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NEW MECHATRONICS AND CYBER-MIX MECHATRONICS SYSTEMS AND ECO-SYSTEMS DESIGNED BY THE RESEARCH INFRASTRUCTURE ECOSIN-MECATRON

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Abstract: *Within the framework of the "ECOSIN – MECATRON" Research Infrastructure project, INCDMTM - Bucharest develops Intelligent Mechatronics and Cyber - Mix - Mechatronics Intelligent Eco Systems, which is the foundation for the Intelligent Mechatronics Industries for the Intelligent Field of Specialization and for Mechatronics and Cyber – Mechatronics, by presenting advanced solutions and intelligent technologies related to the economic, industrial and social sustainability in Romania.*

Keywords*: Intelligent ecosystems, mechatronics and cyber-mechatronics systems, research infrastructure, ecosin-mecatron*

1. I.C. ECOSIN-MECATRON

- **I.C. ECOSIN-MECATRON** = New MECHATRONICS and CYBER-MIXMECHATRONICS MULTIAPLICATIVE Intelligent Systems, is currently research infrastructure I.C. national and distributed and in the future European / international and distributed.
- **Coordinator partners**
  INCDMTM – coordinator and initiator of I.C.);
  Partners (and participants):
  INCD-ICPECA; INCD-IMT; INCD-TP; INCD-INMA; INCD-INOE 2000; INFLPR; IMS-AR; ISSR; S.C. OPTOELECTRONICA 2001; INCD- Victor Babeș; I.N. Fundeni; IPA-CIFAT, Craiova; U.P.B.; U.Gh. Asachi-Iași; U.Tr.-Brașov; U.V. Târgoviște; U. Dunărea de Jos-Galați; U. Ovidiu- Constanța, U. Lucian Blaga- Sibiu; U.T. Cluj-Napoca; U.P.-Timișoara; U. Ștefan cel Mare- Suceava; U.T.- Craiova; U.- Pitești; U.M.F. Carol Davila- București; R.T.R. București; S.C. Automobile Renault- Dacia, Pitești; AroTT;
- **Location:** distributed, at the headquarters of the coordinator and partners and participants (currently- from România and in the future – from Romania and Europe). Headquarters of the coordinator institution is: București, România, șos. Pantelimon, nr. 6-8, sector 2; web: www.incdmtm.ro;
- **Short description**: I.C. ECOSIN-MECATRON, develop Smart Specialized Intelligent Domain Eco-Nano-Technologies and Advanced Materials from SNCDI by Physical Sciences and Engineering correlated and focused with the field of science, Mechatronics and Cyber Mechatronics.
- Due to advances in automation of manufacturing and processes, mechatronics and cyber-mechatronics are gaining more and more importance, and its demands result in the need for advanced intelligent systems. Due to the increasing importance of automation and manufacturing and processes, the automation and cybernetic technology industry takes on an increasingly important role in industrial processes (intelligent manufacturing, intelligent integrated control). The basis of any intelligent mechatronic and / or cyber mechatronic closed loop control system is to detect states and variables of intelligent coloring or data processes that are then remote configured, remote manipulated and remote monitoring.
- **Scientific context and relevance:** I. C. ECOSIN-MECHATRON is relevant in the context of major societal challenges, this project being unique to Romania's industrial and economic construction and to many countries in the world. In Romania, INCDMTM has developed intelligent

and cyber-mechatronic systems and products already implemented in the Romanian industry (ex SC Automobile Renault-Dacia, Pitesti). Since 2000, INCDMTM has created and developed other evolutionary engineering branches, such as Integronics and Adaptronics, as scientific steps to Cyber-Mechatronics and Multi-Media Cyber-Mechatronics, with adaptations to the new working conditions of the intelligent industry and the performing economy. INCDMTM, collaborates in this intelligent specialized field with other national institutes, technical and polytechnical universities and other companies, in the fields of: Mechatronics and Micro-Nano-Mechatronics; Cyber-Mechatronics and Cyber-Micro Nano Mechatronics; Advanced intelligent materials; Mechatronics in Robotics, Mechatronics in Agriculture 4.0; Mechatronics in Industry 4.0; Automobile Mechatronics [Autotronics]; and so on The ECOSIN-MECATRON project contributes to the achievement of the objectives of the National Strategy for RDI 2020, namely general strategic objectives: increasing the competitiveness of the Romanian economy through innovation, increasing the Romanian contribution to the knowledge programs; increasing the role of science in society and specific objectives: increasing the level and efficiency of knowledge in correlation with the public priority: New and emerging technologies.

