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MANAGEMENT PROCESSES AT SOFTWARE LEVEL TO ENHANCE INTELLIGENT VEHICLES ERGONOMICS

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Abstract: *The software development process is at the heart of intelligent vehicles (connected and autonomous vehicles), and it must be managed with diligence. The development of automaticity and connectivity is carried out through functional safety and, respectively, cybersecurity development processes, guided by standards that describe procedures, best practices, hazards, threats, and management strategies. By improving the software development process, the ergonomics of the intelligent vehicles will be increased. This paper presents the way on how to manage the process of achieving automaticity and connectivity through software development and if the COVID-19 pandemic could altered the management team strategy and software development process.*
Key words: *Safety, Cybersecurity, Development Process, Vehicle Ergonomics.*

1. INTRODUCTION

An intelligent vehicle is a vehicle capable of acquiring information from its surroundings and processing it in such a manner that it could move safely by itself, without causing any harm. Additionally, it could communicate in a secure way with other intelligent vehicles or devices.

From the automakers market comes a great desire for fully autonomous, connected, electric vehicles and car sharing. There are also big programs sustained by European Commission, like GEAR 2030 [1], Vision Zero [2], or Horizon Europe 2021-2027 [3]. The same desire comes from the USA, where the US administration give incentives for the electric and autonomous vehicles [4]. Also, China, and all the big powers in the world are following this trend. This desire for more and more innovative technologies within vehicles comes with big challenges; the increase in software development attracts more risks related to safety and security [5].

It became very obvious for all automakers that the automotive industry's new trend is Software-Defined Vehicles. This means that the amount and worth of software (along with electronic hardware) in a vehicle outweighs mechanics. Additionally, cars are moving from being electro-mechanical machines to intelligent machines. In the future, automakers are focusing on bringing cloud computing to the vehicles. This reinforces the concept of utilizing more modern technology, which should comply with far tighter standards than the existing ones.

The E / E components shape the whole intelligence of automated and connected vehicles. In the automotive industry, most of the electrical / electronic (E / E) component manufacturers and developers comply with standards that, by following them, will ensure a high level of safety and security, and after the vehicle integration process, humans will use improved vehicles and ergonomic vehicles. These E / E components could be described as automotive embedded systems that are designed to sense by getting data and actuate after processing the data. The data are usually coming directly from the environment (in real time) and other systems that are interconnected with it. Frequently, on these systems, specific automotive embedded software written by software engineers (or developers) or generated through other software tools is run; the programming languages used by software developers are C or C++ or both combined.

The standards followed to create such components are part of ISO [6], SAE [7], ASPICE [8], IEC [9], MISRA [10], AIAG [11], etc. The most used standards for the software development process are:

- ISO 26262, which describes the whole process of creating a highly safe E / E component. This functional safety standard is designed to cover all the aspects of developing an E / E component from scratch, including the electrical and software parts, from the requirements quotations to the maintenance;
- ISO / SAE 21434, which describes how to ensure security on E / E components. The goal of the cybersecurity standard is to cover all the stages of producing an E/E component, from the requirements quotes to the maintenance, from the outset;
- ASPICE, which describes a framework used to assess the process and best practices to follow for developing an E / E component with a high quality standard;
- The MISRA Consortium has created a set of software development rules called MISRA C and MISRA C++ for the C and, respectively, C++ programming language.

Functional safety and cybersecurity standards can be applied in product development for the passenger cars, motorcycles, and trailers, semitrailers, buses, and trucks (T&B). The mopeds are not included.

In the automotive industry, the very top of the supply chain, like the Original Equipment Manufacturer (OEM) or Tier 1, want to comply to the functional safety and cybersecurity standards in, but combined with the ASPICE at the software level for the product development phase.

Related to the software development process, which is only a part of the whole development process of a component, software engineers usually work in teams, nested to groups or departments or, depending on the granularity of the company, groups that are nested into departments, further nested into one or more layers that are pure management.

Because the number of functions, respectively their accuracy, that will shape the intelligent vehicles will be increased, the software development process is needed to be managed strictly and measured. Each iteration of an E / E component is based on the older version, with few impactful functionalities so that the cost of producing it could be kept under control, namely reusability.

The objective of this research is to answer the following questions:

1. In what manner should the software development teams be managed so that they provide high quality work packages, used further in the software integration, system integration (E/E component), and ultimately vehicle integration so that this vehicle could have increased safety and security levels?
2. Did the COVID-19 pandemic affect the software development process of an E/E component of an intelligent vehicle?

