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CHALLENGES AND RESEARCH IN THE INNOVATION OF DIGITAL ENTERPRISE AND SMART INDUSTRY (4.0)

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Abstract: *The scientific paper "Challenges and Research in the Innovation of the Digital Enterprise and the Intelligent Industry (4.0)",* ***states focused****, the scientific and technological concerns at the highest level, on the construction and development of the digital enterprise and the intelligent industry (4.0), through the results of the research and innovation in the specialized field of intelligent mechatronics and cyber-mechatronics, intelligent products and integrated and cobotic platforms.*
The scientific paper also presents the paradigm of research and innovation regarding the new advanced digital transformation of the enterprise and the intelligent industry corresponding to the integration of cyber-physical systems with the Internet of Things (IoT).

Keywords*: Digital enterprise; smart industry (4.0); mechatronic & cyber-mixmechatronic; intelligent and cobotic technological platforms.*

1. Introduction

The development of mechatronics, cyber-mechatronics and information and communication technology generates more and more things / objects that become integrated (with sensors) and have the ability to communicate with other objects, which **transforms the physical world itself into a systemic information and knowledge.**
Mechatronics, Cyber-Mix Mechatronics and the Internet of Things (IoT) allow things / objects in our environment to be active participants, i.e. they share information with other actors or members of the network; cable / wireless, which often uses the same Internet Protocol (IP) that connects the Internet.
Thus, objects / things are able to recognize events and changes around them and act and react in a quasi-autonomous way without human intervention.
In this exposed context, challenges in research, development and innovation create an "intelligent planet," where physical, digital and virtual worlds converge to create smart environments that can make energy, transport, cities and many other intelligent domains.
The development of some generic technologies such as "nano electronics", "communications", "sensors", "smart phones", "embedded systems", "cloud computing and software" (fig. 1), will be among the key to supporting future innovations of IoT and cyber – mechatronics products, which affects many industrial sectors.
Today, many national and especially European projects and initiatives address technologies and knowledge about mechatronics, cyber-mixmechatronics and Internet of Things. Given that topics can be highly diversified and specialized, there is a strong need to integrate individual results.
The integration of knowledge, in this context in general, is conceptualized as the process by which disparate, specialized, localized knowledge in several projects throughout Europe are combined, applied and assimilated.
The national and European research on the Internet of Things aims at defining IoT technology and developing research challenges at national and European level for global development.

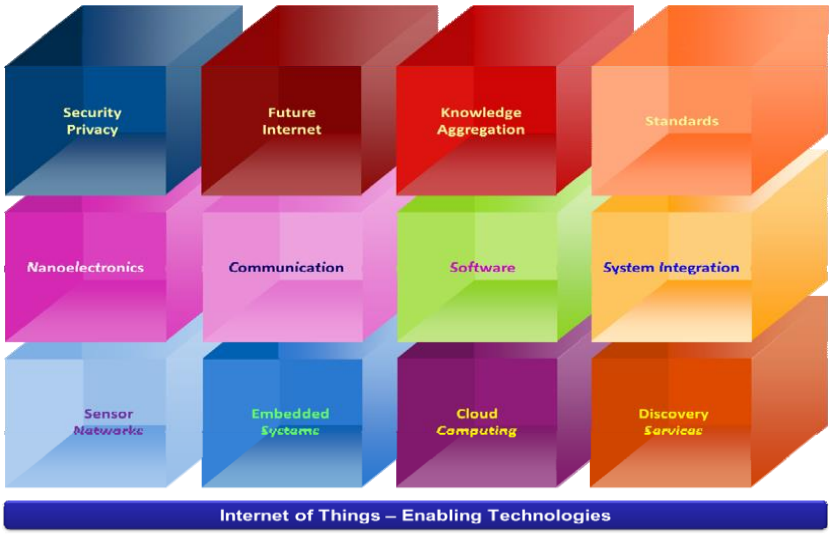

Fig. 1. Internet of Things – Enabled technologies

The research brings together national and European projects in the field of IoT technology, thus supporting the basic multidisciplinary science. The motivation for the Internet of Things is to address the great potential of IoT-based capabilities in Europe - to coordinate / encourage the convergence of ongoing activities on the most important issues - to build a broad consensus based on the ways to achieve IoT in Europe and Romania.
The perspective of the future is the emergence of a network of interconnected, uniquely identifiable objects, and their virtual representations in a similar Internet structure, which is positioned over a network of interconnected computers, which allows the creation of a new platform for economic growth (fig. 2).

Fig. 2. Internet of Things –technology platforms

The major areas of application of the street Internet are the creation of intelligent environments / spaces and things of their own (for example, intelligent transport, cities, buildings, energy, life, etc.) for climate, food, energy, mobility, health applications.

