MINISTRY OF EDUCATION AND RESEARCH

National University of Science and Technology POLYTECHNICA Bucharest

Doctoral School of Industrial Engineering and Robotics

PhD program in Engineering Sciences

Doctoral field Engineering and Management

Author: BOGORIN (BOGORIN - PREDESCU) L. Adrian

THESIS SUMMARY:

Integrated Quality Management System for the Information Communication Process in the Automotive Industry

Scientific coordinator,
Prof. univ. dr. ing. Aurel Mihail ȚÎȚU

2025

Contents of the summary and doctoral thesis

FOREWORD

This doctoral thesis, entitled "*Integrated quality management system for the information communication process in the automotive industry*", represents the result of a long journey of learning, research and personal development. The work was born from the desire to contribute, through my own perspective, to the improvement of communication and quality management processes in the field of embedded systems and in the automotive industry — complex fields, constantly evolving.

The intellectual property rights over this doctoral thesis belong equally to the doctoral student and the doctoral supervisor.

The completion of this research would not have been possible without the support and careful guidance provided by my doctoral supervisor, Prof. univ. dr. ing. dr. ec. Dr. Habil. Dr. h. c. Aurel Mihail ȚÎȚU. I express my profound gratitude for the trust given, for the patience and availability shown throughout the entire development process, as well as for the valuable advice that guided each stage of this scientific endeavor. Academic expertise, methodological rigor and openness to dialogue have been fundamental landmarks in the development of this work, contributing to the clarification of theoretical and applied aspects and to the formation of a rigorous and innovative approach, indispensable for achieving the research objectives.

I would also like to express my special thanks to the members of the Academic Guidance and Integrity Committee for their time, useful observations and recommendations that contributed to improving the content and clarity of the doctoral thesis.

I would like to thank the doctoral committee for publicly supporting the thesis and for the rigorous evaluation, pertinent observations and constructive recommendations that contributed to confirming the scientific quality of this doctoral thesis.

I express my deep appreciation to my colleagues at AUMOVIO for their constant support, patience and understanding during this stage. The openness and spirit of collaboration that you have shown have contributed significantly to overcoming the difficulties and maintaining the balance necessary to complete this thesis.

I express my gratitude to the team of inventors for their essential contributions, expertise and collaboration that substantiated the realization of the prototypes and transformed challenges into opportunities for innovation.

My deepest gratitude goes to my family for their unconditional support throughout the entire period of carrying out this research. Their understanding, patience and constant encouragement were essential for overcoming the challenges and maintaining the balance necessary to complete this endeavor. I thank you for the sacrifices made, for the time and resources invested, as well as for the trust given in difficult moments. In particular, I would like to thank my wife, Oana, for her moral and emotional support, for the patience and understanding she showed during demanding periods. Her presence and constant support represented a pillar of stability and motivation, without which this achievement would not have been possible.

Eng. Adrian BOGORIN (BOGORIN - PREDESCU)

INTRODUCTION

The accelerated digital transformation of the automotive industry has shifted the concept of quality from a narrow focus on compliance to an integrated framework where knowledge management, intellectual property protection, standardization, and communication processes between embedded systems and high-level applications are mutually interdependent. Within this context, the present thesis proposes and validates an integrated quality management system for communication processes, with a dual purpose: enhancing the technical and functional robustness of mechatronic products and reducing prototyping time through a coherent set of methods, tools, and standards that span the entire product lifecycle—from concept and patenting to prototyping and validation.

The conceptual and practical structure of the thesis follows a logical sequence of chapters that interweave critical literature analysis, methodological framework, original contributions, and experimental validations, providing a comprehensive view of the trajectory from problem identification to solution design and its impact on the quality of communication in embedded automotive systems.

Chapter One establishes the current state of knowledge in automotive quality management, starting from organizational models based on knowledge and learning, and continuing with established methodologies (TQM, Six Sigma/DMAIC, Kaizen), emphasizing how these approaches support traceability, reduce variability, and ensure convergence between technological and informational processes.

Chapter Two extends the analysis to the relationship between intellectual property management and the implementation of a quality management system in automotive. It highlights how protecting research outputs (patents, know-how, trademarks) strengthens competitive advantage, while quality assurance requirements impose rigorous mechanisms for documentation, traceability, and change control—essential for leveraging innovation legally and economically. The chapter also provides an overview of recent trends in innovation at European and global levels, arguing that a well-governed and audited communication system is itself a strategic asset, reducing compliance risks, facilitating technology transfer, and accelerating the path from idea to market.

Chapter Three moves from principles to norms, mapping relevant standards that structure communication processes across layers: from the OSI model and AUTOSAR architecture (RTE/COM/PDUR/CanTP/CanIf, etc.) to vehicular protocols and physical interfaces (CAN, LIN, FlexRay, Ethernet, UART, SPI, I²C, BLE), as well as diagnostic services (UDS/ISO 14229). This section clarifies OSI–AUTOSAR correspondences, illustrates fragmentation and reassembly mechanisms (ISO TP), and examines integrity, security, and interoperability requirements, offering a coherent reference framework for designing a unified communication solution capable of ensuring portability across microcontrollers, compilers, and buses.

Chapter Four introduces bibliometric analysis, using quantitative tools to position the thesis topic within the scientific landscape: dynamics of themes such as "quality management," "communication protocol," and "firmware platform," co-citation network density, leading countries/institutions/authors, and key journals. This approach serves a dual role: validating the relevance of the topic (through volume, impact, and trends) and providing an objective map that guided method selection and contribution focus, ensuring the proposed platform addresses real needs of the scientific and industrial community.

Chapter Five transitions from scientific and normative analysis to the applied core of the thesis, preparing the ground for defining requirements and solution architecture. Here, theoretical conclusions are consolidated into a coherent list of needs: 8-byte messages compatible with classic CAN, a robust request–response mechanism inspired by UDS (with positive/negative feedback), explicit commands for testing and parameterization, internal variable traceability, and constraints related to portability, security, and non-intrusiveness regarding ECU operation. This requirement-oriented crystallization sets the stage for the methodology and hardware–software platform presented in subsequent chapters.

Chapter Six specifies the main objective, specific objectives, and research methodology. The general objective is the development and validation of an integrated platform—BIOComProP—combining ECU firmware, PC-based test software, and a dedicated communication protocol to ensure quality, security, traceability, and portability of communication processes throughout the R&D chain. The adopted methodology is iterative and incremental, anchored in the V-model, with strict traceability between requirements, design, implementation, and validation, reinforced by mind maps for deliverable planning and bibliometric analyses for direction calibration. Specific objectives include defining the 8-byte protocol, implementing security mechanisms (password, SEED–KEY, anti-brute-force policies), designing a configurable and portable firmware architecture, developing testing and parameterization tools, creating a unified R&D workspace, and integrating an embedded testing system for ECUs.

Chapter Seven details contributions related to identifying and implementing communication standards applicable to communication processes. It designs and implements the 8-byte message protocol (with request/response, service codes, positive/negative confirmations), defines the command map for digital/analog ports, EEPROM access, and internal variables, and models data frame processing in the ECU alongside security mechanisms. The chapter demonstrates how this communication stack, designed for portability, maps onto UART/CAN/BLE/USB/TCP interfaces and orchestrates interoperability with the testing application.

Chapter Eight introduces the architecture of the BIOComProP platform, both on the ECU side (BIOComProP_ECU) and on the PC-based testing and supervision side (BIOComProP_TS), under a common workspace that launches hardware projects (schematic/PCB), firmware projects, IP documents (patent applications), and software applications dedicated to prototypes. It describes graphical interfaces, microcontroller configuration (e.g., ESP32 via configuration files), hardware abstraction through MCAL, and watchdog integration for robustness. This stage also outlines IoT/edge workflows (environment sensors, BLE/TCP) to demonstrate the platform's scalability beyond a single application domain.

Chapter Nine positions the platform within the V-model methodology and uses it as an "operational skeleton" to unify the design, simulation, integration, and validation of an application. It presents hardware design tools (Proteus VSM simulations, verification during the design phase of HW/Mechanical disciplines), firmware flows (organization into periodic tasks, peripheral drivers, message processing), as well as automated testing tools from BIOComProP_TS (loading the test plan, PASS/FAIL verdict, exporting results). In this logic, each phase on the "left arm" of the V is reflected in a verification test on the "right arm," which reduces iterations, costs, and the risk of late hardware redesign, but above all increases coverage of communication testing scenarios.

Chapter Ten demonstrates the use of the platform both in the innovation environment (validation of prototypes related to patent applications) and in the automotive context. Two classes of applications are presented: a hydroelectric turbine with retractable blades—in which data acquisition (voltages, currents, frequency) is performed based on standardized request–response and cyclic packets, with graphical interfaces dedicated to the operator—and a chair for working at a PC with an active principle for relaxing the spine—in which the ECU controls multiple actuators, and the platform delivers both deterministic commands (lift/lower/stop for lift, seat, armrests) and cyclic telemetry, plus safety thresholds and tolerances based on current measurement through electronic shunts. For both, message response times, acquisition periodicity are quantified, and the entire data path (PC → ECU → PC) is exemplified, including data export and report generation, to show how communication quality becomes measurable and auditable.

Chapter Eleven recaps the conclusions, retains the original contributions, and opens future research directions. The conclusions emphasize that a unified platform for communications practically combines standards, methodology, and tools, increasing process resilience and shortening the path to successive prototyping; contributions concern the 8-byte communication protocol, security mechanisms, portable firmware architecture, testing tools, and the integrative workspace; future directions aim at extending toward OTA updates, integrating AI algorithms for automated testing, strengthening IoT/cloud capabilities, and applying the platform in related fields (collaborative robots, industrial equipment, medical devices). Overall, the thesis argues and experimentally shows that excellence in communication quality is not an epilogue of development but a "Day One" design requirement that must be modeled, codified, tested, and consistently governed.

Transversally, the selection and ordering of chapters reflect a deliberate intention to reconcile two traditions that rarely "speak" the same language: the tradition of quality management (with its tools for process stabilization and organizational learning) and the tradition of embedded systems engineering (with its requirements for determinism, safety, and portability). The theoretical foundation (Chapters 1–3) provides value criteria; bibliometric analysis (Chapter 4) shows where the topic stands in the global landscape; the transition to design (Chapters 5–6) transforms criteria into requirements, objectives, and method; technical contributions (Chapters 7–10) offer a functional ensemble tested on real prototypes; and conclusions (Chapter 11) generalize lessons, outline limits, and propose concrete steps for strengthening and scaling the solution. Through this architecture, the thesis does not offer only a point solution but proposes a "grammar" of communication quality—that is, a vocabulary of messages, roles, protocols, and verifications—that can be reused, extended, and adapted.

Beyond specific contributions, the added value of the approach lies in the way the BIOComProP platform and its associated methodology rethink current practices. The 8-byte communication messages and positive/negative feedback mechanisms simplify interoperability and test instrumentation; clear separation of concerns (MCAL, drivers, application) maximizes portability; the unified workspace reduces entropy in R&D processes and increases repeatability; and integration from requirements to automated testing creates space for auditing communication quality as a process, not just as a result. In this logic, “communication quality” ceases to be an emergent property and becomes an engineering construct, with parameters, limits, evidence, and reports, ready to support both certification rigor and the innovative ambitions of a learning organization.

The chapter organization is designed to meet different needs: practitioners can directly access Chapters 7–10 to adopt the protocol, architecture, and tools; decision-makers will find their benchmarks in Chapters 1–3 and 4; and methodological researchers can analyze Chapter 6 in detail to understand the research design and the way the V-model is customized for ECU–PC communications. All these perspectives converge toward the same conclusion: when approached integrative, quality management of communication processes becomes a value multiplier for smart manufacturing, information security, and rapid transfer of innovation into functional prototypes.

PART I. CURRENT STATE OF KNOWLEDGE IN THE FIELD OF QUALITY MANAGEMENT OF COMMUNICATION PROCESSES IN THE AUTOMOTIVE INDUSTRY

1. CURRENT STATE OF KNOWLEDGE IN THE FIELD OF QUALITY MANAGEMENT IN THE KNOWLEDGE-BASED ORGANIZATION IN THE AUTOMOTIVE INDUSTRY

1.1 Organization. Knowledge-based organization

1.1.1 Organization - concept and typology

Today, there is a wide variety of organizational systems, from simple family associations to complex corporations or companies. The organization is the only form of representation for these entities, which are named according to complexity:

- Family association;
- Firm;
- Enterprise;
- Company;
- Corporation;
- Concern.

...

Organizations are defined as social inventions that are created to achieve common goals through a collective effort. (Nicolescu, Plumb, Pricop, Vasilescu, & Verboncu, 2003).

An organization is a group of people who work together in a specific form of organization to achieve common goals and provide a product or service to a customer. (Oprean, Țîțu, & Bucur, Managementul global al organizației bazată pe cunoștințe, 2011).

...

1.1.2 Organization - the generalized model of the organization system

Any organization can be analyzed from a systemic perspective, which means that one can identify key elements of the system: input elements, state elements, and output elements.

...

Inputs go through a transformation process that is specific to each organization, then becoming state elements, which are regulated by specific mechanisms and laws to control the process. Typically, inputs represent the added value included in the product, which can be both tangible and intangible.

...

1.1.3 The knowledge-based organization. The learning organization. The innovative organization

The theory of the knowledge-based organization is based on the resource-based theory and the knowledge revolution. (Oprean, Țîțu, & Bucur, Managementul global al organizației bazată pe cunoștințe, 2011). The theory starts from the ideas that:

- organizational members acquire knowledge and store it if it is implicit knowledge;
- organizational members must specialize in acquiring and using certain knowledge due to cognitive limitations and time constraints;
- usually, different types of knowledge are used to produce.

...

1.1.4 Specific characteristics of the knowledge-based organization

Analyses conducted by specialists, as well as the realities of organizations operating in leading industries in the US, EU and Japan, reveal that the knowledge-based organization presents different characteristics from the organization that prevails in the current period.

...

1.1.5 Knowledge-based organization with activity in the automotive industry

The knowledge-based organization in the automotive industry is a modern concept that involves the management, use and dissemination of knowledge as a key resource for achieving a competitive advantage over the market. In the automotive industry, this is vital due to rapid technological progress, globalization and digitalization. Such an organization manages to effectively capitalize on the collective expertise of employees, systems and technologies to create better products, optimized processes and innovative solutions.

...

A knowledge-based organization is an entity that uses its intellectual and information resources as an essential means to promote innovation and development. In this framework, both tacit knowledge, which is based on experience and practice and intuition, and explicit knowledge that is documented and codified, become essential active components. In this context, cooperation between teams, optimization of information flows and continuous improvement of processes and products are decisive (von Krogh, Ichijo, & Nonaka, 2000). Organizations in the automotive industry focus on generating, collecting, disseminating and using knowledge to support strategic decisions.

...

Knowledge management in the automotive industry is based on the collection and use of data to streamline operations and avoid a decrease in quality or productivity (Ichijo & Nonaka, 2007).

...

1.2 Knowledge-based management with applicability in the automotive industry

...

Knowledge management is the managerial process that involves the creation, acquisition, storage and review, transfer, dissemination and communication, adaptation and application of knowledge, as well as its integration within the organization (Bratianu, 2015).

Other authors believe that knowledge-based management (KBM) involves the dissemination of knowledge and the optimal use of employee capital. This need arises in contexts where motivation, involvement and knowledge sharing are naturally integrated into the daily activities of the organization and manifest as practices inherent in the work environment (Țîțu & Oprean, Management of intangible assets in the context of knowledge based economy, 2015).

1.2.1 Management concept

...

Management is the art and science of achieving goals with the help of other people. It involves a series of actions and procedures that aim to improve the efficiency and effectiveness of an organization, while maximizing the optimal use of available resources. (Koontz & O'Donnell, 1955).

Management is the decision-making function that aims to ensure the effectiveness of all activities in an organization, in order to achieve maximum results through the optimal use of available resources. A leader must use various resources, such as human and financial, in his work, to capitalize on his own knowledge and skills, which he must administer taking into account the time factor. Management involves the efficient coordination of all operational aspects to achieve organizational objectives (Oprean, Țîțu, & Bucur, Managementul global al organizației bazată pe cunoștințe, 2011).

1.2.2 Management functions. Applicability within the knowledge-based organization with an object of activity in the automotive industry

...

Management functions are essential for the success of a knowledge-based automotive organization. These functions include strategic planning, which helps to establish long-term goals and identify the steps needed to achieve them. Organizing interdisciplinary teams allows for collaboration between specialists from various fields, thus maximizing innovation. Effective coordination between departments ensures fluid communication, minimizing delays. Innovative leadership stimulates employee creativity and adaptability, and strict process control guarantees quality and efficiency. All these elements are fundamental to remaining competitive in an extremely dynamic and technologically advanced market, ensuring efficient resource management and an optimal workflow between research, development and production.

1.2.3 Factors that can influence or drive knowledge-based management

Implementing a knowledge management (KM) system is essential in organizations, and various factors can stimulate and influence the adoption of this managerial approach.

....

Adopting effective knowledge management strategies can lead to significant competitive advantages. These strategies allow organizations to leverage their accumulated knowledge, which helps them achieve better results and improve overall performance.

1.2.4 A correlation between knowledge-based management and global management - the organization of the future with an object of activity in the automotive industry

The link between knowledge-based management (KBM) and global management in the automotive sector is increasingly critical as the industry evolves in response to technological advances and global market dynamics. Knowledge-based management serves as a strategic framework that enables organizations to leverage their intellectual assets to enhance innovation, efficiency, and competitiveness in a global context. This review explores how KBM can be effectively integrated into global automotive management practices, focusing on recent developments and challenges.

First, the automotive industry is undergoing a significant transformation driven by the adoption of Industry 4.0 technologies. These technologies require a robust knowledge management system that facilitates the collection, processing, and dissemination of information across global supply chains. For example, Stawiarska et al. highlight the importance of standardizing competency requirements and job titles within automotive organizations to foster effective collaboration among international partners (Stawiarska, Szwajca, Matusek, & Wolniak, 2021). This standardization is important for improving the maturity level of KBM practices, which can lead to improved operational efficiency and innovation capabilities.

...

1.3 Knowledge-based economy in the context of doctoral research topic

The notion of a knowledge-based economy describes a theoretical and applied model in which economic development is primarily driven by the use, creation, management and dissemination of information. This type of economy is based on the changes brought about by the digital age and globalization, highlighting the importance of innovation, education, technology and human resources. The knowledge-based economy (KBE) refers to an economy in which knowledge is the main resource for economic growth and value creation. Over time, traditional resources, such as natural resources or physical labor, have begun to be replaced by knowledge. In these circumstances, knowledge and information become essential to maintain economic competitiveness.

1.3.1 The concept of knowledge-based economy

According to David and Foray, KBE is distinguished by incorporating knowledge into economic and social processes, generating value through innovation and efficiency. The Organization for Economic Co-operation and Development describes KBE as an economy in which the creation, dissemination and use of knowledge play a key role in increasing productivity and economic competitiveness (David & Foray, 2001).

Kofi Annan gives another meaning to knowledge: "Knowledge is power. Information is liberation. Education is the premise of progress in every society, in every family".

...

The knowledge-based economy is characterized by the intensive use and growth of knowledge to foster innovation and competition. Education, technology, and human resources are fundamental to this economic system, and future success will be determined by the ability of countries and organizations to harness knowledge and stimulate innovation.

1.3.2 Principles of knowledge-based economics applied and commented on in the context of the doctoral research topic

The recognized expert in the field, Jerry Useem, has developed a series of rules regarding the knowledge-based economy.

...

Each of these statements reflects how the automotive industry and its integrated communication and quality management systems are evolving in a global and digitalized context.

1.3.3 Peculiarities of the knowledge-based economy from the perspective of the doctoral research topic

...

A SIMC for communication processes in the automotive industry must include the following components to be effective in the knowledge-based economy: advanced digital platforms that facilitate real-time information analysis, using big data and artificial intelligence, digital collaboration ecosystems designed to connect stakeholders for an optimal flow of information, secure communication infrastructures capable of processing significant amounts of information instantly and protecting confidential data through advanced IT security methods, and tools for simulation and digital testing that allow for the rapid detection of quality issues in the development phase, before critical production processes, and to improve production processes.

1.4 The current state of knowledge regarding knowledge management in the context of the doctoral research topic

1.4.1 Knowledge. Characteristics of knowledge

...

AI is increasingly recognized as a transformative force across sectors, profoundly influencing characteristics of knowledge such as accessibility, adaptability, and scalability. In recent years, the evolution of AI from conventional rule-based systems to advanced machine learning and deep learning methodologies has greatly enhanced its ability to process and analyze vast data sets, thereby enriching the knowledge available to organizations (Pană, Țîțu, Tertereanu, Moldoveanu, & Bogorin-Predescu, 2024). Also in the field of AI, management, and knowledge management, Stan et al. analyze the significant current trends influencing the IT project management industry starting with 2024. Their findings highlight the transformative impact of AI and machine learning technologies, which are revolutionizing traditional project management practices by incorporating predictive analytics that improve the decision-making capabilities of project managers and teams. This integration of AI tools allows organizations to analyze vast data sets quickly and accurately, thus facilitating more informed strategic choices in project planning and execution (Stan, Bogorin-Predescu, & Țîțu, 2024).

...

1.4.2 Typology of knowledge

The current notion of knowledge has its roots in the historical and philosophical research of Gilbert Ryle and Israel Scheffler. They divided knowledge into "procedural knowledge" and "conceptual knowledge", identifying two types of skills: "routine skills" and "critical skills", i.e. intelligent performance. The concept was later developed by Lundvall and Johnson, who defined knowledge from an economic perspective, highlighting four main categories, illustrated in Figure 1.7 (Lundvall, 2016):

- *Know-what* or factual knowledge **...** ;
- *Know-who* or relational knowledge **...** ;
- *Know-how* or practical skills **...** ;
- *Know-why* fundamental knowledge **...** This knowledge encompasses both relational knowledge and practical skills.

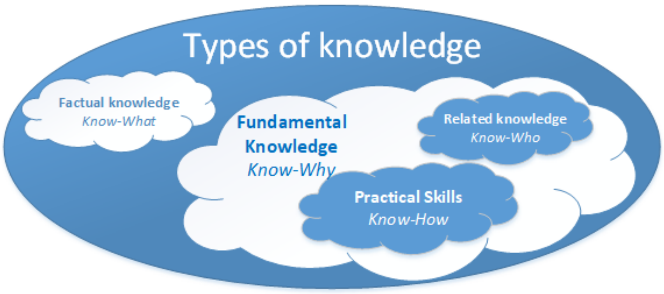

Fig. 1.7 Types of economically relevant knowledge (Personal contribution)

...

1.4.3 The place and role of knowledge within the innovation process with applicability within the doctoral research topic

...

Knowledge sharing is a fundamental component of innovation capacity in organizations. Effective knowledge management, which includes the acquisition, sharing, and application of knowledge, has been shown to significantly influence innovation outcomes and competitive advantage (Le & Lei, 2019) (Than, Nguyen, Tran, & Le, 2019). In the automotive industry, where electronic components are integral to product functionality, the ability to share knowledge across teams and departments can lead to improved creativity and problem-solving capabilities, ultimately driving innovation (Ologbo, Nor, & Okyere-Kwakye, 2015). For example, Nguyen et al. highlight the importance of transformational leadership and knowledge management in stimulating both radical and incremental innovations, suggesting that a collaborative culture enhances these processes (Nguyen, Shen, & Le, 2022).

...

1.4.4 Knowledge necessary to be used within an organization operating in the automotive industry

...

The knowledge required by organizations in the automotive industry, especially regarding electronic components, spans multiple domains, including mechatronics, quality assurance, knowledge management, and software development. As the industry continues to evolve with the integration of advanced technologies, the focus on acquiring and managing this knowledge will be critical to maintaining competitiveness and ensuring the safety and reliability of automotive products.

1.4.5 Knowledge management and its connection to the doctoral research topic

...

As the automotive industry continues to evolve, the integration of digital technologies and innovative practices will play a critical role in shaping the future of KM and SIMC. The adoption of edge computing and the Internet of Things (IoT) presents new opportunities for improving communication processes and improving the quality of automotive components. Using these technologies, automotive organizations can collect real-time data, monitor production processes, and facilitate knowledge sharing among stakeholders (Luciano & Saldanha, 2023). This integration of digital tools into KM and SIMC frameworks can lead to significant improvements in quality management practices and overall operational efficiency.

...

1.4.6 Knowledge transfer and connection to the doctoral research topic

Knowledge transfer is an important aspect of SIMC in the automotive industry, especially regarding electronic components. The automotive sector is characterized by its complexity and the need for high quality standards, which are essential to ensure safety, reliability, and customer satisfaction. Integrating knowledge transfer mechanisms into SIMC can significantly improve the communication processes involved in the production and management of automotive electronic components.

...

The application of Six Sigma methodologies in the automotive sector has been shown to significantly improve quality rates. The DMAIC (Define, Measure, Analyze, Improve, Control) framework in Figure 1.8 provides a structured approach to problem solving that facilitates knowledge transfer between teams (De Carvalho, Potra, & Vels, 2022). This systematic approach ensures that quality improvements are based on data-driven information, which improves communication and collaboration between stakeholders.

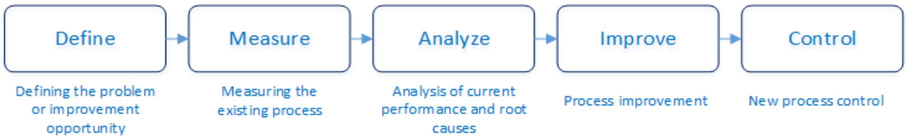

Fig. 1.8 DMAIC method (Personal processing)

...

The relationship between knowledge transfer and integrated quality management systems in the automotive electronics industry is complex and multifaceted. Effective communication processes are essential to ensure that quality management practices are understood and implemented at all levels of the organization.

...

1.5 Quality, quality management and the connection with the doctoral research topic

1.5.1 Quality. Quality management and correlation with the doctoral research topic

...

Quality management has a substantial impact on productivity in the automotive industry. Mismanagement of quality assurance and production can lead to negative outcomes, requiring an integrated approach that balances these two essential areas. The use of sophisticated tools and continuous improvement processes, such as Kaizen and other lean management approaches, reinforces the idea that quality is a continuous process that involves all levels of an organization.

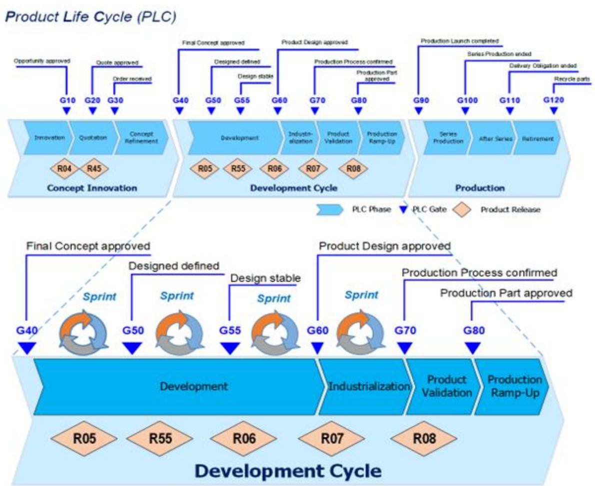

Fig. 1.9 Product Life Cycle (re-adaptation after (Bogorin-Predescu, Țîțu, & Țîțu, Product life cycle in automotive, 2023))

...

The automotive sector is managed by the major automobile manufacturers (MAM): Volkswagen, Ford, General Motors, Tesla, BYD and others. The life cycle, in Figure 1.9, of the product developed and produced by MAM, follows specific phases:

- Quotation;
- contract review;
- product design;
- product design validation with prototypes;
- industrialization;
- product and process validation;
- production optimization.

...

Controlling and monitoring suppliers is a priority for automotive manufacturers. Given the substantial number of components, quality supplier engineers are appointed, responsible for verifying that suppliers are meeting the milestones. They ensure that suppliers deliver compliant prototypes, demonstrate the ability to produce quality parts, and have the necessary resources and workstations. Quality supplier engineers perform pre-production audits, verifying suppliers' ability to produce good parts at the required frequency. The production process is based on efficient logistics, with "just in time" deliveries from an extensive network of suppliers, thus minimizing inventories. Suppliers who deliver directly to production units are classified as Tier 1 suppliers, and those who supply parts to them are Tier 2 suppliers, and so on. To move up this hierarchy, suppliers must demonstrate supply capacity and, above all, quality (Goicoechea & Fenollera, 2012) (Țîțu, Covaci, & Bogorin-Predescu, The evolution of product quality in the automotive sector: the interdependence between raw material quality, finished products, and supplier performance, 2025).

...

1.5.2 The concept of total quality. Total quality management. Concordance with the doctoral research topic

In the automotive sector, the application of Total Quality Management (TQM) principles helps streamline communication procedures and facilitates the harmonized integration of processes into complex quality management systems. TQM focuses on continuous improvement for all members of a business and its suppliers, supporting a comprehensive approach to quality that promotes efficient and consistent communication channels throughout the supply chain.

...

The deliberate adoption of total quality management practices in the supply chain context has a major impact on organizational performance because it promotes a culture of quality throughout production and supplier relationships. TQM promotes collaboration across supply chains, leading to better quality risk management and overall performance (Pattanasiri & Chaiyakul, 2022). The shift from industrial robots to collaborative robots has profound implications for MCTs in the automotive industry. By adopting collaborative robots, automakers can increase flexibility, precision, and response time in their processes (Gusan, și alții, 2024).

...

1.5.3 ZERO defects concept: continuous improvement

The concepts of Zero Defects (ZD) and Continuous Improvement (CI) are important paradigms in manufacturing and organizational quality management, aiming not only to reduce product defects but also to achieve excellence in processes and services. The convergence of these ideas is expressed in a variety of approaches that encourage systematic improvements in different production contexts.

Fig. 1.10 Organizations' motivation for adopting the Zero-Defect concept (Bogorin-Predescu & Țîțu, Total quality management in the knowledge-based organization: Managerial strategies oriented towards

...

Figure 1.10 shows why organizations should consider Zero Defect Manufacturing.

...

This method supports the idea that constant quality improvements not only meet customer expectations, but also optimize operational processes, thus generating significant cost savings (Dinis-Carvalho, 2021).

...

1.5.4 KAIZEN Concept and KAIZEN Management: Continuous Improvement

...

KAIZEN and KANBAN are critical approaches in the field of continuous improvement and lean manufacturing, especially in the automotive industry. The integration of these approaches is critically evaluated by modeling manufacturing processes that maximize efficiency and reduce waste. In "Contributions to Manufacturing Process Modeling for Implementing KANBAN Methodology in the Automotive Industry" (Țițu & Bogorin-Predescu, 2023) the authors emphasize the importance of applying KANBAN concepts to electronic control units (ECUs) in the automotive sector. The authors adopt an analytical approach to understanding the production flow, including investigating the initial processing times at different stations. Figure 1.12 shows the final step in the process of balancing the processing times in the production flow for the application of the KANBAN method. This critical analysis helps to "balance the production line," which is necessary for the successful adoption of KANBAN systems, resulting in a smoother flow of materials and shorter delivery times.

