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Agile Methodologies In The Automotive Industry: A Comprehensive Survey

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Abstract
The automotive industry is undergoing a major transformation driven by trends such as autonomous driving, connectivity, electrification, and rapid digitalization. This results in embracing agile software development practices and new digital architectures to accelerate development cycles and manage increasing complexity. This paper discusses the insights on the agile methodologies into automotive software procedures, extending agility beyond software units , integrating agile with product lines, addressing security concerns, and constructing advanced digital platforms for automotive systems also assessment models like ASPLA (Agile Software Product Line Adoption) for agile adoption in software product lines, and future research directions towards realizing the vision of intelligent, self-driving, connected vehicles through continuous evolutions in agile-based development processes, digital architectures complying with quality standards, cross-domain collaborations, and empirical validations.

Keywords—*Agile-Methods,Software Product Line, Auto- Motive Software Development, Automotive Open System Architecture (AUTOSAR), Agile Systems Engineering (ASE), ASPLA Model Agile, Digitalization.*

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I. Introduction

The automation industry is undergoing major changes driven by disruptive changes such as autonomous driving, increased connectivity, rapid digitalization and electronics. These factors require the use of new digital models to accelerate software development practices and cycles and manage the complexity of transportation, leading to the implementation and use of processes. Agile emerged to solve these problems. Agile is a software development process founded on the collaborative solution and requirements produced by self- organizing, self-directed teams. Support such agile activities as planning and incremental development, as well as fulfilling commercial objectives. Agile methods, including development iterations; early delivery; continuous improvement and adaptation correlator with results from dynamic feedback.There are numerous aspects that can influence the adoption of agility in the automotive industry. The first is that agile enables to manage changes, improve customer participation, and collect customer feedback easily throughout entire development process. This is very important as in today's competitive automotive industry there is increasing pressure on those products to be more up-to- date and feature-rich than ever before.The primary objectives of this survey are: Analyze strategies for integrating agile software development practices into established automotive processes like the V-model Investigate approaches for scaling agile methodologies beyond software teams to the full multi-disciplinary vehicle development life cycle also Study the challenges and solutions in combining agile development with software product line engineering for automotive systems then Examine security aspects of adopting agile in automotive SMES (small and medium enterprises).At-last Outline the key-digital-architectural paradigms, connectivity technologies, and IT practices enabling future intelligent autonomous vehicles Discuss critical challenges like verification, functional safety, optimizing AI/ML workloads, and organizational transformation Present real world applications, assessment models, and future research directions in this trans-formative space.

II. Core Elements Of Agile Methodologies In The Automotive

Digital Architectures and IT Trends to manage complexity from digitalization, service-oriented automotive architectures with centralized computing platforms, hierarchical ECU (electrical control unit)

classifications, decoupled hardware software life-cycles, and tighter integration with back-end cloud systems are being developed. Leveraging high performance processors, AI/ML, vehicle networking technologies like 5G and vehicle-to-everything (V2X) communication are key enablers [6].

Adopting processes, tools, and agile practices from the IT industry adapted for automotive quality and safety demands is critical. At the same time, major infrastructure changes are being made to create a digital vehicle platform that integrates artificial intelligence or machine learning technologies.

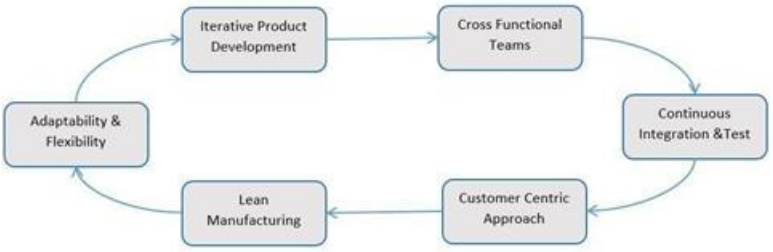

Fig. 1. Elements of Agile Methodology In Automotive Industry

The above Fig-1 illustrates main bricks of agile methodology applied to automotive industry.