2. Common framework at national – European level

The common framework will contribute to the efforts of the researchers involved in these projects to generate new ideas, to transmit their knowledge and to translate them into marketable products / services / concepts of mechatronics, cyber-mixmecatronics and IOTs, with all the circumstances of the research and innovation in that area.
This common framework and the integration concept for mechatronic, cyber-mixmechatronics and IoT activities at national and European level are in line with the global European research strategy in the field.
The Horizon 2020 Research and Innovation Framework Program shows how the Framework Program could support the research and innovation objectives of the Europe 2020 Strategy and the Research and Innovation Framework Program and connects / coordinates the new Framework Program with national initiatives.
The concept creates a true integrated financing system and the coordination of the technical activities.
The research and innovation activities in the field of mechatronics, cyber-mixmechatronics and IoT must be interconnected and integrated into the Horizon 2020 Research and Innovation Framework Program.
These innovation activities must address important advances in the fields of mechatronics, cyber-mixmechatronics and IoT, such as infrastructure development, standardization, educational programs, and measures to support important industrial sectors or that foster innovation such as smart cities or regions.
Integration and coordination between European programs and national initiatives in the field of mechatronics, cyber-mixmechatronics and IoT offers the innovation-oriented, industry-oriented approach as an integral part of the Horizon 2020 Research and Innovation Framework Program, involving SMEs as well as drivers of innovation are assured.
This facilitates the dissemination of knowledge and the transfer of IoT technology, including applications that respond to social and societal challenges.
The common framework and the integration concept for mechatronic, cyber-mechatronic and IoT activities at national and European level generate programs for innovative actions to develop international networks and to support national programs, programs on knowledge and technological innovation.
It makes better use of and enhances the knowledge generated and enhances the ability to interact with SMEs and to enable them to enter new market niches and gain a high level of knowledge. This will generate cooperation in the development of clusters and business networks; innovative projects of SMEs with universities and technology centers; financing innovation, investments, venture capital, start-ups and spin-offs.
The common framework and the concept of integration for mechatronic, cyber-mixmechatronics and IoT activities at national and European level are expected to:

- Diversification and consolidation of research and innovation in the field at European level in partnership with national programs by improving innovation systems.
- Improving the capacity for elaboration and cooperation with the national innovation strategies.
- Building and sustaining new partnerships with Member States.
- Improving the quality of national / European partner programs.
- Assisting EU and national policies with new examples of good practice.
- A new framework for SMEs and the cluster of mechatronic, cyber-mixmechatronics and IoT technologies.
- Creating new transnational links between the companies operating in the field of mechatronics, cyber-mixmechatronics and IoT.
- Exchange of good applications and technological development practices for business networks.
- The transfer of mechatronic, cyber-mixmechatronics and IoT technology between scientific institutions and SMEs.

- New measures through venture capital for financial support for start-ups and spin-offs for new Internet developments.
- Testing innovative pilot measures for mechatronics, cyber-mixmechatronics and IoT.

3. The structure and dimensions of Industrial Internet

Industrial Internet refers to the integration of machines through sensors and network software. It does not just mean a substantial transformation of the global industry, but it has an impact on many aspects of daily life, including how many of us work. The industrial Internet will bring increased speed and efficiency in a variety of industries, such as aviation, rail, electricity, oil and gas and medical care. It brings the promise of stronger economic growth, more and better jobs, as well as improved living standards, regardless of geographic location.
The industrial Internet combines the improvements brought about by the two previous revolutions: the machines, factories, fleets and networks born from the industrial revolution and the innovations in computers, information and communication systems introduced by the much more recent Internet revolution.
Three elements constitute the essence of the industrial internet:
Smart machines: in the form of new ways to connect machines, plants, fleets and networks through sensors, control systems and complex software applications.
Advanced analysis: use of notions such as analytical ability, forecasting algorithms, automation and ultra-specialized experience in materials science and electrical engineering, to understand how large-scale machines and systems work.
People at workplace: connecting people wherever they are - in industrial factories, offices, hospitals, on the move and at any time, to promote smarter design, operations and maintenance and to generate superior quality service, alongside a improved safety.

4. Structural schemes of Digital Enterprise from Smart Industry (4.0)

Connecting smart devices, enterprises, fleets and networks with people in the workplace and on the move opens up new possibilities for process optimization and the potential for increased productivity and efficiency. In addition, it will alter the competitive balance and force the rest of the industry to adapt quickly, if it wants to survive. The pace of this process will differ from industry to industry, but the effects will be amplified in the economy as adoption grows. Thus, they are designed and presented:

- in figure 3, the structural scheme of a digital enterprise from Smart Industry (4.0) is presented, with the identification of the related physical-cybernetic systems.