- **The state of implementation in Romania:** I. C. ECOSIN-MECATRON, includes a National Strategic Consortium (Universities and Research Entities), which will expand its European / international strategy (with existing Mechatronics and Cyber-Mecatronics entities in Europe). The implementation steps are: p1 - the development of the National Consortium (achieved) and the International Strategic Consortium (to be achieved); p2 - offering projects in the fields of I.C., by national and European programs (partially implemented); p3 - project execution (in progress); p4-monitoring of construction and equipment related to projects and infrastructure (in progress); p5-monitoring of national and European project financing (to be achieved); p6-enrollment of I.C. in Networks (national and European / International), completing the National and European Values Chain (to be achieved); p7-value contribution of I.C. (to be achieved). I.C. highlights the achievements already begun with socio-economic impact, as follows: achieving over 250 intelligent mechatronic products implemented in industry (e.g. Automotive Industry – SC Automobile Renault-Dacia, SC Componente Auto Topoloveni, SC Renault Technologie Roumanie, etc.).), the creation of new jobs (about 120); increasing labor productivity, increasing the quality of manufacturing, etc.
- **Socio-economic Impact**: (a) the chronology of events: established in 2010, and based on the SOPE projects. The initiative started with the projects won at the POSCCE competitions, as early as 2010, for the intelligent domains: CENTERS: Sedcontrol, Bio mechatronics, Certim, Cermiso, Knowledge Transfer and Mechatronic Products. (b) the type of service they provide or they will provide: industrial and laboratory; for intelligent manufacturing; new and advanced materials; micro-nanotechnologies; automation and cybernetization of manufacturing, etc.
- The socio-economic impact in Romania will be sustainable and developed for a Romanian information society with a modern and competitive 4.0 industry with intelligent agriculture, etc.
- Socio-economic impact in the E.U. and in the world will be globally sustainable and developed for a society of intelligent knowledge and a neural society, with intelligent industries and economies, with superior and performing social, cultural and communication relations and with societal transformations and changes, corresponding to the level of the 21st century.
- **Unique character of I.C. ECOSIN-MECATRON:**

- radical societal changes (industry 4.0 - intelligence and cybernetics, agriculture 4.0 - intelligent and cybernetics, intelligent medicine, advanced aerospace industry - mechatronic and cyber-mechatronic systems and technologies for adaptive and multifunctional aerospace systems (e.g. drone systems and networks for agriculture - control of crops and agricultural production), etc.

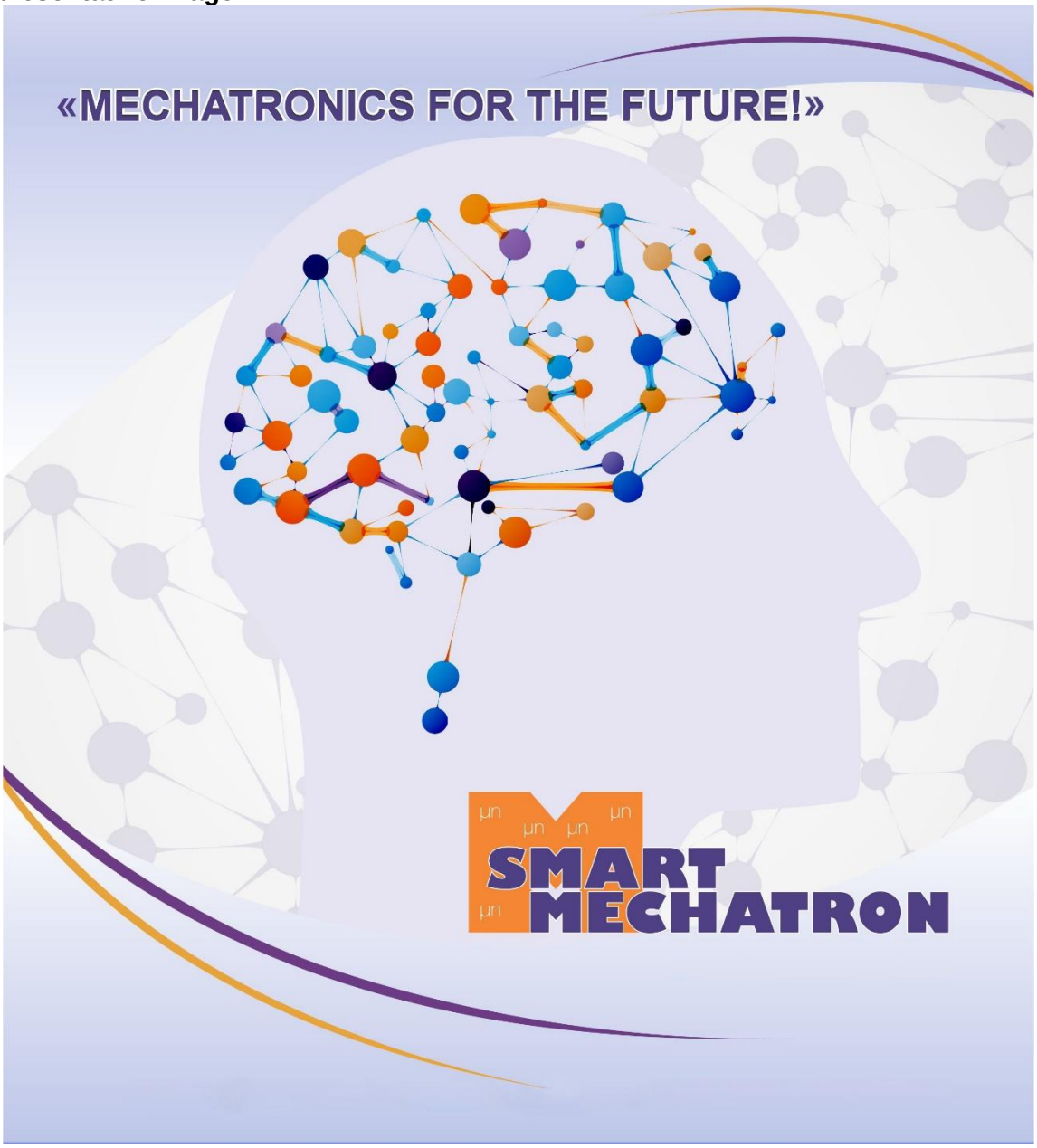
The ECOSIN-MECATRON project contributes to the achievement of the objectives of the National Strategy for CDI2020, namely general strategic objectives:

