

## COMPETITIVE AND INNOVATIVE NEW CONCEPTS OF CYBER-MECHATRONICS SYSTEMS FOR INTELIGENT INDUSTRIAL ENVIRONMENTS

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**Abstract:** *This scientific paper presents the author's original concept, foundation of multi-application cyber-mechatronic systems as part of cyber-physical systems. The paper focuses the fundamental bases of cyber - mechatronic systems in specific constructions and concepts and with potential societal applications.*

**Keywords:** *cyber-physical systems; cyber-mechatronic systems, potential societal applications.*

### 1. Introduction

The Universe of Cyber-Physical Systems (CPS) that also includes the cyber-mechatronic systems (CMS) includes in the programme of development and its application the main stages, step by step, towards their materializing and implementation in society, to ensure innovative national, European and international strategies and for post-informatic and neural society.

Cyber-physical systems (CPS), which also includes the Cyber-Mechatronic Systems (CMS), have become nowadays one of the most computerized applications, with a compact integration of cyber and physical objects [1], [2], [3].

**Cyber objects** refer to any hardware / software resource that can be realized, along with communication, information technologies and functions for control in a discrete, logical and connected environment.

**Physical objects** refer to any natural or human systems that are generated by the technical and technological laws and operating in continuous time.

Therefore, CPS & CMS - will transform the way in which we interact with the physical world, just as the Internet has transformed the way in which we interact with one another [7], [9], [11].

The ultimate goal of the CPS & CMS - is to use the cybernetic infrastructure (including sensing, computing, communication, information and hardware / software infrastructure) to ensure a smart monitoring (from physical to cyber) and take control (from cybernetic to physical) over the physical world (mechatronics).

These concepts set by the author, can be illustrated in Figure 1, [12], [13].

These concepts configured are set out systematically by mapping the basic concept of difficult design issues of CPS and CMS, after presenting the most important theories of design and modeling methods in order to finalize "a practice of CPS and CMS" then about sensors and complex smart architectures of integrated sensors for and incorporation of integrated users with actuators / complete architectures of actuators that will interact with the physical world and then about concrete projects involving CPS and CMS for civil applications, including constructions and management of energy, health care in human society and rehabilitation applications and platforms of virtual recovery for the disabled based on reality, etc. [17], [18], [19], [23].

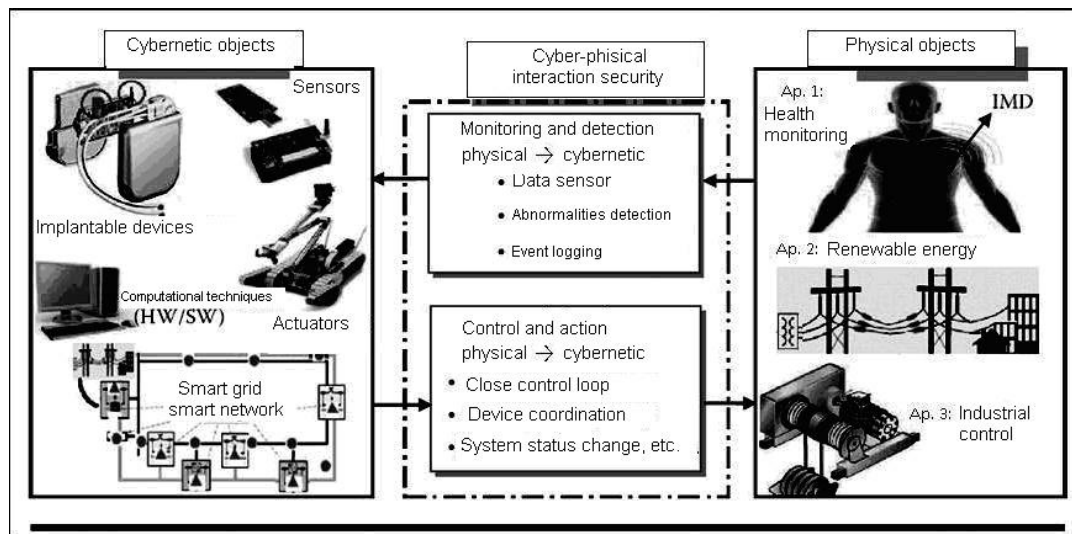


Fig. 1. Cyber-physical systems (CPS). Examples and concepts

All these concepts, theories and fundamentals are suitable for the following groups:

- Students – for classes on CPS and CMS in faculties of computer science, electrical and computer engineering, information technology and science, and so on;
- Researchers – for concepts, theory, scientific content and CPS & CMS design;
- Researchers in computing - computing algorithms for detecting patterns and control of CPS & CMS;
- Engineers – for design principles useful for CPS & CMS.
- Etc.