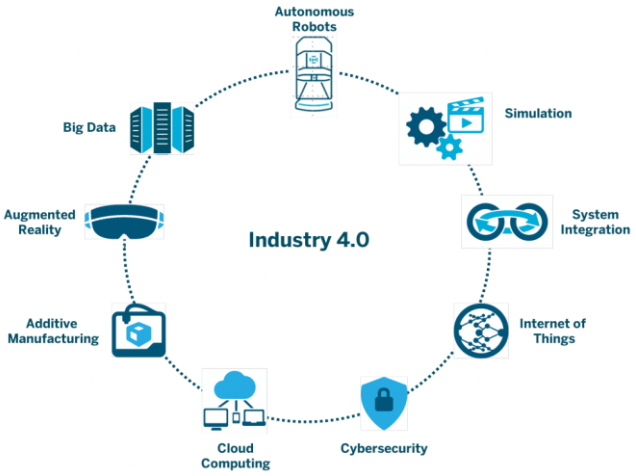

Fig. 3.

Figure 4 shows the optimization of real-time operations from a smart factory.

Fig. 4.

In the Intelligent Factory of the future, centralized control mechanisms are replaced by intelligent networks. Enhancing automation and digitization allows machines to independently organize, monitor and control processes.
For manufacturing companies, this provides many opportunities for intelligent use of analytical methods to generate added value from machine and production data and build new data-driven business models.
Figure 5 shows the COBOT technology platform used in the intelligent manufacturing of the automobile industry.

Fig. 5.

Figure 6 shows "a structure of industrial robots in a digitized factory".

Fig. 6.

In figure 7, there is presented "a robotics structure of parts supplying a CNC machine tool", in a smart factory.

Fig. 7.

Figure 8 shows the "connections of a telemedicine pilot center in Romania".

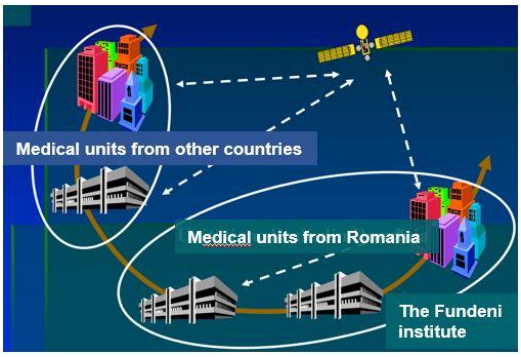

Fig. 8.

Figure 9 shows "an integrated telemedicine network that also includes patient telemonitoring".

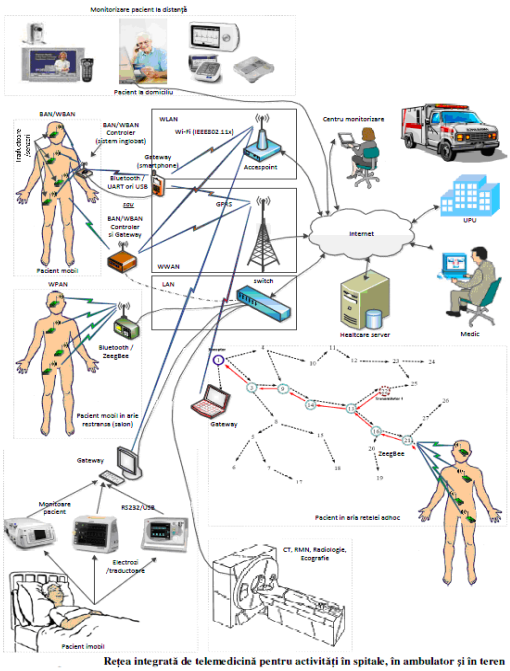

Fig. 9.

Figure 10 shows "an example of a workstation on the automotive manufacturing line", from the smart industry (4.0).

Fig. 10.

5. Structural schemes of Smart Agriculture

The evolution of agriculture is based on a number of decision-makers, important conditions for intelligent agriculture and intelligent food supply chains. Some of them are:

• Innovative technologies: machining hardware (robotics), RFID, sensors, wireless networks, including broadband in rural areas, web technology, cloud computing, big data, predictive analytics tools.

• Standardization: fast, error-free and efficient exchange of digital data within and between companies, based on information standards.

• Skills: knowledge, adoption and knowledge of digital information systems and standards and their ability to use them.

• Governance: organizational implementation and business models, including agreements on property rights and decision rights, remuneration, risk management, etc. (see the section on data ownership below).

Figure 11 shows the "IT effects on business models in the food chain".

