

The Development of Intelligent Industry in Romania

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Abstract—The scientific work deals with Romania's level of readiness for the development of the Intelligent Industry (4.0), in relation to the national, European and international trends, with the identification of the strengths and weaknesses and the steps needed to be taken to reduce the gap compared to the developed countries. The scientific work will focus next on examples of contributions and elaborations of original concepts and constructions of intelligent systems, technological platforms and cobot networks that support the digital enterprise and the Intelligent Industry (4.0) in Romania.

Index Terms—Smart industry (4.0), process chain, smart manufacturing, mechatronic and cyber-mechatronic systems, cobot technology platforms, cobot networks.

I. INTRODUCTION

At European level, a complex and ambitious program called Industry 4.0 has been elaborated, with the aim focused on a new industrial revolution understood more towards a much improved or modernized industry, by using and integrating cyber-physical and cyber-mixmechatronics systems in intelligent manufacturing.

The initiative of starting Industry 4.0, took Germany in 2011, through the so-called Industry 4.0 project, after which other countries in the EU and from around the world have created and adopted similar programs: Factory of the future (in France and Italy), Catapult (in the UK), respectively Smart Manufacturing in the USA, Made in China - 2005 (in China) or Innovation 2025 (in Japan), respectively the principles of the German program Industry 4.0, a program fully adopted by the EU, where integrated industrial products can interact with the production of equipment by transferring the information corresponding to the different stages of processors and development of an intelligent manufacturing environment having the capacity to communicate and make optimal decisions in a self-contained way.

The major economic and political challenge of allowing all industrial sectors to take advantage of digital innovation in products, manufacturing processes and business models.

The European Industry 4.0 program has become of global importance, with the initiative of the World Economic Forum in Davos, to organize a debate on this topic, at the level of 2016.

Industry 4.0 is characterized by the automation, digitization and cybernetization of all components of the intelligent production processes.

In order to reach this very ambitious goal, Europe has set

itself to invest over 1.3 billion euros in the next 15 years.

The major political and economic challenge is to make all industrial sectors take full advantage of digital innovation in products, processes and business models.

Then, is Romania ready to align itself with the European countries that have already started national / European programs to meet this challenge and not to remain an outsider in this competition?

For this, one of the directions of strategic development of Romania must be oriented to Industry 4.0.

Knowing that in this period, the intelligent product options are chosen by the customer, purchased from the manufacturer and then realized with advanced processing systems such as: rapid prototyping technologies, cloud manufacturing, augmented reality, stochastic simulation, Internet of Things - IoT, Internet of people - IoP, data security, data processing, parts manufacturing in the cloud, processing by adding material, Big Data, autonomous robots, process simulation, vertical and horizontal systems integration [1].

The intelligent technical and technological evolution takes place from Embedded Systems to the IoT (Internet of Things) and has been achieved through the Networks of Embedded Systems and Cyber-Physical Systems, and Cyber-MixMechatronics Systems [2].

II. DIGITAL TRANSFORMATION IN INDUSTRIAL MANUFACTURING SECTOR

The strategy of Industry 4.0 in Romania will be a new economic path of the Government, in order to ensure and prosper in a fast-changing global economy, different industrial sectors prioritizing the smart strategic areas.

The firm adoption of Industry 4.0 will be essential for maintaining a competitive production database in the future, which will lead to national productivity gains and to the sustainability of high-quality jobs and economic growth.

Companies in Romania, of all sizes will face challenges in developing and adapting the strategies of Industry 4.0.

Since 2018, the proposal for the Strategy for Industry 4.0 has acknowledged these challenges and signaled Romania's ambition, not only to respond, but to adopt the opportunities offered, including a flourishing community of indigenous SMEs from the value chains of development and the presence of industries, top software and ICT [3].

In this regard, Research-Development-Innovation will play a key role in ensuring that there are already institutions and universities in Romania that face Industry 4.0.

