NEW CYBER-MIXMECHATRONIC CONCEPT FOR THE REALIZATION OF SMART CYBERNETIC SYSTEMS WITH APPLICATIONS IN THE INDUSTRY, ECONOMY AND SOCIETY

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Abstract: *The current scientific work shows for the first time a new complex mixmechatronic concept of integration and fusion in the structures of smart technical and technological systems and of the systems of electronic control for holistic physical-virtual assembly.*
In the content of the paper highlight some results of professional research in Mechatronics and Cyber-Mix Mechatronics the National Institute of Research and Development in Mechatronics and Measurement Technique– Bucharest and universities PUB and in Romania, some of which are in the process of transfer and capitalization to the industry, economy and society.

Keywords*: cyber-mixmechatronic concept; cyber systems; electronic control; holistic physical and virtual assembly; mechatronics and cyber-mechatronics.*

1. INTRODUCTION

This scientific work responds to "challenge in the paradigm of European strategy" to create and develop new scientific concepts and Intelligent new systems with Multi-applications into new industrial value chains, which require focus, combining and merging various skills and innovative solutions, especially new multidisciplinary mechatronic, cyber-mechatronic and cyber-mixmechatronic technologies and integrating them into solutions and advanced competences with high-tech IT & C for efficiency and eco-innovation of more advanced and intelligent products, systems and systems of systems.
In these mechatronic and cyber-mechatronic systems, mechatronics and cyber-mixmechatronics facilitate an integrative-generative behavior in the whole of the elements of mechatronics, mixmechatronics and cyber-mixmechatronics or the elements of calculation, control / remote control, detection / remote sensing and monitoring / remote monitoring and smart grids and that can be deeply integrated and assembled, and their actions can be safe and interoperable.

2. THE NEW CYBER-MIXMECHATRONIC CONCEPT INTEGRATED IN THE ARCHITECTURE AND CONSTRUCTION OF INTELLIGENT MULTI-APPLICATION CYBER SYSTEMS

Integrating the complex new concept includes a flexible fusion of the architecture of smart mechatronic, cyber mechatronic and cyber-mixmechatronic systems expressed by the complex structures of specialized sensors and actuators, placed on physical work systems – both static systems and / or mobile that transmit information to smart 4G devices that process, store or transmit them to other entities / centers of monitoring / remote monitoring, for control and / or databases. Using 4G smart devices allow monitoring, diagnostics and interventions in real-time, remotely, for all intelligent mechatronic systems and static and mobile equipment. Multi-application and adaptive mechatronic, cyber-mechatronic and cyber-mixmechatronic systems, to be used and developed will be in the form of a "black box" entity that will integrate innovative hardware circuitry and software for the capture, modeling and communication of data to / from a "command center". The architecture of multiplicative adaptive devices / mechatronic, cyber-mechatronic and / or cyber-mixmechatronic systems will be modular, with the possibility of integrating other devices / smart sub-devices type "add-on" - special or dedicated to certain specific activities.
The types of data captured by these devices / sub-device smart will be processed, normalized and standardized by a multi-application and adaptive mechatronic cyber-mechatronic and / or cyber-mixmechatronic system/ mother device in formats that ensure interoperability with the platform for real-time monitoring.
The complex mechatronic, cyber-mechatronic and / or cyber-mixmechatronic concepts can be applied in many industrial environments, such as:

- remote monitoring and remote control in real time of the quality and functioning of electronic control of the automotive;
- remote monitoring and remote control in real time of the parameters of complex thermo-chemical treatment for installations with controlled atmosphere for thermo chemical treatment of machine parts;
- remote monitoring and remote control in real time for the quality of hydraulic oil from the drive farm machinery;
- remote monitoring and real-time control for CO2 and other exhaust gases in the automotive industry;
- remote monitoring and remote control in real time of the quality and functioning of electronic and automotive control stability and direction;

• remote monitoring and remote control in real time of innovative technology separation and selection of waste paper and other flexible packaging materials.

• etc.

3. REALIZATION AND EXPERIMENTATION OF CYBER-MIXMECHATRONIC SYSTEMS WITH APPLICATIONS IN INDUSTRY AND ECONOMY

Thought the new cyber-mixmechatronic complex concept was created also the concept of constructive architecture of new solutions for mechatronic cyber systems and integrated intelligent control for the automobile industry and respectively for cast auto parts and machined auto parts.