Adaptability & Flexibility – fast response on changes. Iterative Product Development – product is permanently developed by loops. Cross-Functional Teams – wider and better link between work-packages is provided via multidisciplinary knowledge; Continuous Integration & Testing – component validation will be done as frequent as possible. Customer-Centric Approach – customer has a real impact on development; Lean Manufacturing – waste reduction.

III. Overview Of Agile Frameworks In The Automotive Industry

In the automotive industry, the latest trends in Agile practices are being analyzed through a comprehensive study and the survey of topics like operational agility, software development principles, security practices, defect reduction frameworks, and the adoption of agile methodology with software product lines.

Scaling Agility Beyond Software Teams in Automotive

Automotive OEMS such as Toyota, Volkswagen, Ford, General Motors and BMW are looking to extend operational agility from a single software team to the entire vehicle development life cycle. In this report it highlights how Automotive OEMS' , and in particular what they believe are the essential characteristics of their suppliers level of agility. This includes team autonomy, active collaboration with customers towards meeting ambiguous requirements, and supplier's effectiveness in collaborating with suppliers. It presents some strategies that Automotive OEMs have adopted or plan to adopt in order to increase its suppliers level of agility- for example collaborative teams, increased software integration between the OEM and supplier organization by function ,increased technical training. However changing teams and processes has an even greater impact also on relationship with customers. The best models presented provide guidance to leaders who want measure agility when many types of changes have been made.

Agile Principles in Automotive Software Development

Focus on principles like "continuous integration" and "continuous collaboration." The goal is to develop the V system of automotive software development. Supports long- term problem solving, including expansion, change, chaos, and uncertainty. The main idea is to follow the V model appropriate to the application when using the agile core process. It advocates addressing long-term challenges such as growth, change, lack of coordination, and uncertainty. The main idea involves using key practices while following the V-model and at the same time supporting their thinking through business analysis, experiments and research information.

Security Practices in Agile Software Development for SMES

Specifically, we try in this research for small and medium-sized businesses (SMES) to identify ways and methods that make security built-in into agile software development processes. The authors provide strategies and practices which are proved by many researchers and that have been maintained integrated into the small medium-sized enterprises context. They also proposed new ideas to enforce the building block of security measures in agile processes based on relevant security standards such as OWASP (Open Web Application Security Project). However, there is no practical application or empirical validation for these results.

AUTILE Framework for Reducing Automotive Software Defects

The AUTILE (AUTOSAR-Driven Agile Development) framework [10] proposed a new way of software development for automotive, trying to minor the number and the severity of defects. The proposal intended to reuse agile practices like Scrum for software development; and AUTOSAR standard [11] for modular architecture design. Three Phases were described (initialization, planning, and execution), with statistically significant defect reduction when AUTILE was adopted in a top automotive supplier with respect to baseline traditional practices.

Combining Agile and Software Product Lines in Automotive

The aim of this research was to identify the challenges and recommendations of adopting SPL (Software Product Lines) with ASD in the automobile domain. The authors have applied action research using interview study and systematic literature review. An initial set of 86 obstacles for the ASD/SPL combination model were identified in this paper as a road map for scaling agility risks in industry. The authors plan to investigate how far we can combine Agile System Development (ASD) with an existing automotive Software Product Line development, using our evaluation approach, the ASPLA-approach, based on our results obtained through this work.

IV. Agile Frameworks Utilized In The Automotive Industry

In the automotive industry, the latest trends in Agile practices are being analyzed through a comprehensive study and the survey of topics like operational agility, software development principles, security practices, defect reduction frameworks, and the adoption of agile methodology with software product lines.