The government programs that support the clusters in Romania, will bring together this expertise for developing innovative solutions and new business opportunities, as well as ensuring the widespread adoption of new technologies.

An essential concern of future policy is the effect that digitization will have on employment. It is expected that the

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skills that will be needed from the workforce will be reshaped in the future.

The Government of Romania will ensure that the education system and vocational training will respond to the needs in the exchange of appropriate competences.

The strategy of Industry 4.0 will support the Action Plan of Romania, as digital technologies can lead to processes of increased production of resources in terms of energy and materials. The vision of this Strategy, foresees that by 2030, Romania will be a competitive production point, based on an innovation, at the frontier of the fourth industrial revolution of development and adaptation of Industry 4.0, with the impact that digital technologies will have. such as artificial intelligence, robotics, Big Data, etc.

The new digital technologies must transform the international value chains of production, the supply chains and the business models.

The digitization of production will use digital technologies, data and applications for the year to provide progress in manufacturing operations and to enhance the performance of manufactured products.

The family of advanced technologies, which underlies digitization, comprises: cloud computing, advanced sensors, high performance computing, advanced automated and autonomous systems, robotics, artificial intelligence, machine learning, augmented / virtual reality, encryption security, big data, digital manufacturing , etc.

The capacity of Industry 4.0, will be a critical engine of the respective competitiveness, it will establish the increase of productivity and innovation of new goods and services throughout the value chain.

Businesses of all sizes will face challenges in developing and implementing Industry 4.0 strategies, including: investments in research, development and innovation and access to demonstrations; challenges related to technology adoption, including availability of roadmaps and expertise; interoperability and standards and identifying common opportunities and new partners in the value chain; faces internal challenges around implementation, including firm capacity, skills shortages and costs of technology implementation and integration.

The vision for Industry 4.0 in Romania

The vision underlying this strategy is that, by 2030, Romania will create a competitive, innovative production hub, oriented to the frontier of the fourth industrial revolution, in the adoption and development of Industry 4.0.

The Romanian institutions and SMEs will initiate technologies of Industry 4.0 to support productivity, international growth and sustainable employment through:

- Adopting intelligent manufacturing methods to improve productivity and enable improved customization and manufacturing of intelligent products;
- Competition in new markets based on innovations in goods and services;
- Developing new business models;
- Better integration of supply chains;
- Building a competitive advantage through the

development, adoption and strategic use of the relevant standards;

- Opportunities to develop current and future workforce skills and capabilities for Industry 4.0;
- Developing and deploying new technologies of industry
- based on our strengths in RDI;
- A collaborative culture will support digital transformation in industrial sectors, value chains and supply chains; The Industry 4.0 ecosystem will be supported by a strong and balanced legal and regulatory framework.
- The objectives of Industry 4.0 Strategy in Romania:
- Stimulating institutions and SMEs to adopt the capacity in technologies related to Industry 4.0;
- stimulating institutions and SMEs to take advantage of the new opportunities allowed by the technologies of Industry 4.0;
- Becoming a global leader in the field of RDI, which is the basis of Industry 4.0;
- Facilitating current and future workforce to develop skills to deliver Industry 4.0 transformation;
- Establishing an international business environment for Industry 4.0.
- Strategic actions of Industry 4.0 in Romania:
- future production in Romania (through “future intelligent production”);
- Awareness and understanding of digital concepts;
- Exploration and planning (including roadmap development);
- implementation of Industry 4.0 strategies at the digital enterprise level (including access to finance, skills development and consortia);
- framework conditions (in the Reference Architecture);
- Implementation of the National Industry Strategy 4.0 in Romania (through monitoring and supervision).