## 2. Cyber-Mechatronic Systems designed in INCDMTM

The design of Cyber-Mechatronic Systems (as parts of Global Cyber-Physical Systems) was achieved in research and doctoral teams due to the needs of industry, economy and society and new approaches in industrial doctoral theses, especially due to the creation, development and maturation of new specialized smart integrated advanced competitive fields embedded in technical, technological, economic and societal environments.

In the most developed industrial environment, as is the automobile industry, have been created and realized the first cyber-mechatronic systems for industrial technological processes for the smart integrated control of automotive parts and the automation of the series manufacturing processes and optimized operational processes, as presented below:

### 2.1 Ultra precise 3D multi-application Mechatronic Cyber-System for remote control and remote monitoring

According to Figure 2, the structure of the Physical (mechatronic) and Cybernetics (IT & C) matrix of the system, designed and realized in INCDMTM - in research teams, allows for the automation, computerization and remote communication of the smart control and monitoring, thus contributing to raising the quality and reducing operational costs specific to the automotive industry [22].

The 3D system of axes (x, y, z) (1.1) with ultraprecise displacement is controlled by a PC with a dedicated software (1.4) and (1.5) to achieve the specific functions of measuring the part (1.3) by using the 3D feeler (1.2). The system is protected by infrared safety barriers (1.6) and communicates with special equipments in the electronic unit (1.7) both by means of the internal industrial bus (2.1) as well as with the Internet network via a GPRS modem. Through this communication connection is ensured the link with the remote control centre (3) set with a calculation stand (3.2) and (3.3) connected to the router (3.1) and running specialized software (3.4).

In the regime of movement, the 3D system is designed to be mentioned locally using a program preinstalled on a PC equipped with a display and control software as well as by emulating the position remotely, [4], [5].

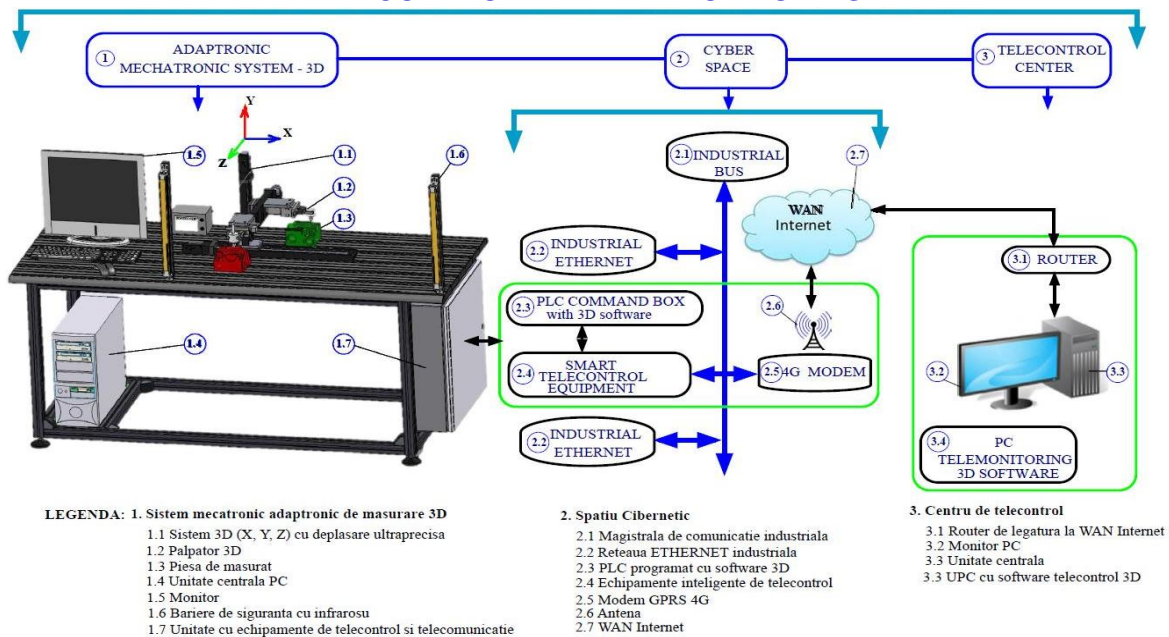
The positioning operation can be performed in a well defined area around the feeler.