In the architecture of the cyber-mixmechatronic architecture an important substantially role is played by smart software sensors integrated into an assembly comprising pre-processing information modules, signal conditioning modules, feature extraction modules, fault detection, calibration and reconfiguration modules and IT & C modules, as follows:

• the initial stage of preprocessing converts the signal into a unit of applied engineering, including basic filtering algorithms of anti-duality, noise rejection and improved signal-to-noise ratio with calibration, normalization and (temperature) compensation algorithms;

• the calibration process may include signal linearization using a simple approach by searching the table using the coefficients stored in the data sheet of electronic sensors;

• the linearization alternative technique involves summing a mutual feature of a sensor signal;

• the additional features offered by the calibration procedure include removal of the sensor polarization;

• the calibrated signals pass through a signal conditioning module software to attract a number of features that characterize data;

• the feature extraction is a process to obscure information derived during the "history" signal sensor information that is useful both as output and as part of the research strategy of defects;

• the derivatives are a component of the main features of self-diagnostics and fault detection;

• communicating information to sensors management uses sets of error codes based on electronic mechanisms and sets of software and IT & C hardware;

• etc.

Figure 1 is a block diagram of an intelligent mechatronic system for measurement and integrated control with the main functional modules and the link between them:

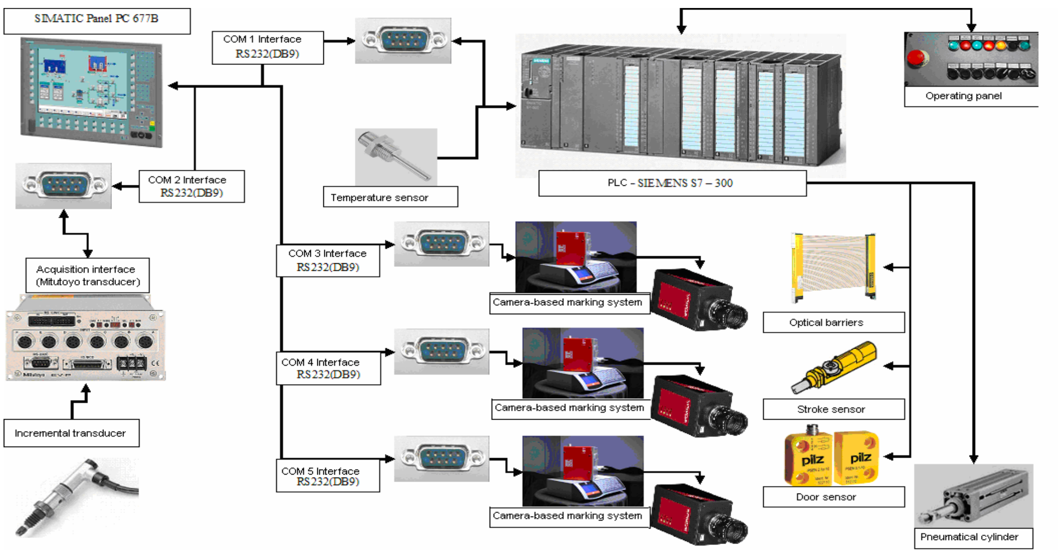


Fig. 1. Block diagram of an intelligent mechatronic system for measurement and integrated control

Figure 2 shows the complex system intelligent mechatronic with three offices (two for measurement and one for marking) for measurement and control of parts.

Legend:
1 – PC with display application;
2 – Optical protection barrier;
3 – Measuring office 1;
4 – Measuring office 2;
5 – Measuring office 1;
6 – Light beam;
7 – PLC;
8 – Sensor interface;
9 – Control panel;

Figure 2. Complex system intelligent mechatronic for measurement and control of auto parts

We will present further a few other examples of such type of smart ultra-precise mechatronic systems of parts in the automotive industry as follows:

Fig. 3

Figure 3 shows Intelligent control system - "crankcase oil S2G Raw":

(The Intelligent control system is based on pneumatic measuring principle based on the comparison with a "standard air room" that has two offices of intelligent control and one office of laser marking for part corresponding to standards,; it has a complex mechatronic structure of ultra precise sensor and actuator architectures with automated functioning and coordinated by a special and adapted software).

4. SMART ARCHITECTURES OF THE PHYSICAL (MECHATRONIC) SYSTEM AND VIRTUAL (IT&C) SYSTEMS

In figures 4 and 5 are presented the smart physical (mechatronic) architectures and virtual (IT&C) architectures, along with data systems:

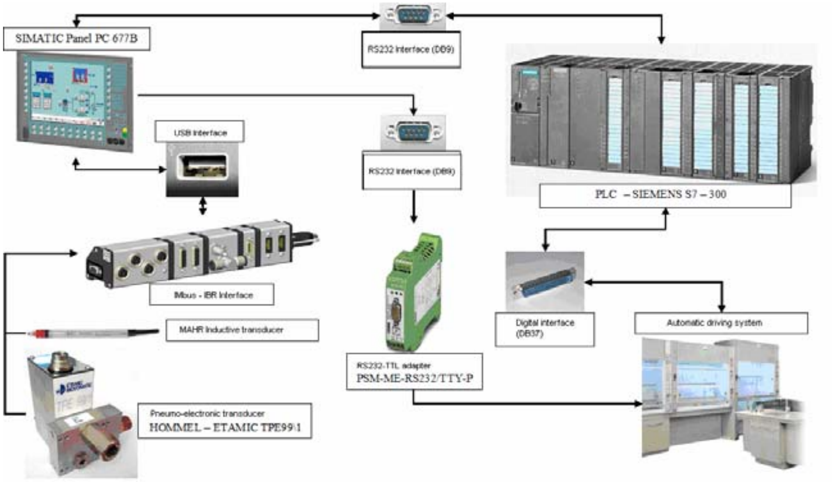


Fig. 4

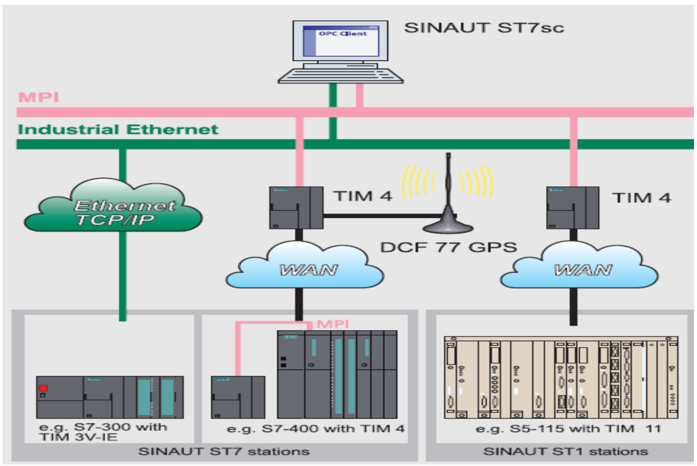
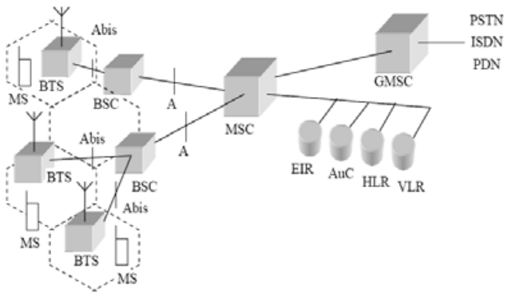


Fig. 5

Along with intelligent architectures, aims to collect data, in which case it is considered that the management system is placed away from the driven process.

Thus, the actuators receive control signals via the communication network while the data acquired from the process by sensors and transducers are also directed to the controller through the network.

Data services are monitored by the GSM communications system, whose architecture is shown in Figure 6, as follows:



Legend:

BTS	Base transceiver station	VLR	Visited location register
BSC	Base station controller	EIR	Equipment identity register
BSS	Base station subsystem (BTS + BSC)	AuC	Authentication center
MSC	Mobile services switching center	PSTN	Public switched telephone network
GMSC	Gateway MSC	ISDN	Integrated services digital network
MS	Mobile station	PDN	Public data network
HLR	Home location register		

Fig. 6

For the remote monitoring (remote control, remote service or remote configuration) process, in the architecture of multi-application smart mechatronic systems are also integrated other additional systems such as:

• Active components for connecting the (PROFIBUS) network with the network of the Wireless industrial environment (IWLAN / PBPN IO mode that supports antennas type IWLAN and WLAN, etc.):

• Active components for connecting the (PROFIBUS)network-DP slave, to the AS-I interface (Figure 7-example of how to use a DP / AS-I module);