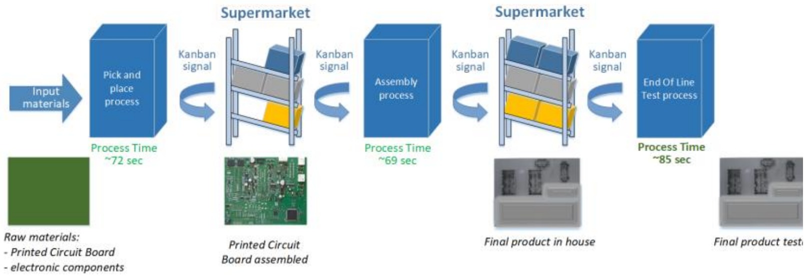

Fig. 1.12 Balancing processing times in the production flow (Țîțu & Bogorin-Predescu, Contributions to the modeling of manufacturing processes for the implementation of the kanban methodology in the automotive industry, 2022)

Furthermore, their subsequent study, "Modeling the Automated Testing Process of Electronic Control Units in the Automotive Industry" (Bogorin-Predescu A. , Țîțu, Niță, & Domnariu, 2022), extends this concept by describing a parallel testing algorithm designed to reduce processing time during the end-of-line testing phase (EOL – End of Line).

...

Examining the interrelationships between multiple testing procedures in "Modeling the Interwoven Parallel Testing Process in the Automotive Industry" (Țițu & Bogorin-Predescu, 2023), the authors show how significantly the processing time at the EOL (End of Line) test station can be reduced by including these procedures in a parallel test architecture. This fits naturally with the ideas of KANBAN, which seeks to synchronize processes and reduce downtime, being a fundamental component of any successful KAIZEN project.

1.5.5 The concept of an integrated quality management system in a knowledge-based organization in the automotive industry

The integrated quality management system (IQMS) is a methodological structure that combines standards and good management practices, designed to increase the quality of products and services, streamline organizational processes and ensure a superior customer experience.

It integrates several standards:

- ISO 9001:2015 Quality management systems — Requirements;
- ISO 14001:2015 Environmental management systems — Requirements with guidance for use;
- ISO 45001:2018 Occupational health and safety management systems — Requirements with guidance for use;
- OHSAS 18001:2008 Occupational Health and Safety Assessment Series;
- ISO 50001:2018 Energy management systems;
- SA 8000:2008 Social Accountability;
- ISO 26000:2010 – Guidance on social responsibility;
- ISO 37001:2025 – Anti-bribery management systems — Requirements with guidance for use;
- ISO/IEC 27001:2022 – Information security, cybersecurity and privacy protection — Information security management systems — Requirements;
- ISO 28000:2022 – Security and resilience — Security management systems — Requirements;

- ISO 31000:2018 – Risk management — Guidelines;
- ISO 26262:2018 – Road vehicles — Functional safety;
- IATF 16949:2016 – Quality Management System for the Automotive Industry;

...

A key component of SIMC in the automotive industry is the integration of quality procedures throughout the supply chain. Supply chain quality management emphasizes group efforts among all stakeholders in the supply chain to increase product quality and customer satisfaction, first reported by Kawalla et al. (Kawalla, Höck, & Ligarski, Supply Chain Quality Management of Magnesium Components: Concept, Examples and Recommendations, 2018), and further developed by Gruszka and Misztal (Gruszka & Misztal, The new IATF 16949:2016 standard in the automotive supply chain, 2017).

...

Integrating quality processes facilitates a holistic perspective on service delivery, allowing organizations to identify areas more effectively for improvement. This perspective aligns with contemporary theories of service quality management, advocating for an inclusive approach that addresses both operational and strategic aspects of service delivery (Deac-Șuteu, Țîțu, & Bogorin-Predescu, 2023) (Țîțu, Deac Șuteu, Dragomir, & Bogorin-Predescu, 2026).

...

1.6 Conclusions

Organizations are social entities created to achieve common goals. They can be classified by purpose (profit, non-profit, governmental), structure (hierarchical, flat, matrix), industry (manufacturing, services, hybrid), ownership (public, private, cooperative), and size (small, large). Knowledge-based organizations are distinguished by their ability to leverage knowledge to create value and gain competitive advantage.

...

The knowledge-based organization is based on the resource theory and the knowledge revolution, having two categories of knowledge: implicit (difficult to formalize) and explicit (documented and shareable). The outsourcing process transforms implicit knowledge into explicit and vice versa, facilitating innovation and continuous improvement. The balance between this knowledge is fundamental for the adaptability and innovation of the organization.

Knowledge-based management in the automotive industry involves planning, organizing, coordinating, leading, and controlling resources to achieve optimal performance. It is essential for the success of organizations in the automotive industry, where the complexity of operations and the constant need for innovation are critical.

...

The knowledge-based economy is a concept in which economic development is stimulated by the use, creation, management, and dissemination of information. Human resources, information and communication technology, and innovation are essential elements in the knowledge-based economy. The knowledge-based economy is distinguished by the intensive use of knowledge to stimulate innovation and competition.

...

The characteristics of knowledge include adaptability to technological advances, collaborative nature, and alignment with standardized practices. Knowledge is essential for effective decision-making and quality assurance in the production process.

...

Quality represents the totality of characteristics of a product or service that satisfy specified requirements. Quality perspectives include standards, customer orientation and conformity. Quality is essential for the success of organizations in the automotive industry, where market requirements are rigorous.

...

Kaizen represents continuous improvement through the participation of all employees. Kaizen methods include the PDCA cycle, the suggestion system, the Just-in-Time method and the 5S method. Kaizen promotes a culture of continuous improvement and the active involvement of employees in the innovation process.

The Integrated Quality Management System integrates multiple management standards and practices to ensure product and service quality, process efficiency, and customer satisfaction. SIMC combines management philosophies and technologies, using an integrated framework that includes total quality management, lean manufacturing concepts, and advanced knowledge management approaches.

2. CURRENT STATE OF KNOWLEDGE REGARDING THE LINK BETWEEN INTELLECTUAL PROPERTY MANAGEMENT AND THE IMPLEMENTATION OF A QUALITY MANAGEMENT SYSTEM IN AN ORGANIZATION IN THE AUTOMOTIVE INDUSTRY

2.1 The Concept of Intellectual Property. Common Established Forms of Intellectual (Industrial) Property

The concept of intellectual property is understood as the legal protection granted to the products of human intellectual creativity that possess economic value. In academic literature, intellectual property is often described as a general concept that brings together various rights generated by creative and innovative activities (Hwang, 2023) (Kumar R. , 2020) (Țîțu, Inventică, inovare organizațională și transfer tehnologic, Curs universitar, 2021).

...

Fig. 2.1 Intellectual Property Classification (Personal contribution)

Briefly, Figure 2.1 presents a classification of intellectual property, encompassing all legal protections afforded to the products of the human brain, including economic innovations of industrial property and cultural expressions under copyright.

...

2.2 Intellectual Property Management applied and commented within an organization in the automotive industry

Intellectual property management in automotive organizations has emerged as a strategic imperative for sustaining competitive advantage and fostering innovation. In today's highly competitive and technology-driven landscape, robust intellectual property management not only protects proprietary technologies and designs, but also serves as a strategic tool in open innovation processes that integrate cross-functional expertise across the organization (Bican, Guderian, & Ringbeck, 2017) (Papagalska, 2024).

...

Technological advances can streamline production processes and improve the user experience in audio technology. Thus, it demonstrates how innovation is not limited to the automotive industry or healthcare, but extends into fields such as audio technology, highlighting the interdisciplinary nature of modern advances (Țîțu, Bâlc, Bogorin-Predescu, & Bâlc, 2024). The authors of the study "Autonomous Mobile Platform with UV Disinfection System, a Modular and Affordable Solution for Virus Elimination" highlight a broader problem in innovation: *while new technologies can offer innovative solutions, they need to be rigorously tested and optimized to ensure they effectively fulfill their intended purpose* (Țîțu, și alții, 2024).

...

2.3 Efficiency and effectiveness in the management of production processes in the automotive industry

Managing production processes in the automotive industry requires a balanced approach to both efficiency and effectiveness. These two dimensions, although interrelated, focus on various aspects of operational performance. Efficiency is about minimizing resource use, waste, and time while maximizing throughput, while effectiveness focuses on achieving desired goals and quality standards that meet customer requirements and strategic objectives (Ammirato, Fattoruso, & Violi, 2022) (Soltanali, și alții, 2018).

...

The effectiveness of production processes is assessed according to the extent to which products meet quality standards and meet customer expectations. This dimension goes beyond the simple optimization of resources, representing the intrinsic capacity of a production system to ensure high product quality and to dynamically adapt to market developments and requirements. In this context, Soltanali et al. (Soltanali, și alții, 2018) proposes a framework based on reliability, availability, and maintainability methodologies. Their research shows that while technical efficiency can be achieved through automation and process optimization, overall efficiency is improved by ensuring consistent product quality and maintaining system resilience. This dual focus ensures that production processes are not only cost-effective, but also reliable and capable of sustaining long-term competitive advantages.

2.3.1 Efficiency versus effectiveness

Efficiency and effectiveness, although distinct, must reinforce each other in modern production management. Yu et al. (Yu, Zhang, & Ahmad, 2024) highlights the critical role of Industry 4.0 initiatives in aligning efficiency and effectiveness. By integrating IoT devices and data analytics, automakers can monitor production in real time, making it possible to adjust processes that are inefficient without compromising quality standards. In addition, methods such as the integrated AHP-DEA (Analytic Hierarchy Process - Data Envelopment Analysis) approach, as described by Ammirato et al., (Ammirato, Fattoruso, & Violi, 2022) provides a systematic assessment of manufacturing processes by quantifying both efficiency (e.g., waste and cost reduction) and effectiveness (e.g., customer satisfaction and quality compliance). This comprehensive approach highlights the need to address both parameters simultaneously in the automotive sector, where rapid innovation and rigorous standards are paramount.

...

In the automotive industry, efficiency and effectiveness are essential to maintain competitiveness and ensure high-quality products. Efficiency focuses on the optimal use of resources, while effectiveness refers to the achievement of set goals. To improve these aspects, organizations must continuously analyze and optimize production processes.

An extremely useful tool for analyzing and improving production processes is the SIPOC model (Supplier, Input, Process, Output, Customer). This model, shown in Figure 2.3, provides a structured method for visualizing and understanding all elements of a process, from suppliers to customers. Using SIPOC helps organizations identify weaknesses and implement measures to increase both efficiency and effectiveness.

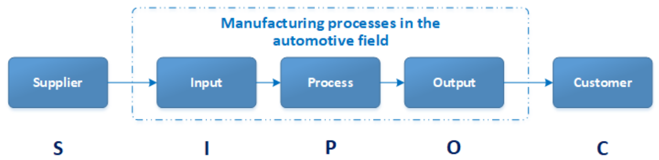

Fig. 2.3 SIPOC model in automotive industry (Bogorin-Predescu & Țîțu, A specific approach about the process management in the automotive industry, 2025)

...

The SIPOC model is not a tool that directly measures or improves efficiency and effectiveness, but is the foundational map that allows management and teams in automotive production to clearly understand the process and its context (who it serves, what resources it consumes), align the process with customer needs (effectiveness), and identify key areas where specific tools and methods can be subsequently applied to optimize resource use and eliminate waste (efficiency).

2.3.2 Production versus manufacturing

Despite their close relationship, the terms production and manufacturing refer to various parts of the process of transforming raw materials into final goods. All the strategic, planning, and operational tasks required to get a finished product to market (from design and sourcing to distribution and quality control) are included in the broad term "production" (Sudibyo, Farida, & Kurdhi, 2024). On the other hand, manufacturing refers specifically to the technical and physical procedures that are used to transform inputs into outputs using a variety of technologies and processes, from conventional assembly lines to rapid and additive manufacturing methods (Ruffo, Tuck, & Hague, 2006) (Ingarao, Priarone, Di Lorenzo, & Settineri, 2020).

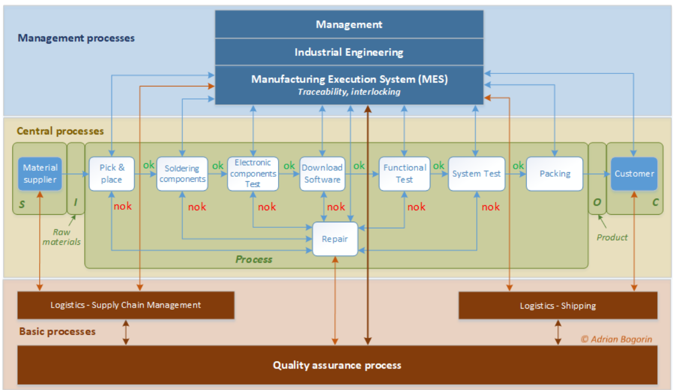

Fig. 2.4 Three perspectives of manufacturing ECUs in automotive (Bogorin-Predescu & Țîțu, A specific approach about the process management in the automotive industry, 2025)

...

The authors of (Bogorin-Predescu & Țîțu, A specific approach about the process management in the automotive industry, 2025) believe that the SIPOC diagram can be extended to map the manufacturing processes within an automotive organization. Figure 2.4 shows a detailed process map for the manufacture of electronic control units. This map integrates the central production steps (such as placing electronic components, soldering them, testing, installing software, and packaging the finished product) with management processes (Industrial Engineering and Manufacturing Execution System, MES) and core processes (Logistics and Quality Assurance).

...

2.3.3 Policies and strategies of Industrial Property and Quality Management in an organization in the automotive industry

...

An effective industrial property policy in the automotive industry organization requires protecting technological innovations through proactive patent applications, thorough portfolio management and strategic licensing agreements. Data from the European Patent Office indicate that the transport sector is among the most important technical areas in Europe (Cioca, Ivașcu, Turi, Artene, & Găman, 2019), emphasizing the importance of protecting automotive inventions worldwide.

...

Titu et al. (Țîțu, Bâlc, Bâlc, & Oprean, 2024) demonstrates that incorporating sophisticated mechatronic systems into organizational management improves operational efficiency and safety, while improving knowledge management.

...

A report by the European Patent Office states that in 2024, a number of 10,026 patent applications were filed in the Transport section (EPO, 2025). The leading organizations producing electronic components in the transportation sector in the top 10 are presented in Figure 2.6.

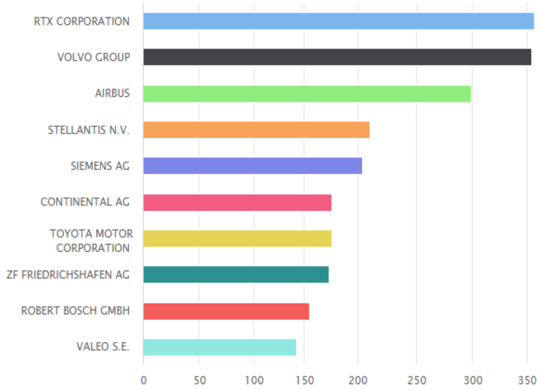

Fig. 2.6 Top 10 transport organizations for 2024 (EPO, 2025)

...

2.4 Quality standards applicable and possible to be implemented in an organization in the automotive industry

Automotive organizations operate within a defined framework of rigorous operational, safety and environmental regulations that require the establishment of strict quality standards. IATF 16949:2016 is a key standard that combines the requirements of ISO 9001 with quality management practices specific to the automotive industry. The use of IATF 16949 and its predecessor ISO/TS 16949 has enabled automotive organizations to methodically enhance production processes, increase customer satisfaction and ensure product safety (Gruszka & Misztal, The new IATF 16949:2016 standard in the automotive supply chain, 2017) (Ostadi, Aghdasi, & Kazemzadeh, 2010). This standard is reinforced by the widespread application of methodologies such as Failure Mode and Effects Analysis (FMEA), which is an essential tool within quality management systems. Through this method, risks can be systematically identified and mitigated throughout the product development and production stages (Plinta, Golińska, & Dulina, 2021).

...

2.4.1 The place and role of the automotive industry organization in doctoral research

The automotive industry is in a state of continuous evolution, characterized by a high degree of technological complexity and an increased level of requirements regarding the quality, safety and interoperability of systems. In this context, automotive industry organizations have an essential role in implementing and supporting an integrated quality management system for the information communication process, especially regarding data exchange between electronic components of the vehicle, but also for their development and testing.

...

2.4.2 The place and role of an integrated quality management system that can be implemented in an organization in the automotive industry

...

The role of such a system is multiple: it contributes to standardizing processes, reducing operational risks and increasing customer satisfaction, but also to facilitating compliance with legal requirements and regulations in force. Its place in the managerial architecture of an organization in the automotive industry is fundamental, having a direct impact on the overall performance, organizational culture and its ability to meet the demands of a global and highly competitive supply chain.

2.4.3 Quality standards that may be implemented in the context addressed

...

The most widespread and relevant standard in the field of quality is ISO 9001:2015, which provides the requirements for a quality management system applicable to any type of organization. It emphasizes customer orientation, management involvement, a process-based approach and continuous improvement. In the specific context of the automotive industry, IATF 16949:2016 is an extension of ISO 9001:2015, adapted to the strict requirements of automotive manufacturers and their suppliers.

In addition to these quality-focused standards, other compatible standards can be included in an integrated management system, such as:

- ISO 14001:2015 for environmental management **...** ;
- ISO 45001:2018 for occupational health and safety **...** ;
- ISO 50001:2018 for energy management **...** .

Other specialized standards can also be implemented that target critical aspects such as information security and functional safety:

- I SO/IEC 27001:2022 – Information security management system (ISMS) **...**;
- ISO 26262:2018 – Functional safety of electrical and/or electronic systems in motor vehicles

...

2.5 Conclusions

Intellectual property is essential for the legal protection of the products of human intellectual creativity, which possess economic value. It includes a wide range of rights arising from creative and innovative activities, thus protecting the tangible expression of mental work. Industrial property, a subset of intellectual property, protects commercial innovations and distinctive identifiers of products or services, such as patents, trademarks, industrial designs and geographical indications. Copyright protects literary, artistic and musical works, providing protection for the specific expression of ideas, rather than the ideas themselves. Copyright protection is granted immediately upon creation, without the need for registration, unlike industrial property rights which require formal registration.

...

Efficiency refers to minimizing the use of resources, waste and time, while effectiveness focuses on achieving desired objectives and quality standards that meet customer requirements and strategic objectives. Efficiency and effectiveness are interdependent and essential for operational performance. Automation technologies significantly contribute to the efficiency of production processes, reducing human error and waste of resources.

...

IATF 16949:2016 combines the requirements of ISO 9001:2015 with quality management practices specific to the automotive industry, methodically facilitating production processes, increasing customer satisfaction and guaranteeing product safety.

...

Integrating intellectual property management with quality management systems is vital for organizations in the automotive industry. This not only protects technological innovations, but also ensures operational excellence, contributing to long-term sustainability and continuous improvement of organizational performance.

3. STANDARDS IN THE FIELD OF QUALITY APPLICABLE AND POSSIBLE TO BE IMPLEMENTED FROM THE PERSPECTIVE OF COMMUNICATION PROCESSES WITHIN THE FRAMEWORK OF DOCTORAL RESEARCH THEME

...

Communication and telecommunications are interconnected fields that form the backbone of information exchange in modern society. Communication encompasses the broader process of transmitting messages and information through various media, while telecommunications refer specifically to the technologies and systems that facilitate communication over distance. This distinction highlights the role of technology in enabling the efficiency and effectiveness of communication, especially in a global context.

...

The importance of telecommunications infrastructure is underscored by its integral role in facilitating economic growth and development. For example, studies have shown that advances in telecommunications can increase per capita income and reduce unemployment in developing regions (Ayub, Rasheed, Ahmad, & Bashir, 2021). The effectiveness of telecommunications networks is essential; their reliability directly influences the efficiency of communication processes, affecting both social and economic outcomes (Luo & Kianfar, 2022). According to Tertereanu et al. on integrated information systems, communication processes are essential for coordinating activities related to border control management, as they allow for the exchange of information in real time, essential for decision-making and operational success (Tertereanu, și alții, 2024). The authors emphasize that these information systems facilitate not only the dissemination of information, but also its analysis, encouraging a collaborative approach between various entities involved in maintaining security within the Schengen area.

...

3.1 Communications processes

...

Claude Shannon's theory of communication, also known as information theory, is a fundamental mathematical framework that describes the process of transmitting information between a source and a receiver, through a communication channel (Fig. 3.1). It was published in 1948 in his work entitled "A Mathematical Theory of Communication" (Shannon & Weaver, 1949).

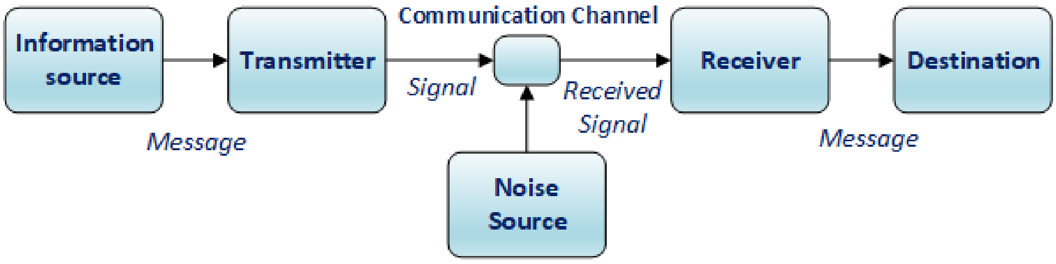

Fig. 3.1 Communication Theory (Shannon & Weaver, 1949)

...

When Shannon and Weaver's theory is adapted for practical uses, such as data transmission in hydroelectric systems, its concepts become essential. In the case of hydroelectric installations, efficient communication between equipment and control systems directly depends on the quality and functionality of the channel through which data is transmitted (Țîțu & Bogorin-Predescu, Communication management for the acquisition of data between the pc and a device called the hydroelectric turbine deployed linearly on the course of flowing water, 2024). This use is a concrete example of the model proposed by Shannon and Weaver, where the hydroelectric turbine acts as the transmitter, the computer that processes the information acts as the receiver, and the communication channel is represented by the data flow provided by technological means.

....

The AUTOSAR architecture represents a significant advance in the automotive industry, particularly in the areas of software architecture, portability, and interoperability. Its structure provides automotive developers with standardized methods for creating software components that can seamlessly interact between electronic control units (ECUs) from different manufacturers. This standardization responds to the increasing complexity of automotive software, especially in advanced driver assistance systems (ADAS), which place high demands on reliability, reusability and maintainability (Park & Choi, 2019) (Freund, 2008) (Sandmann & Thompson, 2008). Study authors (Neamțu, Țîțu, Pop, & Bogorin-Predescu, 2024) highlights the impact of ADAS systems in improving road safety through innovations such as collision avoidance systems, adaptive cruise control, and lane keeping assistance.

...

One of the critical aspects of AUTOSAR is its layered architecture, which includes an application layer where the software components reside, a runtime environment (RTE), and basic software modules (BSW) that facilitate communication between components (Freund, 2008) (Lee, Park, Sunwoo, & Lee, 2013). This modularization enables the development of ECU software that is not only adaptable but also compliant with regulatory standards, such as ISO 26262 for functional safety (Santiago, Machado, Imbasciati, & Costa, 2024). These components can operate independently, allowing greater flexibility in the design and integration of software in the ECU.

3.2 Communication process architectures

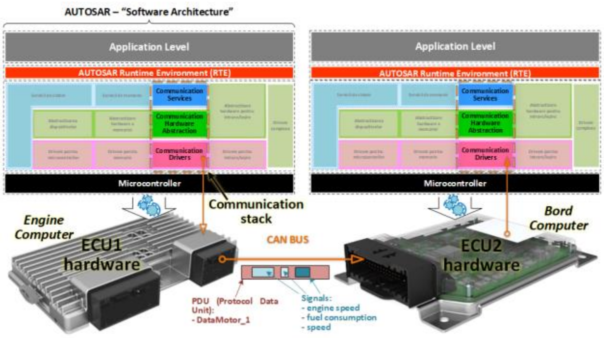

Fig. 3.6 Communication between 2 ECUs on the CAN bus (Personal contribution)

...

Figure 3.6 shows the data flow, on the CAN bus, between 2 electronic control units in a vehicle: ECU 1 – engine computer and ECU 2 – on-board computer. Mainly, in this exchange of information between the 2 control units, the communication stacks between the 2 devices are involved.

...

The migration of AUTOSAR to hardware optimization further facilitates the efficient management of this mapping process. Căpriță and Selișteanu discuss the migration of AUTOSAR communication protection libraries to a hardware-centric approach, which improves the performance and reliability of signal transmission, while accurately reflecting the integrity of the communications data transmitted through PDUs. This migration effectively simplifies the process of creating and sending PDUs, as it provides a robust framework for generating cyclic redundancy checks (CRCs) and other checks necessary to ensure data integrity during transmission. (Căpriță & Selișteanu, 2022).

...

There are 2 standards that are used for vehicle diagnostics:

- OBD (On-Board Diagnostics, ISO 15031-1:2010) refers to the self-diagnostic and reporting capability of a vehicle. OBD systems provide the vehicle owner or the technician repairing the vehicle in the service, access to the status of the various subsystems of the vehicle;
- UDS (ISO 14229-1:2020) specifies the independent data link requirements of automotive diagnostic services in road vehicles. It was implemented by vehicle manufacturers to meet the need for richer diagnostic data and functionality beyond the limitations of emissions-focused OBD protocols.

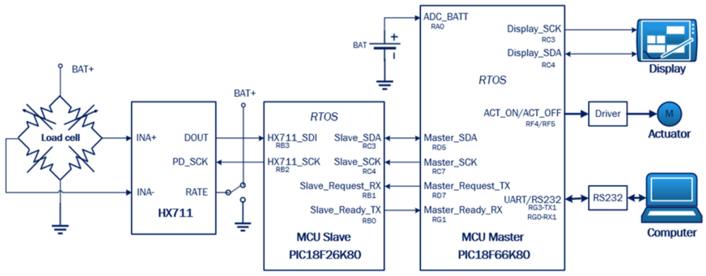

Fig. 3.16 Communication between a master microcontroller and a slave (Țîțu & Bogorin-Predescu, Modeling of the communication process between two microcontrollers in order to optimize the execution of

...

The research conducted by Țîțu and Bogorin-Predescu sheds light on methodologies for improving the communication process between 2 microcontrollers presented in Figure 3.16, highlighting the Master-Slave paradigm inherent in I2C communications. According to the authors, an adequate modeling of the communication process can lead to a significant improvement in performance in executing specific tasks assigned to microcontrollers (Țîțu & Bogorin-Predescu, 2023). Through analytical and empirical approaches, they explore how efficient data management and reduced latency can lead to optimized task execution, which is essential in systems that require real-time responses.

...

3.3 Peculiarities of quality management of communication processes

...

According to Borsese et al., communication quality directly affects the performance of integrated management systems, including those based on IT. Therefore, managing the quality of communication processes requires rigorous attention to the technological infrastructure, but also to human behavior (Borsese, McDowall, & Andrade, 2003).

...

By implementing a robust communication infrastructure and using standardized industrial protocols, the authors in (Țîțu, Gusan, & Bogorin-Predescu, Enhancing collaborative robot communication with electrical discharge machine through modbus TCP integration: a feasibility and application study, 2023) demonstrates how higher levels of quality can be achieved in industrial communication processes, thus facilitating the optimization and flexibility of production processes.

...

3.4 Proposed and possibly implemented quality standards from the perspective of communications processes

...

The most relevant international standard influencing the quality of communication processes is ISO 9001:2015, "Quality management systems. Requirements." Although it does not explicitly dictate "how" to communicate, this standard emphasizes the importance of effective communication within a quality management system.

...

AUTOSAR is a standardization initiative that defines an open software architecture for vehicle ECUs. Its main goal is to ensure software interoperability and portability. Communication within AUTOSAR defines strict rules for the communication layers in the vehicle:

- *Bus communication*...;
- *End-to-End protection (E2E)* **...**;
- *Service-Oriented communication (SOME/IP)* **...**;

Communication quality in the AUTOSAR architecture is guaranteed by standardization (use of common interfaces and protocols), robustness (error tolerance and correction mechanisms), efficiency (optimal bandwidth utilization) and predictability (essential for critical real-time applications).

...

The V-model not only guides system development but also imposes a culture of rigorous and documented communication, essential to ensure quality, traceability and project success, especially in industries with strict requirements such as the automotive industry.

...

CAN (Controller Area Network), standardized by ISO 11898, is the backbone of internal vehicle communications.

...

LIN (Local Interconnect Network), standardized by ISO 17987, was developed as a low-cost and simple solution for network communications. From a quality and communication process perspective, LIN is optimized for applications where speed and complexity requirements are low.

...

FlexRay, standardized by ISO 17458, is a communication protocol designed for critical real-time applications where predictability and safety are paramount, such as electronic brake-by-wire or electronic steer-by-wire systems.

...

Ethernet Automotive, especially through the BroadR-Reach standard, is the answer to the need for high-speed communications and massive data volumes in modern vehicles.

...

Automotive communication standards define the essential communication processes that ensure the quality, safety, and reliability of vehicles. From the robustness of CAN to the simplicity of LIN, from the predictability of FlexRay to the speed of Automotive Ethernet, each standard plays a vital role in the smooth operation of modern automobiles, ensuring that every bit of information contributes significantly to ensuring a safe and high-quality driving experience.

3.5 Conclusions

Communication and communication represent fundamental processes in any contemporary system, be it social, technological or industrial. The semantic distinction between the two terms is relevant in the context of the Romanian language, where "*comunicarea*" describes the process of exchanging information between entities, and "*comunicația*" designates the technical means by which this exchange is achieved. While the English language uses the unifying term "communication", in Romanian a clearer terminological delimitation is necessary, especially in the fields of engineering and information technology.

...

In the field of automotive electronic systems, communication between the internal components of the vehicle is managed by specialized software architectures. One of the most important is AUTOSAR, which provides a standardized framework for the interaction between electronic control units. Its layered structure, comprising software components, execution environments and basic modules, facilitates the scalable and portable development of automotive applications. By separating the application logic from the hardware infrastructure, rapid adaptation to the specific requirements of each vehicle manufacturer or model is allowed.

...

In parallel, the diagnostic activities of electronic components are supported by dedicated standards. ISO 14229, known by the acronym UDS (Unified Diagnostic Services), provides a standardized structure for identifying and fixing faults in vehicle systems. This client-server protocol is implemented in ECUs and allows external testers to request information on the internal state of components, perform tests or download software updates. The integration of UDS into the AUTOSAR architecture brings significant benefits in terms of compatibility, reuse, and extension of diagnostic functionalities.

...

Currently, AUTOSAR is among the only standardized architectures that allows communication between microcontrollers, occasionally integrating a computer for diagnosing the network or a specific ECU. In the automotive industry, the use of microcontrollers is well regulated, as they are specially designed for this field. Thus, they have superior internal resources compared to commercial ones: larger RAM and FLASH memory, multicore architecture, and numerous input/output ports.

...

4. STUDY REGARDING THE CONDUCT OF A BIBLIOMETRIC ANALYSIS IN THE CONTEXT OF THE DOCTORAL RESEARCH TOPIC

4.1 The place and role of bibliometric analysis in the context of research

...

Bibliometric analysis occupies a principal place in the architecture of modern research. It provides a solid framework for measuring and understanding scientific production and supports decision-making at all levels of the research system. Although its application requires discernment and adaptation, the continuous development of analytical methods and access to increasingly complex databases guarantee an increasingly significant role for bibliometrics in shaping the future of science.

4.2 Method used

...

The number of works exported from WOS for bibliometric analysis is presented in table 4.1.

Tab. 4.1 Number of scientific papers subjected to bibliometric analysis

Keywords	Number of scientific papers	Period
”quality management”	28741	2010-2025
”communication protocol”	6858	2010-2025
”firmware platform”	917	2010-2025
”embedded system”	10196	2010-2025

...