To answer these questions, in the chapters 2, 3 and 4 is described the process of software development from the management's point of view, and chapter 5 describes how these processes should be integrated. In chapter 6 is described briefly what it means to be a manager in software development and how the COVID-19 pandemic could have affected the software integration process.

2. PROCESS TO ENSURE THE ASPICE

In Figure 1, a set of processes is shown, inspired from ASPICE. The dashed rectangle represents the processes that should by followed by the management team to obtain the best results in matter of quality.

2.1. Project Management

There are three main goals of managing projects: determining the project's needs and restrictions, as well as establishing and executing a plan to meet those criteria. If these goals are met, then:

- The purpose of the development will be specified;
- An assessment of the project's assets and restrictions to see whether the objectives can be met will be available;
- The tasks and assets required to perform the labor are evaluated and forecasted;

- A system is in place to keep track of how the project interacts with those outside of it, as well as with those inside it (or interfaces);
- The project's plan of action is created and managed;
- Project progress is tracked;
- Repetition of issues discovered is mitigated, and correction is conducted when the objectives of the project are not reached.

2.2. Risk Management

Risk management refers to project risks that could jeopardize the process. These risks should be continually identified, investigated, solved / mitigated, and monitored.

The achievement of the risk management activity will have as a result the following:

- First, it is necessary to establish the extent of the risk management to be carried out;
- Suitable risk management techniques are established and applied;
- Risks are assessed as may occur throughout product development; the most effective use of assets is prioritized;
- To decide the modifications that are made to the risk status and remedial actions, risk metrics are created, implemented, and evaluated;
- A suitable remedy is performed to rectify or prevent the effect of risk depending on its importance, likelihood and outcome or any other predetermined risk criteria.

2.3. Measurement

The goal of the measurement actions is to gather and analyze the information associated to the developed E / E component and the processes followed. This activity will enable efficient management and will prove quality.

- The measurement procedure is implemented with persistent company commitment;
- The measuring data demands of organizational and management activities are recognized;
- A relevant set of measurements, guided by the information demands are defined and/or produced;
- Identify and carry out measuring operations;
- The needed data are gathered, saved, processed, and the findings interpreted;
- Decisions are supported, and clear communication is provided by information products;
- Evaluation and communication to the division head of the measurement procedure and metrics.

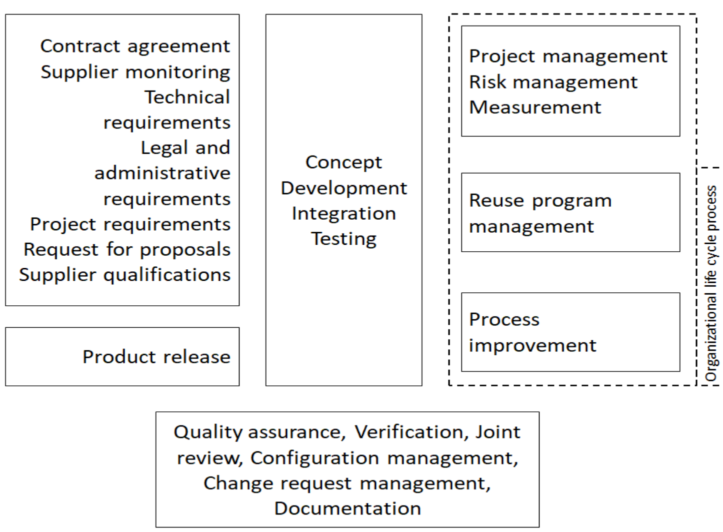

Fig. 1. Process reference model.

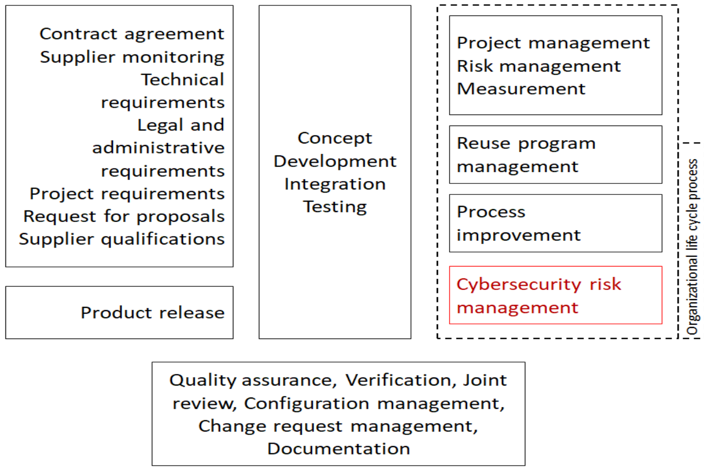

Fig. 2. Process reference model including cybersecurity.

