes. Hence, the automotive industry relies on three types of organization diagrams: Functional, Project-based, Matrix-based.

The most traditional structure is the Functional organization, represented in Figure 1, consisting of divisions and departments oriented on specialization, product development or different manufacturing facilities. A project may be split into phases from various departments and divisions. As an example, this is highlighted in grey in Figure 1. Such structure is proven to favour flexibility towards the clients demanded products, with the capability that some manufacturing technology can be imposed. In such an organization, the procedures, communication and responsibilities are very well-defined. As a disadvantage, this system is reluctant to change, and usually, there is a lengthy process through which organizational changes are considered.

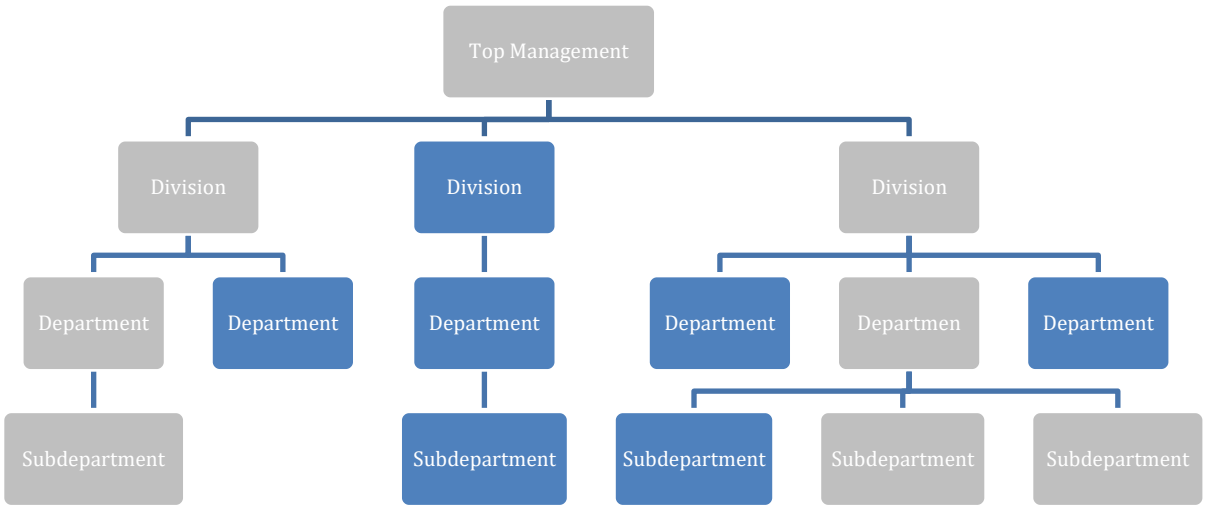

Figure 1. Functional organization [16]

Figure 2 displays a project-based organization, a typical structure for the organizations that offer professional services, including the product design or product development companies, facilitating the cooperation within the company members of different specializations, and having the same membership structure an entire project. There is a risk here that can result in technical capping and frustration caused by isolation; other teams have nothing in common despite being company member.

In this structure, the project manager will be responsible for team management and motivation (organizational and functional), including all project management activities.