Tehnologies related to Industry 4.0 (Fig. 1):

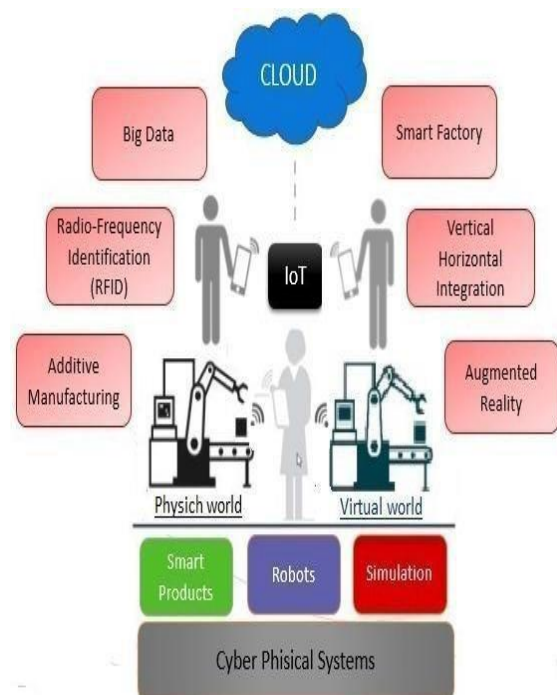


Fig. 1. Tehnologies related to industry 4.0.

- Another definition of Industry 4.0:
- Industry 4.0 is not a revolutionary industry of the 4.0 generation, but an evolutionary improvement of the production and business model;
- Industry 4.0 - strengthening the industrial policy paradigm;
- Industry 4.0 - opportunities and risks in the economy and society; - productivity and competitiveness; - development of employment; - qualification; - big data / data security;
- Industry 4.0 - revolutionary idea, evolutionary implementation;
- Industry 4.0 - political initiatives and players;
- Industry 4.0 - the role of ministries and public administration regarding industry 4.0 (Ministry of Education and Research, Ministry of Internal Affairs, Ministry of European Affairs, Ministry of Labor and Social Protection, Ministry of Economy, Energy and Business Environment, Ministry of Transport, Ministry of Communications and Information, etc., including employers' and trade union organizations, professional associations).

III. THE PRACTICAL ROADMAP FOR IMPLEMENTING INDUSTRY 4.0 IN ROMANIA

Presentation of the Roadmap: is it a promotion or is it actually happening?

The term of "Intelligent Industry" is today known as "the fourth industrial revolution of the 21st century". In other words, Industry 4.0 refers to the digitalization of the business infrastructure, without any consistent standards or definitions being applied for companies worldwide. Industry 4.0 will fundamentally define how a country like Romania will do business in the next years (15-20 years).

The expression "Intelligent Industry 4.0", first invented in Germany in 2010, is expanding more and more, in more and more European countries and in the world, where some of its effects are perceived and seen, in different parts of the value-added chain, and the supply chain (especially in the automotive industry).

However, Industry 4.0 faces several obstacles / barriers, in the applicant countries, but especially in Romania, as a future applicant of the Industry 4.0 concept. Mostly, there is a reluctance and even a suspicion towards the implementation of Industry 4.0 in the respective country, as an influence, often given by the headquarters in its country / countries.

Essentially, many difficulties are taken into account with the understanding in Romania, about what is actually Industry 4.0: it is the fourth industrial revolution or, that it is not a revolution but a logical "evolution" from the implementation of automation / cybernetization.

Industry 4.0, where it is developed, is characterized by the manufacturer through: intelligent manufacturing, connected products and a connected supply chain.

In the long term, under the conditions of its development, Industry 4.0 will require the integration of these three aspects in an evolved strategy to guarantee future competitiveness and growth.

This roadmap will not deviate or focus on a particular

aspect of Industry 4.0, and its guidance may be applied to production, products or the supply chain, depending on the areas a business may wish to grant priority.

The purpose of the roadmap is to provide practical guidance to companies wishing to implement some aspects of Industry 4.0, without engaging in a large amount of capital or time, attracting any doubts about the suitability of Industry 4.0 for certain businesses and emphasizing the benefits. a step-by-step approach.