Scaled Agile Frameworks

The Scaled Agile Framework (SAFe) is a viable way for the vehicle manufacturing industry to get the floor to the agile approach and to carry out the process development processes in the vehicle development life cycle, such as hardware, software, or mechanical components. This is about the reinforcement of the principle that vehicles at the system level use agile feedback loops with the help of continuous integration, automated testing, and the cooperation of all teams for task prioritization. Besides, it is based on combining ASD and SPL practices to generate a seamless and effective process. Meanwhile the implementation of better practices in the industry becomes the merging of formulation, design methodologies, and component selection and co-design as a fundamental part. Consequently, agile disciplines are swallowed up by plan-based and hybrid ones. The scenario is that all of the parts are compatible with one another. The reference model composes it as an executable strategic vehicle as leading the modeling of plan-based, agile, and hybrid frameworks across the automotive value chain. The main goal of the approach is to justify the teams to improve their communication skills and bring out the mobile automotive product faster in many qualities. The paradigm is based on the establishment of motivational and educational systems for continuous improvement and innovation that would help in creating a learning organization.

Agile-V Model Hybrid

The Agile-V-Model Hybrid model blends agile principles with the traditional V-model framework. This new model helps develop a more relaxed approach to software development, with the emphasis on incremental development, continuous collaboration, and prototyping. Using agile practices, teams are able to react to developing demands more efficiently and at the same time maintain a structured process [8].

Progressive software development takes place within the modules on which agile sprints are aligned with the different levels of the V-model in this combined model. Each sprint paves the way for teams to focus on certain functionalities; they can then develop, test, and validate components throughout short duration cycles. This shift is to come up with prototypes to involve clients in not only validation but also early integration of ideas and features [8].

Combining these methodologies, the Agile-V-Model Hybrid model not only empowers a balance between flexibility and structure, it also improves project outcomes that sync with user needs to a great extent.

Scrum-based Agile Practices

Testing powered by Scrum, having the Scrum way of work going on there is a must; The most important elements are sprint, daily scrum, review and retrospective. This is just a good way of delivering high quality software to the end user. It also makes it possible for big projects to be divided into little iterations. That is why companies write so little code so that the customer could check if they have never been off track. Thanks to working in such a team as one with sprint long projects all people realize much better what is to be done first or what comes next etc.. In this effect the technical debt of the feature or the epic task gets easier to notice in the source code rather than in some abstract place. Thus focus on the sense of heroism achieved during

implementation.

For companies in the automobile industry, compliance with a custom process assessment model that is in line with the industry standards can be highly beneficial for bigger SPL software projects. This is the reason why adoption of Agile methods in the software product line (SPL) development life-cycle among automotive software companies is required. And this is achieved by adapting to a process that involves providing a personal assessment process that the company's software practices aim to follow. A company must go through a trough process to adopt new software tools, compare their processes to theirs, work on changing and at the end of the process get verification from the external party about changes which have been made before starting.

As fourth, Scaled Agile Framework (SAFe) can be a great tool for automotive. I emphasize tools and here is the first part of the answer why. It's a multi-tool concept. You need multiple tools or constructs to reduce scaling as seriously intended complexity. Few examples are architecture grains, iterative and incremental development, ticket systems etc. Imagine SAFe principles not being used and Scrum still being implemented in automotive companies – Product Development Rate or Customer Satisfaction.

DevOps and Continuous Practices

These practices henceforth would be the chief subject of the deployment and operations processes, in particular the use of just in time automation, virtual prototyping, and continuous integration. Applied to every interaction, continuous integration is a technique that requires coders and developers to merge their working code into a single stable, secure, and middleware code segment deployed in an agile and flexible way. Actually, it has been proven time and time again that developers who regularly run several tests are the ones who manage to spot most of the potential problems with their code. Consequently, there is always a chance that the software they produce will have an adverse effect. The capability to run a test automatically and through frequent iteration, like in the case of every code update or modification, is not less important. Of paramount importance, apart from the aforementioned, the team members can bang heads together to provide

Security and Quality Practices

It is essential to utilize the security practices of the OWASP framework for secure software development in agile methods particularly in small and medium size enterprises. OWASP practices help to identify and resolve security threats that may arise at early phases. This creates secure applications however it also can be used as a tool for reducing error omissions in software development by integrating AUTOSAR standards into the agile method. The AUTOSAR framework aims to improve the quality of the vehicle electrical and electronic architecture, but unlike OWASP it focuses more on the working aspect between teams and continually training their leaders, as well as how far they have come with regards to quality. To this end, organizations could integrate team-work exercises, and provide mentoring to leaders so that developing quality becomes a part of their culture which would facilitate effective development. In short, this kind of method makes it possible to achieve better security while also improving team dynamic particularly through leadership participation.