- ECOSIN-MECATRON, contributes to the achievement of the main and specific objectives of the National RDI Strategy 2020 at national level and the Europe 2020 and Europe 2030 Strategy at European / International level.
- **Financial Information:**

Construction costs and infrastructure for the European component: 280 mil. Euro

Construction costs and infrastructure for the Romanian component: 56 mil. Euro
(of which spent and provided in contracted projects, 7.009 mil. Euro);
Total operating costs: 38 mil. Euro
Operating costs, Romanian contribution:19 mil. Euro

- **Representative image:**



2. Preamble

The new Intelligent Specialization Mecatronica, Mix - Mechatronics and Cyber - MixMecatronica, addresses the philosophy of education in the new Engineering for the Future and Future Cognitive Society, as well as the holistic multidisciplinarity of it.
Depending on the new requirements of the process, product, materials, technology, energy, application and effect in industry, economy and society, this new field has been developed, upgraded and adapted to meet various operational criteria such as reducing material resources , energy and finance, high-level operation, optimal ergonomics, and cost-cutting at the limit.
In this sense, the concept and the evolutionary structure of the intelligent specialized field develops

towards a generative evolution, by adding new structural, functional elements and components and subsystems, on new principles and adapted accordingly to the new scientific discoveries, in order to obtain technical facilities and effects, technological and economic demands required by the concrete applications of intelligent mechatronic products, technologies and services.
The concepts of the mechatronic and cyber-mixmechatronic experimental models are involved in selective scenarios and variants and in support of their construction, through engineering challenges, as follows:

- selected scenarious on “monitoring system of controllers from distance;
- selected scenarious on “actuator detection control system”;
- selected scenarious on “ Automated Traffic Control and Monitoring System”;
- selected scenarious on “ mobile surveillance system for automobile survival”;
- selected scenarious on “monitoring system of communication channel”;
- the concept of a "cyber-mecatronic robot system with telemonitoring and telecontrol" and modularised programming and coordination systems in cyberspace;
- the concept of a “the concept of a "intelligent 3D mecatronic system with two grippers and two 3D sensors for measurement, integrated control and industrial services" and monitored programming and coordination subsystems in cyberspace;
- the concept of a “ the concept of a "cyber-mecatronic technological instrument system with telemonitoring and telecontrol and modularized programming and coordinating subsystems in cyberspace;
- the modular structure of a “mechatronic and cyber-mecatronic intelligent control system of castings in the automotive industry by telecontrol and telemonitoring" and the modularized programming and coordination subsystems in cyberspace;
- the concept of “ convergence of complexity in cyber-mechatronics’;
- “microcontroller programming and interfacing to intelligent mechatronic and cyber-mixmechronic systems”;
- “ Intelligent Mechatronic 3D Equipment for Processes of Measurement, Control and Industrial Services”;
- “intelligent mecatronic intelligent 3D equipment, dual in triple axes”;
- “ hardware and software structures for mechatronic and cyber-mechatronic systems”;
- “ creating virtual prototypes that increase the speed of development of mechatronic and cyber-mechatronic machines”;
- “conceptual design of the magnetic suspension for the suspension system”;
- the structure of cyber-mixmecatronic 3D multi-application system with telecontrol and telemonitoring”;
- “magneto-rheological damping system for railway vehicle suspensions”;
- etc.