2.4. Reuse Program Management

To take full use of a company's reuse initiatives, there should be personnel dedicated to this scope that should develop a method for doing so.

2.5. Process Improvement

An organization's processes may be improved by using the best practices analyzed and spread by specialized personnel.

3. PROCESS TO ENSURE SAFETY

The preponderance of the standards used to ensure the safety of the E / E components by the entire automotive industry lays in the International Organization for Standardization (ISO), SAE International, and the International Electro Technical Commission (IEC). The most widely used standard, which encompasses all of the general aspects of managing the safety-related E / E components is ISO 26262-2 [4].

The whole ISO 26262 standard is used to tackle systematic and random faults that cause the E / E components to fail. In further detail in this paper, the safety management is centered on the software level.

The companies that are developing the work packages that will be part of the E /E component lifecycle need to follow a bunch of objectives, like:

- Taking care of the whole safety culture that fosters and stimulates the effective achievement of functional safety and fosters information sharing with some other disciplines related to functional safety, like cybersecurity;
- Putting in place and keeping in place suitable policies and procedures for functional safety that are particular to the company;
- Setting up and keeping up procedures to make sure that safety faults are solved quickly and properly;
- Making sure that the people involved have the skills they need to do their job;
- Establishing and managing a quality assurance framework to guarantee functional safety.

Functional safety tasks must be planned and timed correctly if the project is to be carried out in several stages, such as the concept phase, development or testing phases.

One common blunder is to wait until agreements and supplier details have already been signed to define the actual consistency criteria for safety functions. Taking into consideration empirical evidence, if there is no strategy to manage the functional safety, failure is guaranteed. As a result, the necessity of planning functional safety should not be overlooked. It is possible that the strategy will be short and sweet.

Regarding the equipment that should be considered to be purchased, the administrative layers of the company, which is mostly concentrated in a project management team or just one person, are in charge of obtaining the necessary equipment for the product development teams based on the requirements obtained from the stakeholders. In addition, the management team/person will prove that the requirements are met.

Functional safety activities must be meticulously planned, managed, and tracked by safety managers; All stages of the product lifecycle are carried out by these management activities. In relation to functional safety, the product lifecycle includes, in addition to the concept phase and development of the product, the manufacture, deployment, maintenance, and disposal.

When the concept phase starts, development activities related to functional safety will start as well and will be rectified during all stages of development. With respect to manufacturing, deployment, maintenance, and disposal, activities will start throughout system level of product development.

It may help accomplish functional safety to acquire important cybersecurity relevant data, which can jeopardize the E / E components or contribute to achieving safe and reliable operations. The data will be used to monitor the activities, comprising issue reporting, debugging, and solving. Safety activities could be dependent on cybersecurity activities, so both should be planned at least at the same time. If not, the standards used, tool selection, or software development could be affected.

3.1. Safety Culture

As a generic statement, better employees are attracted, and more crucially, those employees are retained when a firm has a strong culture. This generic culture can be partitioned into lower level ones, like safety culture, cybersecurity culture. To create and maintain a safety culture, some factors are needed, like devotion, moral fiber, questioning mindset, proactivity, committed to professionalism, action and responsibility taking of the personnel required to accomplish or sustaining functional safety and the personnel conducting the activities.

Characteristics of a solid safety culture:

- Traceability of the decision-making responsibility, also traceability in all layers, like management, auditors, safety assessor, etc.;
- Prioritization of the safety with a higher importance;
- The company's incentive mechanism encourages and promotes the efficient attainment of functional safety, and those who take unnecessary risks that compromise safety or quality are sanctioned;
- Independent personnel to assess the process;
- Proactivity in finding issues in the first phases of project development and solving them as soon as possible;
- Qualified personnel possess knowledge and abilities required for the task at hand;
- Technical variety is pursued, appreciated, and incorporated into all activities, while activity that is antithetical to the use of variety is disheartened and sanctioned;
- Supportive interaction from the management side, promoting self-disclosure or by any other;
- Perpetual improvement.