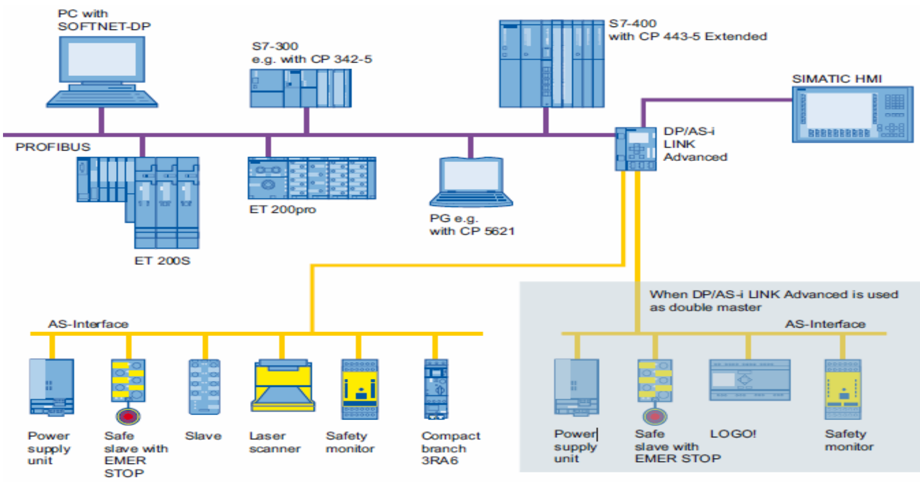


Fig. 7 Example of using a DP/AS-I module

In figure 8 is given an example of linking to internet WAN for remote monitoring the process and the system:

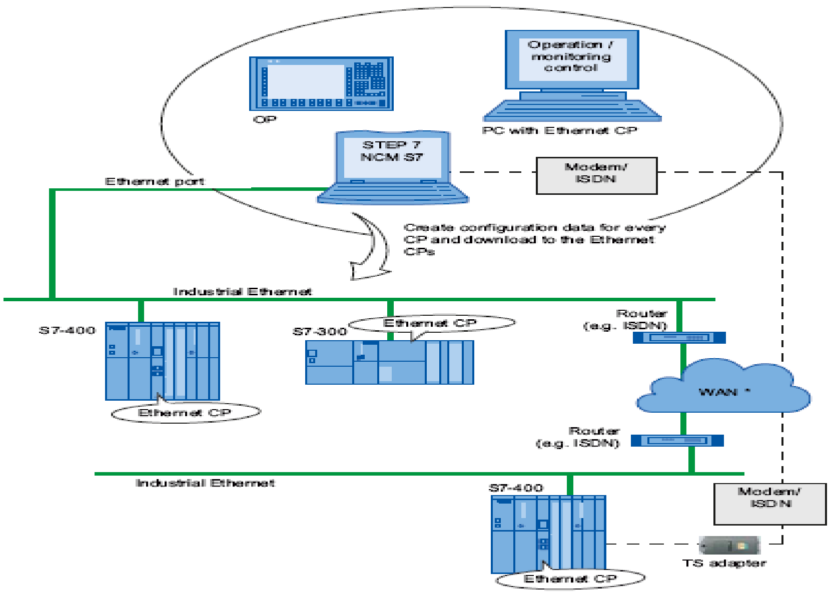


Fig. 8 Example of linking to internet WAN for remote monitoring the equipment

In figure 9 is given the block scheme of remote monitoring and remote configuration of GPS-GPRS and Internet:

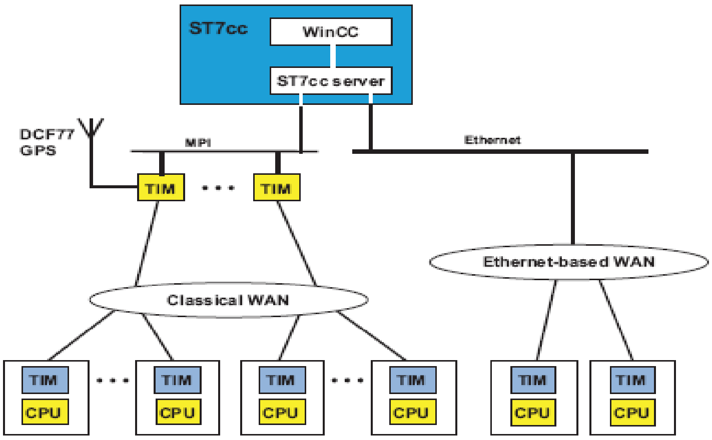


Fig. 9 Block scheme of remote monitoring and remote configuration of GPS-GPRS and Internet

The remote monitoring and remote service software on a PC platform is written in Visual C ++ and uses modem configured "as a client" that connects to the cyber-mechatronic system monitored using a RS232 connection.

Thus, in Figure 10, is presented a screen capture of the software in which are positioned the signs (1)-representing the state of inputs number [xx bitwise, the validation controllers (2)-checkbox that easy means by which the user you can set or reset the desired output Q ++, the sign (3)-representing the current values of the digital outputs Q ++, the button (4) that is pressed to achieve connecting the application of the cyber-mechatronic system to the monitor, the control editing (5) that is supplemented by the number of numeric values to be issued or requested for the actual amount taken from the cyber-mechatronic system monitored, the start address of the publisher (6), which is supplemented by a numerical value between 0 ... 7 specifying the address of the first model IO selected "board" command in the list (8), select the user for reading digital outputs and all the user completes the starting address in the editor (6) and the number of bytes editor (5). The message is transmitted by cyber-mechatronic system (see Figure 11) monitored and feedback is displayed through signs of type (1).