Currently, Romanian companies, both large and small, are under constant pressure from customers for their products to be of good quality, low cost and available as quickly as possible [4]. Industry 4.0 should be viewed by manufacturers as a framework for a group of advanced technology tools that will enable them to meet these customer requirements. Real-time data collection and processing will allow quality checks. at the point of manufacture, the dimensions of the economic chain should be reduced, making production and monitoring of the health of machines and products much more flexible, thus allowing the forecasting and scheduling of maintenance during natural breaks, rather than repair of damage.

Thus, businesses will be encouraged to go further in their implementation of Industry 4.0, in a way that best suits their business model, one step at a time, with a limited budget, without being distracted by the excess of emotion about a concept that has not yet been formally defined.

- What Barriers to Industry White Paper 4.0 can be?

The governments of the world are creating strategies and policies to encourage the adoption of digitized production from the Advanced Production Partnership in the USA, to the Action Plan of the 2020 High-tech Strategy in Germany.

But the real indicator of Industry 4.0's success is the pace at which individual companies are embracing a digital, software-based framework as part of their own strategy.

Surveys were conducted to understand the current sentiment towards Industry 4.0.

These surveys have shown a distinct lack of understanding and investment.

An Industry 4.0 report highlights that 56% of respondents admitted that they do not have an understanding of Industry 4.0.

Further 48% stated that they have no strategy to implement or meet the requirements of Industry 4.0 in the next few years. And of the 20% who had a form of strategy in place, only 2% acknowledged that their strategy was developed and implemented by foreign parent companies.

The bottom line is that the (British) industry remains reluctant to Industry 4.0, often relying on foreign intervention or support to achieve significant digital growth.

Thus, there are concerns about scale, cost and skills that act as barriers in digitizing the manufacturing infrastructure.

By analyzing some of these barriers, it results:

- 1) "the big bang": is it too much, too soon? The capabilities of Industry 4.0 will soon become a "qualifier to compete" for all companies in the world. This leads to the conclusion that each company must transfer its production entirely to a system based on Industry 4.0

- 2) too large in scale?

The suitability of one's manufacturing environment for

Industry 4.0 will certainly vary from business to business, but many Romanian manufacturers are unaware that there are a number of technologies to support the digitization of their infrastructure, without the need to replace existing equipment. This "one-of-a-kind" accounting is another reason behind the (British) industry's reluctance.

3) the cost of implementation

Whether the business has an "all or nothing" or "small, fit" mentality, cost will remain a major concern.

At present, this is difficult: there is little data to demonstrate the return on investments in Industry 4.0.

4) is the workforce ready?

It is very important to say that Industry 4.0 is not just about automation, cloud computing or edge technologies and data sharing.

Therefore, this requires each individual employee to change their thinking and adopt one that is, no longer open to change, but open to concepts that Industry 4.0 embodies, such as using data to improve processes or collaboration. more open with partners along the value chain.

After all, we cannot invest in the latest technologies if we do not have the skills or knowledge to fully exploit them.

5) what is the solution?

This white paper does not offer a broad solution to these barriers. Instead, it recommends that businesses implement Industry 4.0 through a step-by-step approach.

This means prioritizing the areas where digitization would offer the most benefits

The advantage of this approach is that the solid foundations of technology, infrastructure and skills cannot be laid, facilitating the final transition to the so-called "factory of the future".

For the integration of Industry 4.0, three steps are recommended:

- 6) implementation of sensors and controls;
- 7) improving the capabilities of these sensors;
- 8) complete implementation, in which the capabilities of Industry 4.0 are implemented at the factory level.

For the implementation of sensors and controllers, the IoT Gateway combines hardware and software, which are based on Linux operating systems, as well as several Java applications and other open interfaces.

Once the sensors have been installed correctly, a business can start collecting process data.