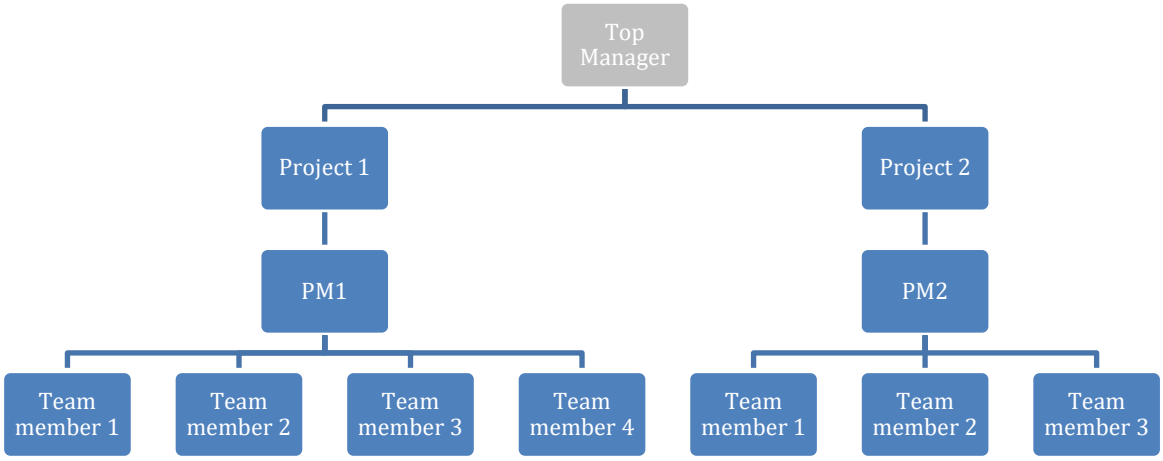

Figure 2. Project-based organization [16]

The structure presented above has its disadvantages because it implies that companies have a continuous flux of projects. There will be periods of peak times during which the teams are stressed due to a lack of personnel to deliver the higher flux of projects. On the other hand, when the company will have a lower flux of projects, the company's budget will be at risk. The situation presented led to a derivate version of the project-based organization. As described in Figure 3, in this hybrid project-based structure, the project managers may form their teams from a single "human resources pool", offering each individual the chance to work in different groups and gather novelty and knowledge. This structure introduces flexibility and promotes teamwork within the organization.

The big challenge of the hybrid structure may be the projects prioritization and the adjacent sharing of the human resources, with less personal or emotional involvement leading to ownership loss.

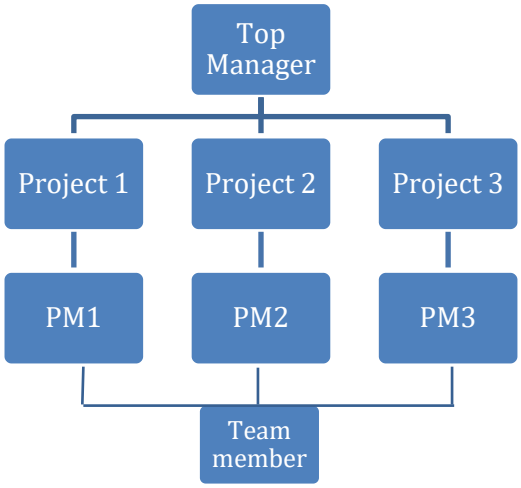

Figure 3. Derivate project-based organization [16]

Figure 4 reveals the Matrix-based organization. This structure is recognized for counteracting most of the disadvantages of the previous structures, offering a balanced environment in which the Project Managers (PM) are organized in a single department. The Project Management Office administrates all the projects, led by a Team Leader (TL), who is usually in charge of distributing the projects within the team. The project managers are at the same level within the department, there is no natural hierarchy, and they are reporting to the Team Lead of the Project Management Office or the Top management.

In this case, the main challenge is the projects distribution and the project managers allocation. The excellent cooperation between the Team Lead and the Project Managers is the key to getting increased department efficiency and project success. The project managers are directly responsible for their assigned projects and their completion. The project managers team has a consultative role but is under the subordination of the Team Lead.