It is presented in ECOSIN-MECATRON, in original concept, foundation of cyber-mixmechatronics multiaplicative systems as parts of cyber-physical systems (cyber-physical / cyber-mechatronics and intelligent virtual solutions in construction. The paper focuses on the basics of cyber-physical systems supported by the world's great strategists, with specific examples and concepts, with potential societal applications - intelligent mechatronic systems and in the future, clatronics, systems in virtual reality, with some major challenges on reliability and uncertainty, abstraction and physical-cybernetic matching, as well as design software, time-sensitive programming languages and networking for superdense time.
The Universe of Cyber Physics (or Physical Cybernetics / Cyber-Mechatronics) includes, in its program of development and implementation, the main stages, step by step, to materialize and implement them in society, to ensure innovative national, European and international strategies for a post-informational and neural society.
Thus, they are based on the "bases of cyber-physical systems" created and grounded by the great strategists of the world regarding:

> **The concepts** of cyber-physical systems (supported by global strategists Christopher Chadwick, Sarah Betzig și Fei Hu);

> **The design challenges of cyber-physical systems** (supported by global strategists Cameron Patterson, Roger Vasquez și Fei Hu);
> **Creating** mobile cyber-physical systems (supported by global strategists Yeqing Wu și Fei Hu),
Follows the "design principles of cyber-physical systems":
> Cyber-physical systems controllers (supported by Tony Huynh, Ahmed Alsadah and Fei Hu);
> Learning apprenticeship on the Physical-Cybernetic Intelligent System (supported by Kassie mccarley, Joseph Pivscan and Fei Hu);
> **Application** of HDP-HMM for the dynamic recognition of "hand gestures" (supported by world strategies Lv Wu Ting Zhang and Fei Hu);
> **Modeling problems** in Cyber-Physics Systems (supported by global strategies Michael Johnson, Tony Randolph and Fei Hu);
> **Modeling** Cyber-Physics Systems (Cognitive Vehicles - Remote Airplane), (backed by global strategy Meng Cheng Ong, Fei Hu and Yang-Ki Hong);
> **Security** of Cyber-Physics Systems (supported by Steven Guy, Erica Boyle and Fei Hu);
> **Physical Cyber Security Systems** - Smart Smart Network example (supported by Rebecca Landrum, Sarah Pace and Fei Hu),
Continuing with "Intelligent Sensor Architecture - the basis of Cyber-Physics Systems, on:
> **Wireless sensors** and wireless actuators for applications in Cyber-Physics (supported by Kassie mccarley, Joseph Pierson and Fei Hu);
> **Communication detection** (supported by Trenton Bennet, John Har and Fei Hu);
> **Integrated / Deployed Wireless Microsystem Architecture and Security** (supported by Derek Chandler, Jonathan Pittman, Jaber Abu-Qahouq, and Fei Hu);
> **Application** of a learning machine in physical sensing activity monitoring (Wenlong Tang, Ting Zhong and Edward Sezonov)
Finally, it concludes with "Cyber-Physical Civil Applications Applications" for:
> Creating efficient energy (supported by great strategists Preston Arnett, Jan Wolfe and Fei Hu);
> Creating cyber-physical systems for smart grid smart applications (supported by great strategists Matei Rell, Loilim Muirhead and Fei Hu);
> Creating Video in Unmanned Aircraft for Cyber-Physical Systems (supported by great strategists Meng Cheng Ong, Fei Hu, Yang-Ki Hong, Kenneth Rieks, and Jaber Abu-Qahouq).

3. Conception and realization of mechatronics and cyber-mix mechatronics experimental models by research infrastructure ECOSIN-MECATRON

- **3D cyber-mix-mecatronic System ultraprecise multiaplicative for remote control and remote monitoring** (fig. 1).
  - According to figure 1, the matrix structure physical (mixmechatronics) and cybernetical (IT&C) of the system, enables automation, computerization and remote communication, intelligent control and monitoring, thereby contributing to raising the quality level and reducing operating costs specific to the automotive industry.
  - The 3D axis system (x, y, z) 1.1 with ultraprecise remote control is ordered by PC with specific software 1.4 and 1.5 for the realization of measuring function of a part 1.3 with 3D ultraprecise probe 1.2. The system is protected with lasser protection barrier 1.6 and communicate with special equipments from the electronic unit 1.7 in PLC 2.1 and Internet GPRS 4G. This communication connection is linked with remote control center 3 provided with a computing station 3.2 and 3.3 connected to the router 3.1 and on which specialized software 3.4 runs.
  - In the 3D mode of travel, the cyber-mix-mechatronic system is designed to be operated locally using a program preinstalled on PC equipped with display and control software and modeling and emulating remote position. Switching between the two operating modes can be done anytime and measurement (3D control) points may be stored in the memory functioning in the automatic PLC mode.