4.3 The results obtained and their interpretation

4.3.1 Analysis of the keywords "quality management"

The keywords “quality management”, which appear more than 5 times in the main WOS database, were included in the analysis. Of the 69728 keywords, 5707 reached the minimum threshold of 5 occurrences. The keywords that appeared most frequently were “quality management” (with a total link strength of 22773), “performance” (with a total link strength of 15966), “impact” (with a total link strength of 16874), “quality” with a total link strength of 9186 and “total quality management” with a total link strength of 10727.

...

4.3.2 Analysis of the keywords "communication protocol"

The keywords “communication protocol”, which appear more than 5 times in the main WOS database, were included in the analysis. Of the 17994 keywords, 1062 reached the minimum threshold of 5 occurrences. The keywords that appeared most frequently were “communication protocol” (with a total link strength of 1215), “internet of things” (with a total link strength of 1368), “security” (with a total link strength of 1302), “protocols” with a total link strength of 1572 and “internet” with a total link strength of 1153.

...

4.3.3 Analysis of the keywords "firmware platform"

The keywords “firmware platform” do not appear together in the WOS database, but they are associated with other keywords. Of the 3260 keywords, only 106 reached the threshold of at least 5 occurrences. The keywords that appeared most often were “internet of things” (with a total link strength of 140), “firmware” (with a total link strength of 106), “iot” (total link strength of 79), “security” with a total link strength of 97, and “internet” with a total link strength of 102.

...

4.3.4 Analysis of the keywords "embedded system"

The keywords “embedded system”, which appears more than 5 times in the main WOS database, were included in the analysis. Of the 24815 keywords, 1430 reached the minimum threshold of 5 occurrences.

...

4.4 Conclusions

...

In conclusion, the bibliometric analysis highlights the need to intensify research in the field of communication platforms for innovation, as well as in that of firmware dedicated to embedded systems. The low frequency of occurrences of the term "firmware platform" in the specialized literature suggests an insufficiently explored field, but with considerable potential for future technological and scientific developments.

...

5. FINAL CONCLUSIONS ON THE CURRENT STATE OF KNOWLEDGE IN THE DOCTORAL RESEARCH TOPIC

Contemporary organizations, especially those in the automotive industry, are undergoing an accelerated transformation process, driven by digitalization, globalization, and the increasing role of knowledge as a strategic resource. In this context, the knowledge-based organization model becomes an imperative, offering flexibility, adaptability, and the ability to capitalize on both explicit and implicit knowledge. The automotive industry, characterized by technological complexity and competitive pressures, constitutes an ideal framework for implementing this model, as success depends on the ability of organizations to transform information into action and to integrate continuous learning processes.

Integrating knowledge management, quality, and intellectual property into an Integrated Quality Management System (IQMS) is essential for ensuring compliance, traceability and innovation. International standards such as ISO 9001, IATF 16949 and ISO 26262 provide the methodological framework necessary for the development of these systems, while Industry 4.0 technologies and software architectures such as AUTOSAR support the interoperability and performance of organizations. In addition, intellectual property management is no longer just a legal instrument but becomes a strategic asset that protects knowledge and facilitates scaling and internationalization.

Patents, trademarks, and industrial designs contribute to creating a sustainable competitive advantage, and their integration into organizational policies is vital. In a knowledge-based economy, the value of an organization is no longer determined exclusively by physical assets, but by the ideas, processes, and knowledge it holds. Thus, the systematic protection and valorization of knowledge become strategic priorities. At the same time, communication processes, supported by standardized architectures and advanced protocols, ensure the coherent functioning of electronic systems in vehicles and allow the integration of diagnostic and software update services. These elements contribute to the creation of an innovative and resilient ecosystem, capable of responding quickly to market changes and managing technological complexity.

In conclusion, the success of organizations in the automotive industry depends on their ability to harmoniously integrate knowledge management, quality, communications, and intellectual property into a unified strategy. Adopting a mature SIMC, supported by digital infrastructures and an organizational culture oriented towards continuous learning, is the foundation of competitiveness. Organizations that manage to transform knowledge into value, effectively manage complexity and respond agilely to change will define the future of the automotive industry.

PART II. CONTRIBUTIONS ON IMPROVING THE QUALITY MANAGEMENT OF COMMUNICATION PROCESSES IN THE FIELD OF INNOVATION WITH DIRECT APPLICABILITY IN THE AUTOMOTIVE INDUSTRY

6. DIRECTIONS, MAIN OBJECTIVE, SPECIFIC OBJECTIVES AND RESEARCH METHODOLOGY PROPOSED WITHIN THE FRAMEWORK OF DOCTORAL RESEARCH

6.1 The main objective of the research

The doctoral thesis entitled "*Integrated quality management system for the information communication process in the automotive industry*" proposes scientific research based on an integrated quality management system with reference to the information communication process within industrial organizations in the automotive industry. The doctoral thesis solves the most common problems regarding the identification and implementation of communication standards within communication processes and proposes original contributions regarding the development, validation and integration of an information platform both in the innovation environment and in the automotive industry.

Chapter 11 presents the original contributions arising from the formulation and further development of the main research focus previously outlined.

6.2 Specific research objectives

The specific objectives of the doctoral research are:

- study of the current state of knowledge in the field of quality management in knowledge-based organizations in the automotive industry;
- study of the correlation between knowledge-based management and global management in the context of considering a scenario developed in an organization of the future with an object of activity in the automotive industry;
- study on the understanding and application of knowledge management in terms of the research topic addressed in the doctoral thesis;
- study of the current state of knowledge regarding the connection between individual property management and the implementation of a quality management system in a knowledge-based organization in the automotive industry;
- study on the identification of quality standards that may be used and subsequently implemented in information communication processes;
- study on the achievement and formulation of pertinent conclusions obtained following a bibliometric analysis directly related to the doctoral research topic;
- contributions regarding the identification and implementation of communication standards applicable in communication processes directly related to the doctoral research topic;
- contributions regarding the design, validation of an IT platform useful for the proper conduct of scientific research within the framework of doctoral training;
- contributions regarding the development at a detailed level in order to use the designed IT platform in the innovation environment but also in an industrial organization based on automotive knowledge;
- definition and implementation of a communication protocol, request-response, interoperable on common buses in the automotive industry, structured on 8-byte communication messages between a supervisory computer and an embedded system equipped with a microcontroller;
- development of a security mechanism, which integrates password-based authentication processes, "SEED–KEY" exchange and protection policies against "brute-force" attacks, aligned with the principles of the Information Security Management System (ISMS), according to the ISO/IEC 27001 standard;
- definition and implementation of a flexible and configurable firmware architecture for embedded systems in order to speed up the development process of the functional prototype;
- implementation of a computer software application that has the role of testing, validating and parameterizing the ECU in the testing and development phase of the prototype through the communication protocol;
- definition and elaboration of internal communication processes within embedded systems and the software application located on the computer for their command and control;
- development of an integrated system that manages all software tools used in research and development activities for ECUs and functional prototypes;

- V-Model approach for all phases of development of projects and prototypes within the integrated platform;
- rapid development of functional prototypes of invention patents based on the IT platform;
- implementation of an embedded test system for testing electronic control units (ECUs), within the automotive industry, in the firmware development phases;

All specific objectives of the doctoral research were achieved.

6.3 Research directions

...

Software reuse is not just a technical option, but a quality and cost management strategy. By implementing modular libraries, project templates and a configurable workspace, not only is the development of prototypes accelerated, but also full traceability between requirements, design and testing is ensured. In addition, this approach facilitates portability between different hardware platforms, a critical aspect in multi-vendor automotive ecosystems.

Thus, the research direction oriented towards platformization and reuse represents the foundation for achieving a high level of technological maturity, reducing development costs and increasing competitiveness in the field of embedded systems.

Within the research directions, two distinct areas have been identified: management and engineering. The management area is focused on quality, processes and governance, and the engineering directions are focused on embedded systems and software.

The management area directions are:

- *End-to-end traceability* "requirement-design-implementation-test" (alignment with the V Model and the double-checking principle at each integration level).
- *Integration of the "Security by Design" principle into communication processes*. **...** ;
- *Governance of knowledge and intellectual property.* **...** ;
- *Industrialization of testing.***...** ;
- *SIPOC model* adapted to describe the information and functional flow of an ECU, providing a clear picture of the incoming elements, internal processes and generated results. **...** .

The engineering area directions, especially of embedded systems and software are:

- *Design of portable communication architectures between PC and ECU* **...** ;
- *Platformization of embedded software development.* **...** ;
- *Ensuring operational security at the ECU level.* **...** ;
- *Integration of HIL (Hardware-in-the-Loop) test frameworks* **...** ;

6.4 Research methodology

The doctoral research methodology was built on an iterative and incremental process, based on the principles of the scientific approach to design and on the methodological structure of the V-model, to guarantee complete traceability between the stages of requirements definition, design, implementation, and validation. The main stages were the following:

- *Establishing the general objective.* The first step consisted in defining the general objective of the research, namely the design of an integrated communication process quality management system, capable of ensuring interoperability, security and portability in the development of prototypes equipped with embedded systems;
- *Using mind maps to structure the research.* **...** ;
- *Analysis of the current state of the field.***...** :
- *Bibliometric analysi* **...** ;
- *Establishing needs and defining requirements.* **...** ;
- *Designing and implementing the integrated platform and firmware architecture.* The central stage of the methodology aimed at developing the integrated platform, including the PC application and firmware architecture for embedded systems. The implementation respected the principles of modularity, reuse and security by design, integrating protocols for communication channels (UART, CAN, USB, TCP, BLE) and authentication mechanisms;
- *Application of the platform on functional prototypes.* **...** ;
- *Expanding of the platform in the automotive industry to implement an embedded system for testing ECUs during the firmware development phase for them.* This allowed testing the communication stack (ComStack) and validating the protocols without connecting real sensors and actuators. By automating

scenarios, injecting errors and monitoring traffic on the buses, the embedded test system reduced testing time, increased coverage, and ensured incremental validation before integration on physical prototypes.

The adopted methodology allowed for the coherent structuring of the entire scientific approach, from defining the general objective and analyzing the current state of the field, to implementing and validating the integrated platform. The use of mind maps, bibliometric analysis, and the correlation of requirements with patent claims ensured the traceability and theoretical substantiation of the proposed solution. The design and implementation stages were completed by incremental testing, including the integration of the embedded system for automotive testing as an intermediate environment between simulation and validation of the embedded software for ECUs. This approach led to the development of a configurable platform, oriented towards reuse and portability, capable of meeting current automotive industry requirements and significantly reducing prototyping time.

7. CONTRIBUTIONS ON THE IDENTIFICATION AND IMPLEMENTATION OF COMMUNICATIONS STANDARDS USABLE IN COMMUNICATIONS PROCESSES

7.1 The place and role of communications standards. The concept used and proposed

...

For an embedded system to be truly functional and autonomous, it must also include a communication subsystem, which ensures the exchange of information with other devices or the external environment. This can use standard protocols such as UART, SPI, I2C, CAN, Ethernet, or even wireless communication (Bluetooth, Wi-Fi, etc.), depending on the application requirements.

...

At the protocol level, the communication between the computer and the ECU must follow a request-response structure. Thus, the computer sends a request to the ECU, which, after processing, responds with the appropriate information. The most suitable standard for this type of communication is UDS (ISO 14229:2022), widely used in the automotive industry.

...

7.2 Contributions on a holistic approach to a research-specific technical system

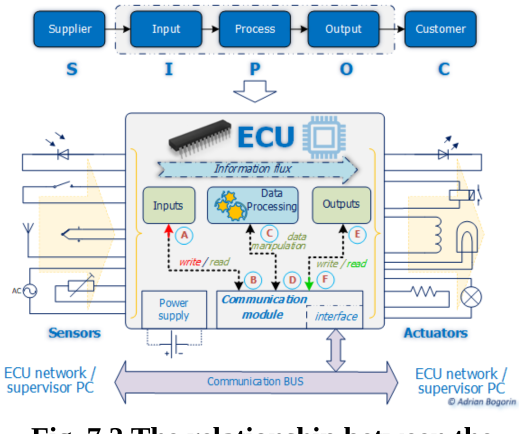

Fig. 7.2 The relationship between the SIPOC model and the ECU (Personal contribution)

A holistic approach is essential in the design and analysis of an embedded system. The system should not be viewed only as an assembly of electronic components (hardware), but also as a unified whole that includes firmware — that is, specialized software that runs inside the microcontroller (MCU). Firmware controls the operation of the system and determines its behavior under different operating conditions.

...

The embedded system, consisting of an electronic control unit (ECU), together with the set of sensors and actuators to which it is connected through inputs and outputs, can be effectively analyzed from the perspective of the SIPOC (Supplier, Input, Process, Output, Customer) model, frequently used for understanding and optimizing processes and is presented in Figure 7.2.

...

From a holistic point of view, the ECU and the computer part have been integrated into a computer platform called BIOComProP. The concept of BIOComProP is derived from the abbreviations shown in Figure 7.4. BIOComProP stands for "Basic Input and Output Communication Protocol Platform".

The **BIOComProP** platform includes:

- The firmware architecture "BIOComProP_ECU" for embedded systems (Embedded Systems), i.e. the software running in microcontrollers;

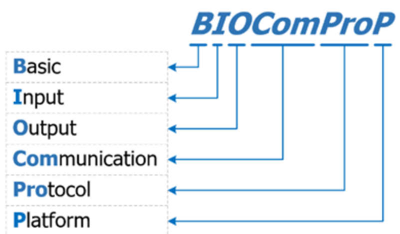

Fig. 7.4 Basic Input Output Communication Protocol Platform (Personal contribution)

- The software on the Computer (computer) with Windows operating system, "BIOComProP_TS";
- The communication protocol that makes the informational connection between "BIOComProP_ECU" and "BIOComProP_TS".

...

Effective communication is the basis for the functioning of any complex system, whether it is human interaction or that between electronic and IT components.

In the modern digital world, understanding the processes of transmitting and receiving information is essential. Figure 7.5 illustrates a fundamental model of communication, inspired by the Shannon-Weaver theory, and its concrete application in the context of the computing platform called BIOComProP, a relevant example in the field of communications between a computer (PC) and an electronic control unit (ECU).

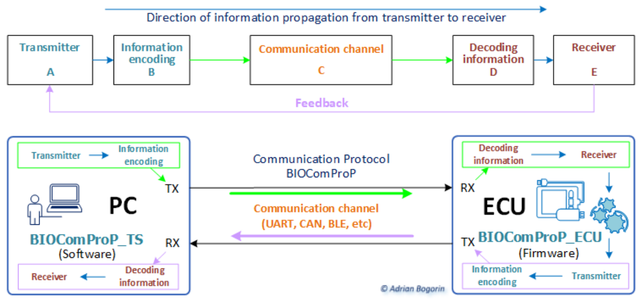

Fig. 7.5 Shannon-Weaver Communication Model applied to the BIOComProP Platform (PC-ECU) (Personal contribution)

...

7.3 Contributions to the methods of utilization and implementation of communication processes: The BIOComProP Platform

...

Hexadecimal representation was chosen for the BIOComProP communication protocol due to its higher information density compared to text format (standard ASCII). Hexadecimal format allows for more compact and efficient data encoding, thus facilitating the transmission of a larger volume of information in the same space.

...

7.3.1 Communication protocol

...

At the ECU level, the “BIOComProP_ECU” firmware decodes and processes the received information. Subsequently, the result is transmitted back to the PC. At this stage, the roles change: the ECU becomes the transmitter, encodes the response message containing the result and transmits it to the PC via the same communication channel. Upon reception, the PC decodes the message, extracts the result, and processes it or displays it on the screen.

...

7.3.2 Internal communication processes of the BIOComProP platform located on the computer (BIOComProP_TS)

...

Figure 7.10 shows the internal communication processes between a technical computing system and an ECU. On the left side of the image, the communication processes A100, A120, A140, E100, E120, E130, E160 and F180 are highlighted, which are implemented on the computer running the BIOComProP_TS test software. On the right side, the internal communication processes of the ECU, from the BIOComProP_ECU firmware, are represented, these being: C100, C120, C130, C140, C150, C160, C175, C180 and C190.

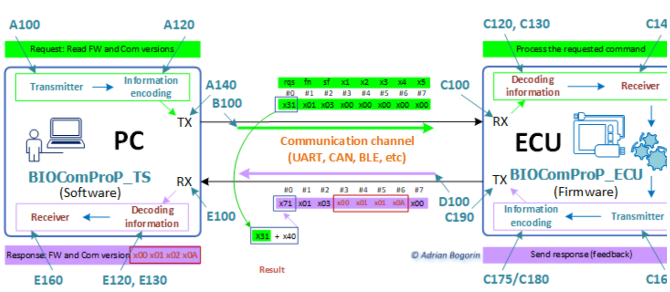

Fig. 7.10 Internal communication processes between a computing system and ECU (Personal contribution)

The main purpose of the BIOComProP_TS software program is to test and validate the product or prototype equipped with an electronic control unit. The ECU has the function of analyzing and controlling the behavior of the functional system – consisting of mechanical and/or electronic components – in various operating scenarios. Depending on the application requirements, the ECU can act passively, limited to acquiring data from sensors mounted on a prototype, or actively, when it is necessary to perform complex mechanical or electronic actions. In this case, the ECU has the role of controlling, monitoring, and evaluating these actions, thus contributing to the “smart” operation of the analyzed system.

...

7.3.3 Internal communication processes of the BIOComProP platform located at the ECU (BIOComProP_ECU)

After sending the request message from the computer, it goes through the B100 process, which represents the transport of the message through the physical communication channel. This channel can be wireless (Bluetooth, Wi-Fi) or through wired connections, such as USB, UART, CAN or other available interfaces.

The firmware running on the ECU is built on the basis of the "bare-metal" architecture. This concept involves the direct execution of the program in a main function, organized in the form of an infinite loop (super loop), conducted by a while or for instruction, within which all associated processes and subprocesses are executed.

...

7.4 Contributions regarding the implementation of quality standards directly related to information security

To ensure the security of the ECU, it is necessary to implement a mechanism that restricts access to it through any communication channel. Access from the computer to the ECU is achieved based on a password authentication system.

For security reasons, the password is not transmitted directly through the communication channel, to prevent the risk of interception by third parties who could have unauthorized access to the network. In this context, a proprietary algorithm was developed to secure access to the ECU, integrated within the BIOComProP communication protocol.

This authentication algorithm has a similar structure, up to a certain point, to the well-known "Seed & Key" mechanism used in the automotive industry, providing an additional level of protection against unauthorized access. The "Seed & Key" algorithm is a security mechanism used in the automotive industry to protect access to critical functions of Electronic Control Units in a vehicle.

...

7.5 Conclusions

...

The block diagram of communication between PC and ECU, transposes the theoretical Shannon-Weaver model into a practical context, in which the PC acts as a source of information, and the ECU as a receiver and processor. The encoding and decoding of messages are performed by software, respectively firmware, ensuring the interoperability and integrity of the transmitted data.

The BIOComProP communication protocol is structured on 8-byte messages, compatible with the classic CAN standard, and includes validation mechanisms, positive and negative responses, as well as detailed error codes. This protocol has been implemented both in the ECU firmware (BIOComProP_ECU) and in the software application on the PC (BIOComProP_TS), ensuring coherent and secure communication.

...

By integrating the holistic approach, the SIPOC model, a robust communication protocol and advanced security mechanisms, the proposed platform meets current performance, flexibility and data protection requirements, opening important perspectives for the development of intelligent solutions in the field of embedded systems and digital communications.

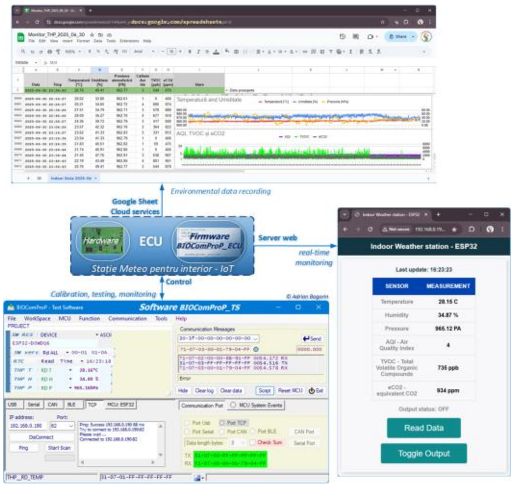

Fig. 8.1 Multiple user interfaces (Personal contribution)

8. CONTRIBUTIONS TO THE DESIGN OF THE BIOCOMPROP COMPUTER PLATFORM

8.1 Communication processes of useful information for the design of the BIOComProP IT platform. Graphical Interface

In certain situations, applications developed on the BIOComProP platform can integrate various methods of user interaction, as shown in figure 8.1.

A relevant example is an IoT (Internet of Things) application designed to monitor air quality in an indoor space (Bogorin-Predescu, Țîțu, Tertereanu, Bâlc, & Gusan, 2024).

This consists of an indoor weather station that measures temperature, humidity and, optionally, atmospheric pressure, while also providing information on air quality. The ECU responsible for the hardware (the electronic components that make up the physical system) supports WiFi connection to the internet for data transfer.

...

8.2 Software and hardware architectures. Modules

The BIOComProP_ECU firmware platform is designed and implemented in a portable way, being independent of the development environment and the type of microcontroller. This approach aims to simplify the integration, configuration and use process, contributing to a significant reduction in the time required to launch the final application to the user.

...

The fundamental structure of the BIOComProP_ECU firmware architecture is illustrated in figure 8.2.

...

The structure of the generic package remains the same from one project to another, regardless of the type of microcontroller used, whether it comes from one vendor or another, or the compiler chosen, such as that from Microchip or another organization. The purpose of the generic package is to provide consistency and universal compatibility, being identical for any microcontroller and compiler.

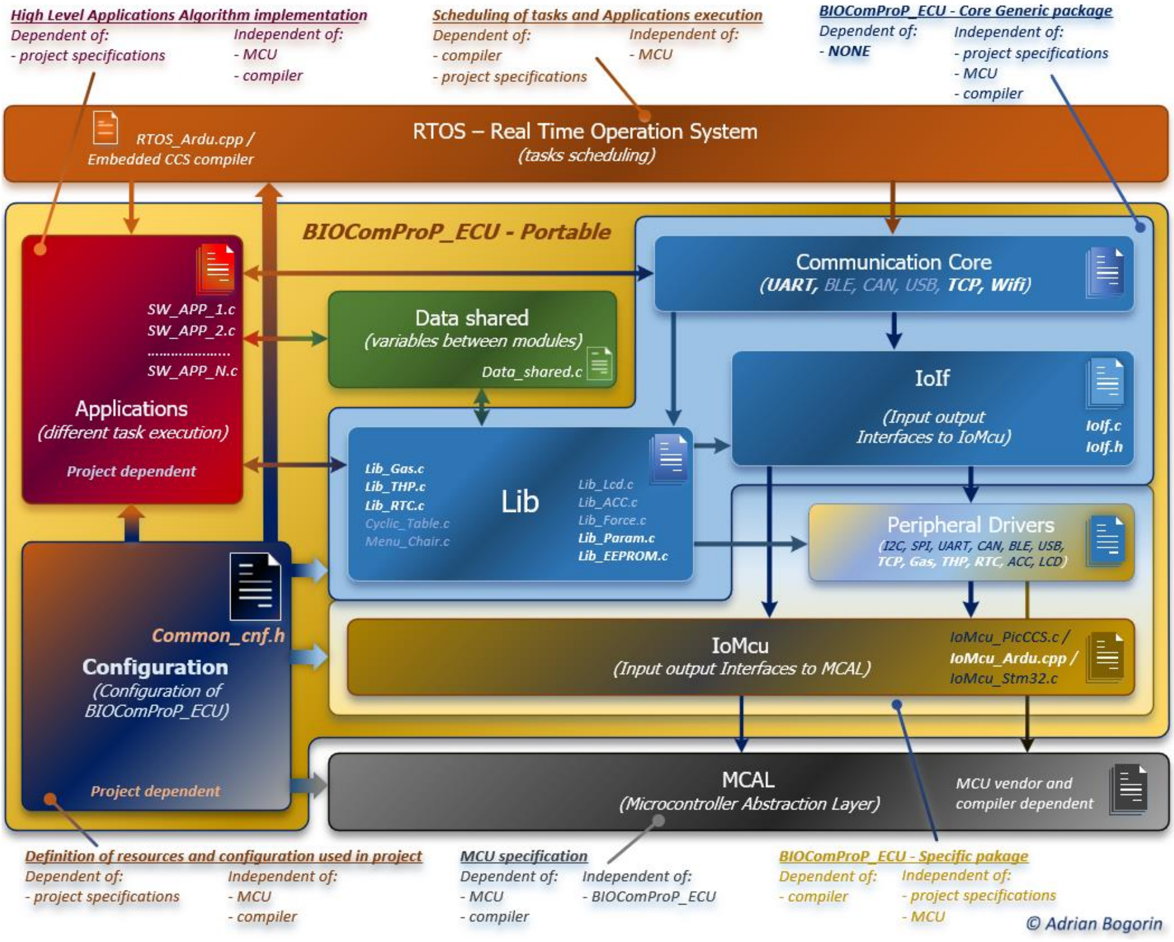

Fig. 8.2 Firmware Architecture of the "BIOComProP_ECU" Platform (Personal contribution)

...

One of the main advantages of the BIOComProP_ECU platform is the possibility of reusing the source code, which has been implemented and used in previous projects. Each new project becomes an opportunity to improve and expand the platform's functionalities.

Also, the fact that the platform is independent of the type of microcontroller used highlights the concept of portability, significantly reducing the need for changes in the source code. This feature becomes essential in situations where the microcontroller needs to be replaced, because it does not meet the project requirements. Due to the portability of the BIOComProP_ECU platform, this change can be easily made, without major efforts.

The most important and valuable feature of the BIOComProP_ECU platform is represented by the significant reduction in the time required for the development of software (Firmware) running on the microcontroller, saving both financial resources and time for future projects in which the platform is integrated.

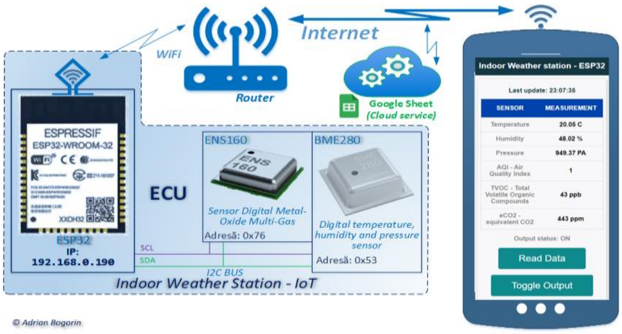

Fig. 8.4 Hardware architecture of the IoT application (Personal contribution)

Returning to the Weather Station demonstration system for monitoring indoor air quality, the context of which was illustrated in Figure 8.1, the hardware architecture of the Electronic Control Unit (ECU) running the BIOComProP_ECU firmware is schematically detailed in Figure 8.4.

This implementation is fully part of the Internet of Things (IoT) paradigm, as it meets and respects all the essential characteristics and defining criteria of this emerging technological field.

...

8.3 Integrating the BIOComProP platform into various programming environments

...

Considering the firmware architecture of the BIOComProP_ECU platform, presented in figure 8.2, and taking the indoor weather station as an example, the firmware architecture for this application was adapted, as illustrated in figure 8.7.

...

The real-time operating system (RTOS) manages the scheduling and execution of tasks at regular, well-established time intervals. Table 8.2 shows the correlation between the tasks in the RTOS and the functions implemented in the application software modules, extracted from Figure 8.7.

...

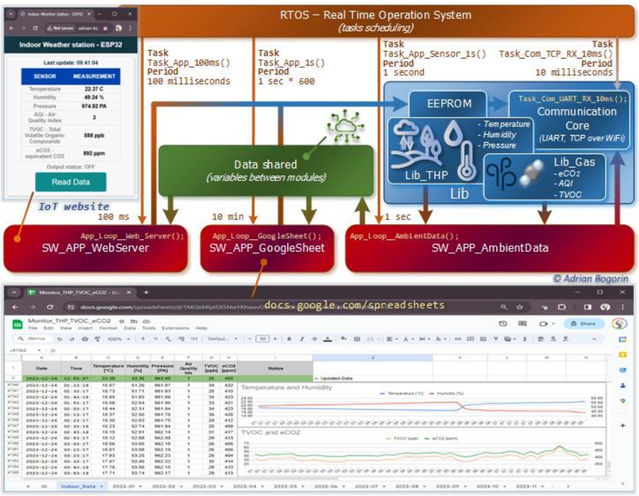

Fig. 8.7 BIOComProP_ECU firmware architecture adapted to the indoor weather station (adaptation according to (Bogorin-Predescu, Țîțu, Tertereanu, Bâlc, & Gusan, 2024), (Bogorin-Predescu, Țîțu, & Oprean, Improving the quality of rapid prototyping processes of electronic control units by using a dedicated software platform, 2023))

8.4 Software for testing and validating a useful application within the BIOComProP platform

The test software associated with the BIOComProP platform, used for transmitting and receiving request-response messages to the ECU running the BIOComProP_ECU firmware, is called "**BIOComProP_TS**" (BIOComProP – Test Software).

This software package has the role of testing and verifying the hardware (electronic) component, as well as evaluating and developing the firmware integrated into the BIOComProP_ECU platform, ensuring their compliance with the specifications and requirements of the implemented project.

...

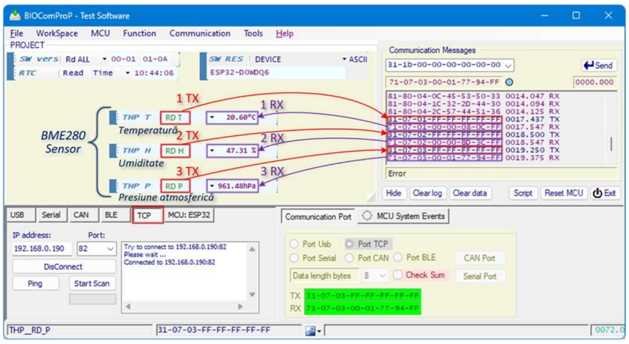

Fig. 8.21 BIOComProP_TS graphical interface used for testing the BME280 sensor in the indoor weather station application (Personal contribution)

Returning to the indoor weather station application, Figure 8.21 shows the user interface, where the operation of the BME280 ambient sensor for measuring temperature, humidity and atmospheric pressure is evaluated. The BME280 sensor is present in 3 different areas on the graphical interface. The first area is marked by the

object “THP T” for temperature, the second area is “THP H” for humidity measurement, and the last is “THP P” for atmospheric pressure.
The test steps for the BME280 sensor connected to the indoor weather station are as follows:

a. In the “1 TX” area, press the “RD T” button (“ReaD Temperature” - temperature reading). **...** The data obtained indicates that the temperature measurement function of the BME280 sensor is working correctly;
b. In the “2 TX” area, the “RD H” button (Read Humidity) is pressed, **...** The correct transmission and interpretation of data demonstrates the proper functioning of the humidity measurement function of the BME280 sensor;
c. When the “RD P” button (Read Pressure) is pressed in the “3 TX” area. **...** The returned value is coherent and correctly interpreted, which confirms the proper functioning of the atmospheric pressure measurement module within the BME280 sensor.

...

8.5 Conclusions

The BIOComProP platform represents a significant contribution to the field of embedded systems, offering a scalable, portable, and efficient solution for the development of embedded applications. By integrating a modular architecture, the platform allows for source code reuse and rapid adaptation to various hardware and software configurations, reducing development time and associated costs.

...

The BIOComProP_ECU firmware platform has been successfully integrated into popular development environments such as Arduino IDE, Sloeber and PlatformIO, allowing users to opt for their preferred tools without compromising the portability or functionality of the applications. In the case of the weather station application, the adaptation of the firmware architecture for a concrete IoT implementation was highlighted, with the use of portable modules and task scheduling through "RTOS", demonstrating the versatility of the solution.