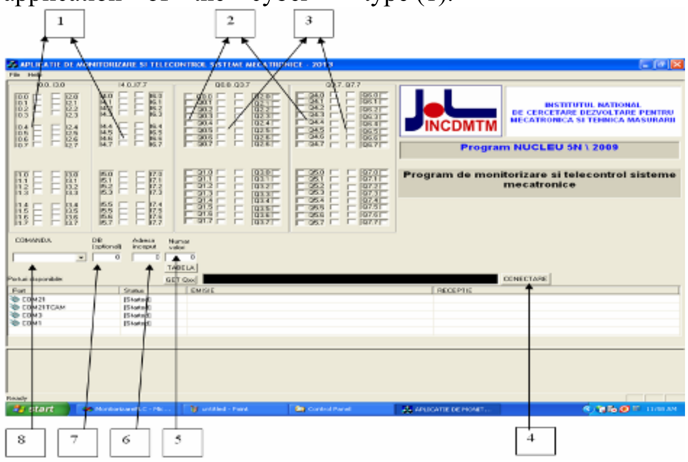


Fig.10

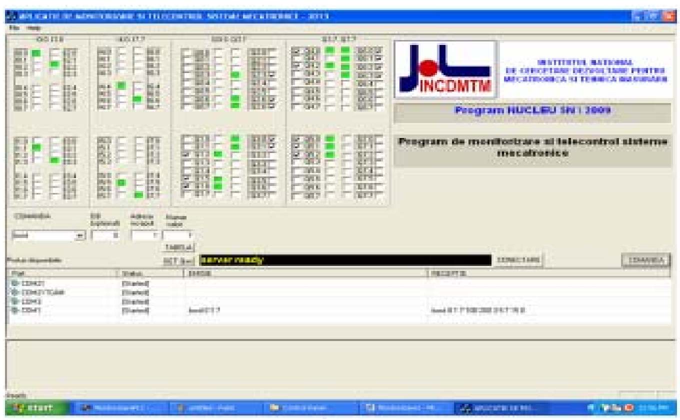


Fig. 11

For writing digital outputs, the user selects the command list (8) and completes the starting address in the editor (6) and the number of bytes in the editor (5). Next, the user actuates the button (9), pressing an editable table (11) (see Figure 12). The number of columns equals the number of output value bytes of which shall be transmitted to cyber-mixmechatronic system monitored. In every column of the table, the operator can enter numeric values between 0 and 255. You can use a method in a more elegant way: the operator selects or resets, as desired, each bit of Oxx configuration using validation checks type (2) and then acts on button (10). The numerical values of each byte of output assembled are in the appropriate box. The command message is sent to the cyber-mixmechatronic system monitored (Figure 12), and feedback is displayed through indicators type (1).