In measurement mode, the pairs of information on position – feel will be converted in array packages for complex mathematical processing that can be done both locally and remotely.

Switching between the two operating modes can be made anytime and measuring points can be stored for automated operation in the PLC memory.

All these complex functions can be achieved by testing the interconnection of several units and assemblies.

### ULTRAPRECISION CYBER-MECHATRONIC 3D SYSTEM MULTIAPPLICATIVE WITH TELECONTROL AND TELEMONTORING



**Fig. 2.**

However, this cyber-mechatronic system does not require continued presence of a qualified human operator and aims to provide operating parameters at nominal values, along with advantages of the cyber technology, such as:

- minimizing operating-time debugging;
- preventive strategies in the operation and maintenance;
- modularity, flexibility and safety.

The ultra precise 3D multi-application mechatronic cyber-system for remote control and remote monitoring ensures the connection of process stations located remotely from one or more control systems with the use of different public or private networks for takeovers type event-driven, determined by an event, or cyclical processing of data taken using special protocols and effectively managed as a whole and in detail, [6], [7].

The cyber-mechatronic system uses one or more software to connect it to the "control and remote monitoring centre" based on modern technologies such as GPRS and several PLCs. The cyber-mechatronic system can achieve and ensure remote service proposing the exchange of data via the remote phone line or via the Internet and Intranet, using the equipment and remote systems, such as computers, machinery, installations and production lines for fault detection, diagnostics, optimization activities, maintenance, repairs, etc.

Thus, the cyber-mechatronic system makes significant contribution to minimizing the cost and increasing the efficiency and productivity of industrial activities.

The main services of the system consist of:

- Remote control - Remote control and monitoring system;
- Remote service, composed of:
  - remote monitoring - determining system status;
  - remote diagnosis - the identification of causes of malfunction;
  - remote maintenance - eliminating causes.
- Acquisition of geometrical and mechanic parameters.

Automatic tracking systems are composed of remote surveillance monitoring stations, which acquire store and process data from transducers located within automatic stations (Fig. 3) and mechatronic cyber-system components structured in three hierarchical levels:

- ▶ **local level** - consisting of sensors and transducers, and the local computers the data type in the structure of the system data logger placed having the function of measuring various mechanical and geometric parameters;
- ▶ **automatic monitoring station** - located in an nearby area and in charge of coordinating the procurement, collection, storage and primary processing of data received from multiple automatic surveillance stations;
- ▶ **central processing** - powerful computer located remotely, the role of data processing and analysis of data processed in the concentrator as well as the warning that the output exceeds preset limits of sizes.