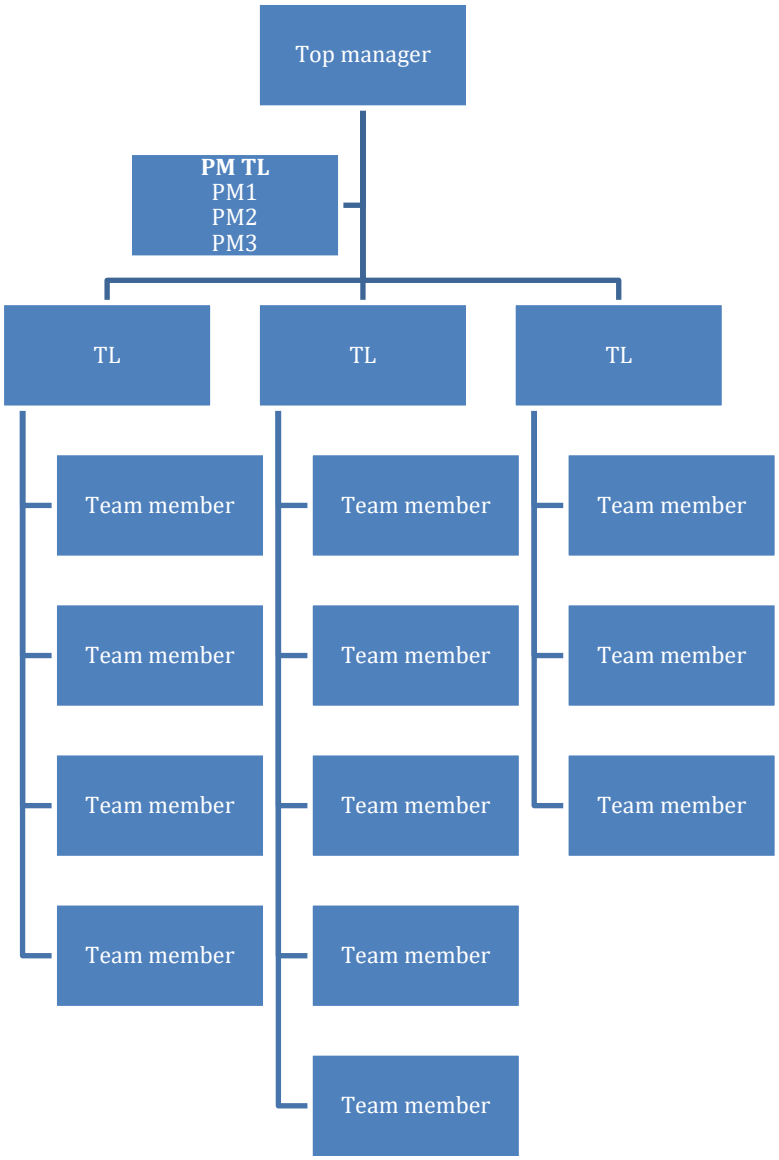

Figure 4. Matrix-based organization [16]

The second challenge of such an organization is the two heads' impressions and the danger of redundancy in documentation, processes and reports. The Agile management style can help overcome this challenge through collaboration and decentralized decision-making. If the organization management style is directive, the managers need to learn to encourage cooperation, delegate and allow their subordinates to make decisions.

Another cultural constraint is the resistance to change, which needs to be reduced. Willingness to embrace the change is a determinant factor for agile implementation success. If the organization culture is reluctant to change, the agile transformation process needs to incorporate existing change leaders or external leadership representatives on board [5]. The managers need to prepare for the transition and learn about the advantages of the agile methodology. Furthermore, trust is an essential element for Agile growth, facilitating the leadership changed approach [6].

A successful agile methodology implementation is always the result of the team's collaboration and effort and should start with a pilot project. Developing a group of agile supporters that understand the methodology and are interested in testing and promoting it represents another pylon of organization agile transition. A team composed of people with knowledge about agile who are also willing to contribute can ensure the pilot project success. Having a team of representatives in each project area with an agile mindset provides the basis for the pilot project's success.

The agile methodology needs supporters in all layers of the organization, from executive levels to individual contributors. One major step in the agile transformation process is to designate agile influencers on the executive company level.

After the pilot project and pilot team are defined, the visual presentation becomes the next major step in implementing the agile methodology. From the project's initiation phase, everyone needs to be informed, and the communication channels must remain open and transparent. The executive support must be demonstrated within the organization and is needs to be visible, starting with the pilot project presentation, available to every member of the organization.

I. The developed software components can be swift and appropriate into the hardware component that requires a longer development process and comes with constraints in the flexible software development.

II. Totally qualification to standards. The hardware-software components are in direct dependency on passenger safety. For these reasons, the industry adopts plenty of quality standards. The software projects should qualify to standards such as ASPICE [7], ISO 9001 [8], ISO 26262 etc. It is necessary for these met standards, but it must be taken into considerations also the generate challenges. For example, a significant impact is the level of detail in documentation, which is very helpful for traceability, planning, and development history that is slowing down the development process and requires a significant level of resources.

1.2 Leadership issues in the automotive industry

In the automotive industry, leadership is much connected with project management and human interaction [9], [10], [11, [12], [13], as the first and necessary more vital element that face the four forces of the change: Political, Economic, Social and Technological. In case of failure, managers are considered the ones responsible. In case of success, the sums of money leaders are paid in the automotive industry each month is justified.