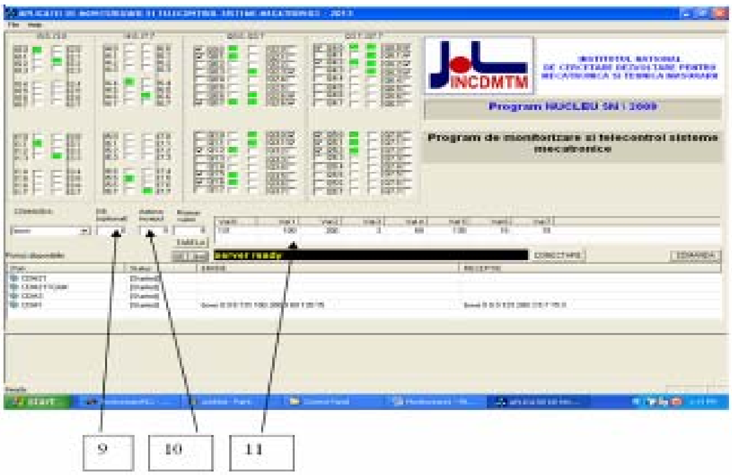


Fig. 12

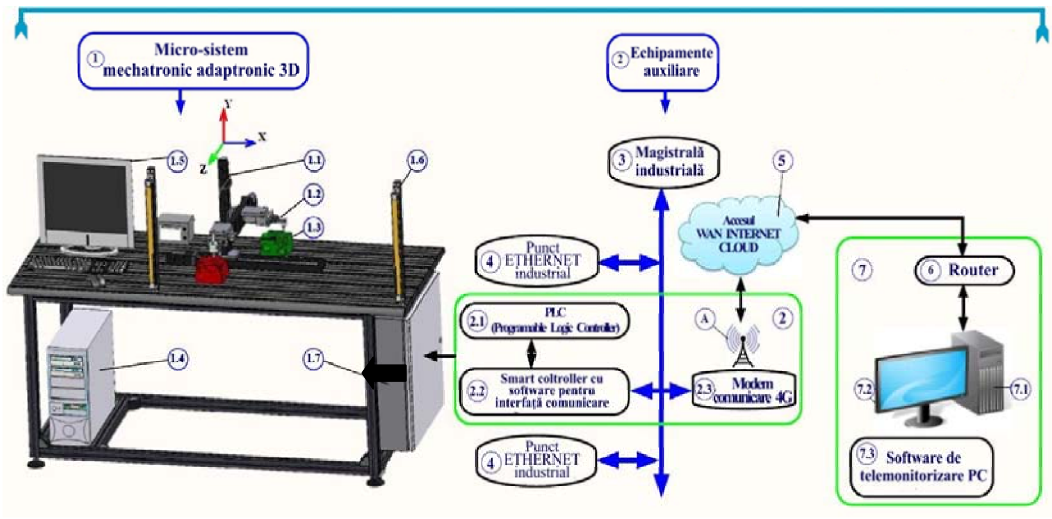
5. NEW CONCEPTIONS OF MULTI-APPLICATIVE CYBER-MIXMECHATRONIC INDUSTRIAL PROCESSES AND LABORATORY PROCESSES

The Presentation of a cyber - mixmechatronic system adaptive to process measurement and control system 3D is configured in Figure 13.

The new complex mechatronic, cyber mechatronic and / or cyber-mix-mechatronic concept created and developed by the author, was implemented in the construction of 3D smart cyber-mechatronic and / or cyber- mix-mechatronic systems for remote control, monitoring the performance of several functions (specific new concept) and ultra precise 3D remote control and adaptive appropriate environment control (metrology laboratory / industrial metrology), for transmission and transfer of data remotely (remote control according to IEC 60870-5-104), remote monitoring / remote monitoring process, and smart control through a command centre (for 3D ultra precise process control) and transfer of information through the Internet and Intranet by means of remote monitoring.

Following is the concept of a 3D Multi-application smart remote control and remote monitored ultra precise cyber mix-mechatronic system used in the metrology laboratory or industrial metrology (Figure 13).

The smart remote control and remote monitored ultra precise cyber mix-mechatronic system is aimed at achieving the control of movement functions X, Y, Z and measurement function (control) based on information from the system and from the " Highly precise 3D probe " button embedded in the designed system.



Legend:

1. 3D 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);
2.2Smart 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

Fig.13 Remote control and remote monitored ultra precise cyber mix-mechatronic system

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.

The overall block diagram of the ultra precise cyber-mix-mechatronic system, shown in figure 13 depicts the componential mix-mechatronic structure & the functional cybernetic presentation below:

• **On the local unit PC** (1.4) are collected data from the 3D Mechatronic System and they care transmitted to the SMART TELECONTROL system. The data provided by SMART TELECONTROL will be wrapped, compressed and protected by a VPN server private key. After establishing bidirectional communication with the remote monitoring system, they will be sent and accepted based on CRC checksums. After unpacking the package, the information gathered will be included in a database which will analyze the components of the cyber-mix-mechatronic micro-system.

Besides all these data into the database will be inserted also in the rangefinder system positions that will be replicated using remote monitoring software desktop. Based on this information, the software will generate a 3D image with maximum accuracy depending on how much data is received, and where there are not enough data, the previous data is interpolated to generate a more fluent. On request provides the possibility of saving the session and the image generated for use and analysis. The micro-cyber-mix-mechatronic system can be controlled in real time by using remote control software.

•**Connections and interconnections** between modules and sub-systems architecture components of the system (system of systems) differ depending on the type. The 3D mechatronic system and the 3D ultra precise probe (with nanometer precision and sub-nanometer accuracy) can be fitted if necessary with smart data transmission cables such as serial cable, parallel cable, CAN, PROFIBUS, SSI, Interpose, Ethernet, Device Net, and other specialized types.

• **The cyber-mix-mechatronic 3D (1)** is an absolute novelty in Romania, not far approached this field clever conception and realization.

• **The Programmable Logic Controller-PLC (2.1)** is a digital computer used for automation of cyber-mix-mechatronic systems to be used for storing the specific control program of the 3D micro-system (with axes X, Y, Z or robot control) to synchronously receives information from the probe in 3D.

This controller is designed for multiple inputs and outputs for use in an extended temperature range and to withstand vibration generated by the machines they control kinematics and accidental impact caused by various factors. The control program is generally protected by a copy or stored on a non-volatile memory. PLC is a system in "real time" as it outputs must be produced in response to input conditions within a limited time, otherwise unintended operation will occur that will result in undesired results. The PLC is programmed in graphic language (“ladder logic") notation used for programming being chosen so as to reduce programming time.