The IoT Gateway works by collecting data through configured sensors, which cover both digital and approval interfaces and connections such as Bluetooth, USB and RFID. The data is then processed by Devises App, which transforms the data into readable information using logical and mathematical operations.

To improve the capacities of these sensors, these capabilities are used by integrating "higher level systems".

For full implementation, in which the capabilities of Industry 4.0 are implemented at the installation level, he can then consider working for the full implementation of Industry 4.0. Through this approach the digitization of a product can be achieved with a natural evolution of the separate elements, connected in a fully connected functional installation.

Thus, before this can be achieved, the infrastructure of an enterprise must be able to support a wider source of

digitization.

Case study: Modernization of old machines for the future Factory.

For this case study, we started by installing sensors on machines, which, after connecting to the IoT Gateway, collected data on performance parameters such as: temperature, pressure, vibration, energy consumption, angle inclination and rotation speed. The IoT Gateway could then transmit this data to a monitor, which displays the results of the lathe operators, in a way that is both intelligible and actionable.

Thus, the lathe is a good example of how the capacity of Industry 4.0 can continue to achieve a return on investments from cars that are over a century old.

Final Thoughts for the Roadmap:

Industry 4.0 is not a revolution, but an evolution

After the case study, we do not have to replace the machines in order not to adopt the existing assets to a new way of working.

We are looking forward to witnessing the results of this digital transformation.

IV. EXAMPLES OF ORIGINAL CONTRIBUTIONS AND DEVELOPMENT OF CONCEPTS AND ONSTRUCTION OF NTELLIGENT SYSTEMS SUPPORTING THE DIGITAL ENTERPRISEAND THE SMART INDUSTRY IN ROMANIA

Application in the field of ultra-precise positioning and dimensional control of microbots

The hexapod microrobotic system (Fig. 2) is composed of the micromechanical subsystem, the mobile platform, supported by six linear actuators, electric drives, controller, PC and software programs. All commands for positioning the mobile platform of the robotic system are given in orthogonal coordinates and transformed by the controller in specific positions of the robotic system and in related speeds. Through the integrated software, with the possibility of updating, the controller can be configured to control the additional axes.

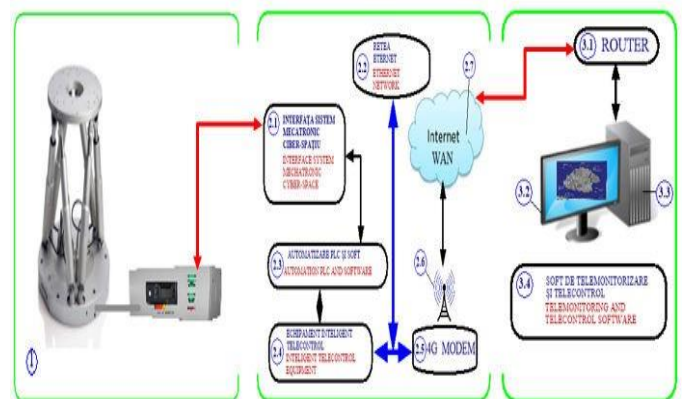


Fig. 2. Application in the field of ultra-precise positioning and dimensional control of microbots.

A hexapod robot is a mechanical and electronic device, the movement of which is based on the six legs. Unlike other types of robots with two, three or four legs, the hexapod robot has superior flexibility and stability. Therefore, the behavior of a hexapod robot is much more complex, especially since not all six legs are required for movement; the others can be used to pick up objects or to better target the robot to

certain areas.

Application in the field of dimensional control of microrobots (Fig. 3)

The presented system is a robotic mechatronic system for dimensional control, integrated and controlled remotely through the Telemonitoring and Telecontrol Center.

The robotic mechatronic system positions, guides and manipulates the high precision probing instrument, as programmed by the command center.