Thus, the organization leader and the methodologies adopted by him are unique factors for success or failure. Consequently, besides the knowledge, skills, competencies, and the employees' involvement, the result is defined by the role of the leader to align all of the above and obtain sustainable and long-lasting competitive advantages. It is essential that the new leadership model and culture work well over time [14].

1.3 Project management methodologies in the automotive industry

The planning of the automotive software projects is a genuine challenge when part of the project scope is to ensure a specific quality for this industry. The development process should be competitive and recognized in the software development world.

A classic waterfall methodology would be disadvantageous for software development because it is very rigid, as described in [15]. This effect can produce significant gaps in the performance of the product's milestones, and customer satisfaction can be seriously impacted at the end of the product development. Incremental development can increase these key performance indicators because the product is developed in an active and dynamic synchronization with the customer needs. On the other side, Agile development with an applied incremental delivery for mechanical/hardware parts can increase significant development costs or be predictable for robotic development.

Figure 5 reveals the hybrid methodology designed for the automotive industry. Taking into consideration all hybrid scenarios [16], [17], the advantages and the disadvantages of this methodology were evaluated [18], with the purpose of reducing the sides effects of this in a mapped methodology with the project's specific needs.

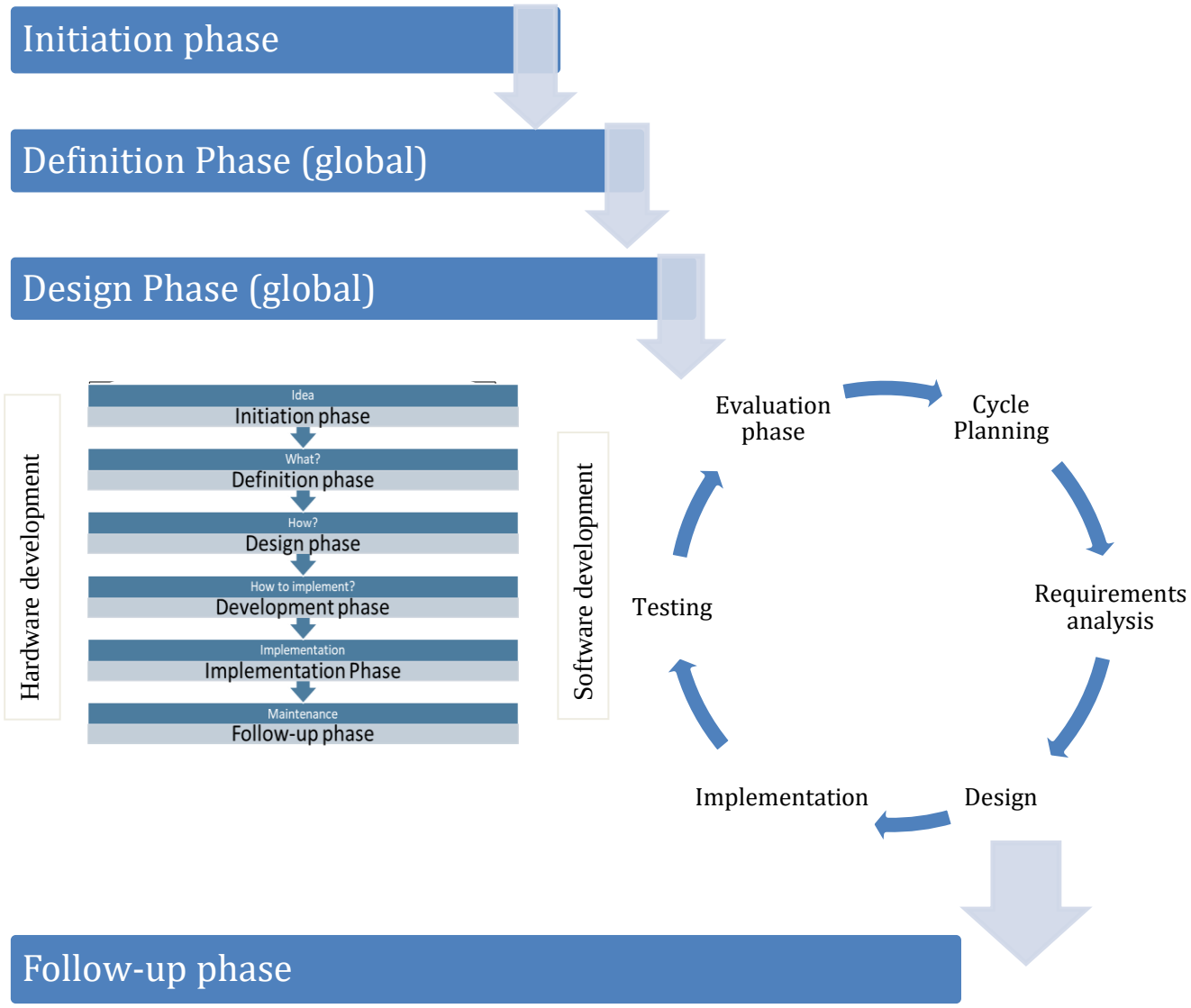

Figure 5. Hybrid methodology in automotive [16]

2. Software component development in automotive industry development

The development workflow was applied to an automotive software development project for the infotainment system centred on the central media system from a car console. For the example below, the project scope is to deliver the product just with unit and integration tests.

As it is shown in Figure 6, the customer requirements play an essential role at the beginning of the project. It is necessary to elicit clear and precise customer requirements. The client (PAG) raises the business requirements with the company's implementation partner, internal or external. The Agile teams need to be cross-functional; they need to have all the skills necessary to deliver increments of working software. Usually, the development team has a business analyst who takes the client requirements and evaluates them together with the team. In this phase, the team collaborates with the client to refine and clarify the business requirements and transforms them into functional requirements.

After the client has approved the specifications, a more detailed analysis occurs, and the final software requirements are defined. After they are revised and validated, the application architecture is developed, which must be designed, reviewed and approved.

The next step is for the development team to create a detailed design of the application. After this phase is complete, the unit test specifications description follows based on the design specifications. In correlation with the defined architecture, the integration tests specifications are prepared. After the acceptance criteria are validated during the testing phase, the final version can be delivered to the client.

The customer may have his own processes to validate the acceptance criteria. For big projects, the companies have acceptance team which verify that the functionality provided is according to the business requirements and the implementation satisfies the business need. After this validation, the customer is doing qualification and validation tests followed by the approval.