- Thus, all these complex functions may be implemented by integrating several functional testing and smart subsystems.

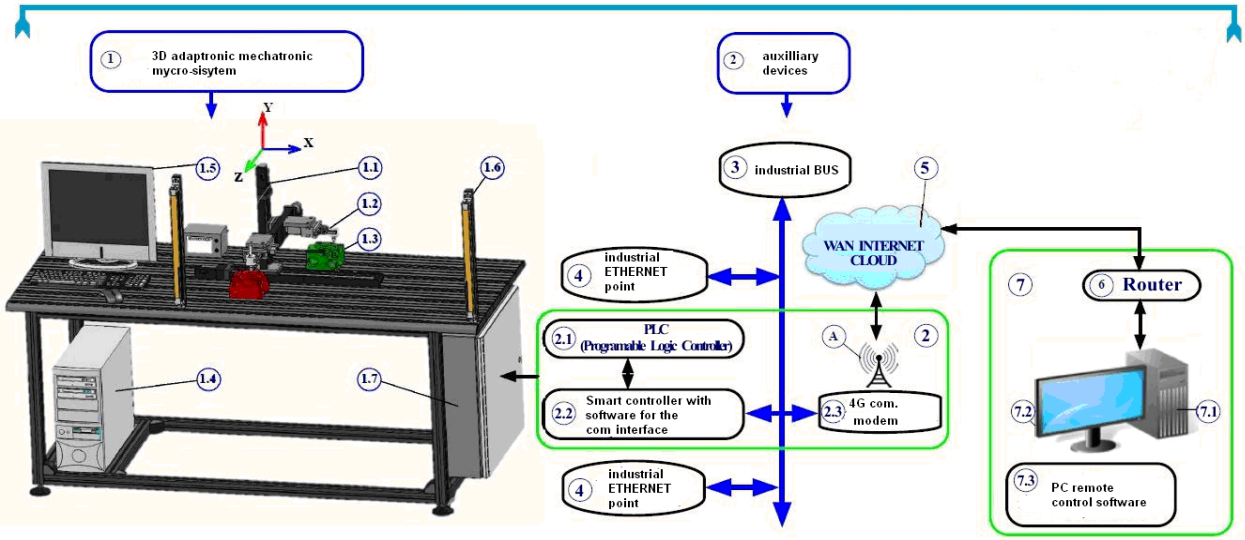


Fig. 1

Caption:

1. 3 D cyber-mix-mechatronic system:
1.1 Ultra-precise 3D measuring system / measuring robot / ultra precise control robot (x-300mm; y=200mm; z=250mm; accuracy:0.1-1nm);
1.2 3D ultra precise probe (accuracy: 0.1 nm);
1.3 Control / measurement part;
1.4 PC local host;
1.5 Display and local user interface;
1.6 Laser protection barrier
1.7 Unit with command system, driving system and telecommunications system;

2. Auxiliary equipments:
2.1 PLC (Programmable Logic Controller);
2.2 Smart controller with software for communication interface;
2.3 4G communication modem;
3. Industrial BUS;
4. Industrial ETHERNET point;
5. WAN INTERNET CLOUD access;
6. 802,1 lb/g router
7. Control Centre
7.2 PC Display
7.3 PC Remote monitoring software

At the same time, this cyber-mixmecatronic system does not require the continued presence of the qualified and costly human operator and aims to ensure operating parameters at nominal values, along with the advantages of cyber technology, such as:

- minimizing operating – troubleshooting time;
- preventive strategies in the operation and maintenance process;
- modularity, flexibility and security.

The 3D multiaplicative cyber-mixmechatronic system, for remote control and monitoring provides connection of remote process stations to one or more centarl control systems , using various public or private networks for event-driven take-backs caused by an event or cyclical data processing performed using special protocols and effectively managed. The cyber-mixmechatronic system uses one or more software to connect it to the "remote control and monitoring center" based on modern GPRS technologies and multiple PLCs. The cyber-mixmecatronic system can also do the teleservice that offers data exchange via the telephone line or via the Internet and Intranet, using remote equipment and systems such as computers, machines, installations and lines production, error detection, diagnostics, activity optimization, maintenance, repairs, etc.
Thus, the cyber-mixmecatronic system makes significant contributions to minimizing the cost and increasing the efficiency and productivity of industrial activities.
The main system servicies consist of:

- remote control - remote control and monitoring of a system;
- remote maintenace, consist of:

- remote monitoring – determining of the status of the system;
- remote diagnosis – identifying the causes of malfunction;
- remote maintenace – eliminating causes;
- acquisition of geometric and mechanical parameters.