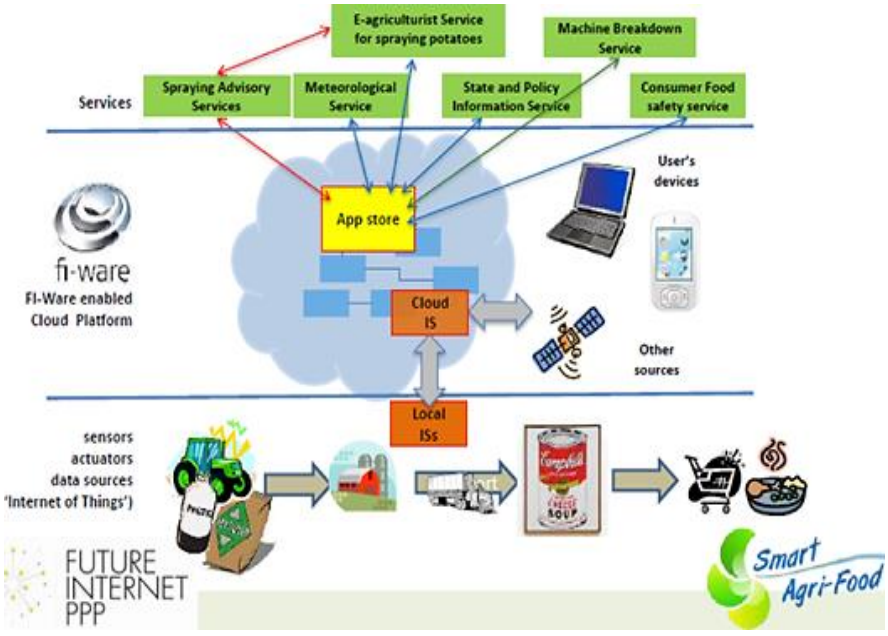

Fig. 11.

The digitization of agricultural processes continues to expand and intensify. The supply and demand of agricultural data is growing rapidly. There is an increase in market data tools and even more in the decision making process. Data-driven initiatives are growing in the agri-food chains. Agriculture becomes a booming business of data collections, in which many players take bites in the data generated by agriculture. Many data-driven initiatives continue to explore viable business models to capture the value of data. A variety of business models are used and developed with different value propositions for different actors.
Figure 12 shows the "use of drones to support agriculture".

Fig. 12.

While some sectors seem to be resisting digital implementation, others are in the process of transformation. In general, this refers to the sectors that face the most constraints (money, time and / or workload). These sectors use digital technology to increase productivity, but also to innovate. Agriculture has seen in digital a way to overcome many difficulties inherent in this sector. If the development of a country goes through industrialized agriculture, it is possible that in the next few years the development will take place through digital agriculture.
Figure 13 shows "an example of precision treatments in agricultural crops using smart drones".

Fig. 13.

Figure 14 shows "an example of agricultural digitization through the use of robots".

Fig. 14.

6. Concepts of technological and cobotics platforms for Digital Enterprise and Smart Industry (4.0)

The development of the technical and technological concepts of type "COBOT" for Enterprise and Industry 4.0, is based, on the one hand, the concepts, the advanced technical sciences, the technological paradigms, the cognitive treasures, the scientific strategies, and on the other hand, the scientists and world strategies, regarding the construction of industry, economy and society at high competitive levels and of excellence, optimum efficiency and maximum productivity.
The holistic architectural structure of the technical and technological concepts of COBOT type for Enterprise and Industry 4.0, includes new approaches embraced by the paradigms of new organizational cultures, in an evolution towards modern practices, still being defined, all subject to digital transformations. A digital transformation, in general, involves a change of leadership style, traditional ways of thinking, in favor of innovation and new business models. Thus, by incorporating the latest digital technologies, the aim is to improve the experience of the employees of the company and of the clients, suppliers, partners and shareholders of that company.
In summary, digital transformation represents the integration of digital technologies in absolutely all areas of a company and has the effect of fundamentally changing the operating mode and the way in which the surplus value is created / delivered to the clients of that company.
Changes and digital transformation are not only reflected in the way business is conducted, but also in the whole of society.
Almost everyone is talking about digital transformation today (or digitizing human activity, as everyone prefers). But is this digital transformation just a trendy word or a phenomenon that has the wave of change that will affect everyone in the years to come?
The attempt to give a relatively unanimously accepted definition would say something like this: Digital transformation represents the profound transformation of business, organizational activities, processes, competencies and working models to fully exploit the changes and opportunities created by a mix of new technologies and the impact on their full acceleration on human society.
Even though the term "digital transformation" is predominantly used in business contexts, it has profound impact on other organizations such as governments, public sector agents and organizations involved in responding to societal challenges such as pollution and aging, precisely by trying to leverage one or more of the existing and emerging technologies. In some countries, such as Japan, digital transformation aims to generate an impact on all aspects of life in that society (hence a beautiful generic name, namely the 5.0 Business Initiative), which is far beyond the limited vision called Industry 4.0 from other countries.
And as Romania is in Europe, and countries such as Japan are far from many points of view, the focus on digital transformation must remain, for the time being, on the business dimension of the term. In this context, the aforementioned development of new skills revolves around the capabilities of companies to increase their agility, to be more people-oriented, to be innovative, to be consumer-centered, efficient and capable of taking advantage of opportunities to change. the