3.2. Management's Work Packages

- Functional guidelines and procedures tailored to individual organizations;
- Managerial expertise proof;
- Quality assurance proof;
- Reports related to safety anomalies;
- Evaluation of the impact on the E / E component and the system that includes this component (vehicle or a function that comprehends more than one E / E component);
- Safety plan and case;
- Reports on verification measures;
- Report for the production start;
- Proof of effective management in all phases of manufacture, functioning, maintenance, and dismantlement.

4. PROCESS TO ENSURE SECURITY

The whole ISO / SAE 21434 standard tackles vulnerabilities caused by outer malicious intentions. In addition, the ISO / IEC 27001 standard should be used; it describes information security management.

Going back to Figure 1, another activity for the management should be added, as depicted in the following image, Figure 2.

The goal of ensuring security activity is to keep track of potential harm to various parties while also checking up on and supervising the various risk solutions. This activity succeeds if:

- Determining the size and purpose of the risk management effort to be undertaken;
- The development and implementation of effective risk management procedures;
- Inherent risks are discovered as they progress;
- Possible threats are selected first for projected harm and effect;
- Possible hazards are examined and risks are assessed;
- Alternatives to risk elimination or mitigation are identified;
- Threats are regularly assessed and determined for the latest updates;
- Remedial measures are taken with respect to the pertinent modifications.

5. PROCESSES INTEGRATION

Figure 3 depicts the product lifecycle form the software perspective (excluding the hardware and mechanics), including the concept phase, product development, and after starting the manufacturing. After the product is manufactured, it is integrated in the vehicle.

Functional safety and cybersecurity are affected by the software development process and the manufacturing and maintenance processes.

The software development process consists of specifying the requirements, designing the software components and the interaction between them, implementing and integrating them, verifying and validating (V&V), also configuring.

Figure 4 describes the integration of the processes defined by the standards of ASPICE, functional safety, and cybersecurity, which are also detailed in the previous chapters. System and software level development, also reuse program management, are part of the product design and development phases.

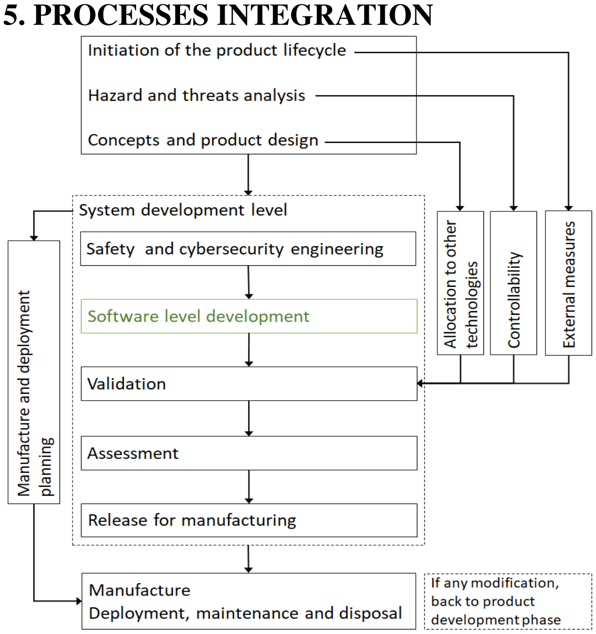

Fig. 3. Product lifecycle

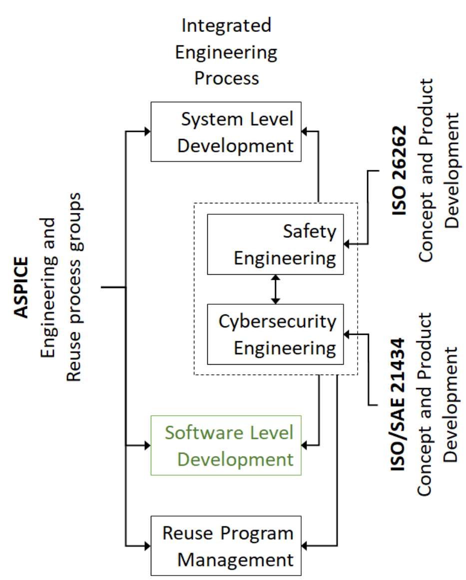

Fig. 4. ASPICE, ISO 26262, ISO 21434 integrated engineering process.

From the system level, system requirements, system architecture, and system test cases will be available at the software level. In this interaction between system and software levels, the management will ensure good communication between them, monitor the process, and further analyze and create reports.

The role of a team leader at the software level is describe in the next chapter.