Hybrid Approach

The Agile practices offer a very fast way to match changing needs and also get feedback from the customer, while traditional procedures make sure that safety standards are met. Through this combination, companies can cultivate safer and more efficient projects in the automotive field.

Besides that, it is of utmost importance to cover agile methodologies for the particular requirements and nature of different automotive projects, along with the organizations. To be able to do that, the projects can resort to such practices as the use of various methods to scale agile, mixing agile and plan-driven models, or applying dedicated technologies such as Scrum and DevOps. The hybrid method is a way to enable the flexibility of the agile method while maintaining the strictness of automotive standards in the industry. In this manner, hybrid teams will be able to operate in a more complementary way and synchronously develop their procedures with the partners; by doing so, they will be able to achieve the safety and quality of all the project components.

V. Comparison Of Agile Frameworks In The Automotive Industry

This analysis is to introduce the comparison of different Agile methodologies from the four views. Table 1 gives an overall to compare some Agile methodologies in term of these characteristics.

Table 1 Comparison Of Agile Frameworks In The Automotive Industry

Agile Framework	Aspects			
	Scalability	Flexibility and Adaptability	Customer and Stakeholder Engagement	Implementation Complexity
Scaled Agile Framework (SAFe)	High: Designed for large-scale implementation across entire value chains.	High: Adapts well to changing requirements with iterative feedback loops.	Effective: Emphasizes regular feedback and collaboration across teams.	High: Requires significant adjustments to existing processes and training.
Agile-V Model Hybrid	Moderate: Suitable for projects requiring integration of Agile and V-model elements	Moderate: Provides flexibility within the constraints of the V-model	Moderate: Engages stakeholders through iterative cycles but maintains structured approach.	Moderate: Involves complexity due to combining two different models.
Scrum-based Agile Practices	Moderate: Effective for medium-sized projects with iterative needs.	High: Offers significant flexibility with iterative sprints and continuous feedback.	Excellent: Involves customers actively through regular reviews and feedback sessions.	Low to Moderate: Relatively straightforward to implement with a focus on sprints.
DevOps and Continuous Practices	High: Supports extensive automation and integration in large environments.	High: Promotes flexibility through continuous integration and deployment.	Excellent: Ensures ongoing stakeholder involvement through continuous integration and testing.	Moderate: Involves setting up continuous integration tools and practices.
Security and Quality Practices	Moderate: Applicable to projects of varying sizes, with a focus on specific security aspects.	Moderate: Focuses on specific areas like security, with some flexibility.	Moderate: Engages stakeholders primarily through security and quality checkpoints.	Moderate: Requires integration of security practices into Agile processes.
Hybrid Approach	High: Allows for scalability through combined Agile and traditional methods.	High: Balances flexibility of Agile with the rigor of traditional methods.	Good: Ensures stakeholder feedback is integrated while maintaining compliance with standards.	High: Involves complex integration of multiple methodologies and practices.

VI. Benefits And Limitations

Different Agile frameworks feature special advantages and disadvantages. To illustrate, where SAFe is the best for the large scale and being responsive to changes, it also needs many changes and heavy training which may be difficult.

The breakthrough Agile-V Model Hybrid combines the blue print of the V model and Agile flexibility; though the obtuseness of the structure and moderate flexibility will consequently affect the effort. Scrum is more flexible, with the possibility of co-creation with excellent customer participation in iterations (sprints), however, in case of large scale there may be some problems.