state of affairs and to open the taps for new sources of income fed by information and services. It is certain that efforts and strategies related to digital transformation are more present and imperative in markets with a high degree of commoditization.
The present and future changes and changes, which lead to the necessity of a digital transformation strategy, can be induced by several causes, often simultaneously, at the level of consumer behavior and expectations, of new economic realities, of changes among populations (such as the aging phenomenon), disruptive events in the ecosystem and industry and the accelerated adoption of digital technologies. In practice, optimizing customer experience, increasing business operational flexibility and innovation are essential drivers of digital transformation, along with the development of new revenue sources and new value ecosystems fueled by the power of information. And all of this leads to major changes in business models.
Many are currently asking whether digital transformation is a goal in itself. However, the most correct one would be, in my view, for digital transformation to be considered a journey with many intermediate goals interconnected, the aim, if we can talk about it, being that of a continuous optimization of business processes and ecosystems. an era of hyper-connectivity, in which the key to success is the construction of the right bridges between the various functions.
A digital transformation strategy aims to create the capabilities to fully exploit the possibilities and opportunities offered by the new technologies and to correct, faster and more innovative management of their impact in the future. Any journey of digital transformation requires a step-by-step approach with a clear roadmap, involving many stakeholders in the process. Such a map must take into account the fact that the final objectives are extremely fluid, because digital transformation itself is a perpetual journey, as are digital change and innovation.
Digital technologies, and the ways we use them in our personal lives, at work and in society, have changed the way business looks and will continue to do so. This has happened permanently in history, but the pace at which things are going now is unprecedented. Yes, more. is in full acceleration, threatening to speed up the pace of internal transformations of organizations, resulting in a huge danger of cleavage between the two phenomena. This is because digital transformation does not refer only to disruptive phenomena or technology.
Digital transformation means new business ecosystems. These are evolutions of partner networks as well as contextual factors that affect the company, such as regulations or priorities and economic developments. Digital transformation means building new ecosystems between companies with diverse backgrounds based on the same digital information network, in which tradable data and information become innovative assets.
Another important node of the digital transformation "network" is business asset management. Certainly, the focus area will continue to be that of traditional assets, but digital transformation will involve increasingly focusing on less "tangible" assets, such as information and customers. Why? Improving customer experience is a leading goal for many digital transformation projects, and information is becoming more and more the "blood" of business, technological developments and inter-human relationships. As such, both clients and information will need to be treated as real assets from all points of view.
Another essential point is the organizational culture. Such a knot means, in a digital context, a clear customer-focused, agile and aware goal for all company staff, an objective that can be achieved by acquiring key personnel skills such as digital maturity, leadership, knowledge of points weak mental ones who have to undergo transformations, and so on.
An important area of transformation is also that of the business ecosystem of the company and of the partnership models. This requires increasing the degree of cooperation, collaboration and collaborative creation, as well as new approaches to business ecosystems, which will lead to new business models and, consequently, to new sources of income.
Last but not least, another important point is the approaches towards clients, employees and partners. Digital transformation puts people and strategies ahead of technology. As such, changing the behaviors, expectations and needs of all stakeholders is essential. This is expressed through many smaller change projects (sub-projects) within which focus on the customer, user experience, employee empowerment, new job models, changing the dynamics of the partner channel, etc.

It is important to note that digital technologies are never the only solution to tackle all these aspects of business and people. People mean respect and empower other people first and foremost, technology is an additional catalyst and part of the equation of fundamental choices and needs.

