MECHATRONICS - TECHNOLOGY COMPATIBLE WITH THE INFORMATION SOCIETY

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Abstract: *We are witnessing the dawn of the Fourth Industrial Revolution, generically called Industry 4.0. The paradox of progress - it's something completely unexpected: we get more and more from less, a phenomenon called dematerialization. One of the important achievements of this phenomenon are the mechatronic products, designed as systems not components.*
Mechatronic technology brings to the center of attention the problem of information, which is the dominant component in relation to the other components (material and energy). Arguments: information ensures the satisfaction of man's spiritual needs; only information increases the newly added value of all things; information is culture.

Keywords: *Mechatronics, dematerialization, system design, transdisciplinary*

1. Introduction

"The strongest argument for the integration of disciplines
is the very fact that life is not divided by subject".
(J. Moffett)

The 21st century marked the beginning of the Knowledge Society with the following dimensions: Social, Educational, Environmental, Cultural, Economic. As a consequence of this Knowledge Society according to a considerable number of personalities we are witnessing the dawn of the Fourth Industrial Revolution, generically called Industry 4.0 with its basic components (intelligent autonomous robots, simulation and prototyping, virtual reality, 3D printing/additive manufacturing, culture E Integration and processes, cyber-physical systems, Internet of things, technologies Data centers, cloud computing). What was the major consequence of these two remarkable decades of the 21st century? Something completely unexpected – the paradox of progress: we get more and more from less, a phenomenon called dematerialization. One of the important achievements of this phenomenon are mechatronic products [1].
We live perhaps more than ever in history, in a "civilization of products". The products generate a standard of living, fuel a level of cultural conduct. Products of great complexity often embody a spirituality comparable to a book or a work of art. One of the basic trends of the 21st century is the development of industrial products as "intelligent with major scientific intensive content" and "multifunctional". This, in fact, fits perfectly into the paradox of this century - to "get more from less". So, industrial products are becoming more and more multifunctional. The most characteristic multifunctional product is the iPhone, which replaces more than 50 other products. In this context, the following important trends in engineering education are more and more prominent: the need to reengineer engineering education; creative learning; systemic design. The new, extremely dynamic realities demand the creation of a specialist capable of self-improvement, capable of proposing solutions, making decisions. "That's a book case. So what?" is the phrase that no longer works.
The computer revolution marked the leap from the industrialized society to the informational society, generating a wave of innovations in technology and education. Mechatronics is a transdisciplinary field of engineering, a synergistic combination of precision mechanics, electronic command and control systems and informatics, which serves the design, realization, commissioning and exploitation of intelligent automatic systems. The Japanese defined the

meaning of these renewal movements, patenting the term mechatronics at the beginning of the 8th decade of the last century.
The content of the term has been constantly enriched as a natural result of the evolution in technological development, becoming a philosophy, a multidisciplinary science of intelligent machines and the environment of integrated design and manufacturing. The mechatronics philosophy marked the leap from traditional, sequential engineering to simultaneous or concurrent engineering. But until the appearance of the first mechatronic products, the mechanical and electrical systems and the steering components experienced a genuine evolution (fig. 1).

Purely mechanical systems	*Until 1900*	*1788 – the steam engine;* *1872 – the Otto engine;* *1887 – Daimler engine; Babbage's calculating machine;* *Mechanical typewriter.*
1870 – the d.c. motor 1889 – the AC motor		
Mechanical systems with electric drive	*1920*	*Machine tools;* *Pumps.*
↓ Electric relays AMPS Regulators		
Mechanical systems with automatic control	*The 1930s*	*Airplanes;* *Automobiles;* *Steam turbines;* *Electric typewriter.*
↓ 1948, 1952 – the transistor 1955 – the thyristor 1959 – the integrated circuit 1971- the microprocessor		
Mechanical systems with: *- Electronic analogue control;* *- Sequential control;* *- Numerical control.*	*Beginning in the 1950s through the mid-1980s.*	*Elevators with automatic control;* *Numerically controlled machine tools;* *Industrial robots;* *Computer peripherals.*
↓ 1978 – the microcontroller 1981 the PC Process mains New sensor and actuators Integration of components		
Mechatronic systems: - Mechanical and electronic integration and calculation technique → Synergy; - The software determines the functions; - New design tools.	*Since the mid-1980s.*	*Mobile robots;* *Flexible lines;* *Electronic vehicle control (ABS, ESP);* *CD-ROM drives.*