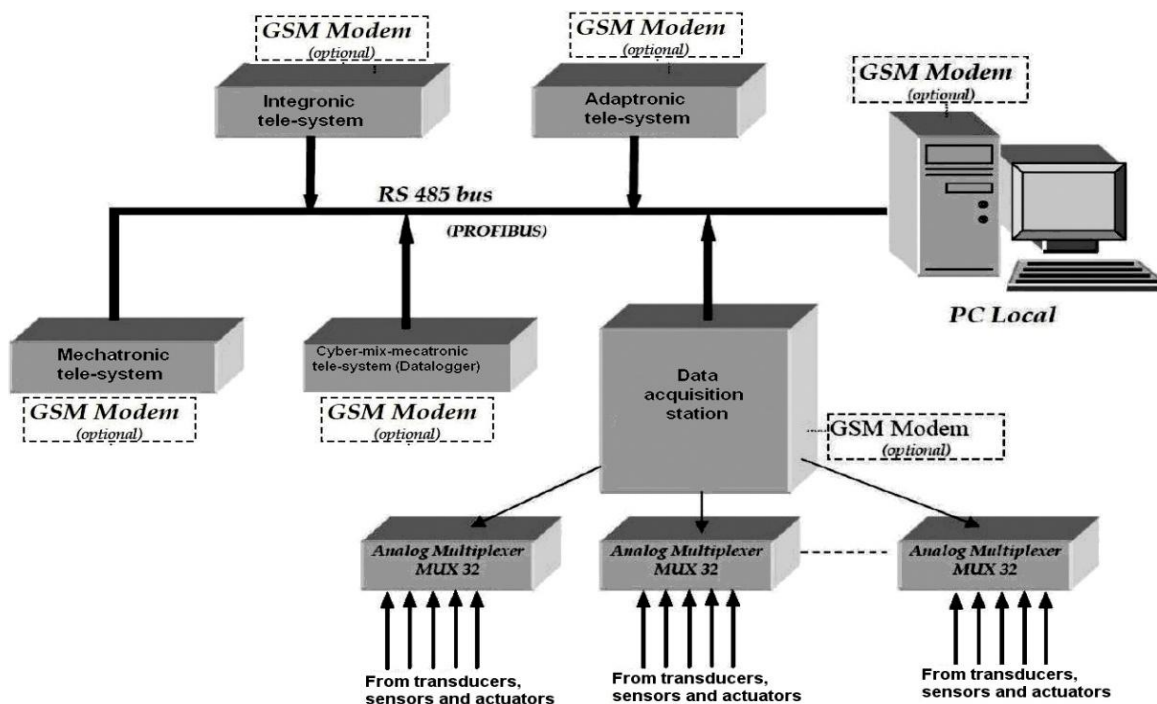


Fig. 3.

The data are collected by:

- GSM systems (data transmission, SMS);
- Radio systems;
- Satellite system(EUMETSAT);
- Mix systems(GSM - radio);
- VPN/Internet from local dispatcher centrals to other users.

## 2.2 Cyber-mechatronic industrial-technological system with remote control and remote monitoring

According to Figure 4, the structure of the physical (mechatronic) matrix and the cybernetic (IT & C) matrix of the technological system, design and made by INCDMTM – in research teams – allows the automation and remote computerization (remote control and remote monitoring) of the industrial line of the plant [10], [13], [14], [23].

The technological protection system performs the function of previous human workstations (1.1) for specific production lines in the industry, such as automotive parts manufacturing industry. Parts (1.2) feature tags with unique RFID IDs (1.3) communicating bidirectionally with a drive (2.4) and with automation equipment and local remote communication but also a smart bracelet 2.3 placed on the hand of the operator who is using the equipment (2.2) with a RFID tag and bidirectional communication. Intercommunication between the mentioned elements (part, device, operator) is collected and transmitted using antennas (2.5) and (4.1) via the Internet to a (4.2) computing station at the centre of remote monitoring and remote control (4).

The computer in the centre of remote monitoring and remote control (4.2) runs special software designed to synchronize tasks on a database technology and eliminate errors caused by real-time tracking and manufacture through comprehensive analysis and forecasts.