...

The BIOComProP_TS software has been introduced as a central tool for testing and validating applications developed on the platform. Developed in C#, with an intuitive graphical interface, this software allows communication with the ECU through configurable protocols, offering extended functionalities, such as import/export in XML format files, EEPROM memory visualization or real-time sensor testing. These capabilities create a complete framework for evaluating the performance of embedded applications.

...

In conclusion, the BIOComProP platform provides a robust, flexible, and extensible framework for the development of embedded applications. The modular architecture, the extensive support for microcontrollers and the compatibility with multiple development environments, together with the software tools dedicated to testing, allow the rapid and efficient development of reliable applications. The contributions highlighted in this chapter reflect a consistent effort towards standardization, portability and optimization, with a direct impact on the quality and speed of development of modern mechatronic products.

9. CONTRIBUTIONS ON THE IMPLEMENTATION OF THE V MODEL WITHIN THE BIOCOMPROP PLATFORM

...

The V-Model is a structured methodology used in complex projects, which requires the definition of detailed testing strategies for each stage. This ensures complete verification, from initial requirements and functionalities to the final validation of the implementation. (Bogorin-Predescu, Țîțu, & Pană, Flow management for software developers in the knowledge based organization from the automotive industry, 2024).

...

9.1 Defining the proposed project and the usefulness of the proposed contribution

The purpose of the BIOComProP IT platform, consisting of the BIOComProp_ECU, BIOComProp_TS packages and the communication protocol, is to support the acceleration of the development and implementation of a functional prototype. It covers the entire path – from the idea, based on the description and claims of a Patent, to the final stage, in which the prototype confirms and validates the initial concept.

The BIOComProP platform has been integrated into numerous functional prototypes that implement the following patents and patent applications:

- Patent No. RO127219-B1, „*Hydroelectric turbine deployed linearly along the flowing water*" (România Patent No. 127219-B1, 2017);
- Patent No. RO128224-B1, „*Hydroelectric turbine with deformable blades*" (România Patent No. 128224-B1, 2018);
- Patent No. RO129280-B1, „*Chair for working at the PC, with active principle of relaxing the spine*" (România Patent No. 129280-B1, 2021);
- Patent No RO131963-B1, „*Hemispherical individual electric car with swivel seat*" (România Patent No. 131963-B1, 2021);
- Patent No RO129293-B1 2022, „*Command and control system for an electric bicycle*" (Romania Patent No. 129293-B1, 2022);
- Patent No RO130763-B1 2022, „*Individual personal electric car*" (România Patent No. 130763-B1, 2022);
- Patent No RO133869-B1 2022, „*Personal anti-sedentary system*" (România Patent No. 133869-B1, 2022);
- Patent application No. RO137487-A0, „*Ergonomic anti-sedentary set for home office*" (România Patent No. 137487-A0, 2023);
- Patent application No. RO139012-A0, „*Dyadic and triadic robotic structure in long-haul aircraft seats to eliminate joint stress for passengers*" (România Patent No. 139012-A0, 2025).

...

So, taking as an example the Patent of Invention "Chair for working at a PC, with active principle of relaxing the spine", the development and implementation processes of the prototype will be presented below.

The purpose of the invention is to reduce the negative and stressful health effects caused by continuous and prolonged compression of the spine during computer work, as well as to reduce or even eliminate the damage already accumulated because of long office work. The invention relates to a chair, shown in Figure 9.1, designed specifically for people who spend a lot of time working at a computer.

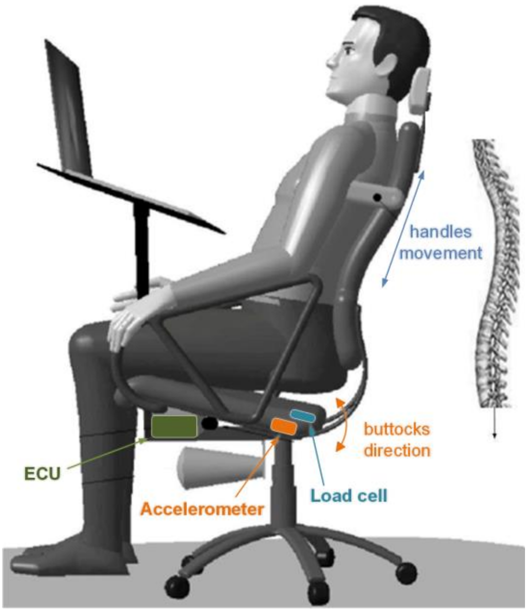

Fig. 9.1 Sketch of the prototype for BI "Chair for working at the PC, with active principle of relaxing the spine" (Romania Patent no. 129280-B1, 2021)

The chair according to the invention is designed as an ergonomic assembly that integrates a computer with its accessories and includes a subassembly for independent, limited raising and lowering of the seat, a system with two folding levers for supporting the trunk in a partially suspended position, a control panel for operating and changing work sequences, as well as an electronic module based on a microcontroller, which ensures the automatic and programmable execution of these sequences.

...

9.2 The process of developing and implementing the proposed project

To create the functional prototype, the V model was applied, established in the automotive industry, but adapted to the specifics of mechatronic systems, as shown in figure 9.2.

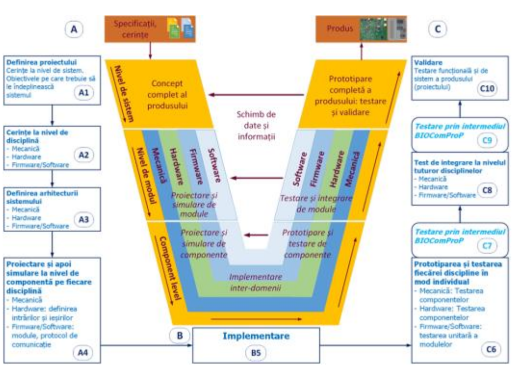

Fig. 9.2 V-model adapted for mechatronic systems (Personal processing)

...

W. Edwards Deming stated that „ *Inspection does not improve quality, nor does it guarantee quality. Inspection comes too late. Quality, good or bad, already exists in the product. Quality cannot be inspected in a product or service; it must be built into it*". This idea, along with the statements above, do not contradict each other, but complement each other. **Quality must be integrated from the product development phase, within the V-model.** However, inspection remains necessary to confirm that the product meets the established specifications.

In case of non-compliance with these requirements, additional costs can accumulate during the manufacturing processes, and, at the customer, they can become exponential for the supplying organization.

The phases presented in figure 9.2 and applied to the project "*PC work chair, with active spinal relaxation principle*" are:

A1) ***Project definition***. **...** :

A2) ***Establishing requirements at the discipline level*** defines the specifications for each area involved in the design of the product/prototype. **...** ;

A3) ***Establishing the architecture at the level of Mechanics, Hardware, Software and Firmware*** is a stage in which the design architecture is established or in broad terms the block diagrams, block schemes are designed at the concept level but not the detailed implementation of each. **...** ;

A4) ***Design and then simulation at the component level for each discipline.*** In this phase, the detailed design of each component in the mechanical, hardware, firmware, and software assembly (if applicable) is conducted. **...** ;

B5) ***Physical*** implementation of the hardware, which includes the creation of the printed circuit board (PCB), as well as the equipping and soldering of the electronic components; implementation of the firmware program for the project-specific "SW_APP_x" application modules; and, optionally, the development of the software application dedicated to the project, where necessary;

C6) ***Prototyping and testing of each discipline individually*** is the stage in which the mechanical, electronic and firmware components are verified separately, using the BIOComProP_TS software. **...**;

C7) ***Testing via the BIOComProP platform*** is performed using the BIOComProP_ECU firmware and the BIOComProP_TS test software. **...** ;

C8) ***Integration testing at the level of all disciplines*** *consists of combining the mechanical, hardware, firmware and software components (if applicable), followed by testing the entire system (prototype) as a complete assembly. This stage is carried out concurrently with phase 9*;

C9) ***Testing via the BIOComProP platform,*** similar to phase 7, is performed using the BIOComProP_ECU firmware and the software dedicated to the respective prototype;

C10) ***Validation of the entire system through functional testing***.

...

9.3 Existing possibilities in the use of software packages, simulation and testing

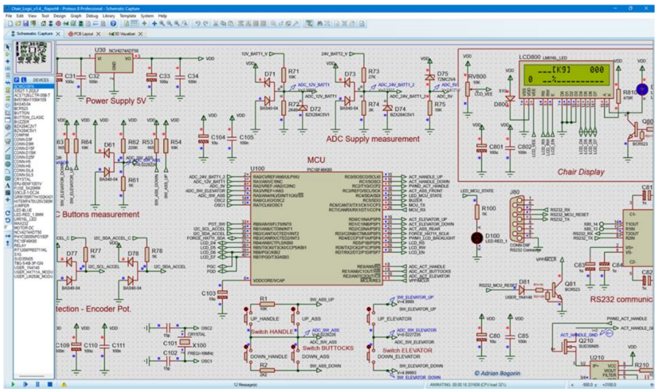

Fig. 9.8 Proteus - "Schematic Capture" Package and VSM (internal documentation from BI RO129280-B1; Personal contribution)

In the fourth phase of the V model, "Design and then simulation at the component level for each discipline", the detailed design of each component in the mechanical assembly, hardware, firmware, and software (if applicable) is carried out.

...

For the electronic part (hardware), the Proteus Design Suite integrated environment from Labcenter Electronics was used. Proteus is a computer-aided electronic design software package, intended for engineers and technicians, which allows the creation, simulation, and design of complex electronic circuits.

...

One of the components of the Proteus integrated environment is shown in Figure 9.8.

...

The construction of the software running in the microcontroller was conducted using the C language compiler from the CCS organization. This compiler, the "CCS C Compiler", developed by "Custom Computer Services" (CCS), is a powerful and specialized environment for programming PIC microcontrollers produced by "Microchip Technology".

...

The software application "BIOComProP_TS", which runs on the computer, was developed in C# (pronounced "si-sharp").

...

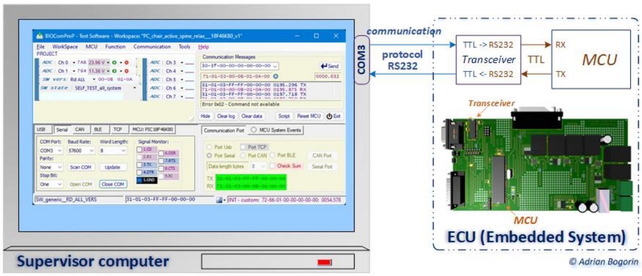

Fig. 9.14 Physical communication between PC and ECU via RS232 serial port (Personal contribution)

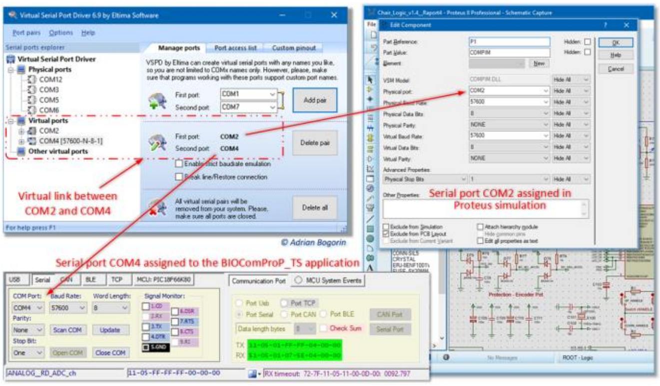

Fig. 9.15 Connection between virtual serial ports COM2 - Proteus and COM4 – BIOCOmProP_TS (Personal contribution)

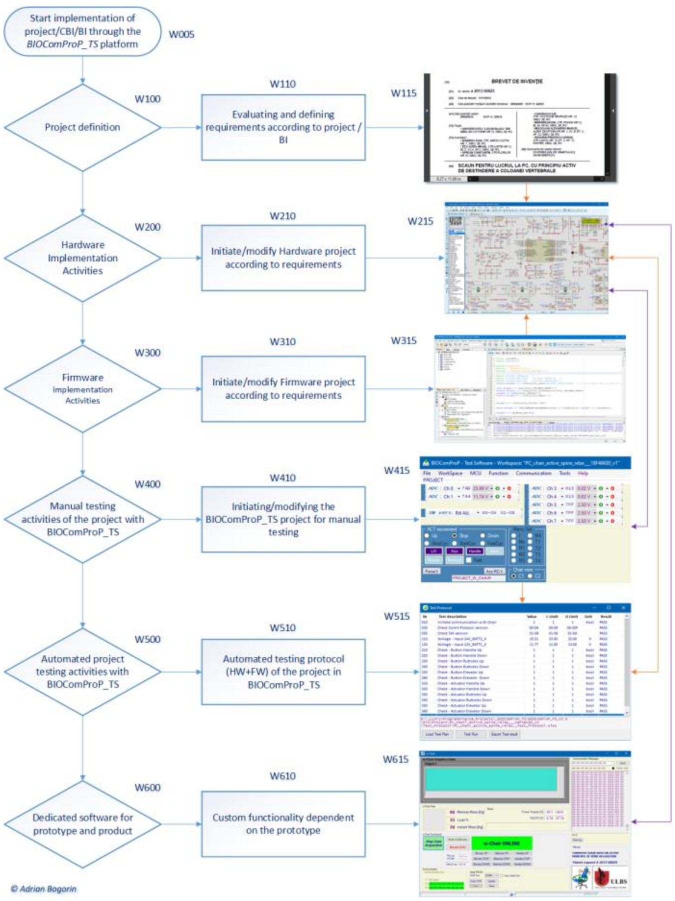

Fig. 9.16 Prototype implementation diagram and interdependence of the disciplines involved (Personal contribution)

One of the great advantages of Windows applications developed in C# is the ability to directly access computer hardware, such as serial ports (COMx). A serial port is a communication interface that transmits data bit by bit, and the RS-232 standard is most often used to connect computers to external devices such as microcontrollers.

By combining the visual interface of Windows Forms with the serial communication logic of C#, user-friendly applications can be created that allow monitoring and control of a microcontroller.

For the BIOComProP_TS application to communicate with an ECU, the simplest way is to use a physical serial port, via the RS-232 protocol. Thus, the application connects to an available port on the computer (for example, COM3), and through this a physical connection is established with the microcontroller, as shown in figure 9.14.

Through the RS232 communication channel, the BIOComProP_TS application allows "remote testing" of the embedded ECU system, which runs on the BIOComProP_ECU firmware. Thus, the testing part corresponding to phases 6 and 7 of the V model can be performed.

...

Figure 9.15 shows the virtual serial ports COM2 and COM4, created with VSPD. The COM2 port is opened from BIOComProP_TS and COM4 is opened from Proteus, the VSM simulation package. In this way, the ECU's response to hardware stimuli and diagnostic messages from the BIOComProP_TS application is tested only on the computer, through electronic simulation.

...

9.4 Contributions to the development and implementation of a logical scheme in the proposed project

The phases of the V model, illustrated in figure 9.2, can be viewed as a logical diagram for the development of a functional prototype, starting from a project or a Patent Application/Patent and reaching its physical realization.

The BIOComProP platform, through the BIOComProP_TS application, supports the completion of all these phases, presented in figure 9.16 in the form of a process diagram.

Stages W005, W100, W200, W300, W400, W500 and W600, in figure 9.16, correspond to the phases of the V model and coincide with the workspace, i.e. the structure of a complex project in BIOComProP_TS, which is configured and run directly from the platform's graphical interface.

...

9.5 Contributions regarding the connection between the graphical interface and the communication, simulation, and testing processes of the proposed project. Results obtained

The fourth phase of the V model, called "Design and then simulation at the discipline level", corresponds to the W200 stage, in which the electronic scheme of the ECU responsible for managing the prototype associated with the invention patent BI RO129280-B1 of 2021 ("Chair for working on a PC, with active spine relaxation principle") is designed.

...

An essential aspect of the V-model and quality assurance processes is early design verification to ensure that the implementation complies with the established requirements. The use of simulations through CAD (Computer Assisted Design) techniques brings multiple advantages: it reduces development costs and time, eliminates the need for intermediate prototypes and minimizes the risks to which end users could be exposed in the event of improper operation.

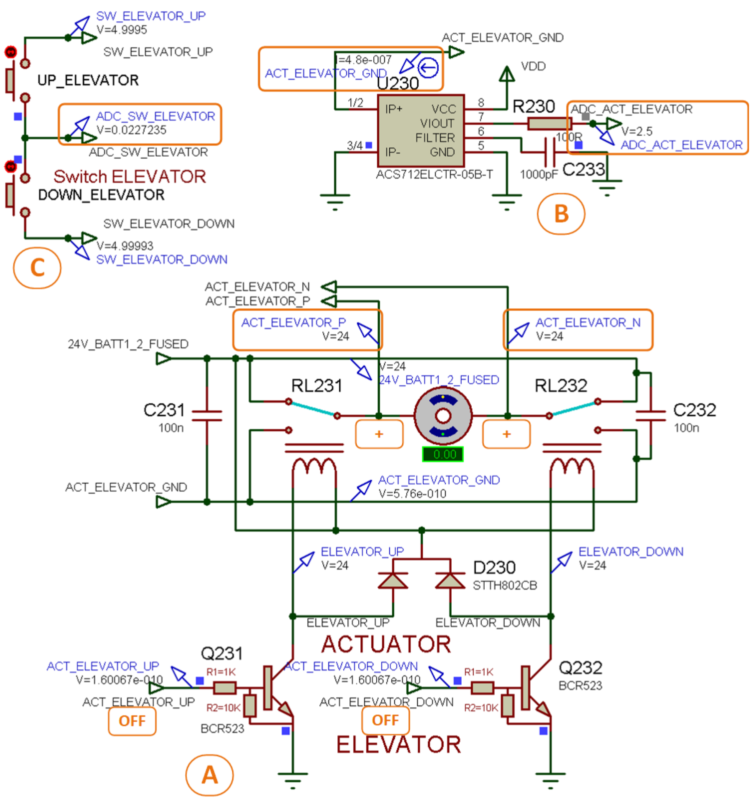

Fig. 9.19 Example of simulation of the ELEVATOR actuator block - neutral position (Personal contribution)

Figure 9.19 illustrates an example of a simulation of the control and execution block of the “ELEVATOR” actuator, a component that replaces the classic piston responsible for raising and lowering the seat. The simulation is shown in the neutral position, and the areas highlighted with orange rectangles emphasize the differences in operation between various scenarios, such as the interaction between the control buttons area and the command area of the ELEVATOR actuator.

...

Under load, the increase in current through the actuator is directly proportional to the mechanical effort applied. The microcontroller firmware continuously monitors these variations to detect any mechanical blockages that could damage the assembly. This provides additional electronic protection, which contributes to the reliability and quality of the prototype.

...

The physical execution of the hardware (ECU) and the mechanical component takes several days, and the activities can be carried out in parallel. However, the system testing phase is longer, and the implementation and validation of the firmware in the microcontroller is a separate process, with a high degree of complexity.

In the automotive industry, it is well known that the development of hardware and mechanics is usually completed much faster than the software part of the ECU. The basic, critical functionalities are ensured from the initial stages, but even in production, software non-conformities can occur. One of the main reasons is the shortening of the development time at a global level (sometimes even halving it), while the workload for implementation has remained at least at the same level, if not higher, given the increasing complexity of new generations of vehicles.

...

Figure 9.28 shows the operational flow for reading the 24V supply voltage from the ECU, by the BIOComProP_TS software with the following actions described in table 9.4.

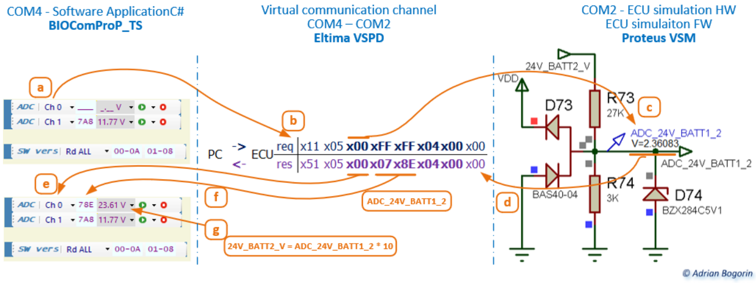

Fig. 9.28 Operational and information flow for reading ADC channel 0 from ECU (Personal contribution)

Figure 9.28 and table 9.4 demonstrate the process of telemetry of electrical parameters from the ECU taking the 24V supply voltage as an example. The other analog signals included in table 9.1 are measured similarly to the supply signal "24V_BATT2_V", as presented in the previous example.

Furthermore, this type of testing also indirectly verifies the electronic components that make up the voltage dividers, in column 3 of table 9.1, for adapting the signals for their application to the microcontroller. This ensures the quality of these functional blocks that include the respective circuit elements.

Tab. 9.4 Actions taken for remote measurement of the 24-volt supply voltage

Action	Description
a	Select ADC channel 0 on which you want to measure the signal.
b	A request (TX) is sent to the ECU to measure the requested signal exactly as in table 2.3, columns 2 and 3.
c	The ECU recognizes the request and performs a voltage measurement on the "ADC_24V_BATT1_2" signal. The measured value is **2.36083V.**
d	The ECU sends the response containing the digital value 0x078E of the requested signal.
e	The ECU receives the message containing information for ADC channel 0.
f	The digital value 0x078E from the received message for the "ADC_24V_BATT1_2" signal is transferred to the graphical interface.
g	The measured signal is scaled by the division ratio of resistors R73 and R74, which has a value of 0.1. To find the real value of the supply signal "24V_BATT2_V", the digital value of the signal "ADC_24V_BATT1_2" must be multiplied by the inverse of 0.1 and the final value will be 23.61V.

...

9.6 Conclusions

...

The implementation of the V model within the BIOComProP platform demonstrated the efficiency of a rigorous, structured, and multidisciplinary approach in the development of functional mechatronic prototypes, with direct applicability in the validation of invention patents.

The case study focused on the invention patent "Chair for working at a PC, with active principle of spinal relaxation" highlighted how mechanical engineering, electronics and software (including firmware) can be harmoniously integrated into a complex system, capable of meeting the ergonomic and medical requirements of users.

...

An innovative aspect of the approach in the testing phase was the virtual communication between the BIOComProP_TS application and the hardware part simulated in Proteus, achieved through the Eltima "Virtual Serial Port Driver" (VSPD). This communication allowed the functional testing and verification of the system in a virtual environment before the physical prototype was created. Thus, errors could be identified and corrected at an early stage, saving time and resources. The use of VSPD demonstrated the effectiveness of a virtual approach in validating complex systems, offering a high degree of flexibility and control.

The benefits of teletesting and telemetry in hardware verification during the prototyping phase of the V model were evident throughout the project. These methods allowed for remote monitoring and control of the system's functional parameters, facilitating an accurate and rapid assessment of performance. By integrating these technologies, extensive and efficient testing was achieved, which contributed to the complete validation of the prototype and the demonstration of compliance with quality requirements.

...

The BIOComProP platform is a valuable tool in the patent validation process, providing an integrated environment for development, testing and demonstration of technical feasibility. By using this platform, one can obtain:

- Reducing development time through advanced simulations and virtual testing;
- Significant resource savings by avoiding intermediate prototypes and hardware errors;
- Increasing the quality of the final product by integrating testing from the design phase;
- Flexibility in adapting to new requirements, through the platform's modularity and the possibility of rapid recalibration.

...

Virtual communication, teletesting, telemetry and rigorous verification principles have contributed to the achievement of a complex, adaptable and high-quality system, opening new perspectives for technological innovation and applied research.

This approach opens new perspectives for technological innovation, laying the foundations for quality, safety, and performance-oriented engineering.

10. CONTRIBUTIONS TO THE DEVELOPMENT AND USE OF THE BIOCOMPROP COMPUTER PLATFORM BOTH IN THE INNOVATION ENVIRONMENT AND IN THE AUTOMOTIVE INDUSTRY

10.1 Presentation of the platform and its usefulness from the perspective of the doctoral research topic

The BIOComProP IT platform represents an essential contribution within the research theme "Integrated quality management system for automotive information communication processes", offering a scalable, portable, and efficient solution for the development, testing and validation of embedded systems. This platform is composed of three main components: the BIOComProP_ECU firmware, the BIOComProP_TS test software, and a dedicated communication protocol, all integrated into a coherent framework that supports the entire life cycle of a mechatronic product.

...

10.2 Graphical interface. Platform design and connection with Intellectual Property Protection theory

Nowadays, in a world dominated by technology, the graphical interface is no longer just an aesthetic detail, but a key tool for testing, validating and even implementing and protecting innovation. The **BIOComProP** platform, created for embedded applications in the automotive and mechatronics fields, perfectly illustrates how software design, hardware architecture and intellectual property protection principles come together.

The **BIOComProP_TS** graphical interface, made in C# with Visual Studio, is designed to provide the user with an intuitive and efficient experience. Through the graphical interface and coded messages, embedded systems can be evaluated and calibrated, data from EEPROM can be viewed in real time for ECU parameterization, and sensors and actuators connected to the microcontroller can be checked and controlled.

...

BIOComProP_TS and **BIOComProP_ECU** are not simple software and hardware components, but essential parts of an integrated ecosystem. They bring together technical innovation, ergonomics, and legal protection, providing a solid framework for the development of modern, scientifically validated and legally protected mechatronic products.

10.3 Design of the BIOComProP IT platform from a hardware and software perspective

...

The main role of this integrated platform is to facilitate the rapid prototyping process, with the objective of early validation of concepts generated following the filing of a patent application or obtaining a patent. At the same time, the platform supports the materialization of these concepts into a functional prototype, which can include mechanical components, hardware, firmware, and software.

Figure 10.1 presents the overview, from several perspectives, of this platform, BIOComProP, dedicated to the innovation environment.

The upper left part presents the SIPOC concept, which is a process management tool adapted for testing, controlling, and supervising embedded systems through a communication channel.

The upper central part illustrates the “Concept of transmitting information in a request/response mode” between a supervisor computer and an embedded system that acts as an ECU. The connecting element between the two components is the communication protocol, which has the role of regulating the information transmitted on the communication channel between the computer systems.

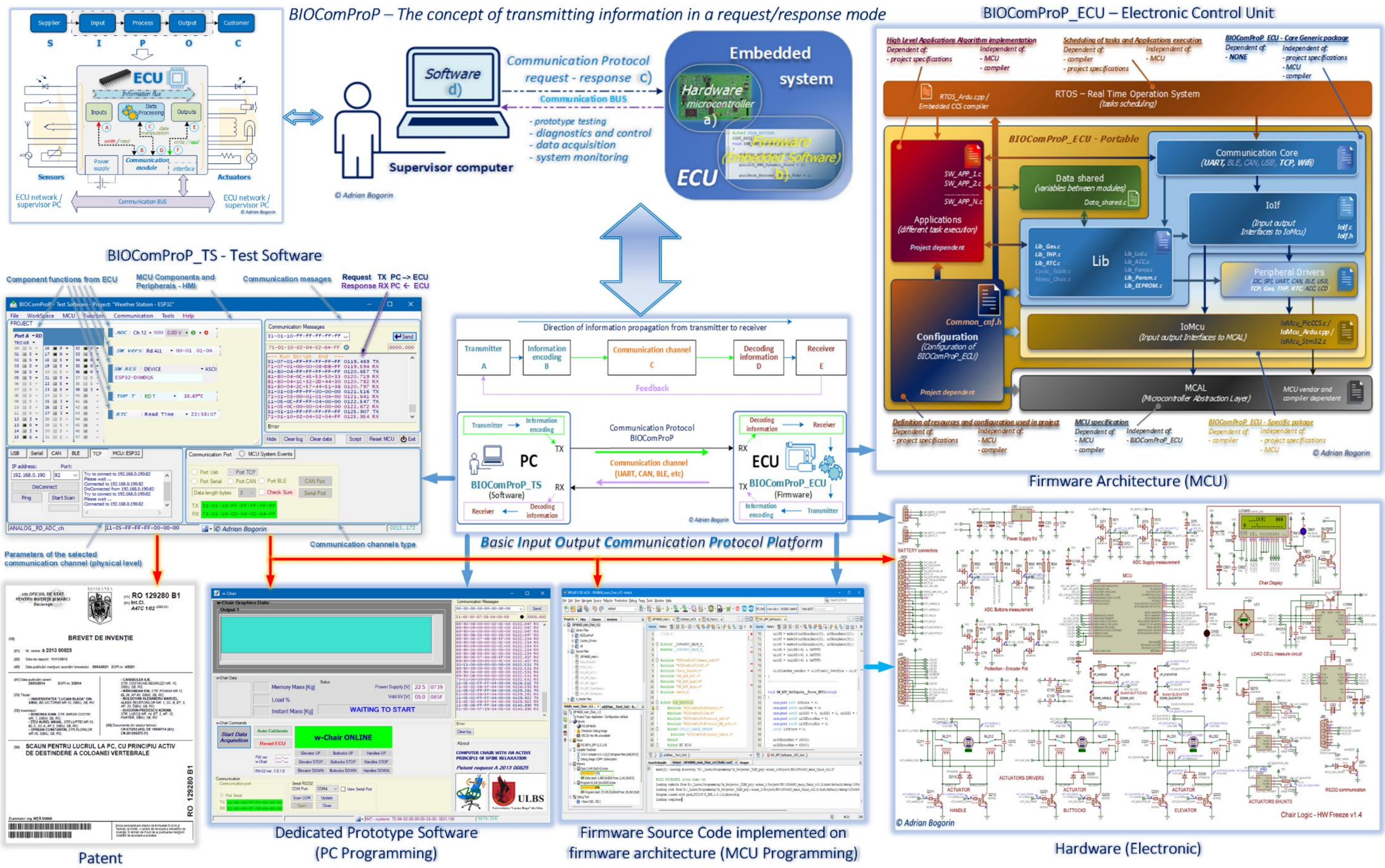

Fig. 10.1 Overview of the BIOComProP integrated platform, dedicated to the innovation environment (Personal contribution)

The central element of Figure 10.1 is the BIOComProP platform “Basic Input Output Communication Protocol Platform”. This representation is in accordance with the “Shannon and Weaver Communication Theory” which specifies the direction and processes of information propagation from the transmitter to the receiver. This theory is then applied to the communication processes between a computer (PC) and an embedded system (ECU).

The “Firmware Architecture” for the MCU, called the BIOComProP_ECU platform, the architecture according to which the source code of the microcontroller is implemented, is in the upper right part of Figure 10.1. It is detached from the central element, the BIOComProP platform on its right side, in the ECU area.

The “Hardware”, the electronics, is also detached from the ECU area, and constitutes the material part from which the ECU is built.

Also from the ECU area, the Firmware part is detached. This is in fact the source code that is implemented according to the BIOComProP_ECU architecture and will run in the MCU microcontroller in the hardware that forms the ECU. From figure 10.1, the connection between the image representing the firmware part and the image with the electronic circuit diagram representing the hardware part, located in the lower right area of the figure, can be seen.

The software application dedicated to the prototype is in the lower left part of Figure 10.1. It is in the PC area of the central image of the BIOComProP platform. This application is specifically built for the functional prototype and incorporates its functionalities for remote control and telemetry data collection.

...