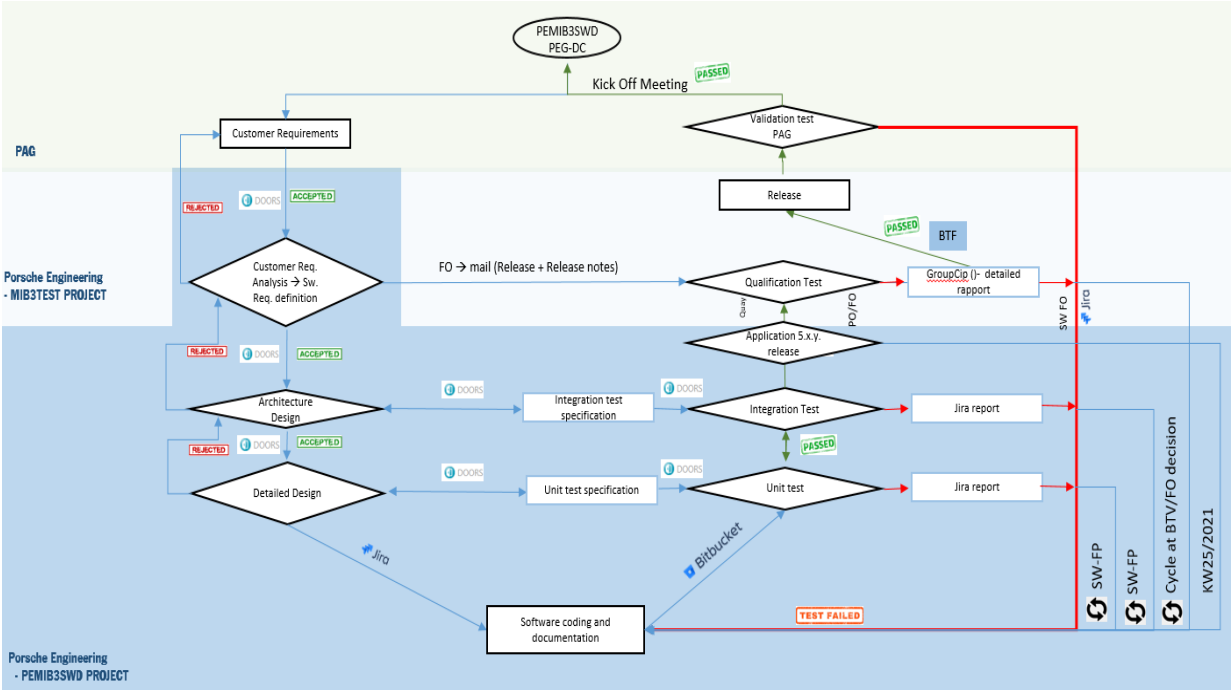

Figure 6. Development workflow for a software component used in the infotainment system

As it can be observed, a V-Model methodology is used for the development of the software component. However, the application can be developed in more iterations by leveraging the implementation methods of the Agile methodology. The most popular ones are Scrum and Kanban, which are well-known for their success rates and easiness of usage. Project iterations are called sprints in the Scrum framework. The agile development process was adjusted to create a new working methodology, as shown in Figure 7.