• **The module for achieving smart remote control (2.2)** can be implemented either with RISC microcontroller or FPGA microcontroller and will link the PLC and the 4G telecommunication modem using a specific RS232 protocol.

• **To access the 4G connection (2.3)** the system will use different public or private networks. In order to ensure the connection there are a variety of modems (2.3) compatible with RS232 data protocols. Event-driven type processing or cyclic data processing is performed using special protocols allowing remote operating personnel to control and effectively managing the process as a whole or in detail. One or more software platforms developed can be used for connecting remotely, based on modern GPRS technologies or Internet global WAN network with

PLC control system often used in other mechatronic automation equipment.

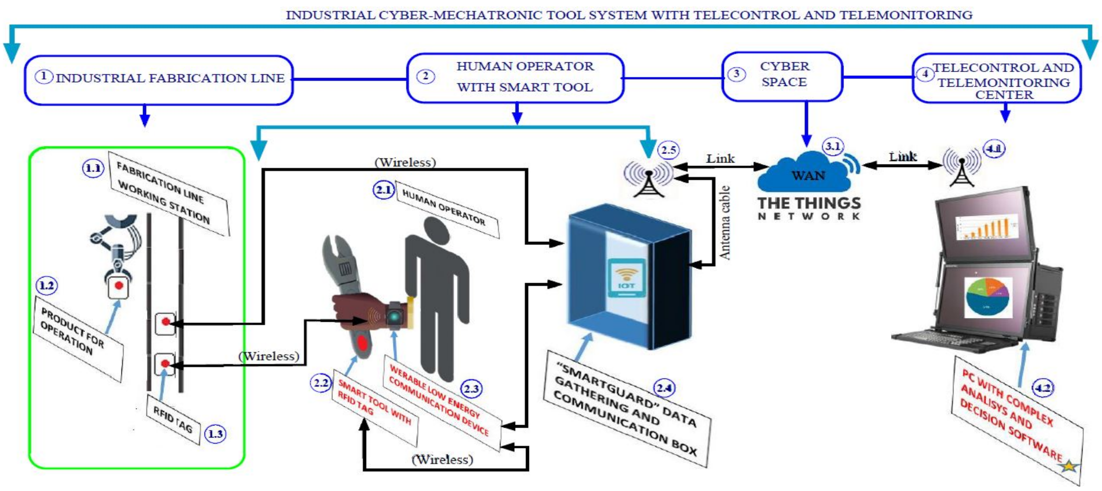
• **In the remote control Centre (7)** ensures Internet connection (5) using a router equipped with the VPN to provide a first level of data security. A 2nd level of security will be studied by using a proprietary algorithm and an encryption function for the FIREWALL specific configuration of the operating system on your PC (Windows or Linux). Scheduling an application on the network requires an RTOS (Real Time Operating System), which is offered by Dream DSP ++ kernel by VDK. This is a multitasking kernel, which incorporates mechanisms for planning and resource allocation compatible with the memory space and time constraints required by Blackfin programming process. Other facilities are VDK development of powerful applications using templates (such as the implementation of applications TCP / IP).

• **The software (7.3)** is a web application for remote controlling desktop that can be considered as two separate components: a web service and PHP front-end remote control software with real-time emulation capability. PHP Web Service is responsible for integrating telemetry database back-end and front-end and returning results from performing the remote control function in the format. To minimize the amount of data that is transferred to the front-end in real time it will be necessary to request data only for mechatronic measurement regime. After receiving the front-end data the remote control software generates a virtual model in real-time of the 3D mix-mechatronic cyber emulated system.

• The structural component of the testing notions of the evaluation and validation of the mix-cyber-mechatronic system aim to ensure a final configuration of the system developed so that it meets the initial requirements and specifications. To meet this goal, the following aspects must be detailed:

- determining the criteria for testing, evaluation and validation of the 3D cyber-mix-mechatronic system;
- description of categories of tests and evaluations involved;
- planning tests and assessments within the period of development of the mechatronic system;
- preparation of the mechatronic system for testing and evaluation.

The presentation of another industrial cyber-mixmechatronic system for protecting against human error in smart fabrication lines, using remote control and remote monitoring capabilities is configured in Figure 14.