- **The cyber-mixmechatronic system with remote control and remote monitoring (fig. 2)**

- According to figure 2, the physical (mechatronics) and cybernetics (IT&C) matrix structure of the system, enables automation and computerization of remote processes (telecontrol and telemonitoring) of the industrial manufacturing line.
- The system performs the function of protecting workstations from human errors specific to fabrication lines (1.1) in the series in the industry, such as automotive parts in the manufacturing industry. Parts (1.2) call feature tags with unique ID RFID (1.3) communicating bi-directionally with a drive (2.4) with automation equipment and telecommunication local but also a smart bracelet (2.3) situated on the hand of the operator who is using the device (2.2) equipped with RFID tag and bidirectional communication. Intercommunication between elements listed (part, device, operator) is collected and transmitted using antennas (2.5) and (4.1) through the Internet to a (4.2) computing station at the center of remote monitoring and remote control (4).
- The computer center remote monitoring and remote control (4.2) running special software designed to synchronize tasks on a database technology and eliminate errors caused by real-time tracking and manufacturing through a comprehensive analysis and forecasts.

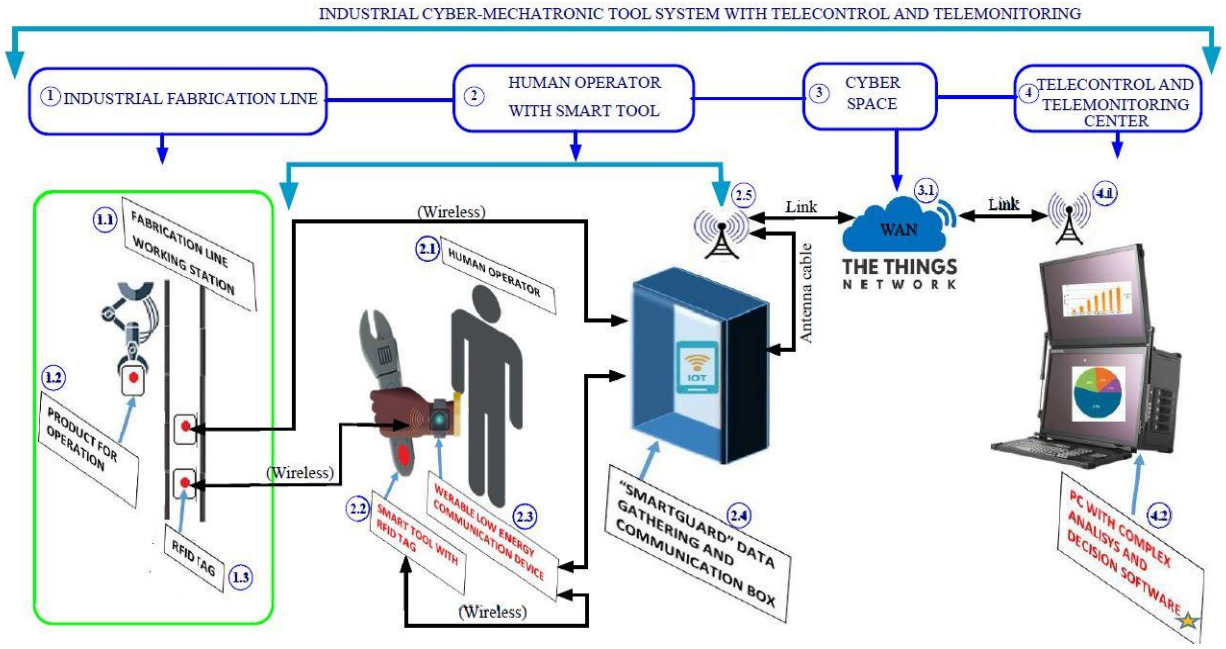


Fig. 2

Caption:

1. Industrial manufacturing line
1.1 Workstation on the fabrication line
1.2 Product for technological applications
1.3 Unique identification system with RFID

2. Human operator with smart instruments
2.1 Human operator
2.2 Unique identification system with RFID
2.3 Smart communication and warning bracelet
2.4 Unit with system for data acquisition and communication
2.5 Antenna