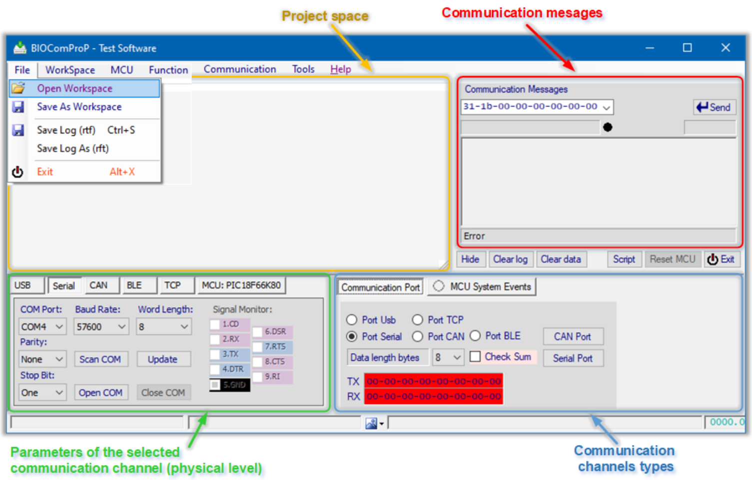

Fig. 10.2 BIOComProP_TS - Basic graphical interface (Personal contribution)

The graphical interface in figure 10.2 is divided into four distinct areas marked by different colors.:

1) Communication channel selection area. Here you choose the communication channel on which communication with the ECU will take place. **...** ;
2) Communication traffic area. All communication messages that take place on the previously selected communication channel to and from the ECU are recorded here. **...** ;
3) Area of parameters specific to each communication channel;
4) The project area is the most intensively used and is populated with "control objects" of the microcontroller in the ECU.**...** .

...

The "Workspace" working mode within the BIOComProP_TS integrated system has the role of keeping all the software "tools" together, to accelerate the process of developing and implementing prototypes.

10.4 Contributions to improving the quality management of the communications process for the first chosen patent using the BIOComProP IT platform

10.4.1 Presentation of the patent chosen for analysis

"*Hydroelectric turbine with deformable blades*" is a modern invention for capturing hydraulic energy. The Invention Patent number RO128224-B1, entitled "Hydroelectric turbine with deformable blades", proposes an ingenious solution to efficiently capture hydraulic energy, even in low-speed water currents. Unlike traditional turbines with rigid blades, this turbine uses a system of flexible blades that can change their shape, dynamically adapting to water flow conditions (România Patent No. 128224-B1, 2018). The invention refers to a floating construction that can be easily transported and, being placed on a nearby stream, anchored to the banks, produces electricity for the needs of a house, the construction being carried out at affordable costs compared to those for windmills and solar panels currently used for individual households.

...

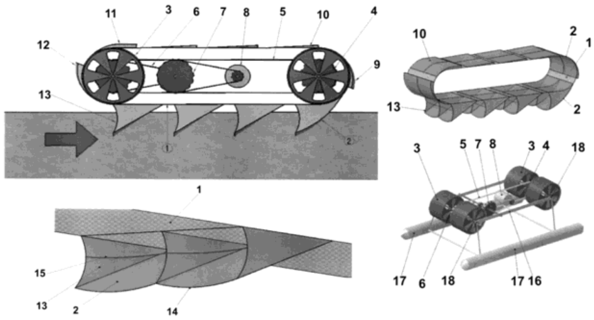

Fig. 10.14 Constructive elements of the prototype from patent RO128224-B1 (România Patent No. 128224-B1, 2018)

In figure 10.14, the elements of BI RO128224-B1 are identified. The proposed device consists of a portable hydroelectric turbine, equipped with deformable blades, intended to harness the kinetic energy of water currents for the generation of electricity.

...

Given that the optimal operation of the system requires additional measurements and experiments, the aim is to identify and record the relevant parameters, which will subsequently be converted into electrical and digital signals, transmitted remotely. The need for remote data transmission derives from the limitations of the constructive structure, which is small and unable to support the weight of a human operator. Thus, direct intervention would be conditional on entering the water or bringing the system to the shore, which would generate periods of downtime and affect the continuity of the experiment.

...

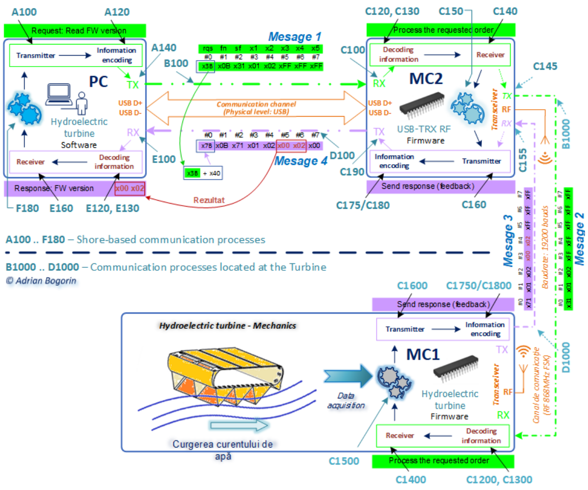

Fig. 10.18 Communication processes conducted during data acquisition (Personal contribution)

10.4.2 Contributions and results achieved

...

The communication between the computer and MC2, as well as between MC2 and MC1, complies with the specifications of the BIOComProP communication protocol. The data exchange between the computer and MC2, then between MC2 and MC1 complies with the communication processes described in figure 7.10. **...**

Figure 10.18 is similar to the communication processes described by the same authors of the Patent “Hydroelectric turbine with deformable blades” (România Brevet nr. 128224-B1, 2018), published in (Țîțu & Bogorin-Predescu, Communication management for the acquisition of data between the pc and a device called the hydroelectric turbine deployed linearly on the course of flowing water, 2024) for the prototype of the Patent of Invention "Hydroelectric turbine deployed linearly on the line of flowing waters" (România Brevet nr. 127219-B1, 2017).

From the perspective of communication processes, the main difference between the two mentioned patents lies in the size of the data packets circulated between MC1 and MC2: for the associated functional prototype BI RO127219-B1, they were structured on 5 bytes, while for BI RO128224-B1 they are organized on 8 bytes.

Fig. 10.24 Functional tests on water (Bogorin-Predescu, Țîțu, & Țîțu, Data acquisition system for a hydroelectric turbine with deformable blades, 2024)

The data acquisition system for BI RO127219-B1, named "Hydroelectric turbine deployed linearly on the stream of flowing water", was extensively detailed by the same authors of the invention patent in (Bogorin-Predescu A. , Țîțu, Țîțu, & Nabiałek, Data acquisition system for a hydroelectric turbine located linearly on the course of flowing water, 2025).

...

Figure 10.24 shows the functional prototype of BI RO128224-B1, "Hydroelectric turbine with deformable blades", during functional testing on the “Sadului River”.

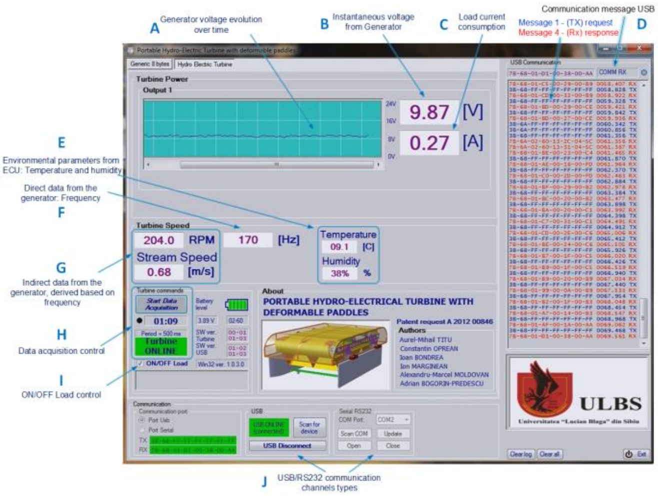

Fig. 10.25 The software (Graphical Interface) dedicated to the functional prototype implementing BI RO128224-B1 (internal documentation RO128224-B1, (Bogorin-Predescu, Țîțu, & Țîțu, Data acquisition system for a hydroelectric turbine with deformable blades, 2024))

The testing included the entire acquisition system, from the turbine to the computer, and as a consumption element, an LED projector with a nominal power of 10W was used.

The graphical interface of the software application running on the computer is illustrated in Figure 10.25.

The graphical interface is developed based on the libraries and software modules integrated into the BIOComProP_TS platform. The communication part, which includes the processes described in figures 7.12 and 7.13, is implemented within the BIOComProP_TS graphical interface and integrated into the software represented in figure 10.25, dedicated to the functional prototype.

The information that is displayed on the graphical interface is divided into two groups:

- Directly, based on measured values based on electrical parameters from the turbine and the state of the MC1 system:
  - o The electrical output voltage from the generator;
  - o Three-phase generator frequency;
  - o The electrical output current from the generator, depending on the consumers powered;
  - o The temperature in MC1, in this case, is 9.1°C;
  - o The humidity in MC1, in this case, is 38%;
  - o Battery status, in this case the voltage at the battery terminals in MC1 is 3.89V.
- Indirect, based on measuring the frequency from the generator:
  - o Generator shaft rotation speed, based on the generator frequency;
  - o river flow speed.

...

BI RO127219-B1 *"Hydroelectric turbine deployed linearly along the flowing water"*
BI RO128224-B1 *"Hydroelectric turbine with deformable blades"*

Fig. 10.31 Patents RO127219-B1 and RO128224-B1, for hydroelectric turbines ((România Brevet nr. 127219-B1, 2017) (România Brevet nr. 128224-B1, 2018))

Experimental tests conducted on the "Sadului River" confirmed the viability of the proposed solution, highlighting the turbine's ability to generate electricity autonomously, even in low flow conditions. Thus, the functional prototype contributes to the development of sustainable technologies to produce green energy in isolated areas with limited access to conventional networks.

Figure 10.31 shows the Patents RO127219-B1 "*Hydroelectric turbine deployed linearly on the line of flowing water*" granted in 2017 and RO128224-B1 "*Hydroelectric turbine with deformable blades*" which was granted in 2018 by the State Office for Inventions and Trademarks (OSIM).

10.5 Contributions to improving the quality management of the communications process for the second chosen patent using the BIOComProP IT platform

10.5.1 Presentation of the second patent chosen for analysis

Invention "Chair for working at a PC, with active principle of relaxing the spine" with number RO129280-B1 (România Patent No. 129280-B1, 2021) refers to a chair designed for people who spend long periods of time working at a computer, designed to counteract the harmful effects of continuous compression of the spine. Compared to bureaucratic adjustable chairs on wheels, which maintain the spine in a pronounced vertical position and generate permanent pressure on the intervertebral discs, and unlike existing ergonomic chairs, which provide postural comfort but do not combat pre-existing decompressive effects, the new solution allows for the controlled interruption of gravitational compression on the spine through short sequences of elongation, placed voluntarily during use of the chair.

Fig. 10.33 The functional prototype al BI RO129280-B1 *(BI RO129280-B1)*

...

Figure 10.33 shows the functional prototype in the workshop area (a) and in the office area (b).

The system is provided for protection in case of accidental falling asleep with an electronic module that can detect lack of movement and automatically stop the elongation after a programmed interval. Micro-climate for the foot area completes the physical comfort experience.

...

Claims 1, 2, and 3 have been implemented in the functional prototype shown in Figure 10.33.

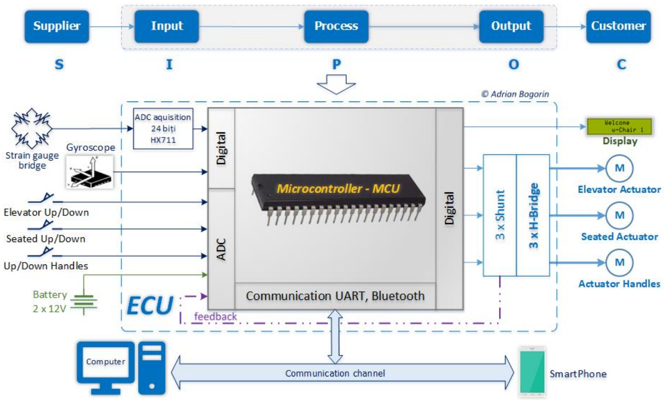

Fig. 10.34 The components of the functional prototype from the SIPOC perspective for ECU (Personal contribution)

10.5.2 Contributions and results achieved

Figure 10.34 shows the block diagram of the components connected to the ECU, which constitute the core of the functional prototype of BI RO129280-B1.

Compared to Figure 9.6, the new diagram highlights the electronic and electromechanical elements from the perspective of the SIPOC methodology. Thus, the structure of the electronic system associated with the ECU can be described as follows:

- *Suppliers*: transmit information regarding the environment to the ECU**...** ;
- *Inputs*: 24-bit precision ADC converter, used as an instrumentation amplifier to take signals from the strain gauge bridge;
- *Processing*: performed by the Microchip PIC18F46K80 microcontroller, which interprets the signals coming from the interfaces connected to the ECU, makes decisions and generates commands to the output elements;
- *Output* **...** ;
- *Customer* **...** ;

...

Each actuator is equipped with a current sensor that monitors the level of mechanical load during operation. **A safety measure** has been implemented in the microcontroller firmware for the “Handle” actuator, responsible for operating the levers intended for spinal relaxation. Since excessive lifting force could compromise the therapeutic process, the system detects overcurrent consumption and automatically blocks the action when the safety threshold is exceeded.

...

The operating algorithm of the input circuits corresponding to the six buttons was previously detailed in Figures 9.19, 9.20 and 9.21, Tables 9.1 and 9.2, as well as in the specialized literature (Țîțu A. M., Bogorin-Predescu A., Bogorin-Predescu O., & Țîțu Ș., 2023) developed by the authors of the same patent.

...

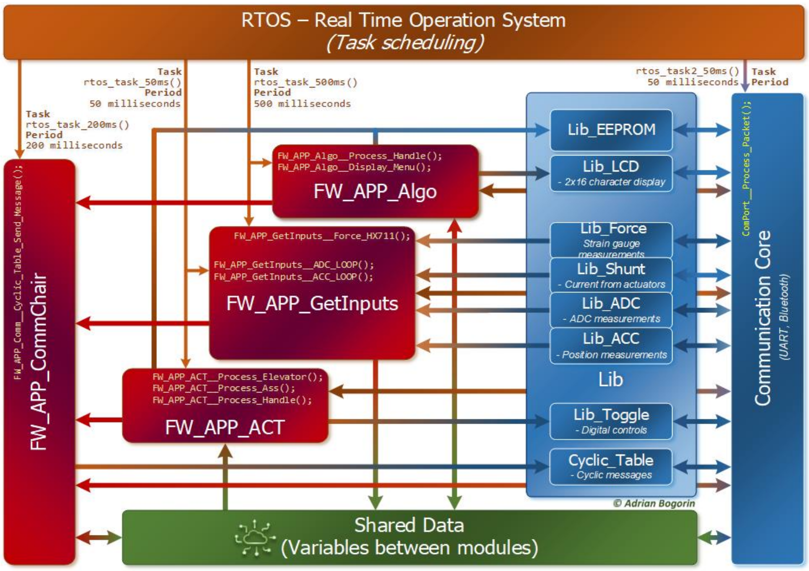

Fig. 10.36 BIOComProP_ECU platform integrated into the prototype's Firmware architecture (Personal contribution)

The firmware installed on the MCU microcontroller, illustrated in figure 10.34 (and implicitly in figures 9.17 and 9.18), is developed on the BIOComProP_ECU platform. Its architecture, related to the associated functional prototype BI RO129280-B1, is presented in figure 10.36.

The firmware implementation was done in the MPLAB X (Microchip) integrated development environment, using the PICC (CCS) compiler. It integrates four software applications independent of the microcontroller type, but dependent on the specifics of the project. For the functional prototype BI 129280/2021, the applications are as follows:

- ”FW_APP_GetInputs”;
- ”FW_APP_ACT”;
- ”FW_APP_Algo”;
- ”FW_APP_CommChair”.

In figure 10.36, the first three applications are arranged diagonally, while “FW_APP_CommChair” occupies a distinct position, as it manages communication through messages generated by the internal events of each software application.

...

In the case of the two prototypes of hydroelectric turbines, the classic request-response communication mechanism was used, with the disadvantage of periodic data requests. In contrast, for the chair prototypes, an innovative mechanism for cyclic information transmission was developed in the BIOComProP platform, reducing the traffic on the communication channel by half. This is achieved through the “Cyclic_Table” module implemented in the ECU and the corresponding visual object “Cyclic Data” in the BIOComProP_TS interface, capable of configuring, displaying in real time, and exporting data in Excel format (fig. 10.38).

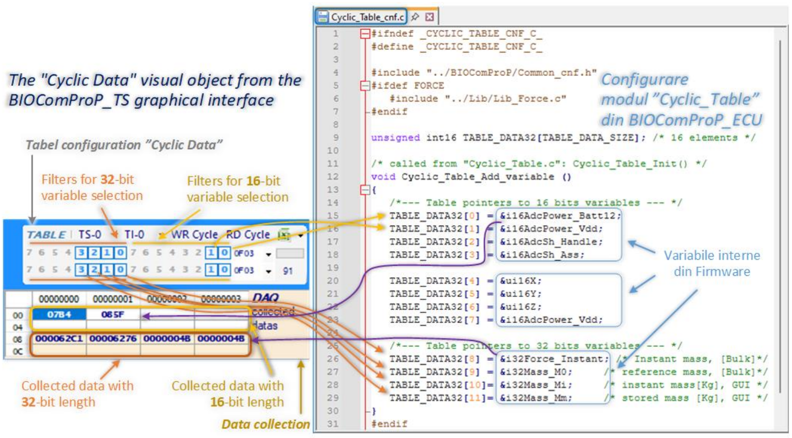

Fig. 10.38 Configuring the “Cyclic_Table” mode from the “Cyclic Data” visual object (Personal contribution)

On the right side of Figure 10.38, at line 9, a 16-element array “TABLE_DATA32” is defined. This array contains memory addresses where various variables (internal firmware data) used to read values from sensors, supply voltages, system variables are stored. The first 8 positions in “TABLE_DATA32” are reserved for 16-bit structured data types, and the next 8 positions are for 32-bit structured data.

...

Figure 10.40 shows the graphs of the variations in force, supply voltage and shunt current consumption from the seat actuator, depending on the actuations of the control buttons for seat movement.

The four graphs, shown in figure 10.40, were built ***solely*** *based on data collected through the "Cycle_Table" module from the seat ECU and through the "Cyclic Data" graphic object from the BIOComProP_TS software application.*

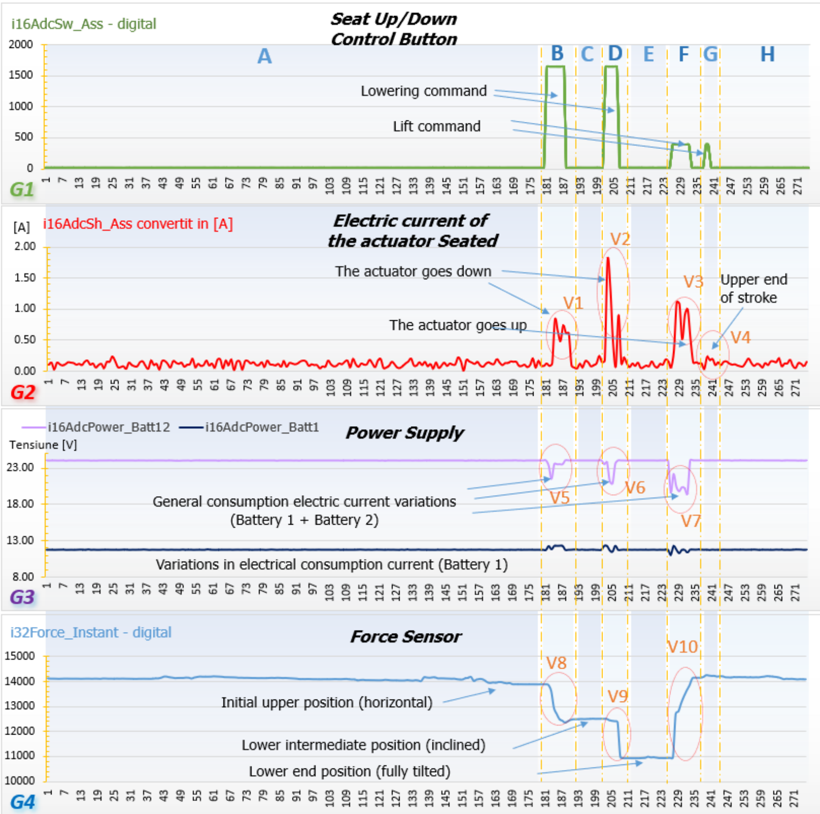

Fig. 10.40 Variation of force, supply voltage and consumption current depending on the seat movement command (Personal contribution)

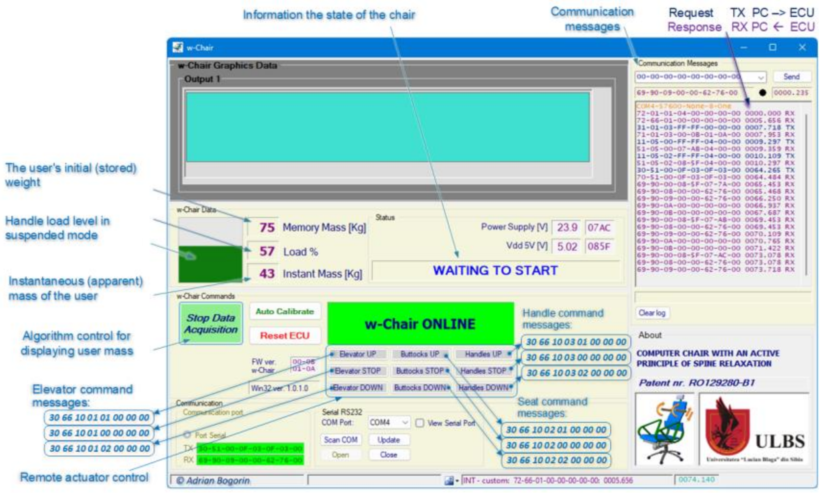

Fig. 10.41 Graphical interface with actuator movement commands (Personal contribution)

Each curve in the graph consists of 271 points, values acquired by telemetry from the ECU. Graphs 1, 2 and 4 contain one curve each, and the third graph consists of two curves, one for the 24 V voltage and the other for the 12 V voltage. All four graphs are temporally synchronized horizontally.

...

Of the 8 internal variables acquired cyclically from the ECU in table 10.11, 5 were used. The data collected in the visual object "Cyclic Data" were exported in excel format, and from there the 4 graphs presented in figure 10.40 were built.

Figure 10.41 shows the graphical interface together with the commands for the control buttons for the three types of chair movements: lift up/down, seat lowered/raised, handles lowered/raised. These are in the central part of the graphical interface, in the "w-Chair Commands" section. The commands associated with the remote actuator control buttons are described in Table 10.7, in column 4 with rows 1, 3, 5, 7, 9, 11, 13, 15 and 17. The "Stop Data Acquisition" button activates or deactivates the cyclic messages presented in the previous algorithm and in Table 10.11.

Based on the information collected from the cyclic messages (internal variables in the firmware), it refreshes the chair status displayed in the upper section of the graphical interface, in "w-Chair Data". Here are indicated the instantaneous mass of the user, the degree of loading of the handles that suspend the human body, and the mass memorized before the start of the treatment by hanging the human body from the handles.

...

In figure 10.43, the user is in the seated position on the chair, in the mode of suspending the body from the handles in the backrest. The screen in the lower area of the figure displays information about the initial mass of the user memorized in advance, in this case being 82 Kg. When the user activates the button to raise the handles, they suspend the human body according to the user's voluntary will.

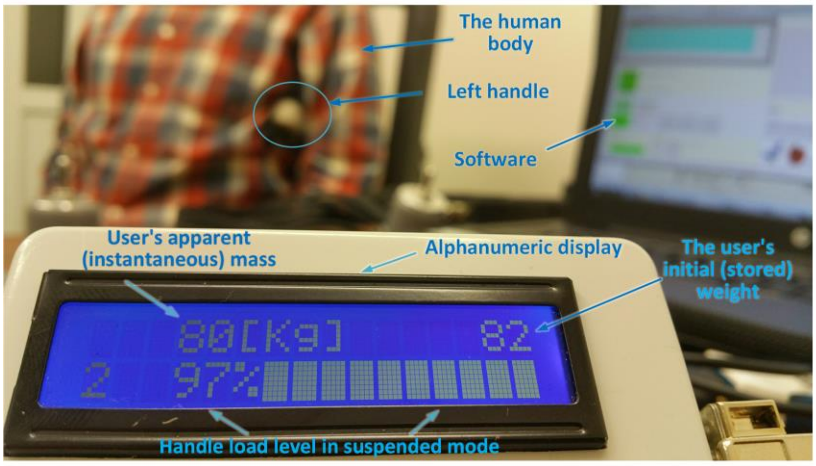

Fig. 10.43 Functional testing at the functional prototype level (Țîțu A. M., Bogorin-Predescu A., Bogorin-Predescu O., & Țîțu Ș., 2023)

After operating the handles in lifting mode, the apparent user mass detected by the seat force sensor becomes 80 Kg, because part of his mass is supported by the handles.

The chair does not automatically operate the handles to suspend the human body. Rather, it is an actuation controlled exclusively by the human user, and the ECU calculates and displays information regarding its mass and then the calculated trunk suspension force, converted into kilograms of force.

The chair assists the user in the process of suspending the human body to lengthen the spine.

...

The functional prototype was highly appreciated at international invention shows by the jury and visitors, and in 2018, being exhibited at the "EUROINVENT 2018" event, the "Lucian Blaga" University of Sibiu won the grand prize with this achievement. **....**

The invention patent was granted by the State Office for Inventions and Trademarks (OSIM) in 2021.

10.6 Contributions to improving the quality management of the communications process for a testing system using the BIOComProP platform with applicability in the automotive industry

...

Figure 10.45 illustrates the traditional workflow associated with developing new functionality or correcting a bug in embedded software.

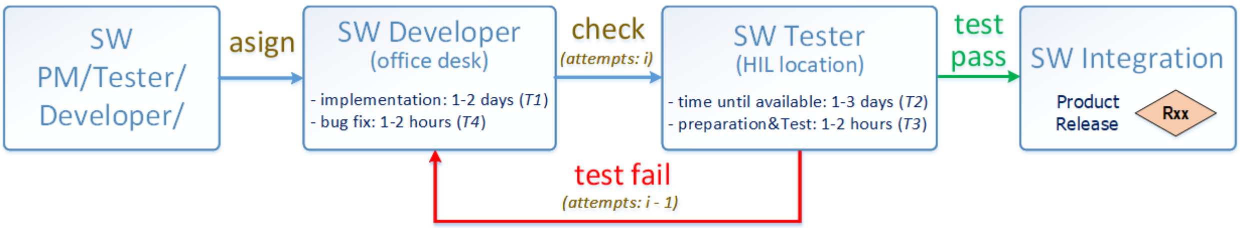

Fig. 10.45 Traditional workflow for implementing/developing/fixing a bug for embedded software (Personal contribution)

...

For the embedded software developer, a new implementation usually requires an average of 1 to 2 days. The SW Tester engineer checks the firmware implementations on the Hardware-in-the-Loop (HIL) test system. HIL testing involves connecting the ECU to a test system that simulates the operation of an assembled product under real conditions.

...

The duration of access to the HIL can vary from one day to several days in such cases. If the tested firmware does not comply, it must be returned to the developer for bug fixes, which can take several hours, followed by several days until the HIL equipment is accessible again.

Consequently, during each deployment/testing cycle, several days are wasted waiting for the HIL to be available.

If the FW evaluated on the HIL does not meet the criteria it must meet, the test engineer returns the FW to the software developer to fix the non-conformities. Fixing them takes several hours, and then the FW is delivered back to the test engineer to check it on the HIL. These implementation-test (fail)-fix attempts are denoted in Figure 10.45 as “attempts: i”, where “i” represents the number of iterations needed to implement-fix the FW until it meets the requirements.

...

The times depicted in Figure 10.45 are:

- T1: implementation/development time of a task by the SW developer. **...** ;
- T2: the wasted time waiting for the HIL test system to be available for the test engineer to access. **...** ;
- T3: time required for testing the FW by the software test engineer. **...**

...

To reduce the number of iterations "i" in the testing part of the FW, a change to the process is proposed in Figure 10.46, in which the software developer personally verifies the minimum functionality of the implementations.

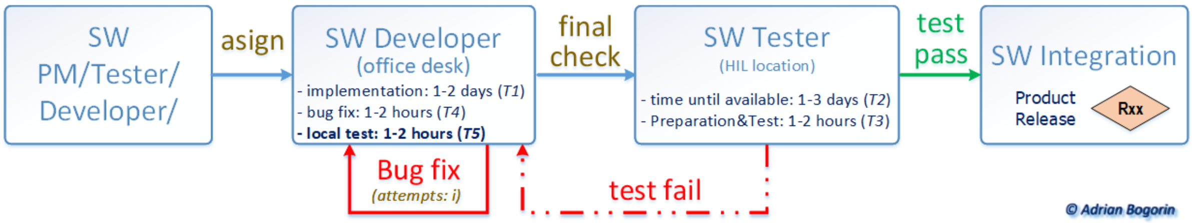

Fig. 10.46 Optimized process for implementing/developing a task (personal contribution)

Thus, the number of iterations "i" moves from the HIL (hard-to-reach equipment) to the FW/SW developer, in a specially designed place equipped with equipment for the bare necessities called a *test bench*.

...

To understand the differences between the two workflow strategies illustrated in Figures 10.45 and 10.46, the example provided in Table 10.12 is essential.

...

Tab. 10.12 Traditional workflow vs. optimized workflow

Task responsible	**Activity SW [ore]**	**Traditional workflow [hours]**	**Optimized workflow [hours]**
SW developer (**T1**)	Implementation time	2 days = 16 hours	2 days = 16 hours
SW tester (**T2+T3**)	Waiting + testing time	3 days + 2 h = 26 hours	3 days + 2h = 26 hours
Trials (**i**)	-	5	5
SW developer (**T4**)	Fix time	2 hours	2 hours
SW developer (**T5**)	Testing time	-	1 hours
Calculation formula	-	T1 + i x (T2+T3) + (i-1) x T4	T1 + i x (T4+T5) + (T2+T3)
Total number of hours	-	**154 hours**	**57** hours

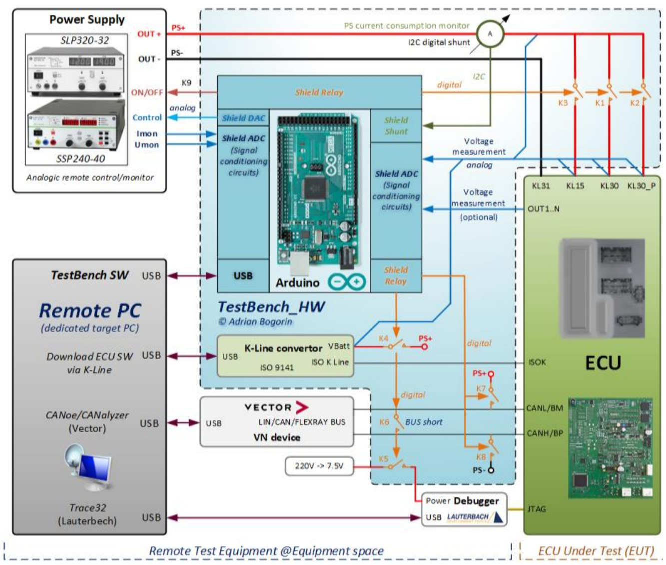

Fig. 10.49 Block diagram of the TestBench remote testing system (Personal contribution)

It is found that, in the case of five successive iterations of firmware remediation by the developer, following the traditional workflow, the maximum duration required to complete the task reaches 154 hours. In contrast, applying an optimized, “hybrid” workflow leads, for the same number of iterations, to a significant reduction in the total time, which is only 57 hours.

...

The proposed embedded system, called TestBench, manages in a controlled manner all the equipment on the test bench accessible to the embedded software developer.