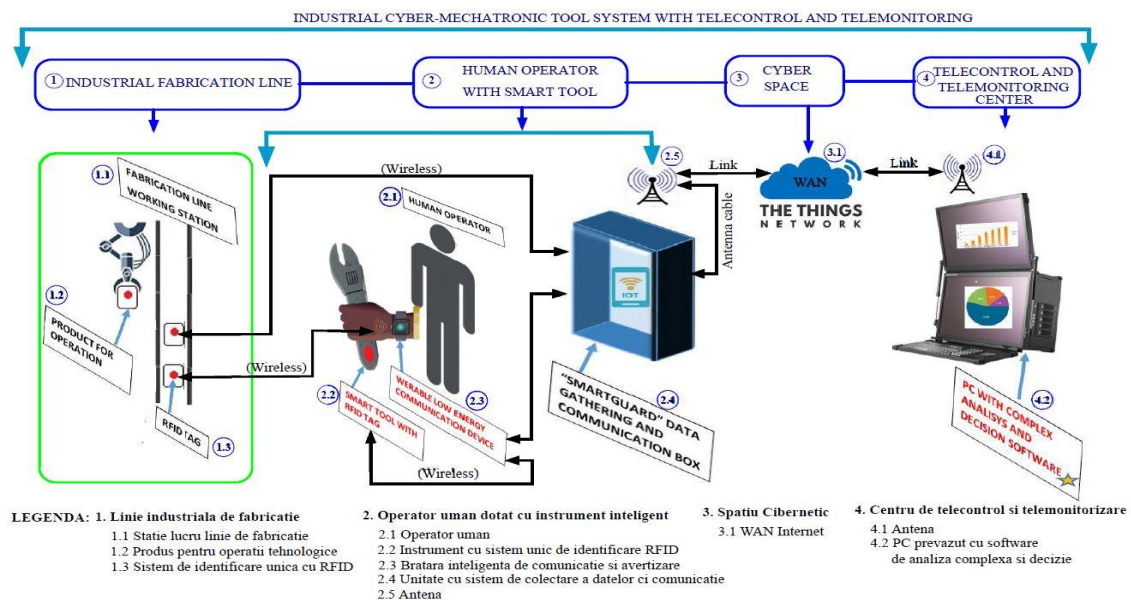


Fig. 4.

## 2.3 Multi-application cyber-mechatronic industrial robot for remote control and remote monitoring (the operational and service processes)

According to Figure 5, the structure of the physical (industrial robot) matrix and cybernetic (IT & C) matrix of the industrial cyber-mechatronic robot design and made by INCDMTM – in research teams – allows the cybernetization and communication of remote processes and operational industrial services, contributing to the dramatic rise in productivity and quality of smart industrial processes [16], [15], [20].

The multi-application cyber-mechatronic industrial system will perform remote control and remote monitoring via robot (1) connected to a computer environment through a command unit (1.2) and an interface (1.3) with both an internal industrial bus and Internet network (2.1) via a GPRS modem 4G.

Through this communication connection the link to the central remote control and remote monitoring (3) is made provided with a computing station connected to the router (3.2) and (3.3) and (3.1) running specialized software for robot control (3.4).

INDUSTRIAL CYBER-MECHATRONIC ROBOT MULTIPLICATIVE FOR TELECONTROL AND TELEMONTORING

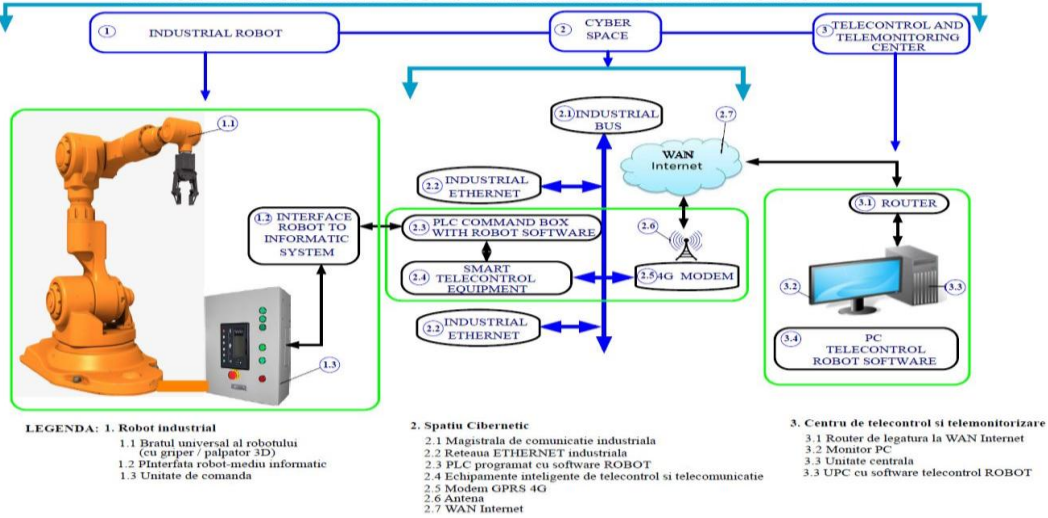


Fig. 5.