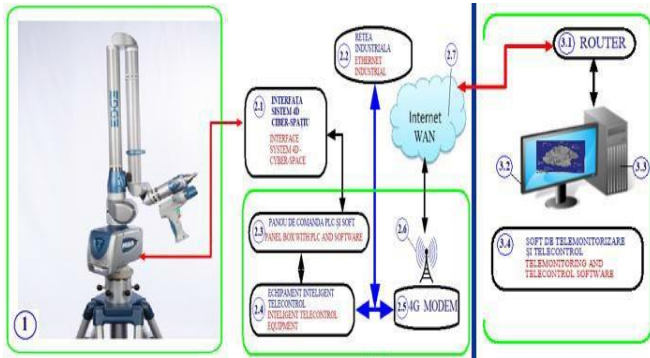


Fig. 3. Application in the field of dimensional control of microrobots.

In general, the action of the robotic arm equipped with the high precision probe, is much better performed by the robot compared to the other mechatronic systems of measurement with manual actuation.

When testing the communication network that will be used in the management and / or monitoring process; the average delay times and the probability of error / data packet loss are considered. If these delay times are much shorter than the required sampling period, the process can be conducted by including a delay block. If the delay times become comparable with the sampling period then it is recommended to use a structure that uses a Smith preacher (closed loop adjustment system with offset compensation).

After the experiments carried out, it was possible to group in three different situations the automatic remote control of the processes:

Case 1: Predictive dimensional control for delayed automatic systems.

Case 2: Adaptive predictive dimensional control using a delay calculated a posteriori to which, based on the experimental values of the delays, an average value is calculated which is used in the automatic driving algorithm.

Case 3: Adaptive predictive dimensional control using an a priori estimated variable delay: based on the experimental values of the delays, the delay time was estimated at the next sampling period.

Application in the field of electronic and electrotechnical industry (cobot platform for assembly and inspection pick and place) (Fig. 4).

Most pick and place applications can run autonomously using Universal Robots and Kuka collaborative robots and essentially contribute to increased process productivity and application flexibility. It takes superhuman abilities to repeat the same movements for many hours with the same precision. Therefore, the repeatability of ± 0.1 mm of the bumpers is perfect for the automation of precision pick and place applications.

Due to their small size and constructive shape,

collaborative robots can be easily integrated into small workspaces.

Due to the easy programming and the short start-up time of the Universal Robots, these are ideal for small volumes of production, they can be easily reprogrammed and relocated for different handling applications.

Adapting the collaborative robot to other handling applications is quick and easy, allowing you to automate almost any manual process, including for small series production.

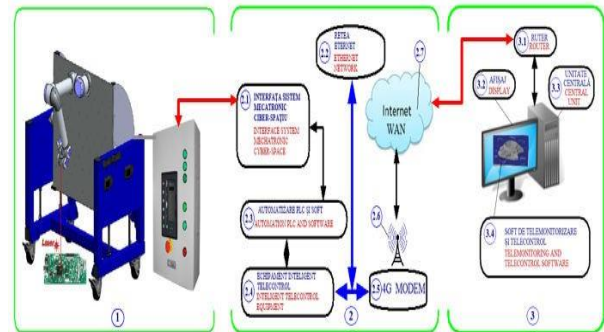


Fig. 4. application in the field of electronic and electrotechnical industry (cobot platform for assembly and inspection pick and place).

Application in the field of automobiles - intelligent cobotic platform for measuring and controlling the car body (Fig. 5)

Collaborative robots can reduce assembly time, increase productivity by increasing speed and at the same time improve production quality on auto assembly lines.