In the following are presented, in original concepts, examples of COBOT technology platforms:

- In the figure 15, COBOT technology platform for verification and integrated control processes in the Enterprise and Smart Industry (4.0)

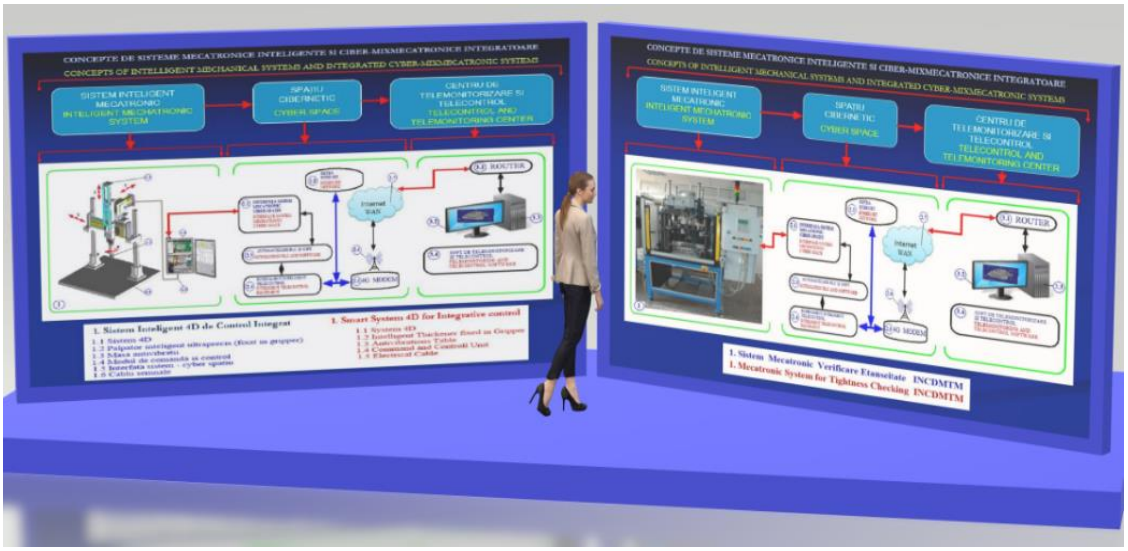

Fig. 15. COBOT technology platform for verification and integrated control processes in the Enterprise and Smart Industry (4.0)

- in the figure 16, COBOT technology platform for measuring and intelligent control processes in the Digitized Enterprise and Smart Industry (4.0) in the field of Technological Equipments

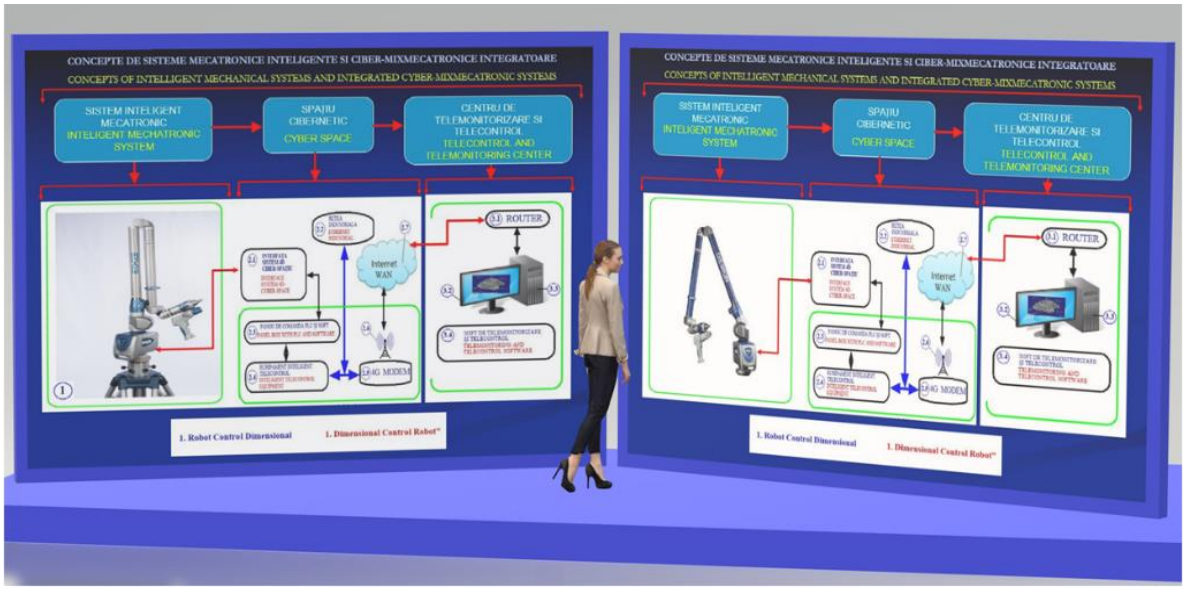

Fig. 16. COBOT technology platform for measuring and intelligent control processes in the Digitized Enterprise and Smart Industry (4.0) in the field of Technological Equipments

- in the figure 17, COBOT technology platform for assembly processes and industrial parts from Enterprise and Industry 4.0, in the field of Machine Construction