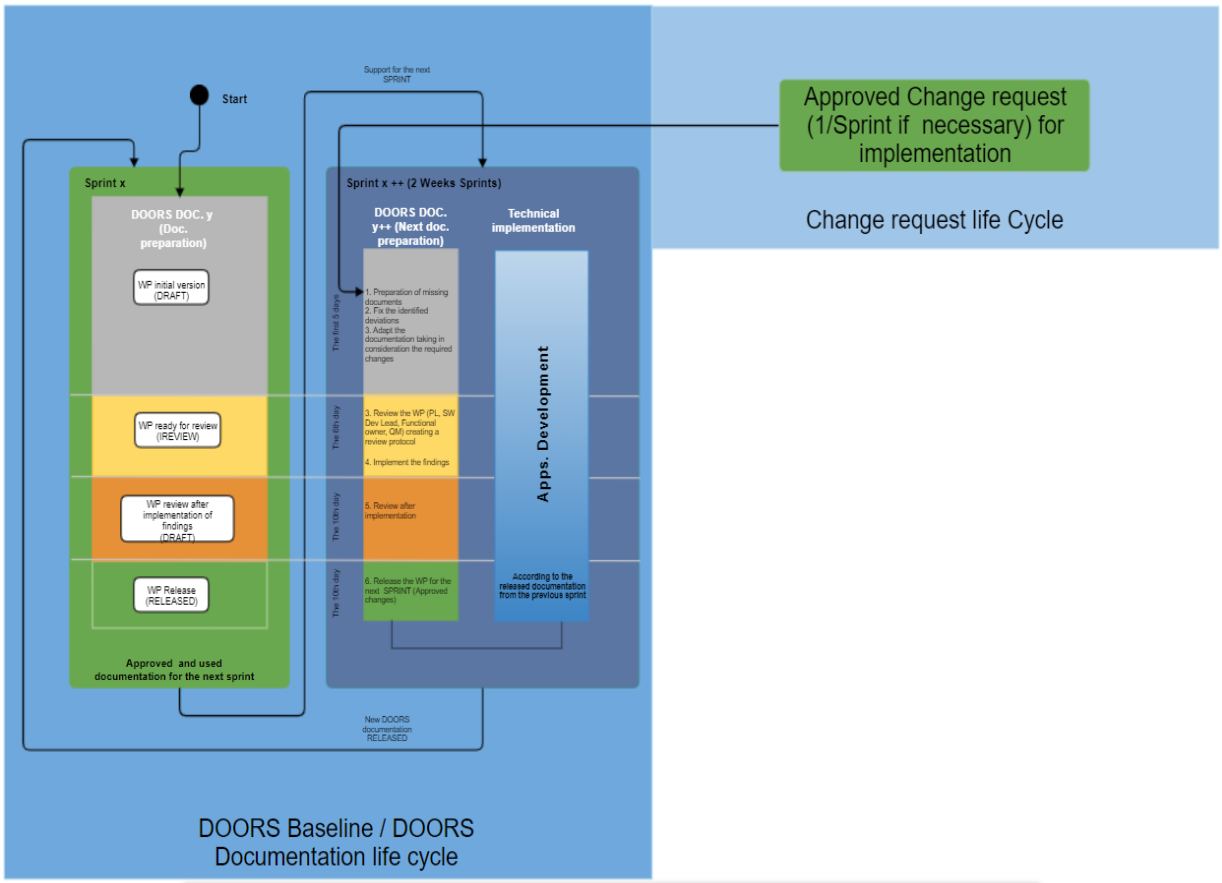

Figure 7. Iterative methodology integrated into V-Model development workflow

All projects have kick-offs during the initiating phase. After this formal meeting with the project team, as Figure 7 shows, Sprint x is started, which is the first sprint of the development phase. In this iteration, the first version of the project's documentation is produced, and any technical project setup can be done. Once the documentation is revised and approved during the sprint review meeting, the priorities for the next iteration are discussed. The application development can begin based on the approved documentation from the previous sprint in the second sprint, even if it is not entirely validated.

As part of the new iteration, the documentation is further developed by adjusting it or introducing any missing elements. Furthermore, in the first week of the current sprint, the approved change requests can be submitted in the documentation so the client can adapt the requirements according to the dynamic changes or needs. Once the second sprint is finalized, a new version of the documentation is approved. This documentation will become the base of the application development in the third sprint.

Through this interactive method, the project can permanently be flexible related to new requirements of the client through a Change Request process, taking the overall picture of the product development. It can be observed that the V-Model allows systematic documentation and planning to the automotive industry.

3. Conclusions

The project management methodologies have the main scope to help the projects in every domain perform and compete in the market. The automotive industry has procedures and standards, which are well-defined. Still, the sector should inspect and continually adapt the development procedure to be faster, more flexible, and incorporate the Agile mindset. Despite the fact that the hardware development and the standard's requirements come with many limitations, the results can be significant if the agile spirit is adopted in all industry branches.