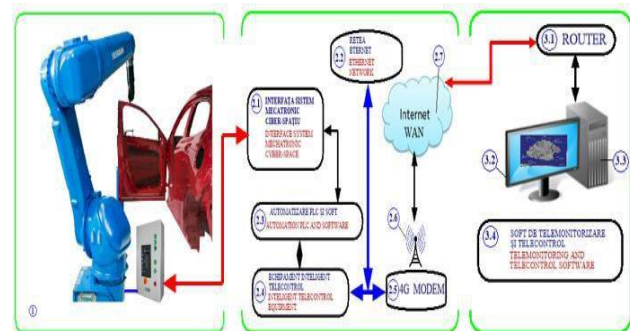


Fig. 5. Application in the field of automobiles - intelligent cobotic platform for measuring and controlling the car body.

Application in the robotic industry - intelligent cobotic platform with DODECAPOD positioning system (Fig. 6)

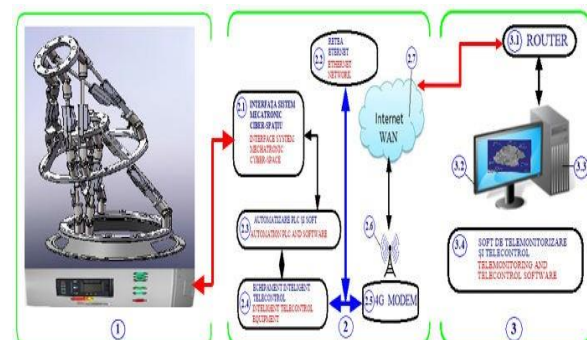


Fig. 6. Application in the robotic industry - intelligent cobotic platform with DODECAPOD positioning system.

Unlike other types of robots, with two, three or four degrees of freedom, the hexapod robot has greater flexibility and

stability. Therefore, the behavior of a hexapod robot is much more complex, especially because the six legs are necessary for movement; the others can be used to pick up objects or to better target the robot to certain areas.

Application in the metrology industry - COBOT intelligent platform (Fig. 7)

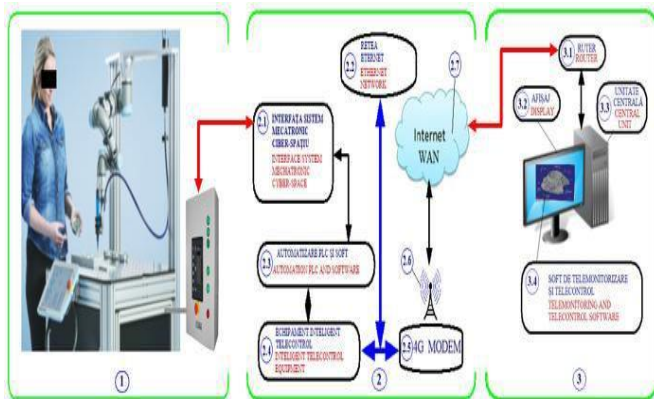


Fig. 7. Application in the metrology industry - COBOT intelligent platform

Dimensional control robots for metrological processes, are digitized parts of Industry 4.0 and are integrative architectures of the digitized enterprise related to Industry 4.0.

Dimensional control robots for metrological processes are designed and made in mechatronic and cyber-mixing mechatronic solutions, in digitized architectures specific to the parts and assemblies of digitized enterprises of Industry 4.0.

The Cobot network of technological platforms has the following integrated components

COBOT / Intelligent Drones technology platform for postal services;

COBOT / Intelligent Drones fire extinguisher technology platform;

COBOT technology platform / Intelligent drone system for agriculture;

COBOT / Smart Drones technology platform for shooting.

Each of the COBOT technology platforms / Drone system / Smart drone / Intelligent drone system for corporate and postal services / fire extinguishing / crop treatment and filming services, has a modular / typed structure, as follows:

the intelligent equipment / mechatronic system / drone that operates all the activities related to the social services, based on the special and specialized software0 and which forms the specific database for the social services and the agricultural services.

The variety of equipment / systems and drones is very extensive, covering the whole agricultural area, fruit trees, fish, etc. and it is expressed technically and technologically in diverse subtype dimensions with intelligent variants and with integrated functions and specific to agricultural services.

the cybernetic environment / cyber space consists of intelligent electronic components such as antennas, 4G generation and 5G generation modems, etc., which ensure the transport of information through the communication bus to the other parts of the technology platform or cobot network.