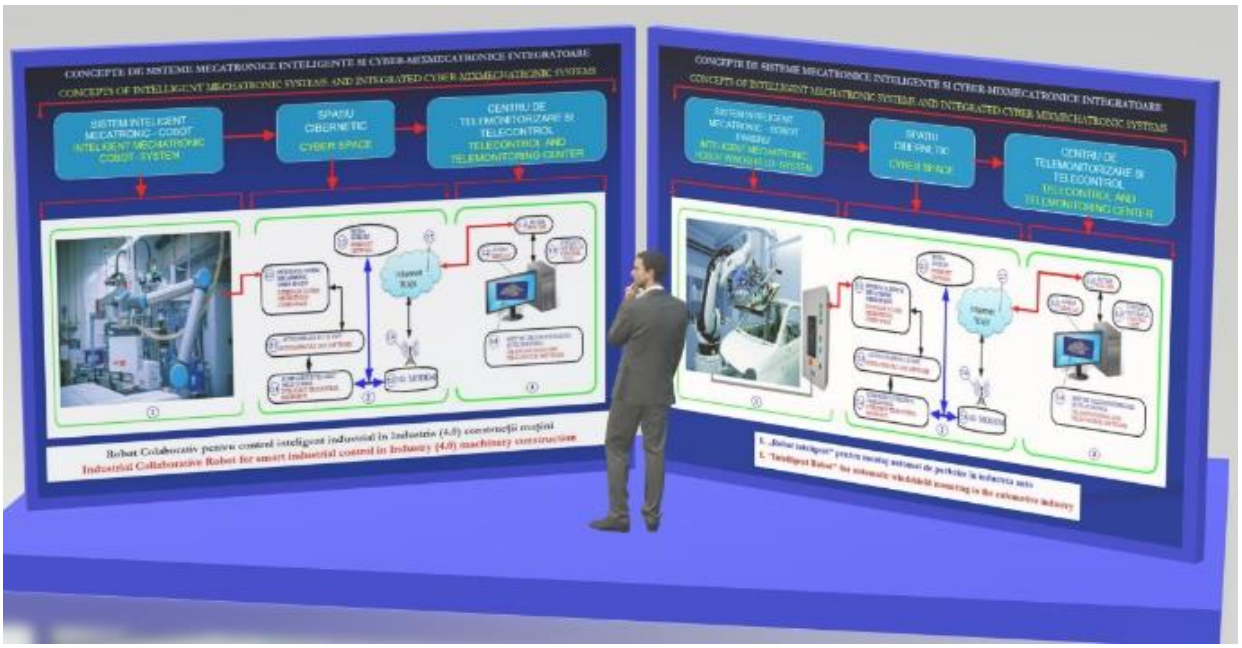

Fig. 17. COBOT technology platform for assembly processes and industrial parts from Enterprise and Industry 4.0, in the field of Machine Construction

- in the figure 18, COBOT technology platform for positioning processes in metrology laboratories in the Enterprise and Intelligent Industry (4.0) in the field of Intelligent Metrology.

Fig. 18. COBOT technology platform for positioning processes in metrology laboratories in the Enterprise and Intelligent Industry (4.0) in the field of Intelligent Metrology

7. Conclusions

The scientific paper shows that industrial digitization will have an impact both horizontally and vertically on the value chain, which means that, on the one hand, companies must integrate and digitize their vertical data flow much better, in the development of products and procurement up to the processing and logistics of transport, and on the other hand, implies a horizontal collaboration with key suppliers, customers and other partners in the value chain.
Companies, businesses and industry in general 4.0 must be involved in the development and implementation of complex digital solutions, and all staff are confident that industrial digitalization is the most appropriate and necessary choice for the future.
The scientific work also synthesizes the beginnings of industrial digitization, by presenting intelligent concepts and solutions proposed by the author, for integrating mechatronic and cyber-mixmechatronics mechatronic systems that are or are to be implemented in different industrial sectors (automotive, aerospace, agriculture, medicine, etc.) from Romania.
The digitization strategy of Enterprise and Industry 4.0 is synthesized, for national and European level in the following diagram:
Pillar 1
Single Digital Market - Free cross-border access to online services and information
Pillar 2
Interoperability and standards - integration, devices, applications, data and services in the code of social ethics
Pillar 3
Trust and security - Increase Internet users' trust in electronic services and online transactions through transparency and security
Pillar 4
Fast and ultrafast access to the Internet - aims to invest in infrastructure in broadband equipment
Pillar 5
Research and Innovation in ICT - Stimulates adequate funding for increased competitiveness
Pillar 6
Increasing the digital literacy of skills and inclusion - Creating a bridge to the digital divide
Pillar 7
ICT benefits for EU society - ICT's ability to reduce bureaucracy, support elderly care, improve health services, and deliver public services
Goals to be achieved by 2020:

- Employment (75% of people between 20 and 65 years should be employed)
- Research / Development (3% of GDP should be allocated to R / D)
- In the field of education (40% of people between 30 and 34 years to complete the third level of education)
- Combating poverty and social exclusion.