6. SOFTWARE DEVELOPMENT MANAGEMENT

In the following research [13] is stated that a leader has the ability to influence others to accomplish things. Leadership is a partnership among a person with leading responsibility and his or her followers in which they work together to achieve mutually beneficial goals.

These days, the development process of the software level is done mostly by teams formed by embedded software engineers, led by a person who has the same technical background as his teammates – a team leader.

The team leader should must include collaboration, organization, and information exchange in order to forecast the team's performance and productivity [14].

The team leader's role in his team is mainly to serve as a facilitator, including:

- Communicate the systems, functional safety, and cybersecurity requirements, which are derived from the top level of the system design, the stage where the functions of the E / E component are designed and agreed with the customer (the car manufacturer) for the whole product lifecycle.
- Plan the activities that contribute to the development of a product function;
- Lead the software development activities, by consulting with both his team members and internal/external stakeholders, in such a way that the end of the planned due date is not exceeded, the quality of the work package respects the planned ones, and the team morale is at lead the same or increased;
- Collaborate with other team leaders and analyze the changes that could be made within the team to improve the efficiency of the delivery of the work packages;
- Collaborate with other team leaders or higher management to get support in case of some blocking point inside his team or to get knowledge that could help the team increase the working efficiency, offer support or knowledge to the other teams;
- Perform analysis of team needs, workload, burn-down charts, and create reports for higher management and team;
- Conduct one-on-one meetings whenever team members or internal stakeholders need them.

Research showed that if the team leader is managing the team remotely and not on site, the team members show greater satisfaction with the team itself and the team leader, and they are able to decipher communications from their leader [15]. Another study indicated that although the association between traditional leadership and productivity was reduced by WFH, the association between structural support and productivity was increased [16]. There are studies showing that when teams are coordinated remotely, coordination suffers but trust soars [17].

During the COVID-19 pandemic, new types of work became extremely used and popular among automotive companies: work-from-home (WFH) or teleworking [18] and hybrid work [19]. The pandemic created an unprecedented situation, affecting the entire strategy of creating an E/E component in the automotive industry, so in the last two years and for the next five, two main factors influence the management methodology that a team leader follows: the type of work, now considering WFH and hybrid types of work, and the new cybersecurity process (ISO 21434).

Including the COVID-19 pandemic in studies which show if the WFH increases the efficiency and productivity, new research from April 2022 [20], details that among software engineers, the productivity is not notable increased if we consider an average. Otherwise, the research shows that people perceive working from home differently, so they could be classified into two groups:

1. People who consider themselves more productive, who found a way to create an ergonomic working environment at home; and
2. People who consider themselves less productive. Most of them were productive when they worked on-site.

This classification forces the team leaders and the upper layers of management to adopt and adapt the hybrid working mode.

In the software development group from the product lifecycle, at this point, the presence on-site is not mandatory for the software engineers to perform their work. Most of the embedded systems that they work on could be accessed remotely; this means that these E/E components could be flashed, debugged, and tested remotely.

A study conducted on December 2021, within a Tier 1 company, confirmed the results from reference [20]. Due to confidentiality clauses, the company name and the questions cannot be disclosed for this paper, only the project activity, results and conclusion for the software integration process. Further, the company will be referred as Tier 1 company.

The purpose of this study is to find out if something was changed during the COVID-19 pandemic in the software development process.

The Tier 1 company develops an advanced driver-assistance system (ADAS), including mechanics, electronic, and software. With a focus only on the software development process, the following types of activity were done, and for each activity one or many teams were assigned:

A1: Teams and activities management; A2: Functional safety requirements implementation; A3: Cybersecurity requirements implementation; A4: Implementation of system requirements related to ADAS functions. Here, the activity is split into two teams for each decisional microcontroller on the electronic board: Aurix TC39x and nVidia Xavier; A5: Integration. This activity is split into three teams due to the project work load; A6: Build and configuration management; A7: Continuous integration (Jenkins configuration); A8: Service desk. This activity was split into four teams; A9: Testing. Here, there are many levels of testing; for each level of integration, a testing team is assigned, but for this study was not considered.

Note 1: The requirements to be implemented by the software engineers are defined at the system level by the system engineers.

Note 2: For each team, a team leader was assigned.

These teams are virtual teams spread all around Europe. The project manager manages the timeline for all of these activities; additionally he negotiates the resources (people and tools) and the work packages of each team.

The factors considered for this study were the work-life balance, team structure, team communication, overall leadership, cross-team collaboration, technology used, and the overall stress perceived. Most of the respondents gave positive responses to the questions; only those of the activities' groups A5 and A8 had many complaints, which also motivated their negative responses.