It ensures the transmission of information through the INTERNET and INTRANET, to the beneficiary as well as to the supplier.

The telemaintenance center of the technological platform, ensures the real and virtual communication with the beneficiary, in order to ensure the quality of the products and the processes of intelligent manufacture.

Through the Integrative Center for telemonitoring of the Cobot Network, a good development of the activities characteristic of the field of intelligent and ecological agriculture is ensured.

Each COBOT type technology platform in the Cobot Platform Network carries out its specific activities, ensuring the contribution of the platforms to the digital development and transformation of SMEs and the Intelligent Industry.

Also, each Cobot Platform Network contributes to the digital development and transformation of SMEs and the Intelligent Industry.

V. CONCLUSION

The development of the Intelligent Industry in Romania can take place and can be carried out in stages (stage I - digital development and transformation of the intelligent parts and subsystems, stage II - digital development and transformation of the Digital Enterprise and the Intelligent Industry ensemble and by domains different industries with strategic priorities according to the Intelligent Industry Strategy, Action Plan, Roadmap, etc.

In the next stage of Romania, the basic elements of the Industry 4.0 are initiated, through decisions at national level to elaborate the Strategy of Industry 4.0 for Romania and its integration / implementation in the National Development Strategies of Romania in the medium and base period, for a strategic start of Industry 4.0, of the National Action Plan of those foreseen in these strategies.

The Roadmap for Industry Strategy 4.0 will include all the elements necessary for the implementation of the Industry 4.0 strategy, the relative architecture for digitization and all other professional and technological components, human and social resources, for a sustainable support of Industry 4.0 in Romania.

Therefore, the solutions that are designed, realized and implemented in the industrial environments for the consolidation of the Intelligent Industry, become the basic pillars for the Smart Industry and for the Digital Enterprise.

REFERENCES

- [1] G. Gheorghe, V. Bajeianru, and I. Ilie, "Ingineria mecatronică și cyber-MIXMECATRONICĂ pentru construcția întreprinderii digitale și industriei inteligente (4.0)," Bucharest, CEFIN Publishing House, 2019.
- [2] G. Gheorghe, "Concept and mechatronics and cyber-mixmechatronics constructions, in- tegrated in COBOT type technology platform for intelligent industry (4.0)," in *Proc. International Conference of Mechatronics and Cyber-Mix Mechatronics*, Springer Link, Publishing House, 2019.
- [3] D. Costa, M. Martins, S. Martins, E. Teixeira, A. Bastos, A. R. Cunha, L. Varela, and J. Machado, "Evaluation of different mechanisms of production activity control in the context of industry 4.0," in *Proc. International Conference of Mechatronics and Cyber-Mix Mechatronics*, Springer Link Publishing House, 2019.
- [4] G. Gheorghe, "Challenges and research in the innovation of digital enterprise and smart in-dustry (4.0)," 2019.
- [5] International Conference on Hydraulics and Pneumatics – HERVEX, November 13-15, Baile Govora, Romania, ISSN 1454 – 8003, 2019.
- [6] German Engineering Association, German association of ICT industry, and German association of electrics and electronics industry.

- [7] Club IT&C – TAG Media – Mai 2018: Digital Transformation 2018, ISSN 1583-5111.
- [8] F. Acatech, “Ensuring the future of manufacturing in Germany — Recommendations for implementing the strategic initiative Industrie 4.0,” Final Report, 2013.
- [9] I. G. Gheorghe, A. Constantin, and I. Ilie, “Mechatronics and cyber mechatronics in intelligent applications from industry and society,” Romania, 2016.
- [10] I. G. Gheorghe, “Mecatronics and cyber-mixmechatronics in industry 4.0,” CEFIN Publishing House, 2018.



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