...

The block diagram of the TestBench test system is presented in Figure 10.49.

The central core of the TestBench system is the Arduino Mega2560 board, equipped with the 8-bit ATmega2560 microcontroller from Microchip, operating at a frequency of 16 MHz. Figure 10.49 shows the block diagram of the TestBench, which coordinates four types of additional electronic modules: the “Shunt Module”, the “DAC Module” (Digital-to-Analog Converter), the “Relay Module” and the “ADC Module”, together with the analog signal conditioning circuits. The first three modules are low-cost, commercial electronic assemblies available on the market from several electronic component manufacturers, while the signal conditioning circuit was designed and built specifically for this application. The ADC module is directly integrated into the microcontroller.

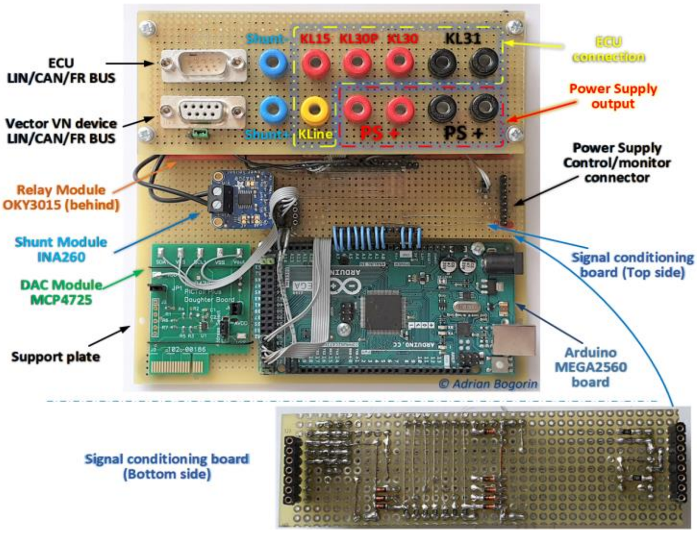

Fig. 10.52 TestBench - hardware prototype (Personal contribution)

...

Figure 10.52 shows the TestBench in the prototype phase. To hold everything together, on a PCB (backplane), the Arduino Mega2560 board, the DAC module, the signal conditioning board, and the relay module were mounted.

Above the relay module, a board was mounted in which the connectors that ensure the connection with the voltage source, ECU and the "Vector VN" equipment were added. On the signal conditioning board, the shunt module and the connector for controlling and monitoring the Power Supply were mounted (Bogorin-Predescu A. , et al., Innovative Cost-Effective Embedded System to Enhance ECU Firmware Quality Through Remote Hybrid Testing in Automotive Domain, 2025).

At the beginning of the TestBench project, it was intended to be flexible, easily expandable, and modular. In this sense, the Arduino Mega2560 board was used, which was designed by the Arduino community with the idea of being compatible with the concept of rapid prototyping. Arduino is an accessible and intuitive electronic platform, intended for both professionals and enthusiasts, which facilitates the rapid development of interactive electronic prototypes and experiments. Arduino-compatible modules, such as the relay, shunt, and DAC module, are inexpensive, and additional components are easy to find and replace, which makes project development more affordable.

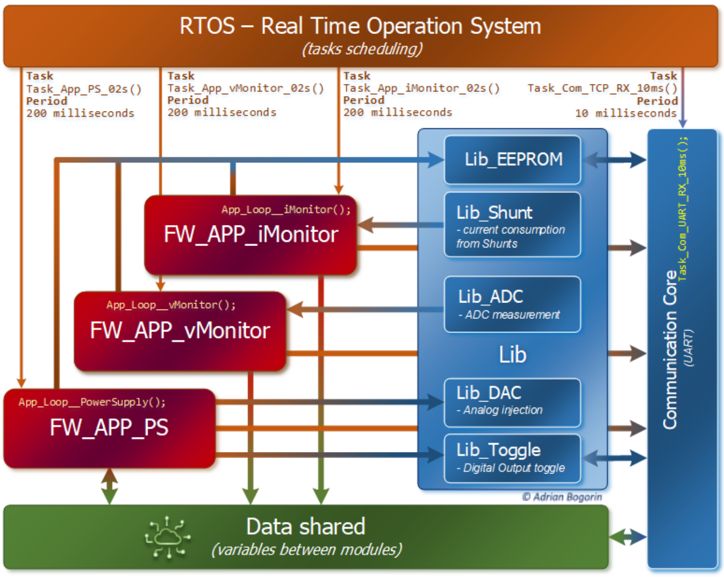

Fig. 10.55 Firmware architecture of the TestBench test system (Personal contribution)

...

Like any smart product equipped with a microcontroller, it operates based on a software program. *To enable the development of the TestBench firmware in a short time frame, using rapid prototyping, the BIOComProP_ECU firmware architecture was adopted.*

Before presenting the TestBench firmware architecture illustrated in figure 10.55, it is necessary to define the requirements that the mini-test system must meet.

The primary function that the TestBench must fulfill is to operate the switches K1 .. K9. Through these switches, the power supply lines are connected to the EUT, the power supply control is managed, faults are injected on the communication bus between the EUT and the VN equipment and the K-Line converter is supervised.

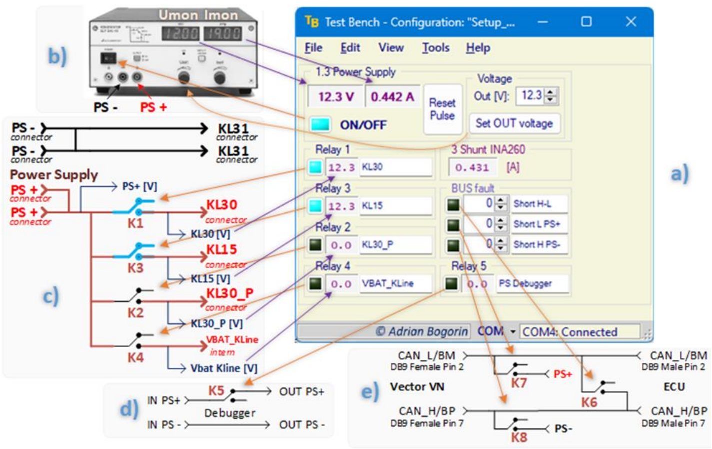

Fig. 10.57 TestBench - Graphical User Interface (Personal contribution)

Another primary function is to measure the voltages at the EUT terminals, obtaining important feedback following the operation of the switches.

...

The graphical interface that controls the TestBench hardware is described in minimal detail in Figure 10.57. In the center of Figure 10.57 (a), the graphical user interface (GUI) serves as a visual representation of the switches that facilitate the transmission of electrical signals to the EUT, while simultaneously monitoring the electrical voltages at the EUT terminals.

The GUI functions as a human-machine interface (HMI).

At the top right of the GUI is the Power Supply area that manages the power supply in Figure 10.57 (b). The Set OUT voltage button applies a control voltage through the DAC to the power supply so that the output voltage at the power supply terminals is the same as the value set in the GUI.

...

The link between the TestBench SW application and the TestBench HW equipment is the BIOComProP communication protocol mentioned earlier.

The BIOComProP platform has also been applied in the automotive industry, as a tool, incorporated into the TestBench testing system to help and speed up the testing process of electronic control units. In the first phase, at the prototype level, until the development of the TestBench system stabilized, it was applied in a limited number to workbenches, then it was multiplied in several dozen copies within two segments of the Research and Development Center of the AUMOVIO organization in Sibiu.

...

The TestBench test system is primarily aimed at embedded software developers who are not involved in implementing sensor and actuator software. It is intended for engineers working on the AUTOSAR communication stack ("ComStack").

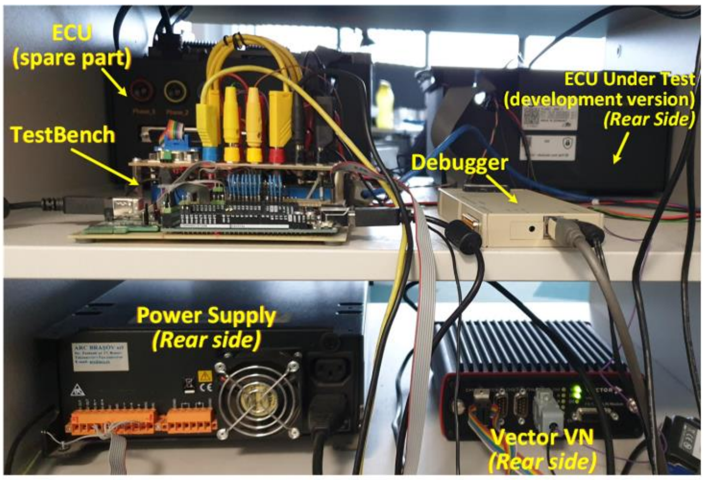

Fig. 10.59 The back side of the TestBench test stand (Personal contribution)

...

The evaluated ECU is not error-free. This is beneficial because it reduces the footprint of the TestBench test system, eliminating the need for sensors and actuators that take up physical space. Figure 10.59 shows a test bench using the TestBench equipment. The test bench is used by developers of embedded software for mechatronic braking systems.

...

Given the "Comstack" team's specialization in firmware implementation from a communication perspective, test benches equipped with the TestBench system do not require the integration of the vehicle's physical sensors and actuators into the EUT. Therefore, it is not imperative to develop a fully equipped Hardware-in-the-Loop (HIL) test system. The main objective is not to achieve an error-free emulation of the entire physical system (i.e., with the hardware fully coupled to the EUT, including sensors and actuators). Instead, the testing process is circumscribed and focused exclusively on the communication discipline. This approach allows for rigorous evaluation of the firmware's communication layer without the complexity and costs associated with full vehicle hardware emulation.

...

The introduction of the TestBench testing system coincided with a significant reduction in the learning curve and time required to develop skills among junior-level personnel. The system facilitated a notable acceleration in the acquisition of the following professional skills by junior engineers:

- ***Analytical Thinking:*** *Improve the ability to evaluate complex systems and diagnose problems.*
- ***Technical Expertise:*** *Strengthen specific knowledge and skills related to firmware architecture and testing processes.*

...

10.7 Conclusions

The BIOComProP IT platform, presented in chapter 10, stands out for its complexity and versatility, being a significant contribution in the field of embedded systems, with direct applicability in the automotive industry and in the validation of functional prototypes related to invention patents.

...

"*Hydroelectric turbine with deformable blades*" is a concrete example of a functional prototype of a patent, in which the BIOComProP platform was used to achieve communication between the computer and the turbine located on the river. Communication is achieved through an intermediate microcomputer, MC2, which receives requests from the graphical interface and transmits them to MC1, located on the turbine. The parameters acquired from the turbine include voltage, current, generator frequency, temperature, and humidity in the ECU housing, as well as the battery level. The data acquisition module operates based on a request-response mechanism, in which the computer initiates the request, and the turbine responds with the corresponding data, transmitted through messages structured on 8 bytes. This data is then exported in Excel format, facilitating numerical and graphical analysis of the system's performance.

"*PC chair with active spine relaxation principle*" is another functional prototype validated through the BIOComProP platform. Unlike the hydroelectric turbine, this system integrates digital commands for controlling the actuators, which adjust the position of the seat, handles and lift. The electronic part of the chair is presented from the perspective of the SIPOC methodology, highlighting the flow of information from sensors and buttons to the microcontroller and actuators. The firmware is built on the BIOComProP_ECU architecture, using dedicated software applications for data acquisition, algorithmic processing, and output control.

...

TestBench, developed as a test system for ECUs, was born from the need to optimize the development, implementation, repair, and testing time of embedded software in the automotive industry. The comparative study conducted between the traditional and the optimized hybrid workflow highlighted the significant advantages of introducing a test system directly accessible to firmware developers. In the optimized workflow, the developer can evaluate the implementations locally, reducing the number of iterations on HIL equipment and considerably shortening the total duration of the validation process.

The TestBench was built starting from a conceptual block diagram, followed by the creation of a detailed electronic scheme and a graphical user interface. The firmware of the test system is also developed on the BIOComProP_ECU architecture, integrating modules for power supply control, voltage and current measurement, fault injection on the communication bus and saving state parameters in EEPROM. After the prototype phase, the TestBench was produced in mini-series, being implemented in dozens of test benches within the organization, with international expansion.

...

For younger colleagues, TestBench offers the opportunity to gain an in-depth understanding of the firmware architecture, communication mechanisms, power supply interaction, and monitoring and control processes of an ECU. Using the intuitive graphical interface and real-time visual feedback, they can directly observe the effects of sent commands, analyze system behavior in different scenarios, and learn to diagnose and fix errors in a systematic way. In addition, integration with the BIOComProP_ECU platform allows them to familiarize themselves with a standardized architecture used in real projects, which contributes to the formation of analytical thinking and the development of solid technical expertise.

For *learning organizations*, TestBench is a catalyst for operational efficiency and knowledge transfer. By *reducing reliance on HIL equipment* and facilitating local testing, it optimizes resources, shortens development times, and creates a collaborative environment where engineers can work iteratively, quickly validate hypotheses, and document results in a reproducible manner. Furthermore, by extending TestBench’s use across international teams, including outside of local working hours, it maximizes test bench availability and promotes an *organizational culture based on autonomy, accountability, and continuous learning*.

...

In conclusion, Chapter 10 demonstrates the broad applicability of the BIOComProP platform in the development, testing and validation of embedded systems, both in the context of patents and in the automotive industry. By integrating the graphical interface, the "workspace" structure, the firmware architecture, and the advanced communication mechanisms, BIOComProP provides a robust and efficient framework for the creation of functional prototypes and modern test systems, contributing to increasing product quality and protecting intellectual property.

11. FINAL CONCLUSIONS, ORIGINAL CONTRIBUTIONS AND FURTHER RESEARCH DIRECTIONS

11.1 Final conclusions

The research has addressed the issue of quality management of the communication process in embedded systems for the mechatronic and automotive fields in an integrated manner, from theoretical foundations and current status to the development of its own platform – BIOComProP (“Basic Input Output Communication Protocol Platform”) – and its validation through functional prototypes and a dedicated test bench (TestBench). The platform connects a PC to an ECU through an application-level protocol and asynchronous transmission/reception processes, inspired by the Shannon–Weaver model and adapted to the physical channels used (UART, CAN, BLE). This integration is presented in layers, from the theoretical model to the concrete implementation (PC–ECU), with encoding/decoding in BIOComProP_TS (PC - Calculator) and BIOComProP_ECU (ECU – “Electronic Control Unit”), for interoperability and traceability.

...

The bibliometric analysis, from the first part of the scientific research, confirmed that the research direction is aligned with the leading literature: terms such as "*quality management*", "*firmware platform*", "*embedded systems*" and "*communication protocol*" appear with high frequencies and consistent links in the WOS platform, which validates the orientation towards portable firmware platforms, IoT connectivity and communication security. This diagnosis supports the standardization of the PC–ECU language, modularity and portability promoted in BIOComProP.

From an architectural perspective, an important contribution is the adoption of an asynchronous communication model. Instead of a blocking “request-response” chain, the reception of messages from the ECU is decoupled from the transmission of commands from the PC, which increases the application’s resilience to delays or lack of response from the ECU, prevents blocking of the graphical interface, and allows concurrent processing. This technical choice – together with logging and a clear separation of roles between the PC and the ECU – has allowed the development of robust, quality-oriented flows, both in prototyping and in post-release support.

...

The V-model represented the methodological foundation for the development of the functional prototype, being adapted to the specifics of mechatronic systems. The process began with the definition of product requirements and specifications, followed by the design at the system, module, and component level. The left side of the model covered the analysis and design phases, and the right side ensured the verification and validation corresponding to each stage. Thus, the design and simulation of the components were confirmed by prototyping and testing, and the complete product concept was validated by evaluating the final prototype.

This approach allowed complete traceability between requirements, design, and testing, reducing the risk of errors and ensuring compliance with quality standards. In addition, the integration of the BIOComProP platform facilitated the completion of the V-model stages in a unified environment, providing tools for simulation, control, and documentation. The result was a coherent development flow, with significant savings in time and resources, confirming the efficiency of the V-model in complex projects in the automotive and mechatronic industries.

The applied part of the scientific research illustrated the methodological transfer to real prototypes. For the patent “Hydroelectric turbine with deformable blades” (RO128224-B1) a distributed acquisition system was created, with a mobile ECU (MC1) on the watercourse and a stationary ECU (MC2) on the bank, communicating by radio in “half-duplex” through 8-byte packets, so that the PC could view in real time the voltage/frequency of the generator, the current through the loads, the temperature/humidity in MC1 and the battery status. Derived indicators were also implemented (generator rotation speed, river flow speed), and the graphical interface was structured into thematic areas (commands, instantaneous values, message history).

The patent RO129280-B1, entitled "Chair for working at a PC, with active principle of spinal relaxation", was implemented through an integrated mechatronic prototype. The purpose of the invention is to reduce the negative effects of spinal compression during prolonged computer work, by introducing controlled sequences of spinal elongation.

The prototype includes an ergonomic assembly, electromechanical actuators for adjusting the seat position and the folding levers, as well as a microcontroller-based electronic module that manages the seat movements. The system is completed by sensors for monitoring force and position, actuator drivers and dedicated software that allows local or remote control.

...

To accelerate development and diagnostic activities in the automotive industry, a modular test bench ("TestBench") was created, built around a rapid prototyping hardware system (Arduino Mega2560) and extended with various modular circuits for controlling the source voltage and measuring the current. The scheme includes resistive dividers for adapting the voltages to the ADC channels, control lines and relays for the purpose of injecting errors for the ECU under test. This solution is flexible, extensible, and low-cost, facilitating rapid testing of the EUT and integration with communication tools.

...

The comparative study on the hybrid workflow for firmware development showed a substantial reduction in the duration on iterative scenarios (from 154 hours to 57 hours for 5 iterations). The benefit becomes even more pronounced as the number of iterations increases, which reflects the reality of embedded systems in the automotive industry.

In conclusion, the approach demonstrated that a rigorous, standardized, and secure management of the communications process – treated as a quality objective – produces concrete effects: reduction of development time, increase of traceability, acceleration of diagnostics and rapid validation of prototypes. The BIOComProP platform is transferable between microcontroller families and projects and can become the core of a "digital factory" for prototyping and testing for mechatronic systems.

11.2 Original contributions

Original contributions derived from scientific research are:

- **The concept of a holistic embedded system.** The contribution consists in treating communication as an integrative function of quality, with a transversal role on hardware architecture, firmware, software tools and test/diagnostic methodology. **...** ;
- **BIOComProP Platform.** The platform defines a complete framework for PC–ECU: **BIOComProP_ECU** (firmware), **BIOComProP_TS** (computer test software) and a communication protocol. **...** ;
- **BIOComProP communication protocol.** An application protocol was designed with compact 8-byte packets, with clear meaning at the byte level, with confirmation/error codes and security mechanisms ("seed" generated by the ECU, key derived through XOR and circular rotations, blocking after multiple attempts). **...** ;
- **BIOComProP_ECU firmware architecture and BIOComProP_ECU infrastructure.** The architecture includes: "*Communication Core*", Libraries ("*Lib*"), "*Shared Data*" for inter-modular exchange, "*IoMcu*" and specific drivers, plus a periodic task "*Task_Com_XXX_RX_10ms*" coordinated by RTOS/super-loop. Requirements for compatibility (ANSI C/C++), for various compilers (CCS, MPLAB X, GCC) and MCU families (8/16/32 bits) were defined, which allowed for rapid replication of solutions between the projects addressed;
- **Integrated software platform BIOComProP_TS.** The graphical interface (designed in C#) brings together in a "Workspace" all the tools and artifacts used for the *holistic development* of projects/prototypes: protocol XML files (the "language" of messages), MCU description XML files, EEPROM maps, schematic projects (e.g. Proteus), firmware projects (CCS/MPLAB/Arduino), respectively software applications dedicated to prototypes. **...** ;
- **Scalability of the firmware architecture.** *The BIOComProP_ECU architecture* was designed to be completely portable and independent of the hardware platform, which allows easy integration on any microcontroller, regardless of family or compiler. **...** ;
- **- The versatility of the BIOComProP platform.** BIOComProP is not just a communication platform, but an integrated tool that *covers all phases of the V model*: from requirements definition and initial configuration to final testing and validation. In the development phase, BIOComProP_TS provides a unified environment for configuration, monitoring and testing, and BIOComProP_ECU provides a modular, easy-to-parameterize firmware. A major advantage of the *versatility is the rapid porting of*

projects: an existing project can be adapted to new hardware with minimal changes, thanks to the modular structure and the clear separation between generic and specific components.... .

Functional prototypes, the embedded test system TestBench and the IoT Indoor Weather Station are ***applications*** of the BIOComProP platform:

- **First patent:** *"Hydroelectric turbine with deformable blades"* with number RO128224-B1 – floating, easily transportable construction, which transforms the linear movement of water into rotation through a "belt" with deformable pockets, supplying isolated households; the solution targets slow flows, where classic turbines are inefficient. An embedded systems architecture was designed and executed consisting of the MC1 microcomputer (located on the water) and MC2 (located on the shore); MC1 monitors the generator voltage/frequency and transmits the data by radio to MC2, which sends it to the PC. **...** ;
- **The second patent:** "*Chair for working at a PC, with active principle of spinal relaxation*" with the number RO129280-B1 assumed a multidisciplinary approach. The contribution focused on the electronics and software, with emphasis on the integration of the ECU, bidirectional communication, and the development of dedicated applications. The electronic architecture of the control unit (ECU) was created, including circuits for actuators, sensors, and communication interfaces. A modular firmware was also created, which ensures precise control of actuator movements and monitoring of safety parameters. **...** ;
- ***The TestBench* embedded test system** was designed to accelerate development and diagnostic activities in the automotive industry, as an integrated platform for the verification and validation of mechatronic systems, in a holistic way. Its structure includes hardware and software components that allow the simulation, monitoring and remote control of ECUs used in automotive vehicles, providing a complete environment for testing. The project is built around a rapid prototyping hardware system (Arduino Mega2560), extended with dedicated modules for controlling the source voltage, measuring the current and injecting controlled errors into the ECU under test. **...** ;
- Following the creation of the functional prototype of the "TestBench" testing system, the functionality of the signal conditioning board was expanded to cover a larger number of circuit elements. **...** ;
- A comparative study was conducted between the *traditional workflow* and an *optimized hybrid workflow* for ECU testing, to identify the critical points that generate delays in the software development process. The analysis highlighted the fact that, in the classic scenario, the dependence on HIL (Hardware-in-the-Loop) equipment and the long waiting times for their reservation lead to a significant increase in the total testing duration. Within the optimized workflow, it was proposed to move part of the validation activities from the HIL area to a dedicated test bench, located in a space accessible to the developer. **...** ;
- The BIOComProP_ECU architecture was integrated into the Arduino open-source platform for the development of the "Weather station for indoor air quality" application, an IoT (Internet of Things) application. The microcontroller used, ESP32, is part of the 32-bit category, being a controller with high processing power.

11.3 Further research directions

Based on the results obtained, the following future directions can be outlined::

- **Expansion of the BIOComProP platform** to include support for new microcontroller families and communication protocols;
- **Extension of commands related to the BIOComProP communication protocol** for reading program variables from the microcontroller's RAM memory;
- **Integration of OTA (Over-The-Air) functionality for BIOComProP_ECU,** with extended support for software update operations through the BIOComProP_TS platform, thus ensuring a fully automated and secure flow for the maintenance and evolution of mechatronic systems;
- **Complete automation of testing through artificial intelligence algorithms** that detect and correct errors in real time;
- **Integration with IoT and cloud technologies,** for remote monitoring and analysis of data collected from prototypes;
- **Development of educational modules** based on the BIOComProP platform, for the training of engineers in the field of mechatronic systems;
- **Applying the methodology to other fields,** such as medical robotics, industrial equipment or personal assistance devices.

References

1. Abatan, A., Jacks, B. S., Ugwuanyi, E. D., Nwokediegwu, Z. Q., Obaigbena, A., Daraojimba, A. I., & Lottu, O. A. (2024). The Role of Environmental Health and Safety Practices in the Automotive Manufacturing Industry. *Engineering Science &Amp; Technology Journal, 5*(2), 531-542. doi:10.51594/estj.v5i2.830
2. Abdullah, D. A., Khidir, H. A., Maolood, I. Y., Ameen, A. K., Hamad, D. R., Beitolahi, H. S., . . . Shakor, M. Y. (2024). Elevating Information System Performance: A Deep Dive into Quality Metrics. *arXiv*, 22. doi:10.48550/arXiv.2412.18512
3. Adafruit. (2024). *Adafruit INA260 Current + Voltage + Power Sensor Breakout.* Retrieved 12 12, 2024, from https://cdn-learn.adafruit.com/downloads/pdf/adafruit-ina260-current-voltage-power-sensor-breakout.pdf
4. Ahmad, A., Farooq, M. I., Rasool, S., & Farooq, O. (2023). Approaching The Firm's Innovation Capability through Knowledge Management Lens. *Pakistan Journal of Humanities and Social Sciences, 11*(4), 4742-4753.
5. Aji, I. T., & Priyono, A. (2021). The role of equity crowdfunding company as a knowledge broker in supporting the digital transformation of SMEs through knowledge sharing and dissemination process. *Strategic Approach to Business Ecosystem and Organizational Development, 10*(3), 109-122. doi:10.20525/ijrbs.v10i3.1158
6. Alavi, M., & Leidner, D. E. (2001). Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS Quarterly*.
7. Al-Azzam, Z. F., & Al-Qura'an, A. B. (2019). How knowledge management mediates the strategic role of talent management in enhancing customer's satisfaction. *Independent Journal of Management & Production, 10*(2), 334-354. doi:10.14807/ijmp.v10i2.854
8. Alenezi, M. (2021). Deep Dive into Digital Transformation in Higher Education Institutions. *education sciences, 11*(12), 13. doi:10.3390/educsci11120770
9. Al-Tit, A. A., Al-Ayed, S., Alhammadi, A., Hunitie, M., Alsarayreh, A., & Albassam, W. (2022). The Impact of Employee Development Practices on Human Capital and Social Capital: The Mediating Contribution of Knowledge Management. *Journal of Open Innovation: Technology, Market, and Complexity, 8*(4), 218. doi:10.3390/joitmc8040218
10. Ammirato, S., Fattoruso, G., & Violi, A. (2022). Parsimonious AHP-DEA Integrated Approach for Efficiency Evaluation of Production Processes. *Journal of Risk and FInancial Management, 15*(7), 15. doi:10.3390/jrfm15070293
11. Andriani, M., Samadhi, A. T., Siswanto, J., & Suryadi, K. (2019). Knowledge management strategy: an organisational development approach. *Business Process Management Journal, 25*(7), 1474-1490. doi:10.1108/BPMJ-07-2018-0191
12. Antari, N. P., Hastama, R., Noviyanti, A. A., & Juanita, R. A. (2024). Enablers and Barriers to Effective Communication about Drug Information: A Qualitative Study. *Indonesian Journal of Pharmacy, 35*(2), 340-354. doi:10.22146/ijp.6620
13. Arcanjo, R. R., Martins, L. G., & Graci, D. F. (2024). ProTSA: A Testing Process for Automotive Software Domain. *Journal of Software Engineering and Applications*. doi:10.4236/jsea.2024.177033
14. Arestova, A., Martin, M., Hielscher, K.-S., & German, R. (2021). A Service-Oriented Real-Time Communication Scheme for AUTOSAR Adaptive Using OPC UA and Time-Sensitive Networking. *Sensors, 21*(7), 29. doi:10.3390/s21072337
15. AUTOSAR. (2021, 11 25). *Specification of Diagnostic Communication Manager.* Retrieved from https://www.autosar.org/fileadmin/standards/classic/19-11/AUTOSAR_SWS_DiagnosticEventManager.pdf
16. AUTOSAR. (2022, 11 04). *Layered Software Architecture.* Retrieved 01 03, 2023, from https://www.autosar.org/fileadmin/standards/classic/22-11/AUTOSAR_EXP_LayeredSoftwareArchitecture.pdf
17. Ayub, M., Rasheed, R., Ahmad, R., & Bashir, F. (2021). Infrastructural Investments and Economic Growth: Evidence from Pakistan. *Journal of Business and Social Review in Emerging Economies, 7*(3), 591-598. doi:10.26710/jbsee.v7i3.1845
18. Banica, C. F., & Belu, N. (2019). Application of 8d methodology - an effective problem solving tool in automotive industry. *University of Pitesti Scientific Bulletin - Automotive Series, XXV*(29), 1-7. doi:10.26825/bup.ar.2019.005