3. Cyber space
3.1 Internet WAN

4. Remote control and remote monitoring centre
4.1 Antenna
4.2 PC with software for complex analysis and decision

- **Smart multi-application cyber-mixmechatronic device type industrial robot for remote control and remote monitoring of operational and service processes (fig.3).**

➢ According to the mentioned figure, the structure of the physical matrix [Mechatronics and Cybernetics (IT & C)] of the system allows the cybernetization and remote communication of technological operational processes and of processes that service the industry, thus contributing to a higher increase in productivity and of quality of smart industrial. The cyber-mixmechatronic multi-application system performs a remote control and remote monitoring of an industrial robot (1) connected to the cyberspace via the control unit 1.2 and the interface 1.3 with both the internal industrial bus (2.1) and Internet via a 4G GPRS modem. Through this communication connection is made the link to a centre of remote control and remote monitoring (3) provided with a computing station (3.2) and (3.3) connected to the router (3.1) and running specialized software for robot control (3.4).

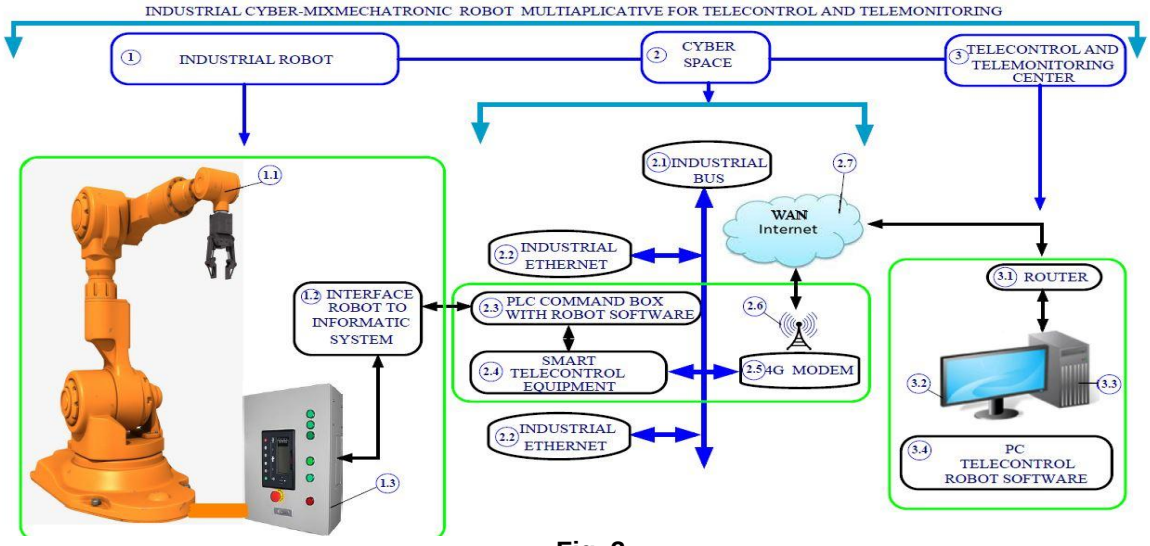


Fig. 3

Caption:

1. Industrial robot
1.1Universal robotic arm (with gripper / 3D feeler)
1.2Interface between the robot and the informatic environment
1.3Command tools

2. Cyber space
2.1Industrial communication bus
2.2Industrial ETHERNET network
2.3Programmable PLC with ROBOT software
2.4Smart devices for remote control and remote communication
2.54D GPRS modem
2.6Internet WAN

3. Center of remote control and remote monitoring
3.1 Router linking to WAN Internet
3.2 PC monitor
3.3 Central unit
3.4 UPC with ROBOT remote control software

- **Cyber-mixmechatronic system for dampening for automotives and with remote control and remote monitoring functions (fig.4).**

According to the mentioned figure, the structure of the physical matrix (damper and cybernetics (IT & C) of the cyber-mixmechatronic system for dampening for automotives allows the smart computerization and cybernetization of the automotive and of the automotive industry, by raising the quality and increasing productivity of the automotive industry.
The cyber-mixmechatronic system for dampening for automotives allows the function of remote monitoring and remote control of a smart damper (1) provided with an electromagnet (1.1) powered by a high voltage source (1.6) in order to modulate the degree of viscosity of the rheologic fluid (1.3).

To obtain information on the global acceleration of the cyber-mechatronic assembly attached to a tire of a vehicle uses the sensor (1.4) and the interface (1.5) connected to an intelligent control and remote control equipment (1.7).
Internet wan network connection is performed using a specialized 4g gprs modem (1.9) provided with an antenna (1.8).
Through this communication connection is made the link to a centre of remote control and remote monitoring (3) provided with a computing station (3.2) and (3.3) connected to the router (3.1) and running specialized software for robot control (3.4).