2.4 Cyber-mechatronic automotive damper system for remote control and remote monitoring

According to Figure 6, the structure of the physical (damper system) matrix and cybernetic (IT & C) matrix of the industrial cyber-mechatronic damper system and made by – in a research team – allows the computerization and cybernetization of the smart automotive and the respective automotive industry, by raising the quality and increasing the productivity of the automotive industry [21], [23].

The cyber-mechatronic automotive damper system for remote control and remote monitoring performs the function of remote monitoring and remote control of a damper is equipped with an electromagnet (1.1) powered by a high voltage source (1.6) to ensure the viscosity grade of modelling of the rheological fluid (1.3).

To obtain information on the global acceleration of the cyber-mechatronic assembly attached to a wheel of a vehicle it is used the (1.5) sensor with the (1.4) interface connected to a smart control and a remote control equipment (1.7).

The Internet WAN network connection is performed using a specialized GPRS modem (1.9) provided with a 4G antenna (1.8).

SMART AUTOMOTIVE CYBER-MECHATRONIC DUMPING SYSTEM WITH TELECONTROL AND TELEMONTORING

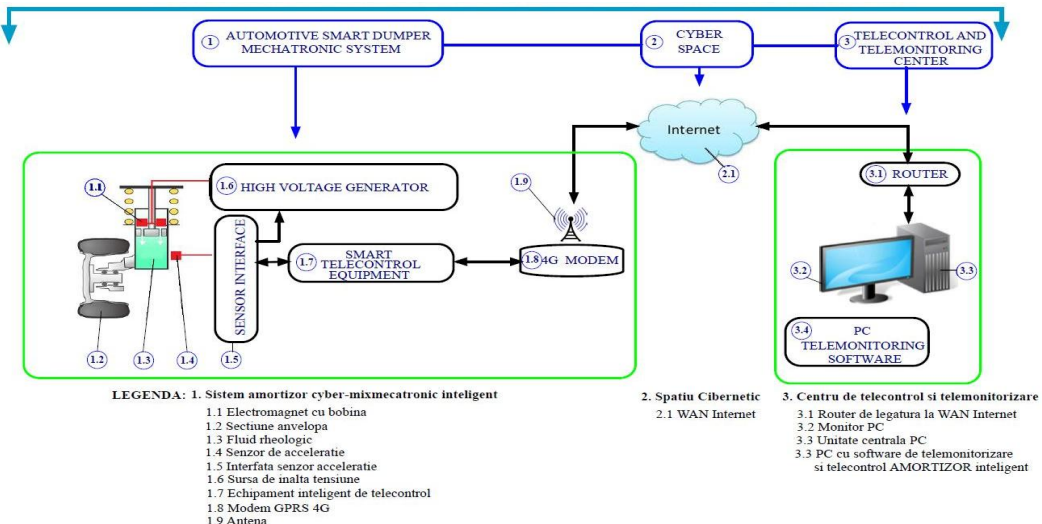


Fig. 6.

Through this communication connection the link to the central remote control and remote monitoring (3) is made provided with a computing station connected to the router (3.2) and (3.3) and (3.1) running specialized software for smart dampers control (3.4).

### 3. Conclusions

The development of physical cybernetic (cyber-physical) systems and of cyber-mechatronic systems as a smart solution for the future includes focusing on smart structural domains designed in steps and according to the appropriate scientific levels already discovered and ongoing discovery related to the virtual potential needs and performances.

Thus were created by INCDMTM – in research teams – concepts, design principles, smart architectures and construction schemes of cyber – mechatronic systems as building blocks of the global cyber - physical systems, with concrete applications in the automotive industry or the industry in general.

For high - tech developments, will be addressed by INCDMTM – in research teams – for the future in the future, smart cyber-mechatronic, cyber-mix-mechatronic and claytronic micro and nano scale systems with virtual reality as well as the some provocative approaches to smart systems in specialized areas smart with high economic potential efficiency and competitive efficiency well above current levels of and ensuring security, safety and predictability at national and international scale.

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