In Table 1, only the A1, A5, and A8 groups are shown. These groups also work very closely together. It was obvious to management that these two groups are stressed and poorly managed. The service desk is the front-line in the interaction with the automaker, which tends to put all the pressure on. The A5 group is the second line, where the issues reported by the automaker and filtered out by A1 are thoroughly analyzed, debugged, passed to other teams to be solved or solved internally, and reports are created. Besides software component integration, configuration, building processes, the A5 group is also checking if the software components comply with the versions required by the automaker of the standards described in this paper.

Table 1

Results for A1, A5 and A8 groups

	A1	**A5**			**A8**			
Country	RS	RS	RO	AT	CN	RS	RO	AT
Work-life balance	G	B	B	G	B	B	B	B
Team structure	G	B	B	G	B	G	G	G
Team comm.	B	B	G	G	B	B	G	G
Overall leadership	G	B	B	B	B	B	B	B
Cross-team collab.	G	B	G	G	B	G	G	G
Technology used	G	B	B	B	G	G	G	G
Stress level	B	B	B	B	B	B	B	B

Notes: ISO 2-Letter abbreviation is used for the country names (e.g., RO stands for Romania). G represents good and B represents bad.

The A5 teams are following the documentation and the implementation described in detail.

The conclusions of the company's leaders for the integration teams were:

- Integration teams should more assist the service desk teams more; the communication between these teams and others will be possible only through the leader, who absorbs the intensity and manages the time, also reporting to the project manager only for overview;

- The integration teams should transform into self-managed teams;
- The team leaders of the integration teams will be chosen considering the individual proactivity and empathy for his team members; they will be trained for time management, so they could perform a better empathy / time constraints tradeoff;
- The integration teams should assist other integration teams in case of work-load imbalances; the communication between them will be facilitated by the team leaders;
- The team leaders can now give feedback to the upper management, to create room for improvement;
- Team leaders will measure more factors that influence the productivity;
- The team members will have two hours per week to share feedback, knowledge, new tools that could be used, even personal stories; Regarding tools, the technology used by the engineers seems to be very important;
- The team members will meet in person based on the location or at request they will have business trips;
- The team leader will initiate a celebration in case of a major achievement;

7. CONCLUSION

A healthy culture inside the companies which participates in developing an E / E component will conduct to a better product iteration by iteration, and this will increase the vehicles ergonomics.

In modern intelligent vehicles, software plays the biggest role, so software engineers are the main actors' contributing to technology progress. Due to this progress, vehicles will perform better maneuvers and better communication, but this comes with challenges such as ensuring security and safety. To increase even more technological progress, all automakers, OEMs, and Tier 1 companies created consortiums to share technologies and have in common processes, standards, frameworks, architectures, but the most impactful processes on how to manage the software development related to technical matter are functional safety (ISO 26262), cybersecurity engineering (ISO 21434), and ASPICE. The leaders should take care of the following: Project management; Risk management; Measurements; Reuse program management; Process improvements.

Regarding organizational matter, besides tailoring the development processes according to the standards and stakeholders requirements, management should measure several factors that influence the team members soft skills so that they could tailor and promote better cultures to engineers. The culture is usually spread by upper management to team leaders. The team leaders are tweaking the factors that influence the culture because they have direct access to their team members and resources.

Future research will take into consideration the previous developments related to the automated business process management using Machine Learning or Artificial Intelligence presented by [21, 22]. The research context will be extended considering the university – industry collaborations consulting contracts framework, because of the mutual advantages identified [23].

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Procese de management la nivel de software pentru a îmbunătăți ergonomia vehiculelor inteligente

Procesul de dezvoltare a produselor software se află la baza vehiculelor inteligente (vehicule conectate și autonome) și trebuie să fie gestionat cu diligență. Dezvoltarea automatismului și a conectivității se realizează prin intermediul proceselor de dezvoltare a siguranței funcționale și, respectiv, a securității cibernetice, ghidate de standarde care descriu procedurile, cele mai bune practici, pericolele, amenințările și strategiile de gestionare. Prin îmbunătățirea procesului de dezvoltare a software-ului, ergonomia vehiculelor inteligente va fi sporită. Această lucrare prezintă modul de gestionare a procesului de obținere a automaticii și a conectivității prin dezvoltarea de software și dacă pandemia COVID-19 ar putea modifica strategia echipei de management și procesul de dezvoltare de software.

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