19. Batko, I. (2024). PROTECTION OF RIGHTS TO AN INDUSTRIAL DESIGN. *Visnyk of the Lviv University. Series Law, 78*, 108-115. doi:10.30970/vla.2024.78.108
20. Beraha, I., Đuričin, S., & Lazarević, M. (2023). The impact of clustering on competitiveness and business performance of smes: evidence from the serbian automotive industry. *SCIENCE International Journal, 2*(4), 147-152. doi:10.35120/sciencej0204147b
21. Beske, P., Koplin, J., & Seuring, S. (2006). The use of environmental and social standards by German first-tier suppliers of the Volkswagen AG. *Corporate Social Responsibility and Environmental Management, 15*(2), 63-75. doi:10.1002/csr.136
22. Bican, P. M., Guderian, C. C., & Ringbeck, A. K. (2017). Managing knowledge in open innovation processes: an intellectual property perspective. *Journal of Knowledge Management, 21*(6), 1384-1405. doi:10.1108/jkm-11-2016-0509
23. Bizmanualz. (2025). *What is the Purpose of a Process Map?* Retrieved from bizmanualz: https://www.bizmanualz.com/make-a-process-map/what-is-a-process-map.html
24. Bogdan, R., Crișan-Vida, M., Barmayoun, D., Staicu, L. L., Puiu, R. V., Lup, M., & Marcu, M. (2021). Optimization of AUTOSAR Communication Stack in the Context of Advanced Driver Assistance Systems. *Sensors, 21*(13), 27. doi:10.3390/s21134561
25. **Bogorin-Predescu, A.**, & Țîțu, A. M. (2025, June). A specific approach about the process management in the automotive industry. *Annals – Series on Economy, Law and Sociology, 8*(1), 42-48. doi:10.56082/annalsarscieco.2025.1.42
26. **Bogorin-Predescu, A.**, & Țîțu, A. M. (2025). Total quality management in the knowledge-based organization: Managerial strategies oriented towards excellence. *Annals of the Academy of Romanian Scientists Series on Economy, Law and Sociology*, 20-26. doi:10.56082/annalsarscieco.2025.3.20
27. **Bogorin-Predescu, A.**, Țîțu, A. M., & Oprean, C. (2023). Improving the quality of rapid prototyping processes of electronic control units by using a dedicated software platform. *ACTA TECHNICA NAPOCENSIS-Series: APPLIED MATHEMATICS, MECHANICS, and ENGINEERING, 66*(1S), 10.
28. **Bogorin-Predescu, A.**, Țîțu, A. M., Niță, N. M., & Domnariu, V. L. (2022). Modeling of the automatic testing process of electronic control units in the automotive industry. *International Journal of Mechatronics and Applied Mechanics, 12*, 145-155. doi:10.17683/ijomam/issue12.22
29. **Bogorin-Predescu, A.**, Țîțu, A. M., Tertereanu, P., Bâlc, D., & Gusan, V. (2024). IOT system for acquiring ambient data using a dedicated portable platform. *International Journal of Mechatronics and Applied Mechanics*(15), 15. doi:10.17683/ijomam/issue15.6
30. **Bogorin-Predescu, A.**, Țîțu, A., & Pană, M. (2024). Flow management for software developers in the knowledge based organization from the automotive industry. *IJOMAM, 18*, 44-51. doi:10.17683/ijomam/issue18.5
31. **Bogorin-Predescu, A.**, Țîțu, S., & Țîțu, A. M. (2023). Product life cycle in automotive. In *New Technologies, Development and Application VI* (pp. 411-417). Springer Nature Switzerland. doi:10.1007/978-3-031-31066-9_45
32. **Bogorin-Predescu, A.**, Țîțu, Ș., & Țîțu, A. M. (2024). Data acquisition system for a hydroelectric turbine with deformable blades. *Archive of Metallurgy and Materials Review, 69*(4), 1649-1657. doi:10.24425/amm.2024.151437
33. **Bogorin-Predescu, A.**, Țîțu, Ș., Țîțu, A. M., & Nabiałek, M. (2025). Data acquisition system for a hydroelectric turbine located linearly on the course of flowing water. *Archive of Metallurgy and Materials Review*, 1207-1215. doi:10.24425/amm.2025.154469
34. **Bogorin-Predescu, A.**, Țîțu, Ș., Țîțu, A. M., Dragos, F. M., Dragomir, D. C., & Dragomir, M. (2025). Innovative Cost-Effective Embedded System to Enhance ECU Firmware Quality Through Remote Hybrid Testing in Automotive Domain. (MDPI, Ed.) *Applied Sciences, 15*(23). doi:10.3390/app152312736
35. Bondrea, I., Țîțu, A., Oprean, C., Carabulea, I., Mărginean, I., Moldovan, A., & **Bogorin-Predescu, A.** (2021, 04 29). *România Patent No. 129280-B1.*
36. Borsese, A., McDowall, R. D., & Andrade, J. M. (2003). Communication: the essential factor when implementing management systems. *Accreditation and Quality Assurance, 81*(1), 2-12. doi:10.1007/s00769-002-0557-9
37. Bouncken, R. B., Fredrich, V., & Ritala, P. (2017). Coopetition in New Product Development Alliances: Advantages and Tensions for Incremental and Radical Innovation. *British Journal of Management*. doi:10.1111/1467-8551.12213
38. Bozola, P. M., Nunhes, T. V., Barbarosa, L., Machando, M. C., & Oliveira, O. J. (2022). Overcoming the challenges of moving from ISO/TS 16949 to IATF 16949: recommendations for implementing a

quality management system in automotive companies. *Benchmarking an International Journal, 30(9)*. doi:10.1108/bij-04-2022-0215
39. Bratianu, C. (2015). *Managementul cunostintelor. Concepte fundamentale.* București. doi:10.5682/9786062801991
40. Brătianu, C., & Bejinaru, R. (2019). Knowledge dynamics: a thermodynamics approach. (Kybernetes, Ed.) *49,* 6-21. doi:10.1108/K-02-2019-0122
41. Brătianu, C., & Bejinaru, R. (2019). The Theory of Knowledge Fields: A Thermodynamics Approach. *Systems, 7*(2). doi:10.3390/systems7020020
42. Burgos, D. (2020). *Radical Solutions and Open Science: An Open Approach to Boost Higher Education.* Singapore: Springer. doi:10.1007/978-981-15-4276-3
43. Căpriță, H. V., & Selișteanu, D. (2022). Improvement of Automotive Sensors by Migrating AUTOSAR End-to-End Communication Protection Library into Hardware. *Elektronika Ir Elektrotechnika, 28*(5), 34-44. doi:10.5755/j02.eie.31154
44. Chang, C. L.-h., & Lin, T.-C. (2015). The role of organizational culture in the knowledge management process. *Journal of Knowledge Management*. doi:10.1108/JKM-08-2014-0353
45. Chen, G., Zhang, L., Arinez, J., & Biller, S. (2013). Energy-Efficient Production Systems Through Schedule-Based Operations. *IEEE Transactions on Automation Science and Engineering, 10*(1), 27-37. doi:10.1109/tase.2012.2202226
46. Chen, Y., & Xu, Y. (2021). Influencing factors of knowledge enhancement of corporate universities in China. *Kybernetes*. doi:10.1108/k-03-2021-0218
47. Chesbrough, H. W. (2003). *Open Innovation: The New Imperative for Creating and Profiting from Technology.* Harvard Business Press.
48. Chiliban, B., Chiliban, M., & Ință, M. (2013). Advanced Product Quality Planning Reference Model in Automotive Industry. *Applied Mechanics and Materials, 371,* 802–806. doi:10.4028/www.scientific.net/amm.371.802
49. Cieśla, J., & Ulewicz, R. (2024). The Future of Automotive Quality Control: How Cloud-Based Reporting is Changing the Game. *Management Systems in Production Engineering, 32*(1). doi:10.2478/mspe-2024-0008
50. Cioca, L.–I., Ivașcu, L., Turi, A., Artene, A. E., & Găman, G. A. (2019). Sustainable Development Model for the Automotive Industry. *Sustainability, 11*(22), 22. doi:10.3390/su11226447
51. Comisia Europeană. (2024). *European Innovation Scoreboard 2024.* Publications Office of the European Union. doi:10.2777/779689
52. Cooper, A. L., Huscroft, J. R., Overstreet, R. E., & Hazen, B. T. (2016). Knowledge management for logistics service providers: the role of learning culture. *Industrial Management & Data Systems*. doi:10.1108/IMDS-06-2015-0262
53. Crosby, P. B. (1979). *Quality is free.* New York: McGraw-Hill.
54. Daft, R. L. (2020). Cengage Learning.
55. Dalkir, K. (2005). *Knowledge Management in Theory and Practice.* (Butterworth–Heinemann, Ed.) Elsevier.
56. David, P. A., & Foray, D. (2001). An Introduction to the Economy of the Knowledge Society. *International Social Science Journal, 54*(1). doi:10.1111/1468-2451.00355
57. Dawoood, S., Mammona, Fahmeeda, & Aijaz, A. (2015, April). LEARNING ORGANIZATION–Conceptual and Theoretical Overview. *International Journal of Humanities Social Sciences and Education (IJHSSE), 2*(4), 6.
58. De Carvalho, R. F., Potra, S., & Vels, S. (2022). Using six sigma to improve the quality rate of a display production line in the automotive industry. *Transactions on engineering and management, 8*(1&2), 65-71. doi:10.59168/AZVM7230
59. Deac-Șuteu, D. V., Țîțu, A. M., & **Bogorin-Predescu, A.** (2023). Applicative scientific research on the possibility of improving service quality management in the service of local and regional interest. *The XXVII-th INTERNATIONAL CONFERENCE of INVENTICS "INVENTICA 2023. Science of creativity",* 65-74. doi:10.2478/9788367405201-006
60. Denil, J., Meulenaere, P. D., Demeyer, S., & Vangheluwe, H. (2017). DEVS for AUTOSAR-based system deployment modeling and simulation. *Simulation, 93*(6), 489-513. doi:10.1177/0037549716684552
61. Dewa, M., & Makua, E. (2024). DEPLOYING BUILT-IN QUALITY TO REDUCE SCRAP IN AN AUTOMOTIVE COMPONENT MANUFACTURER. *The South African Journal of Industrial Engineering, 35*(1), 137-151. doi:10.7166/35-1-2967

62. *Dictionar explicativ al limbii romane*. (2022, 3 2). Retrieved 03 02, 2022, from https://dexonline.ro/definitie/standard
63. Dinis-Carvalho, J. (2021). Continuous Improvement. *Concepts, Applications and Emerging Opportunities in Industrial Engineering*. doi:10.5772/intechopen.93638
64. Dmitrieva, E. (2023). Overview of Copyright as a Part of Intellectual Property Law in Russia and Abroad. *Herald of Omsk University. Series: Law, 3*, 51-60. doi:10.24147/1990-5173.2023.20(3).51-60
65. Donate, M. J., & Guadamillas, F. (2011). Organizational factors to support knowledge management and innovation. *Journal of Knowledge Management*.
66. Dongo, A. (2024). Evaluating knowledge management practices in a hospital pharmacy: A comprehensive investigation. *GSC Biological and Pharmaceutical Sciences, 27*(1), 43-50. doi:10.30574/gscbps.2024.27.1.0112
67. Drucker, P. (1975). *The Practice Of Management.* Allied Publishers.
68. Durst, S. (2022). KNOWLEDGE RISK MANAGEMENT IN ORGANISATIONS: FINDINGS FROM LATIN AMERICA. *Un journal de asfae chile*, 11-19. doi:10.35692/07183992.15.1.3
69. Dyer, J., Gregersen, H., & Christensen, C. M. (2011). *The Innovator's DNA: Mastering the Five Skills of Disruptive Innovators.* Harvard Business Review Press.
70. El Dardery, O. I., Gomaa, I., Rayan, A. R., Frendy, F., El Khayat, G., & Sabry, S. (2023). Using Fuzzy TOPSIS and Balanced Scorecard for Kaizen Evaluation. *Business Systems Research Journal*, 112-130. doi:10.2478/bsrj-2023-0006
71. EPO. (2025). *Transport.* European Patent Office. Retrieved from https://www.epo.org/en/about-us/statistics/patent-index-2024/statistics-and-indicators/european-patent-applications/top-10-technical-fields/transport#
72. Fakandu, A. M., & Yabagi, A. (2023). ICT as enabler for the adoption of knowledge management practices in selected north-west Nigeria federal university libraries. *Journal of ICT Development, Applications and Research, 5*(1), 35-44. doi:10.47524/jictdar.v5i1.36
73. Falch, M. (2022, 04). *UDS Explained - A Simple Intro (Unified Diagnostic Services).* Retrieved 01 04, 2023, from CSS Electronics: https://www.csselectronics.com/pages/uds-protocol-tutorial-unified-diagnostic-services
74. Fang, Z., Wu, F., Zhang, Y. G., Guo, Q., & Luo, D. (2010). Development of Diagnostic Communication Module on KWP 2000 According to AUTOSAR. *Advanced Materials Research, 171-172*, 462-467. doi:10.4028/www.scientific.net/amr.171-172.462
75. Fayol, H. (1916). *General and Industrial Management.* London: Pitman Publishing.
76. Ferraresi, A. A., Quandt, C. O., Santos, S. A., & Frega, J. R. (2012). Knowledge Management and Strategic Orientation: Leveraging Innovativeness and Performance. *Journal of Knowledge Management*. doi:10.1108/13673271211262754
77. Filatov, V. (2022). Automating the Assembly Process of Passenger Car Gearboxes. *Asian Journal of Research in Computer Science*, 147-165. doi:10.9734/ajrcos/2022/v14i4299
78. Freund, U. (2008). Mulit-level system integration based on AUTOSAR. *Proceedings of the 13th International Conference on Software Engineering - ICSE '08*. doi:10.1145/1368088.1368168
79. Gasper, L., & Mwenda, B. (2023). Quantitative analysis of Kaizen philosophy on productivity improvement. *International Journal of Research in Business and Social Science, 12*(3), 557-562. doi:10.20525/ijrbs.v12i3.2455
80. Gati, S. A., & Khoirunurrofik, K. (2023). The Effect of Telecommunications Infrastructure on Inclusive Economic Growth in Indonesia 2011−2021. *International Journal of Innovative Technologies in Social Science, 2*(38). doi:10.31435/rsglobal_ijitss/30062023/8007
81. Gesell, C., Glas, A. H., & Essig, M. (2021). The impact of buyer–supplier communication on production ramp-up performance. *Journal of Business & Industrial Marketing, 37*(5), 945–960. doi:10.1108/JBIM-06-2020-0284
82. Getchell, K., Dubinsky, J. M., & Lentz, P. (2023). A Critique of Transmission Communication Models in Introductory Management and Organizational Behavior Textbooks. *Journal of Management Education, 47*(5), 407-504. doi:10.1177/10525629231182156
83. Gillespie, D. J., & Schiffman, R. F. (2018). A Critique of the Shannon-Weaver Theory of Communication and Its Implications for Nursing. *Research and Theory for Nursing Practice, 32*(2), 216–225. doi:10.1891/1541-6577.32.2.216
84. Goicoechea, I., & Fenollera, M. (2012). Quality Management in the Automotive Industry. *DAAAM INTERNATIONAL SCIENTIFIC BOOK*, 619-632.

85. Gonzalez, R. V., & Melo, T. M. (n.d.). The effects of organization context on knowledge exploration and exploitation. *Journal of Business Research, 90*, 215-225. doi:10.1016/j.jbusres.2018.05.025
86. Gowda, K., & Thatkur, R. (2023). COMPREHENSIVE REVIEW ON ANALYZING THE NEED FOR ELECTRONIC COMPONENTS AND THEIR DEMAND INCREASE IN AUTOMOTIVES. *International Research Journal of Modernization in Engineering Technology and Science, 5*(4), 4998-5004. doi:10.56726/IRJMETS36746
87. Grobler-Dębska, K., Kucharska, E., & Baranowski, J. (2021). Formal Scheduling Method for Zero-Defect. *Research Square Platform LLC*. doi:10.21203/rs.3.rs-315238/v1
88. Gruszka, J., & Misztal, A. (2017). The new IATF 16949:2016 standard in the automotive supply chain. *Research in Logistics and Production*, 311-318. doi:10.21008/j.2083-4950.2017.7.4.3
89. Gruszka, J., & Misztal, A. (2017). The new IATF 16949:2016 standard in the automotive supply chain. *Research in Logistics and Production*, *7*(4), 311-318. doi:10.21008/j.2083-4950.2017.7.4.3
90. Gumiel, J. Á., Mabe, J., Jiménez, J., & Barruetabeña, J. (2022). Introducing the Electronic Knowledge Framework into the Traditional Automotive Suppliers' Industry: From Mechanical Engineering to Mechatronics. *Businesses*, *2*(2), 279-289. doi:10.3390/businesses2020018
91. Gunasekera, V. S., & Chong, S.-C. (2018). Knowledge management for construction organisations: a research agenda. *Kybernetes, 47*(9), 1778-1800. doi:10.1108/K-10-2017-0378
92. Gusan, V., Țîțu, A. M., **Bogorin-Predescu, A.**, Tertereanu, P., Bâlc, D., & Pop, A. B. (2024). From industrial robots to collaborative robots: exploring the transformation in the collaborative work environment. *New Technologies, Development and Application VII*, 32-41. doi:10.1007/978-3-031-66268-3_3
93. Hamed, A., El-Kharashi, M. W., Salem, A., & Safar, M. (2022). Two-Layer Bus-Independent Instruction Set Architecture for Securing Long Protocol Data Units in Automotive Open System Architecture-Based Automotive Electronic Control Units. *Electronics*, *11*(6), 28. doi:10.3390/electronics11060952
94. Hameed, A. M., Safar, M., El-Kharashi, M. W., & Salem, A. (2021). Bus-independent Instruction Set Architecture for Handling Long Protocol Data Units in AUTOSAR-based Automotive ECUs. *FISITA World Congress 2021 - Technical Programme*. doi:10.46720/f2020-ves-016
95. Hassana, N., & Raziq, A. (2019). Effects of knowledge management practices on innovation in SMEs. *Growing Science*, 997-1008. doi:10.5267/j.msl.2019.4.005
96. Haythornthwaite, C., & Kendall, L. (2010). Internet and Community. *American Behavioral Scientist, 53*(8), 1083–1094. doi:10.1177/0002764209356242
97. Hodel, K. N., Reinaldo Da Silva, J., Yoshioka, L. R., Justo, J. F., & Santos, M. M. (2021). FAT-AES: Systematic Methodology of Functional Testing for Automotive Embedded Software. *IEEE Access, 10*, 74259-74279. doi:10.1109/ACCESS.2021.3128431
98. Honey, P., & Mumford, A. (1992). *The manual of learning styles.* Peter Honey Publications.
99. Hong, D., & Moon, C.-J. (2024). Autonomous Driving System Architecture with Integrated ROS2 and Adaptive AUTOSAR. *Electronics, 13*(7), 20. doi:10.3390/electronics13071303
100. Hu, L., & Basiglio, A. (2023). A multiple-case study on the adoption of customer relationship management and big data analytics in the automotive industry. *The TQM Journal, 36*(9), 1-21. doi:10.1108/tqm-05-2023-0137
101. Hussin, N., & Mokhtar, S. H. (2018). The Impacts of Knowledge Management Practices on Employees' Job Satisfaction. *International Journal of Academic Research in Progressive Education and Development, 7*(3), 338-351. doi:10.6007/IJARPED/v7-i3/4371
102. Hwang, S. Y. (2023). A Study on the Intellectual Property Rights and Design Protection Laws. *The Korea Association for Corruption Studies, 28*(2), 63-83. doi:10.52663/kcsr.2023.28.2.63
103. Ichijo, K., & Nonaka, I. (2007). *Knowledge Creation and Management: New Challenges for Managers.* Oxford University Press.
104. Imansuri, F., Chayatunnufus, T., Safril, S., Sumasto, F., Purwojatmiko, H. B., & Salati, D. (2024). Reducing Defects Using DMAIC Methodology in an Automotive Industry. *Spektrum Industri, 22*(1), 1-13. doi:10.12928/si.v22i1.171
105. Ingarao, G., Priarone, P. C., Di Lorenzo, R., & Settineri, L. (2020). Guidelines to compare additive and subtractive manufacturing approaches under the energy demand perspective. *International Journal of Sustainable Manufacturing, 4*(2/3/4), 266-280. doi:10.1504/IJSM.2020.107126
106. Inkinen, H. (2016). Review of Empirical Research on Knowledge Management Practices and Firm Performance. *Journal of Knowledge Management*. doi:10.1108/JKM-09-2015-0336

107. Ionescu, N., Ionescu, L. M., Rachieru, N., & Mazare, A. G. (2022). A MODEL FOR MONITORING OF THE 8D AND FMEA TOOLS INTERDEPENDENCE IN THE ERA OF INDUSTRY 4.0. *International Journal of Modern Manufacturing Technologies, XIV*(3), 86-91. doi:10.54684/ijmmt.2022.14.3.86
108. Iskandar, M. L., & Ariffin, A. S. (2019). Relationship between National Automotive Policy (NAP), innovation and automotive vendors' performance in Malaysia. *Management Science Letters*, 1181-1198. doi:10.5267/j.msl.2019.4.022
109. Islamy, J. F., Yuniarsih, T., Ahman, E., & Kusnendi, K. (2020). Cross Level Analysis: The Role of Knowledge Management Mediates the Effect of Organizational Culture on Job Performance. *Jurnal Minds Manajemen Ide dan Inspirasi*. doi:10.24252/minds.v7i1.13991
110. ISO. (1994). *ISO/IEC 7498-1:1994 Information technology — Open Systems Interconnection — Basic Reference Model: The Basic Model*. Retrieved from ISO/IEC 7498: https://www.iso.org/standard/20269.html
111. ISO. (2022, 05 05). *ISO 9000 FAMILY*. Retrieved 05 03, 2022, from ISO 9001: https://www.iso.org/iso-9001-quality-management.html
112. Ivaldi, S., Scaratti, G., & Fregnan, E. (2021). Dwelling within the fourth industrial revolution: organizational learning for new competences, processes and work cultures. Journal of Workplace Learning. *Journal of Workplace Learning, 34*(1), 1-26. doi:10.1108/jwl-07-2020-0127
113. Johnson, D. M. (2002). Empirical study of second-tier automotive suppliers achieving QS-9000 Reference No. 718. *International Journal of Operations &Amp; Production Management, 22*(8), 902-928. doi:10.1108/01443570210436208
114. Jokanović, B., Zivlak, N., Okanović, A., Ćulibrk, J., & Dudak, L. (2020). The Model of Knowledge Management Based on Organizational Climate. *Sustainability*. doi:10.3390/su12083273
115. Jones, B. A. (1999). *nowledge Capitalism: Business, Work, and Learning in the New Economy.* Oxford University Press.
116. Jones, G. R. (2013). *Organizational Theory, Design and Change* (7 ed.). Pearson.
117. Juran, J. M. (1988). Quality Control Handbook. In *Quality Control Handbook.* New York: McGraw-Hill.
118. Karabegović, I., Karabegović, E., Mahmić, M., & Husak, E. (2021). The Application of Industry 4.0 in Production Processes of the Automotive Industry. *Mobility and Vehicle Mechanics*, *47*(2), 35-44. doi:10.24874/mvm.2021.47.02.03
119. Katz, J. E., Rice, R. E., Acord, S., Dasgupta, K., & David, K. (2004). Personal Mediated Communication and the Concept of Community in Theory and Practice. *Communication Yearbook, 28*(1), 315–371. doi:10.1080/23808985.2004.11679039
120. Katz, V. S., & Hampton, K. N. (2015). Communication in City and Community. *American Behavioral Scientist, 60*(1). doi:10.1177/0002764215601708
121. Kavalić, M., Nikolić, M., Radosav, D., & Stanisavljev, S. (2021). Influencing Factors on Knowledge Management for Organizational Sustainability. *Sustainability*. doi:10.3390/su13031497
122. Kawalla, C., Höck, M., & Ligarski, M. J. (2018). Supply Chain Quality Management of Magnesium Components: Concept, Examples and Recommendations. *Materials Science Forum*, 657-662. doi:10.4028/www.scientific.net/msf.941.657
123. Kawalla, C., Ligarski, M. J., & Höck, M. (2019). Supply Chain Quality Management of Automotive 2 Components. *Scientific Papers of Silesian University of Technology*, 69-83. doi:10.29119/1641-3466.2019.133.6
124. Khanam, S., Siddiqui, J., & Talib, F. (2013). Role of Information Technology in Total Quality Management: A Literature Review. *International Journal of Advanced Research in Computer Engineering &Technology (IJARCET), 2*(18), 2433-2445.
125. Kim, J., Bhatia, G., Rajkumar, R., & Jochim, M. (2011). An AUTOSAR-Compliant Automotive Platform for Meeting Reliability and Timing Constraints. *SAE Technical Paper Series*. doi:10.4271/2011-01-0448
126. Kluge, F., Yu, C.-L., Mische, J., Uhrig, S., & Ungerer, T. (2009). Implementing AUTOSAR scheduling and resource management on an embedded SMT processor. *Proceedings of Th 12th International Workshop on Software and Compilers for Embedded Systems*, 33-42. doi:10.1145/1543820.1543828
127. Knapp, F., & Šimon, M. (2023). Standardization of Project Management Practices of Automotive Industry Suppliers - Systematic Literature Review. *Tehnički glasnik, 17*(3), 432-439. doi:10.31803/tg-20230504094426

128. Kohn. (2020, 1 20). *What is an Organizational Knowledge Base and Why is it Useful?* (KMS Lighthouse) Retrieved 9 1, 2024, from https://www.kmslh.com/what-is-organizational-knowledge-base/
129. Kolodyazhnaya, O. A., Kolodyazhnaya, A. A., Anisimov, Y. P., Selutin, E. V., Osipov, A. A., & Arakcheev, D. V. (2020). Development Model of the Intellectual Property Management System. *Proceedings of the Russian Conference on Digital Economy and Knowledge Management (RuDEcK 2020), 148*, 300-305. doi:10.2991/aebmr.k.200730.056
130. Komatina, N., Tadić, D., Aleksić, A., & Banduka, N. (2021). The integrated PFMEA approach with interval type-2 fuzzy sets and FBWM: A case study in the automotive industry. *Proceedings of the Institution of Mechanical Engineers, Part D: Journal of Automobile Engineering*, 1201-1212. doi:https://doi.org/10.1177/09544070211034799
131. Koontz, H., & O'Donnell, C. (1955). *Principles of Management: An Analysis of Managerial Functions.* McGraw-Hill.
132. Korkmaz, K. A., & Bahidrah, S. (2018). Implementation of Knowledge Management in Construction Projects. *Advancements in Civil Engineering & Technology, 2*(3), 192-198. doi:10.31031/ACET.2018.02.000539
133. Kouzes, J. M., & Posner, B. Z. (2017). *The Leadership Challenge: How to Make Extraordinary Things Happen in Organizations.* John Wiley & Sons.
134. Kryssanov, V. V., & Kakusho, K. (2005). From semiotics of hypermedia to physics of semiosis: A view from system theory. *Semiotica*. doi:10.1515/semi.2005.2005.154-1-4.11
135. Kumar, R. (2019). Kaizen a Tool for Continuous Quality Improvement in Indian Manufacturing Organization. *International Journal of Mathematical, Engineering and Management Sciences, 4*(2), 452-459. doi:10.33889/ijmems.2019.4.2-037
136. Kumar, R. (2020). Intellectual Property Rights in India: Legal analysis, Status and Strategies. *International Journal of Social Sciences, 9*(3), 141-150. doi:10.30954/2249-6637.03.2020.5
137. Labs, P. (2025, 07 14). *Your Gateway to Embedded Software Development Excellence*. Retrieved from platformio: https://platformio.org/
138. Le, B. P., Lei, H., Le, T. T., Gong, J., & Ha, A. T. (2020). Developing a collaborative culture for radical and incremental innovation: the mediating roles of tacit and explicit knowledge sharing. *Chinese Management Studies, 14*(4), 957-975. doi:10.1108/CMS-04-2019-0151
139. Le, P. B., & Lei, H. (2019). Determinants of innovation capability: the roles of transformational leadership, knowledge sharing and perceived organizational support. *Journal of Knowledge Management, 23*(3), 557-547. doi:10.1108/JKM-09-2018-0568
140. Lee, K., Park, I., Sunwoo, M., & Lee, W. (2013). AUTOSAR-ready Light Software Architecture for Automotive Embedded Control Systems. *Transactions of the Korean Society of Automotive Engineers, 21*(1), 68-77. doi:10.7467/ksae.2013.21.1.068
141. Lee, R. (2021). The Effect of Supply Chain Management Strategy on Operational and Financial Performance. *Sustainability, 13*(9). doi:10.3390/su13095138
142. Lee, S.-O., Hong, A., & Hwang, J. (2017). ICT diffusion as a determinant of human progress. *Information Technology for Development, 23*(4), 687–705. doi:10.1080/02681102.2017.1383874
143. Lei, H., Khamkhoutlavong, M., & Le, P. B. (2021). Fostering exploitative and exploratory innovation through HRM practices and knowledge management capability: the moderating effect of knowledge-centered culture. *Journal of Knowledge Management, 25*(8), 1926-1946. doi:10.1108/JKM-07-2020-0505
144. Lemghari, R., Okar, C., & Sarsri, D. (2018). Supply Chain Performance Measurement: A Case Study about Applicability of SCOR®Model in Automotive Industry Firm. *MATEC Web of Conferences*, 8. doi:10.1051/matecconf/201820000016
145. Li, C., Ashraf, F. S., Shahzad, F., Bashir, I., & Murad, M. (2020). Influence of Knowledge Management Practices on Entrepreneurial and Organizational Performance: A Mediated-Moderation Model. *Frontiers in Psychology, 11*. doi:10.3389/fpsyg.2020.577106
146. Li, C., Gong, J., Luo, J., & Qiu, Z. (2024). The Impact of Technology Convergence on the Sustainable Innovation of China's Modern Manufacturing Enterprises: The Mediating Role of the Knowledge Base. *Sustainability, 16*(13), 20. doi:10.3390/su16135307
147. Li, J., Wang, L., Liao, C., & Gou, J. (2014). Research on the Flexray communication protocol based on AUTOSAR and it's multi-node test. *IEEE Conference and Expo Transportation Electrification Asia-Pacific (ITEC Asia-Pacific)*, 1-4. doi:10.1109/itec-ap.2014.6940754

148. Liu, W., & Lu, S. (2023). Optimization of Automotive Wire Harness Production Process Based on Lean Manufacturing. *Proceedings of the 2nd International Conference on Engineering Management and Information Science, EMIS 2023*, 8. doi:10.4108/eai.24-2-2023.2330620
149. Liubertė, I. (2019). On Social Knowledge and Its Empirical Investigation in Contemporary Organisations. *Management of Organizations: Systematic Research, 81*(1), 21-37. doi:10.1515/mosr-2019-0002
150. Lourenco, P. R., Kaur, G., Allison, M., & Evetts, T. (2021). Data sharing and collaborations with Telco data during the COVID-19 pandemic: A Vodafone case study. *Data & Policy, 3*. doi:10.1017/dap.2021.26
151. Luciano, M. R., & Saldanha, R. (2023). Validation of Automotive Centrals using Hardware in the Loop - BCM and Lights. *STELLANTIS South America - Universidade Federal de Minas Gerais*, 1-14. doi:10.21203/rs.3.rs-2529771/v1
152. Lundvall, B. Å. (2016). *The Learning Economy and the Economics of Hope.* Anthem Press.
153. Luo, H., & Kianfar, K. (2022). Valid inequalities and facets for multi-module survivable network design problem. *Networks, 81*(2), 155-176. doi:10.1002/net.22122
154. Makua, E. S., & Dewa, M. (2023). Process Improvement through Built in quality in Automotive Component Manufacturers. *Proceedings of the International Conference on Industrial Engineering and Operations Management*, 23-35. doi:10.46254/af04.20230010
155. Manaba, N. A., & Aziz, N. A. (2019). Integrating knowledge management in sustainability risk management practices for company survival. *In Management Science Letters*, 585-594. doi:10.5267/j.msl.2019.1.004
156. Mandala, V., Surabhi, S. N., Kommisetty, P. D., Kuppala, B. M., & Ingole, R. (2024). Towards Carbon-Free Automotive Futures: Leveraging AI And ML For Sustainable Transformation. *Educational Administration Theory and Practices*. doi:10.53555/kuey.v30i5.3474
157. Maslak, M. (2023). Intellectual Property as a Competitive Resource of an Industrial Enterprise. *Bulletin of the National Technical University "Kharkiv Polytechnic Institute" (Economic Sciences), 1*, 99-104. doi:10.20998/2519-4461.2023.1.99
158. Massaaki, I. (2013). *Gemba Kaizen - o abordare a strategiei de imbuntatire continua.* Editura Finmedia.
159. Mazur, M. (2019). Quality Assurance Processes in Series Production of Car Elements. *Conference Quality Production Improvement, 1*(1), 610-617. doi:10.2478/cqpi-2019-0082
160. Mazzocato, P., Stenfors, T., Schwarz, U., Hasson, H., & Nyström, M. (2016). Kaizen practice in healthcare: a qualitative analysis of hospital employees' suggestions for improvement. *BMJ Open, 6*(7). doi:10.1136/bmjopen-2016-012256
161. Menard, C., Goens, A., Lohstroh, M., & Castrillon, J. (2019). Achieving Determinism in Adaptive AUTOSAR. *Distributed, Parallel, and Cluster Computing*. doi:10.48550/arxiv.1912.01367
162. Microchip. (2008). *MCP4725 PICtail Plus Daughter Board User's Guide.* Retrieved 12 12, 2024, from https://ww1.microchip.com/downloads/aemDocuments/documents/OTH/ProductDocuments/UserGuides/51722a.pdf
163. MICROSOFT. (2025, 07 14). *Visual Studio Code*. Retrieved from https://code.visualstudio.com/
164. Mintzberg, H. (1973). *The nature of managerial work.* New York: Harper & Row.
165. Moya, A., Bastida, L., Aguirrezabal, P., Pantano, M., & Abril-Jiménez, P. (2023). Augmented Reality for Supporting Workers in Human–Robot Collaboration. *Multimodal Technologies and Interaction, 7*(4), 1-15. doi:10.3390/mti7040040
166. Muhidin, A., Hufad, A., Sutarni, N., Islamy, F. J., Rasto, R., & Inayati, T. (2022). Knowledge Management And Job Performance in Higher Education: The Role Of Leadership and Organizational Culture. *Al-Ishlah Jurnal Pendidikan*. doi:10.35445/alishlah.v14i4.1765
167. Namiri, A. M., & Rahmat, H. (2022). Students' Virtual Learning Challenges and Learning Satisfaction During COVID-19 Pandemic: A Conceptual Framework. *Journal of Communication, Language and Culture, 2*(2), 34-44. doi:10.33093/jclc.2022.2.2.3
168. Neamțu, G., Țîțu, A. M., Pop, A. B., & **Bogorin-Predescu, A.** (2024). Road Safety in The European Road Transport System and the Correlation with Sustainable Development. *IOP Conference Series: Materials Science and Engineering, 1311*, 8. doi:10.1088/1757-899x/1311/1/012047
169. Nguyen, T. N., Shen, C. H., & Le, B. P. (2022). Influence of transformational leadership and knowledge management on radical and incremental innovation: the moderating role of collaborative culture. *Kybernetes, 51*(7), 2240-2258. doi:10.1108/K-12-2020-0905