DevOps is all about automation and continuous feedback, however, it has very much complicated installation processes and potential overheads. Security and Quality practices can help the organizations to integrate security measures as well as external quality activities into technologies that are used in production projects but restrict flexibility due to constraints imposed by the related controls activities.

The hybrid method combines the advantages of the Agile methodology with those of the traditional one for scalability purposes and adaptability but they interfere because of the increase in difficulties resulting from both of them. These implementations mostly take the form of a selection process in terms of the required frameworks and organizational context regarding technology and project needs.analysis is to introduce the comparison of different Agile methodologies from the four views.

Table 1 gives an overall to compare some Agile methodologies in term of these characteristics. We should notice that each kind of Agile will have different opinions about how we can use Agile generally for project and which agile methodologies are most appropriate for each depending on organizational level.

VII. Conclusion

The Agile methodologies have been applied in the automotive industry to deal with the digitalization changes that autonomous driving, connectivity and electrification trends are imposing. This work surveys some of these Agile practices (SAFe, Agile-V Model Hybrid, Scrum based methods, DevOps, Security and Quality Practices) and their effects for automotive software development. The report also shows how Agile practices have been integrated with product lines, addressing security concerns and working on advanced digital platforms. The work points out the benefits and challenges of each Agile approach. The results indicate that Agile methodologies are indeed instrumental in dealing with complexity, increasing flexibility and optimizing stakeholder's involvement in the context of automotive software development. At the same time, however, those methodologies pose difficulties resulting from their high

References

[1] Anjum, S.K., & Wolff, C. (2021). Agile Principles In Automotive Software Development: Analysis Of Potential Levers. Presented At The Ieee Conference, Isbn: 978-1-6654-1978-9.

[2] Valdés-Rodríguez, Y., Hochstetter-Diez, J., Diéguez-Rebolledo, M., Bustamante-Mora, A., & Cadena-Martínez, R. (2024). Analysis Of Strategies For The Integration Of Security Practices In Agile Software Development: A Sustainable Sme Approach. Ieee Access, Doi: 10.1109/Access.2024.3372385.

[3] Khan, A.M., & Blackburn, T.D. (2021). Autile Framework: An Autosar Driven Agile Development Methodology To Reduce Automotive Software Defects. Ieee Systems Journal, 15(3).

[4] Traub, M., Vögel, H-J., Sax, E., Streichert, T., & Härri, J. (2018). Digitalization In Automotive And Industrial Systems. Isbn: 978-3- 9819263-0-9. Presented At Date18, Published By Edaa.

[5] Hohl, P., Stupperich, M., Münch, J., & Schneider, K. (2018). Combining Agile Development And Software Product Lines In Automotive: Challenges And Recommendations. Presented At The 2018 Ieee International Conference On Engineering, Technology, And Innovation (Ice/Itmc), Isbn: 978-1-5386-1469-3y.

[6] Traub, M., Maier, A., & Barbehön, K.L. (2017). Future Automotive Architecture And The Impact Of It Trends. Ieee, 0740-7459/17.

[7] Gren, L., & Shepperd, M. (2022). Problem Reports And Team Maturity In Agile Automotive Software Development. Presented At The Acm/Ieee 15th International Conference On Cooperative And Human Aspects Of Software Engineering, Acm Isbn 978-1-4503- 9342-3/22/05

[8] Takahira, R.Y., Laraia, L.R., Dias, F.A., Yu, A.S., Nascimento, P.T.S., & Camargo Jr., A.S. (2014). Scrum And Embedded Software Development For The Automotive Industry. Ieee, 978-1-890843-29- 8/14

[9] Schmidtner, M., Timinger, H., Blust, M., Doering, C., & Hilpoltsteiner, D. (2020). Towards An Adaptive Reference Model For Agile And Hybrid Frameworks In Automotive Development. Presented At The 2020 Ieee International Conference On Engineering, Technology And Innovation, Ieee, Isbn: 978-1-7281-7037-4.