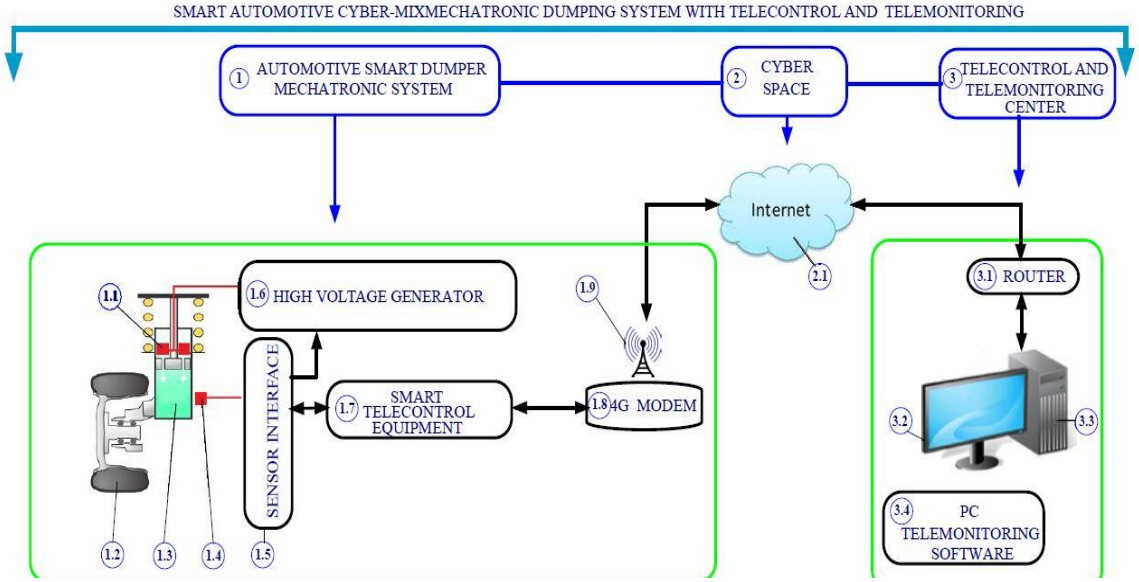


Fig. 4

Caption:

1. Smart cyber mix-mechatronic system for dampening
1.1 Electromagnet or coil
1.2 Section of a tire
1.3 Rheological fluid
1.4 Acceleration sensor
1.5 Interface between sensor and acceleration
1.6 High tension source
1.7 Smart remote control device
1.8 4D GPRS modem
Antenna

2. Cyber space
2.1 Internet WAN

3. Centre of remote control and remote monitoring
3.1 Router linking with WAN Internet
3.2 PC monitor
3.3 Central PC unit
3.4 PC with software for remote monitoring and remote control smart DAMPER

4. Scientific results

The scientific results obtained in the paper are synthesized as follows:
• **concepts of virtual models** in variants and scenarios for mechatronic and cyber-mechatronic systems, with applications in industry (eg automobile industry - SC Automobile Renault - Dacia SA Pitesti, SC Componente Auto SA Topoloveni, SC Comis SRL Valenii de munte etc) in medicine (eg smart mechatronic technologies for selective sintering with laser beam - Hospitals in Bucharest, etc.)
• Physical models in original solutions for mechatronic and cyber-mix-mechatronics systems with industrial applications (eg the fine mechanics and mechatronics industry - Mechatronics and Cyber - Mix - Mechatronics Laboratory at INCDMTM Bucharest, for measurements, micro and nano technologies for PhD thesis, from the Doctoral School of Mechanical Engineering and Mechatronics of UPB and UVT, etc);

• real parametric values for remote metered and mechatronic systems: telecontrol, telemonitoring, teleservice and teleconfiguration;
• process validation and mechatronic and cyber-mix-mecatronic system in real industrial applications.

5. Conclusions

By carrying out this scientific work" Systems and Intelligent mechatronics and cyber-mixmechatronics ecosystems developed in"ECOSIN-MECATRON", research infrastructure", the author presented:
• the creation and development of a new, specialized 21st century intelligent specialized domain to ensure the sustainable development of the national and international economy and industry, the field of Mechatronics and Cyber-Mix-Mechatronics;
• creation and development of new mechatronic and cyber-mixmechronic systems, in original and multi-purpose applications in many industrial, economic and societal environments;
• substantial contributions to solving the scientific paradigm Mechatronics, MixMecatronics and Cyber-MixMecatronics;
• Original contributions to research, development and innovation in the intelligent specialized fields of Mechatronics, MixMecatronics (Integral and Adaptronics) and Cyber-MixMecatronics.

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