170. Nicolescu, O., & Nicolescu, L. (2005). *Economia, firma si managementul bazate pe cunoştinţe.* (Economică, Ed.)
171. Nicolescu, O., Nicolescu, C., & Popa, I. (n.d.). *Managementul întreprinderilor mici și mijlocii, suport de curs.*
172. Nicolescu, O., Plumb, I., Pricop, M., Vasilescu, I., & Verboncu, I. (2003). *Abordări moderne în Managementul și Economia Organizației* (Vol. 1). (Economică, Ed.)
173. Niekurzak, M., Lewicki, W., Çoban, H. H., & Bera, M. (2023). A Model to Reduce Machine Changeover Time and Improve Production Efficiency in an Automotive Manufacturing Organisation. *Sustainability, 15*(13). doi:10.3390/su151310558
174. Nonaka, I., & Takeuchi, H. (1995). *The Knowledge-creating Company: How Japanese Companies Create the Dynamics of Innovation.* Oxford University Press.
175. Okystar. (2024). *Product Model: OKY3015.* Retrieved 12 12, 2024, from https://www.okystar.com/product-item/5v-12v-24v-8-channel-relay-module-oky3015/#tab-id-2
176. Olaru, M. (1999). *Managementul calităţii.* (Economică, Ed.) Bucureşti.
177. Olaru, M. (2000). *Tehnici şi instrumente utilizate în managementul calităţii.* (Economică, Ed.) Bucureşti.
178. Ologbo, A. C., Nor, K. M., & Okyere-Kwakye, E. (2015). The Influence of Knowledge Sharing on Employee Innovation Capabilities. *International Journal of Human Resource Studies, 5*(3). doi:10.5296/ijhrs.v5i3.8210
179. Omel'yanyuk, G. G., Gulevskaya, V. V., & Savenko, A. S. (2019). Systematization of Intellectual Property Objects for Forensic Purposes. *Theory and Practice of Forensic Science, 14*(1), 6-12. doi:10.30764/1819-2785-2019-14-1-6-12
180. Oprean, C., & ş, a. (2000). *Managementul calităţii în administraţia publică.* (CRFCAPL, Ed.) Sibiu.
181. Oprean, C., & ş, a. (2006). *Metode şi tehnici ale cunoaşterii ştiinţifice.* (E. U. Sibiu, Ed.) Sibiu.
182. Oprean, C., & Țîțu, A. M. (2007). *Cercetarea experimentală şi prelucrarea datelor. Partea a II-a.* (E. U. Sibiu, Ed.) Sibiu.
183. Oprean, C., & Țîțu, A. M. (2008). *Managementul calităţii în economia şi organizaţia bazate pe cunoştinţe.* (AGIR, Ed.) București.
184. Oprean, C., & Țîțu, A. M. (2023). *Politici și mecanisme instituționale în domeniul calității.* (E. U. Napoca, Ed.) Cluj-Napoca.
185. Oprean, C., Oprean, L., Țîțu, A. M., Bondrea, I., Mărginean, I., Moldovan, A. M., & **Bogorin-Predescu, A.** (2020). *România Patent No. 128180-B1.*
186. Oprean, C., Țîțu, A. M., & Bucur, V. (2011). *Managementul global al organizației bazată pe cunoștințe.* (AGIR, Ed.) București.
187. Oprean, C., Țițu, M., & Oprean, C. (2002). *Managementul strategic.* Sibiu.
188. Ostadi, B., Aghdasi, M., & Kazemzadeh, R. B. (2010). The impact of ISO/TS 16949 on automotive industries and created organizational capabilities from its implementation. *Journal of Industrial Engineering and Management, 3*(3), 494-510. doi:10.3926/jiem.2010.v3n3.p494-511
189. Pakocs, R., & Lupulescu, N. B. (2017). Investigations regarding the lowering of specific intellectual property risks identified in the production process. *MATEC Web of Conferences*. doi:10.1051/matecconf/20179406014
190. Pană, M. M., Țîțu, A. M., Tertereanu, P., Moldoveanu, A. M., & **Bogorin-Predescu, A.** (2024). Can artificial intelligence still be considered a nonconventional technology in 2023? *Revista de Management și Inginerie Economică, 23*(1), 23-32. doi:10.71235/rmee.19
191. Papagalska, D. (2024). Knowledge Management and Intellectual Property in the Organization. *Strategies for Policy in Science and Education-Strategii Na Obrazovatelnata I Nauchnata Politika, 32*(1s), 131-138. doi:10.53656/str2024-1s-10-kno
192. Park, J., & Choi, B. W. (2019). Design and Implementation Procedure for an Advanced Driver Assistance System Based on an Open Source AUTOSAR. *Electronics, 8*(1025), 18. doi:10.3390/electronics8091025
193. Patidar, S. (2018). Supply Chain Challenges for Indian Automotive Industries. *International Journal for Research in Applied Science and Engineering Technology, 6*(6), 1735-1737. doi:10.22214/ijraset.2018.6255
194. Pattanasiri, S., & Chaiyakul, T. (2022). Causal Relationships Model for Total Quality Management, Supply Chain Management, and Organizational Performance: the Automotive and Automotive Parts Industries in the Eastern Economic Corridor (EEC), Thailand. *Asia Social Issues, 16*(1). doi:10.48048/asi.2023.254783

195. Pereira, N. L., Lunardi, G. M., Bento da Silva, J., & Nardi da Silva, I. (2022). Knowledge Management Practices Integrated to Teaching Methodologies: An integrative review. *International Journal of Advanced Engineering Research and Science, 9*(8), 153-164. doi:10.22161/ijaers.98.19
196. Pérez-Aróstegui, M. N., Bustinza-Sánchez, F., & Barrales-Molina, V. (2015). Exploring the relationship between information technology competence and quality management. *BRQ Business Research Quarterly, 18*(1), 4-17. doi:10.1016/j.brq.2013.11.003
197. Petkovic, M. (2008). *Organizaciono ponasanje.* Beograd: Centar za izdavacku delatnost Ekonomskog fakulteta u Beogradu.
198. Pham Thi, T. T., & Helfert, M. (2017). A review of quality frameworks in information systems. *arXiv*, 13. doi:10.48550/arXiv.1706.03030
199. PLC DEV. (2023, 01). *ASCII Chart*. Retrieved 01 25, 2023, from PLC DEV Tools for PLC programming: http://www.plcdev.com/ascii_chart
200. Plinta, D., Golińska, E., & Dulina, Ľ. (2021). Practical Application of the New Approach To FMEA Method according to AIAG and VDA Reference Manual. *Communications - Scientific Letters of the University of Zilina,, 23*(4), B325-B335. doi:10.26552/com.c.2021.4.b325-b335
201. Popa, I. (2005). *Management general.* (ASE, Ed.)
202. Popa, M. (2012). Methods and Techniques of Quality Management for ICT Audit Processes. 9. doi:10.48550/arXiv.1201.0395
203. Prashar, A., & Aggarwal, S. (2019). Modeling enablers of supply chain quality risk management: a grey-DEMATEL approach. *The TQM Journal, 32*(5), 1059-1076. doi:10.1108/TQM-05-2019-0132
204. Prashar, A., & Aggarwal, S. (2020). Modeling enablers of supply chain quality risk management: a grey-DEMATEL approach. *The TQM Journal, 32*(5), 1859-1876. doi:10.1108/TQM-05-2019-0132
205. Raiko, D., Cherepanova, V., Sylka, I., Podrez, O., & Fedorenko, I. (2021). Development of scientific and methodological approach to quantitative and qualitative assessment of intellectual property management in industrial enterprises. *Eastern-European Journal of Enterprise Technologies, 2*(13(110)), 28-41. doi:10.15587/1729-4061.2021.230262
206. Raj, R., Beck, V., & Soliman, A. (2019). Utilization of Value-based Management in the Strategic Management of German Automotive Industry. *Sage Journals, 20*(4), 871-886. doi:10.1177/0972150919845236
207. Rajashekharaiah, J., & Deshpande, S. (2022). Enabling the Ambitious ZED Target Initiative of the Government of India Through CLAG Operations. *SEDME (Small Enterprises Development, Management &Amp; Extension Journal): A Worldwide Window on MSME Studies, 50*(1), 23-37. doi:10.1177/09708464221130909
208. Ramírez, A. K., Pumisacho, V., Dávila, M. J., & Suárez-Barraza, M. (2018). Kaizen, a continuous improvement practice in organizations. *The TQM Journal, 30*(4), 255-268. doi:10.1108/tqm-07-2017-0085
209. Ratnasari, A., Kahpi, S. H., & Wulandari, S. S. (2023). The Role of Knowledge Management: Organizational Culture and Leadership in Shaping Competitive Advantage. *Journal of Economics, Finance and Management Studies*. doi:10.47191/jefms/v6-i7-46
210. Ruffo, M., Tuck, C., & Hague, R. (2006). Cost estimation for rapid manufacturing - laser sintering production for low to medium volumes. *Journal of Engineering Manufacture, 220*(9), 1417-1427. doi:10.1243/09544054JEM517
211. Sandmann, G., & Thompson, R. (2008). Development of AUTOSAR Software Components within Model-Based Design. *SAE Technical Paper Series,* 7. doi:10.4271/2008-01-0383
212. Santiago, F., Machado, C. J., Imbasciati, H., & Costa, S. (2024). Development and Simulation of an AUTOSAR Software Component for Functional Safety according to ISO 26262 Fault Detection and Safety Mechanisms. *SAE Technical Paper Series, 1*. doi:10.4271/2024-36-0132
213. Sapta, K. S., Sudja, N., Landra, N., & Rustiarini, N. W. (2021). Sustainability Performance of Organization: Mediating Role of Knowledge Management. *Economies*. doi:doi.org/10.3390/economies9030097
214. Sari, Y., Santoso, A., & Pangestu, N. A. (2023). The Adoption of the Response Surface Methodology within the DMAIC Process to Achieve Optimal Solutions in Reducing Product Defect. *Atlantis Highlights in Engineering*, 132-145. doi:10.2991/978-94-6463-288-0_13
215. Schwab, K. (2017). *The Fourth Industrial Revolution.* Portfolio.
216. Senge, P. M. (1990). *The fifth discipline: The art and practice of the learning organization.* New York: Doubleday.

217. Seňová, A., Štofová, L., Szaryszová, P., & Dugas, J. (2021). Superstructure of ISO/TS 16949 for the Measurement of Material-Technological Parameters of the Products in Automotive Production. *Management Systems in Production Engineering, 29*(3). doi:10.2478/mspe-2021-0022
218. Setiawan, I., & Setiawan, S. (2020). Defect reduction of roof panel part in the export delivery process using the DMAIC method: a case study. *Jurnal Sistem Dan Manajemen Industri, 4*(2), 108-116. doi:10.30656/jsmi.v4i2.2775
219. Shannon, C. E., & Weaver, W. (1949). *A Mathematical Theory of Communication.* Urbana: THE UNIVERSITY OF ILLINOIS PRESS.
220. Shenkoya, T., & Kim, E. (2023). Sustainability in Higher Education: Digital Transformation of the Fourth Industrial Revolution and Its Impact on Open Knowledge. *Sustainability, 15*(3), 1-16. doi:10.3390/su15032473
221. Shojaei, G. M., & Shojaeiává, P. (2022). Kaizen and employee performance: A path analysis. *Journal of Administrative and Business Studies, 8*(2), 27-34. doi:10.20474/jabs-8.2.4
222. Shvetsova, O. A., Tanubamrungsuk, P., & Lee, S. (2021). Organization Leadership in the Automobile Industry: Knowledge Management and Intellectual Capital. *The Open Transportation Journal, 15*(1), 16-30. doi:10.2174/1874447802115010016
223. Silva, S. R., Barbosa de Alencar, D., Costa, T. A., & Sanches, E. A. (2019). Kaizen Philosophy Application as Production Standardization and Process Optimization. *International Journal for Innovation Education and Research, 7*(11), 808-816. doi:10.31686/ijier.vol7.iss11.1936
224. Silvianita, A., & Ling, T. C. (2020). Role Impact in Knowledge Management of Automotive Component Firms in Indonesia. *Advances in Economics, Business and Management Research*, 79-82. doi:10.2991/aebmr.k.200514.018
225. Situmorang, H. N., Purba, S., & Situmorang, M. (2020). Learning Innovations During the Pandemic COVID-19 for Teaching of Automotive Industrial Management. *Advances in Social Science, Education and Humanities Research, 488*, 261-267. doi:10.2991/assehr.k.201124.055
226. Sloeber. (2025, 07 14). *Where Arduino meets Eclipse*. Retrieved from http://eclipse.baeyens.it/index.shtml
227. Smith, J. Y. (1986). Communication Quality in Information Systems Development: The Effect of Computer-Mediated Communication on Task-Oriented Problem Solving. *dissertation*. Denton, Texas. Retrieved 05 25, 2025, from https://digital.library.unt.edu/ark:/67531/metadc331600/
228. Soltanali, H., Garmabaki, A. H., Thaduri, A., Parida, A., Kumar, U., & Rohani, A. (2018). Sustainable production process: An application of reliability, availability, and maintainability methodologies in automotive manufacturing. *Proceedings of the Institution of Mechanical Engineers, Part O: Journal of Risk and Reliability, 233*(4), 682-697. doi:10.1177/1748006x18818266
229. Stan, N. M., **Bogorin-Predescu, A.**, & Țîțu, A. (2024). Market Trends in 2024 in the IT Project Management Industry. *Journal of Research and Innovation for Sustainable Society, 6*(2), 26-33. doi:10.33727/JRISS.2024.2.3:26-33
230. Stawiarska, E., Szwajca, D., Matusek, M., & Wolniak, R. (2021). Diagnosis of the Maturity Level of Implementing Industry 4.0 Solutions in Selected Functional Areas of Management of Automotive Companies in Poland. *Sustainability*(13(9)). doi:https://doi.org/10.3390/su13094867
231. Stepien, M. (2023). Knowledge Management in the Implementation of the Company's Business Strategy. *Proceedings of the 24th European Conference on Knowledge Management, 24*(2), 1263-1270. doi:10.34190/eckm.24.2.1343
232. Steuperaert, D., Poels, G., & Devos, J. (2024). A Reference Model for Information Quality in an IT Governance Context. *arXiv*, 69. doi:10.48550/arXiv.2405.04558
233. Strambach, S., & Dieterich, I. (2011). The territorial shaping of knowledge dynamics in Baden-Württemberg - Inter-organizational relations in the sectoral knowledge domain of the automotive industry. *Working Papers on Innovation and Space*, 27.
234. Succar, A. S., Brissaud, D., Evrard, D., Flick, D., & Fontaine, D. (2023). Decarbonization Measure: A Concept towards the Acceleration of the Automotive Plant Decarbonization. *System, 11*(7). doi:10.3390/systems11070335
235. Suciu, O., & Oprean, C. (2007). *Calitatea globală concurenţială.* (AGIR, Ed.) București.
236. Sudibyo, N. A., Farida, A., & Kurdhi, N. A. (2024). Comparative Analysis of Manufacturer vs. Retailer Refurbishing Models: Profitability, Production Efficiency, and Strategic Implications. *Jurnal Lebesgue : Jurnal Ilmiah Pendidikan Matematika, Matematika Dan Statistika, 5*(3), 1637-1655. doi:10.46306/lb.v5i3.744

237. Sumasto, F., Maharani, C. P., Purwojatmiko, B. H., Imansuri, F., & Aisyah, S. (2023). PDCA Method Implementation to Reduce the Potential Product Defects in the Automotive Components Industry. *IJIEM - Indonesian Journal of Industrial Engineering and Management, 4*(2), 87-98. doi:10.22441/ijiem.v4i2.19527
238. Supermane, S., & Tahir, L. M. (2018). An overview of knowledge management practice among teachers. *Global Knowledge, Memory and Communication, 67*(8/9), 616-631. doi:10.1108/GKMC-08-2017-0065
239. Surjandy, Meyliana, Warnars, H. L., & Abdurachman, E. (2020). A Proposed Supply Chain Model of Blockchain Technology-Based in Automotive Component Industry. *International Journal of Recent Technology and Engineering, 8*(5), 3310-3314. doi:10.35940/ijrte.E6440.018520
240. Sutrisno, B., Rimawan, E., & Sitorus, T. M. (2022). A Systematic Review of Kaizen Approach in Industries. *IJIEM - Indonesian Journal of Industrial Engineering and Management, 3*(2), 103-115. doi:10.22441/ijiem.v3i2.14131
241. Süzeroğlu-Melchiors, S., Gassmann, O., & Palmié, M. (2017). Friend or foe? The effects of patent attorney use on filing strategy vis-a-vis the effects of firm experience. *Management Decision, 55*(6), 1122-1142. doi:10.1108/md-01-2016-0047
242. Swarnakar, V., & Vinodh, S. (2016). Deploying Lean Six Sigma framework in an automotive component manufacturing organization. *International Journal of Lean Six Sigma, 7*(3), 267-293. doi:10.1108/ijlss-06-2015-0023
243. Szécsi, G. (2012). Mediated Communities in the Age of Electronic Communication. *KOME, 1*(1), 46-53. doi:10.17646/kome.2012.15
244. Taghizadeh, G., & Ghavidast, N. (2019). Identifying and Prioritizing the Barriers of Implementation of Knowledge Management in Industrial Units and Providing Solutions to Eliminate them (Case Study: ParsianFanavaran Group). *International Journal of Engineering and Technology, 11*(4), 1002-1018. doi:10.21817/ijet/2019/v11i4/191104082
245. Taylor, F. W. (1911). *The Principles of Scientific Management.* Harper.
246. Teplická, K., Khouri, S., Mudarri, T., & Freňáková, M. (2023). Improving the Quality of Automotive Components through the Effective Management of Complaints in Industry 4.0. *Applied sciences, 13(14)*. doi:https://doi.org/10.3390/app13148402
247. Tertereanu, P., Țîțu, A. M., **Bogorin-Predescu, A.**, Gusan, V., Bâlc, D., & Pop, A. B. (2024). Integrated IT systems for the management of activities related to border control at the Schengen Space. *New Technologies, Development and Application VII*, 98-107. doi:10.1007/978-3-031-66271-3_11
248. Texas Instruments. (2016). *INA260 Precision Digital Current and Power Monitor With Low-Drift, Precision Integrated Shunt.* Retrieved 12 12, 2024, from https://www.ti.com/lit/ds/symlink/ina260.pdf?ts=1735906791794&ref_url=https%253A%252F%252Fwww.google.com%252F
249. Than, S. T., Nguyen, C. H., Tran, T. Q., & Le, P. B. (2019). Building Competitive Advantage for Vietnamese Firms: The Roles of Knowledge Sharing and Innovation. *International Journal of Business Administration, 10*(4), 1. doi:10.5430/ijba.v10n4p1
250. Țîțu A. M., **Bogorin-Predescu A.**, Bogorin-Predescu O., & Țîțu Ș. (2023). Contributions to the design and implementation of an advanced electronic system for controlling the elongation of the vertebral column. *ACTA TECHNICA NAPOCENSIS, 66*(II), 235-244. Retrieved from https://atna-mam.utcluj.ro/index.php/Acta/article/view/2295
251. Țîțu, A. M. (2007). *Managementul calității în organizațiile industriale moderne, Teză de doctorat 2.* Sibiu: Universitatea Lucian Blaga din Sibiu.
252. Țîțu, A. M. (2021). *Inventică, inovare organizațională și transfer tehnologic, Curs universitar.* București: AGIR.
253. Țîțu, A. M., & **Bogorin-Predescu, A.** (2022). Contributions to the modeling of manufacturing processes for the implementation of the kanban methodology in the automotive industry. *International Journal of Mechatronics and Applied Mechanics*, 94-98. doi:10.17683/ijomam/issue12.14
254. Țîțu, A. M., & **Bogorin-Predescu, A.** (2023). Modeling of the communication process between two microcontrollers in order to optimize the execution of specific tasks. *International Conference on reliable systems engineering. 762*, pp. 490-503. Bucharest: Springer Nature Switzerland. doi:10.1007/978-3-031-40628-7_40
255. Țițu, A. M., & **Bogorin-Predescu, A.** (2023). Modelling the interwoven parallel testing process in the automotive industry. *International Journal of Mechatronics and Applied Mechanics, 3*, 128-135. doi:10.17683/ijomam/issue13.16

256. Țîțu, A. M., & **Bogorin-Predescu, A.** (2024). Communication management for the acquisition of data between the pc and a device called the hydroelectric turbine deployed linearly on the course of flowing water. *International Journal of Mechatronics and Applied Mechanics, 17*, 166-177. doi:10.17683/ijomam/issue17.19
257. Țîțu, A. M., & Oprean, C. (2006). *Cercetarea experimentală şi prelucrarea datelor. Partea I.* (E. U. Sibiu, Ed.) Sibiu.
258. Țîțu, A. M., & Oprean, C. (2007). *Managementul calităţii.* Pitești.
259. Țîțu, A. M., & Oprean, C. (2007). *Managementul strategic.* (E. U. Piteşti, Ed.) Pitești.
260. Țîțu, A. M., & Oprean, C. (2015). *Management of intangible assets in the context of knowledge based economy.* (L. Lambert, Ed.) Germany.
261. Țîțu, A. M., Bâlc, D., Bâlc, E., & Oprean, C. (2024). Leveraging Mechatronic Systems for Organizational Management: A Knowledge Management Approach in the Automotive Industry. *Management of Sustainable Development, 16*(2), 72-81. doi:10.54989/msd-2024-0016
262. Țîțu, A. M., Bâlc, D., **Bogorin-Predescu, A.**, & Bâlc, E. (2024). The contribution of a mechatronic system for withdrawal and arrangement of microphone cables in the context of audio system optimization. *Lecture Notes in Networks and Systems, 1129*, 260-272. doi:10.1007/978-3-031-70670-7_23
263. Țîțu, A. M., Bâlc, D., Gusan, V., **Bogorin-Predescu, A.**, Tertereanu, P., & Stanciu, A. (2024). Autonomous mobile platform with Uv ray disinfection system, a modular and affordable solution for virus elimination. *International Journal of Mechatronics and Applied Mechanics, 15*, 146-157. doi:10.17683/ijomam/issue15.17
264. Țîțu, A. M., Covaci, C.-A., & **Bogorin-Predescu, A.** (2025). The evolution of product quality in the automotive sector: the interdependence between raw material quality, finished products, and supplier performance. In I. Karabegović, A. Kovačević, & S. Mandžuka (Ed.), *New Technologies, Development and Application VIII. NT2025. 1482*, pp. 27-38. Sarajevo: Springer Nature Switzerland. doi:10.1007/978-3-031-95194-7_3
265. Țîțu, A. M., Deac Șuteu, D. V., Dragomir, M., & **Bogorin-Predescu, A.** (2026). Contributions to reducing the carbon footprint in the context of the delivery of public services of local and regional interest through electronic interoperability of service providers. (Springer, Ed.) *Eco-Production: Circular economy*.
266. Țîțu, A. M., Gusan, V., & **Bogorin-Predescu, A.** (2023). Enhancing collaborative robot communication with electrical discharge machine through modbus TCP integration: a feasibility and application study. *International Journal of Mechatronics and Applied Mechanics, 14*, 27-34. doi:0.17683/ijomam/issue14.4
267. Țîțu, A. M., Mărginean, I., Țîțu, Ș., Bogorin-Predescu, O. M., **Bogorin-Predescu, A.**, Moldovan, A. M., & Oprean, C. (2023). *România Patent No. 137487-A0.*
268. Țîțu, A. M., Mărginean, I., Țîțu, Ș., Bogorin-Predescu, O. M., **Bogorin-Predescu, A.**, Moldovan, A. M., & Oprean, C. (2025). *România Patent No. 139012-A0.*
269. Țîțu, A. M., Moldovan, A. M., **Bogorin-Predescu, A.**, Țîțu, Ș., Bogorin-Predescu, O. M., Oprean, C., & Mărginean, I. (2022). *România Patent No. 133869-B1.*
270. Țîțu, A. M., Oprean, C., & Boroiu, A. (2011). *Cercetarea experimentală aplicată în creșterea calității produselor și serviciilor.* (AGIR, Ed.) București.
271. Țîțu, A. M., Oprean, C., & Tomuță, I. (2007). *Cercetarea experimentală şi prelucrarea datelor. Studii de caz.* (E. U. Sibiu, Ed.) Sibiu.
272. Țîțu, A. M., Oprean, C., Bondrea, I., Carabulea, I., Mărginean, I., Moldovan, A. M., & **Bogorin-Predescu, A.** (2013). *Patent No. 129463-B1.*
273. Țîțu, A. M., Oprean, C., Bondrea, I., Carabulea, I., Mărginean, I., Moldovan, A. M., . . . Iuonaș, I. (2022, 04 29). *Romania Patent No. 129293-B1.*
274. Țîțu, A. M., Oprean, C., Bondrea, I., Mărginean, I., & **Bogorin-Predescu, A.** (2018). *România Patent No. 128224-B1.*
275. Țîțu, A. M., Oprean, C., Bondrea, I., Mărginean, I., Țîțu, Ș., Moldovan, A. M., & **Bogorin-Predescu, A.** (2022). *România Patent No. 130763-B1.*
276. Țîțu, A. M., Oprean, C., Mărginean, I., Moldovan, A. M., & **Bogorin-Predescu, A.** (2017). *România Patent No. 127219-B1.*
277. Țîțu, A. M., Oprean, C., Mărginean, I., Moldovan, A. M., **Bogorin-Predescu, A.**, & Țîțu, Ș. (2021). *România Patent No. 131963-B1.*

278. Ülengin, F., Ekici, Ş. Ö., Aktaş, E., Kabak, Ö., & Özaydın, Ö. (2014). A decision support methodology to enhance the competitiveness of the Turkish automotive industry. *European Journal of Operational Research, 234*(3), 789-801. doi:10.1016/j.ejor.2013.09.044
279. Valiyan, H., Abdoli, M., Jahromi, A. K., Zamanianfar, L., & Gholizadeh, P. (2023). Analysis of the integrating sustainable value creation process: evidence from Iran's automotive industry. *The TQM Journal, 35*(7), 1632-1657. doi:10.1108/TQM-11-2021-0323
280. Varzhapetyan, A. G., Semenova, E. G., Solnitsev, R. I., Fomina, A. V., & Balashov, B. (2018). Knowledge base in system of value-oriented management of innovative projects. *Proceedings of the International Conference "Economy in the Modern World" (ICMW 2018)*. doi:https://doi.org/10.2991/icemw-18.2018.45
281. vector. (2025). *Introduction to CAN*. Retrieved 05 30, 2025, from Vector E-Learning: https://elearning.vector.com/mod/page/view.php?id=363
282. Velkoska, C., & Tomov, M. (2023). Understanding and application of quality costs in automotive manufacturing companies in North Macedonia: empirical study. *International Journal of Quality & Reliability Management, 40*(6), 1463-1484. doi:10.1108/IJQRM-01-2022-0032
283. Verboncu, I., Popa, I., & Ștefan, S. C. (2020). *Diagnosticarea organizatiei.* (E. P. Universitaria, Ed.)
284. Vest, E. (2018). *Design Considerations Which Can Simplify Manufacturing (U).* doi:10.2172/1489928
285. Visconti, P., Giannoccaro, N. I., & de Fazio, R. (2021). Special Issue on Electronic Systems and Energy Harvesting Methods for Automation, Mechatronics and Automotive. *Energies, 14*(23), 1-5. doi:10.3390/en14238050
286. von Krogh, G., Ichijo, K., & Nonaka, I. (2000). *Enabling Knowledge Creation: How to Unlock the Mystery of Tacit Knowledge and Release the Power of Innovation.* Oxford University Press.
287. VOSviewer. (2025, 07 31). *VOSviewer Visualizing scientific landscape*. Retrieved from https://www.vosviewer.com/: https://www.vosviewer.com/
288. WIPO. (2021). *Global Innovation Index 2021: Tracking Innovation through the COVID-19 Crisis.* Retrieved from https://www.wipo.int/edocs/pubdocs/en/wipo_pub_gii_2021.pdf
289. Wohlrab, R., Pelliccione, P., Knauss, E., & Larsson, M. (2019). Boundary objects and their use in agile systems engineering. *Journal of Software Evolution and Process, 31*(5). doi:10.1002/smr.2166
290. World Bank. (2020). *Trading for Development in the Age of Global Value Chains.* Washington, DC: World Development Report 2020. Retrieved from https://hdl.handle.net/10986/32437
291. Wu, X. Q., Li, L. L., & Chen, H. J. (2013). Realization of can based on automotive open system architecture. *Applied Mechanics and Materials, 347-350*, 1625-1629. doi:10.4028/www.scientific.net/amm.347-350.1625
292. Xu, J., Liu, F., & Xie, J. (2022). Is Too Much a Good Thing? The Non-Linear Relationship Between Intellectual Capital and Financial Competitiveness in the Chinese Automotive Industry. *Journal of Business Economics and Management, 23*(4), 773-796. doi:10.3846/jbem.2022.16406
293. Xu, Y., Zhang, X., Wang, J., & Zeng, B. (2021). Systematic Development of Knowledge Management in State-owned Enterprises. *Advances in Social Science, Education and Humanities Research, 571*, 811-814. doi:10.2991/assehr.k.210806.154
294. Yadav, N., Mathiyazhagan, K., Saikouk, T., Goswami, S., & Görçün, F. Ö. (2022). Framework for zero-defect manufacturing in Indian industries – Voice of the customer. *Benchmarking: An International Journal, 30*(7), 2303-2329. doi:10.1108/bij-01-2022-0001
295. Yahya, S., & Goh, W.-K. (2002). Managing human resources toward achieving knowledge management. *Journal of knowledge management*.
296. Yang, X. (2024). Framework of Electric Vehicle Fault Diagnosis System Based on Diagnostic Communication. *International Journal of Engineering, 37*(6), 1194-1207. doi:10.5829/ije.2024.37.06c.16
297. Yu, H., Zhang, Y., & Ahmad, N. (2024). Modeling Challenges in Low-Carbon Manufacturing Adoption Using the ISM-MICMAC Approach: A Case of Green Tech Projects of the Chinese Automotive Industry. *Processes, 12*(4), 22. doi:10.3390/pr12040749
298. Yusof, N. M., Hamat, Z., Marzuki@Yahaya, N., Awang, N., & Drani, W. S. (2020). The Influence of Knowledge Management on Leadership Methods in Islamic Institution: A Conceptual Review. *International Journal of Academic Research in Business and Social Sciences, 10*(10), 859-864. doi:10.6007/IJARBSS/v10-i10/8017
299. Zheng, W., Yang, B., & McLean, G. N. (2010). Linking organizational culture, structure, strategy, and organizational effectiveness: Mediating role of knowledge management. *Journal of Business Research*. doi:10.1016/j.jbusres.2009.06.005

...

ANNEXES

...