References

[1] Noble, B.D., and J. Flinn. 2007. “Wireless, self-organizing cyber-physical systems.” NSF Workshop on Cyber-Physical Systems. Austin, TX.
[2] Busse, M., and F.-J. Wostmann. “Intelligent Cast Parts - Application of Adaptronic Components with Cast Parts.” Proc. Adaptronic Congress, Gottingen, Germany, May, 2006.
[3] Barros, C., C.P. Leão, F. Soares, G. Minas, and J. Machado. “RePhyS: A multidisciplinary experience in remote physiological systems laboratory.” *International Journal of Online Engineering* 9, no. 5 (2013): 21-24, DOI: 10.3991/ijoe.v9iS5.2756.
[4] Pereira, C.E., S. Paladini, and F.M. Schaf. “Control and Automation Engineering Education: Combining Physical, Remote and Virtual Labs.” Proceedings of the 9th International Multi-Conference on Systems, Signals and Devices – SSD 2012, Chemnitz, Germany, 20-23 March, 2012.

[5] ***. “Digital Transformation Monitor – Key lessons from national Industry 4.0 policy initiatives in Europe.” https://ec.europa.eu/growth/tools-databases/dem/.
[6] Gheorghe, Gh. *Mecatronica și Cyber-MixMecatronica în Industria 4.0*. Bucharest, CEFIN Publishing House, ISBN: 978-606-8261-28-7, 2018.
[7] Gheorghe, Gh. *Ingineria Cyber-Mecatronică și Clatronică*. Bucharest, CEFIN Publishing House, ISBN 978-606-8261-26-3, 2017.
[8] Gheorghe, Gh. *Elaboration of new scientific and technological concepts and new virtual mechatronics and adaptronics models and cyber-mechatronics and cyber-adaptronics*. Bucharest, CEFIN Publishing House, 2016.
[9] Gheorghe, Gh., A. Constantin, I. Ilie. ”Scientific Evolution from Mix – Integrating Mechatronics to Cyber-Intelligent Mechatronics and to Claytronics Science.” Proceedings of International Conference on Aerospace, Robotics, Manufacturing Systems, Mechatronics and Neurorehabilitation OPTIROB 2016, Jupiter, Romania, June 29- July 2, 2016.
[10] Gheorghe, Gh., A. Constantin, I. Ilie. ”Mechatronics and Cyber Mechatronics in Intelligent Applications from Industry and Society.” Proceedings of International Conference on Aerospace, Robotics, Manufacturing Systems, Mechatronics and Neurorehabilitation OPTIROB 2016, Jupiter, Romania, June 29- July 2, 2016.
[11] Machado, J., F. Soares, and L. Celina. “A virtual Workbench applied to Automation Students Response Analysis.” Proceedings of 11th Portuguese Conference on Automatic Control - Controlo 2014, Porto, Portugal, July 21-23, 2014.
[12] Varela, M.L.R., G.D. Putnik, V.K. Manupati, G. Rajyalakshmi, J. Trojanowska, and J. Machado. “Collaborative manufacturing based on cloud, and on other I4.0 oriented principles and technologies: A systematic literature review and reflections.” *Management and Production Engineering Review* 9, no. 3 (2018): 90--99.
[13] Gheorghe, Gh. *Micro-nano-ingineria inteligentă integronică*. Bucharest, CEFIN Publishing House, ISBN: 978-973-720-538-4, 2014.
[14] Gheorghe, Gh. *Study and analysis regarding the concepts of mechatronics and adatronics virtual models and cyber-mechatronics and cyber-adaptronics*. Bucharest, CEFIN Publishing House, 2016.
[15] Bruns, F.W., H.H. Erbe, and M. Faust. “Engineering Future Laboratories.” *Marvel – A Leonardo da Vinci Pilot Project– Mechatronics Training in Real and Virtual Environments*. Bremen, 2005.
[16] Noble, B., and J. Flinn. “Wireless, self-organizing cyberphysical systems.” Proc. of the NSF Workshop on CyberPhysical Systems, Austin, TX., 2007.
[17] Pop, I.G., and V. Matiec. “Transdisciplinary Approach of the Mechatronics in the Knowledge-based Society. Advances in Mechatronics.” H. Martinez-Alfaro (Ed.), InTech, 2011.
[18] Gharavi, H., K.V. Prasad, and P. Ioannou. “Scanning advanced automobile technology.” Proc. IEEE 95 (2007): 328–333.