For the automotive software development area, it was shown that a combination of the Agile software development lifecycle and a V-Model documentation process adapted in short, incremental releases can be a suitable solution in this dynamic and rigorous context.

Acknowledgement: This paper was supported by Porsche Engineering Romania.

4. References

[1] Die DIN 69901:2009-01 "Projektmanagement - Projektmanagementsysteme", January 2009, replacing the former valid norms DIN 69901:1987-08, DIN 69902:1987-08, DIN 69903:1987-08; DIN 69904:2000-11 and DIN 69905:1997-05, (2009).
[2] Gary Yukl, Leadership in Organizations (7th edition), Prentice-Hall (2009).
[3] Editors: Jay A. Conger & Ronald E. Riggio, The Practice of Leadership, John Wiley & Sons Inc, ISBN13 (EAN):9780787983055, (2007).
[4] Edgar H. Schein, Organizational Culture and Leadership, (4th edition), Jossey-Bass Business & Management, (2010).
[5] Richard L. Hughes, Leadership: Enhancing the Lessons of Experience. (7th edition). Ginnett, & Curphy. McGraw-Hill/Irwin, (2010).
[6] James MacGregor Burns, Leadership, New York: Harper Collins, (1978).
[7] Automotive SPICE, Process Reference Model, Process Assessment Model, Version 3.1, Author VDA QMC Working Group 13 / Automotive SIG (2021).
[8] International standard ISO 9001, Quality Management System-Requirements (2021).
[9] Narcis Popescu, Project Management MZT815 Materiale Auxiliare, (2021).
[10] Adrian Danet, Managementul Proiectelor, editura Disz Tipo, Brașov (2001).
[11] Project Management, Olad Passnheim & Ventus Publishing ApS, (2009).
[12] R. N. Lussier, Human Relations in Organizations: Applications and Skills Building, (1999).
[13] David V. Day & John Antonakis, The Nature of Leadership (2nd edition), SAGE press, (2011).
[14] Bruce J. Avolio, Full Range Leadership Development, (2nd edition) SAGE press, (2010).
[15] Kelley O'Connell, Transitioning from Waterfall to Agile Project Management, (2015).
[16] Project Management Handbook, Wouter Baars, (2006).
[17] Bernard M. Bass with Ruth Bass, Bass's Handbook of Leadership (4th edition), New York: Free Press, (2008).
[18] Management 3.0, Leading Agile developers, developing Agile leaders, Jurgen Appelo, (2011).