Legend:

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

Fig. 14

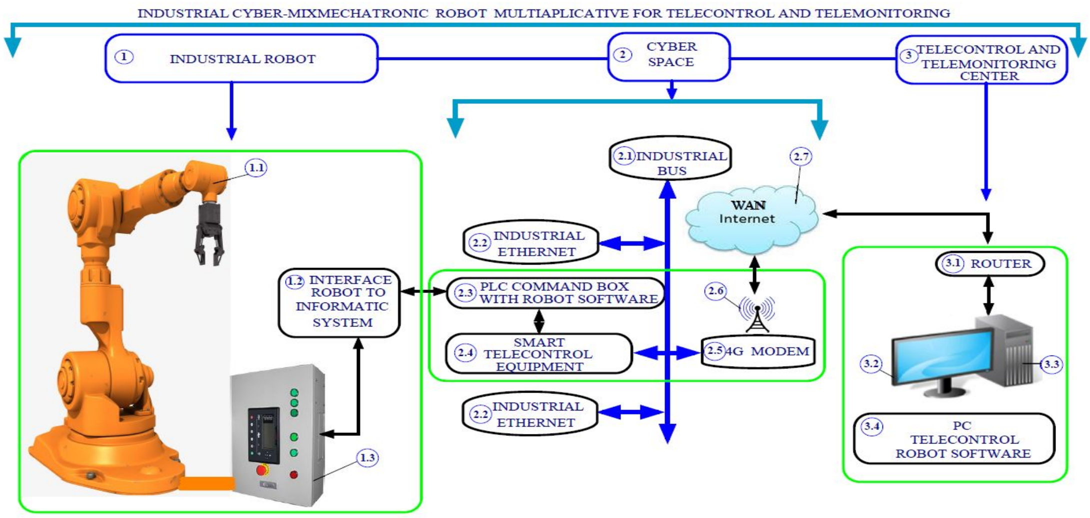
According to the mentioned figure, the structure of the physical matrix [Mechatronics and Cybernetics (IT & C)] of the system allows remote automation and computerization remote control and remote monitoring) in the industrial line of manufacturing.

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.

Presenting another complex smart multi-application cyber-mixmechatronic device type industrial robot for remote control and remote monitoring of operational and service processes is configured in Figure (15).



Legend:

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

2. Cyber space
2.1 Industrial communication bus
2.2 Industrial ETHERNET network
2.3 Programmable PLC with ROBOT software
2.4 Smart devices for remote control and remote communication
2.5 4D GPRS modem
2.6 Internet 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

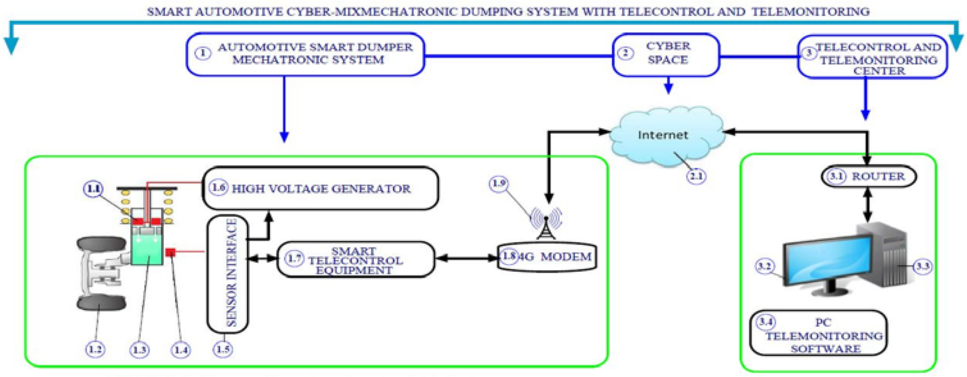
Fig. 15

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).

The presentation of another cyber-mixmechatronic system for dampening for automotives and with remote control and remote monitoring functions is configured in Figure 16



Legend:
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
1.9 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

Fig. 16

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).

6. CONCLUSION

This scientific paper aims to present "The New Complex Multi-application Cyber - Mixmechatronic Concept " used in the construction of "Ultra precise Cyber-Mixmechatronic Systems for 3D Smart Control" for laboratory metrology processes and / or industrial processes (in the automotive industry, aerospace industry, hydronic and pneutronic industry , medical and biomedical industry, etc.).
Cyber-mixmechatronic systems in coordinates, in the conception of the authors, are an absolute novelty in Romania, addressing for the first time this complex cyber-mixmechatronic concept and designed to perform the functions of 3D remote control and remote monitoring in the process of measurement and / or in the smart industrial process through signals and information on Cartesian X,Y,Z travel and ultra precise rotation travel ψ1, ψ2, ψ3 and probe measurement / control in 3D and of the software preinstalled on your PC and the software of control and modeling and remote position emulation so " position-touch information packets " will build "packages of vectors" for complex mathematical processing that can be done both locally and remotely.

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