Fig. 1. Evolution of mechanical, electrical and mechatronic systems

2. Design of non-component systems – a new direction

An increasingly widespread direction in design is the design of systems rather than separate components. A systemic design of a product means [1]:

- *optimal operation within a system;*

- fulfilling the pre-established functions within the limits of the life span;
- possibility of recycling after end of life.

Design itself is a science, which includes a set of goals for exploring design processes, for organizing and memorizing all design-related knowledge. In order to create a real and optimal system, it is necessary to be nominated, mainly, two decisions:

- *about the content, elements, terminology, etc. and through this about the system border;*
- *about the internal structure, relationships, taxonomy, etc.*

A number of paradigms have been proposed to describe the design process:

- *design → search. From a systemic point of view, a project is based on a lot of input parameters and "objects", which must be positioned according to some functional relationships so that the output value represented by the product model can be defined. The design process consists of a search for options and solutions;*
- *design → satisfaction of some conditions;*
- *design → compilation;*
- *design → optimization*.

There is knowledge that can be designated as traditional design knowledge. Knowledge about the strength of materials, constructive elements, technology or other fields is strictly necessary for mechanical design. This knowledge is not always presented in a form convenient for designers. Existing knowledge must be sorted and reviewed. A large part of knowledge about systems and design must complete the knowledge base of a designer, forming the designer's own informational background. Starting from these aspects, four fundamental concepts for the content of design science are stated:

- *Traditional knowledge and extensions;*
- *Selections from traditional knowledge and extensions, additions;*
- *Revised selections from traditional knowledge and extensions, additions;*
- *Only expansions.*

***The first concept** includes all engineering sciences within the science of design. In the second concept the domain is improved only if common knowledge is selected. The third concept can fulfill the goal of relevant knowledge for designers in a convenient form. The last concept is attractive because no contradictions appear for the existing order. Furthermore, researching the design process seems to be just the right research task. This point of view is possible only if one assumes that designers are the only basic executive powers of the actual design process. No complete basis can appear in this way, describing the general transformations of information as they occur in the design process, including those made with the computer.*

Thus, new fields based on multidisciplinary, multifunctionality such as Mechatronics, Bionics, Adaptronics, Integronics etc. appeared.

3. Mechatronics

Mechatronics is a transdisciplinary field of engineering, a synergistic combination of precision mechanics, electronic command and control systems and informatics, which serves the design, realization, commissioning and exploitation of intelligent automatic systems. The revelation of the engineer from the "Yaskawa" concern was inevitable, given that electronics had become a component that could no longer be separated from mechanical systems. The term was used to describe the technological fusion: mechanical-electronic-informatics [2] (fig. 2). *"Mechatronics is the synergistic integration of mechanical engineering with electronic and intelligent computer control in the design and manufacture of products and processes".*

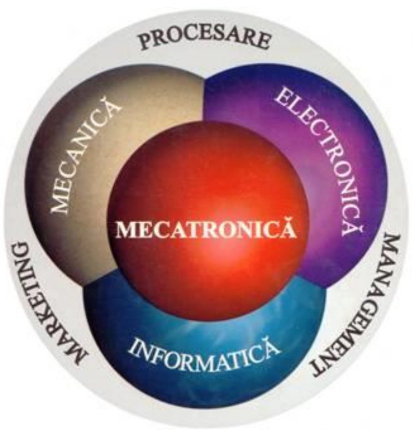


Fig. 2. Mechatronics concept

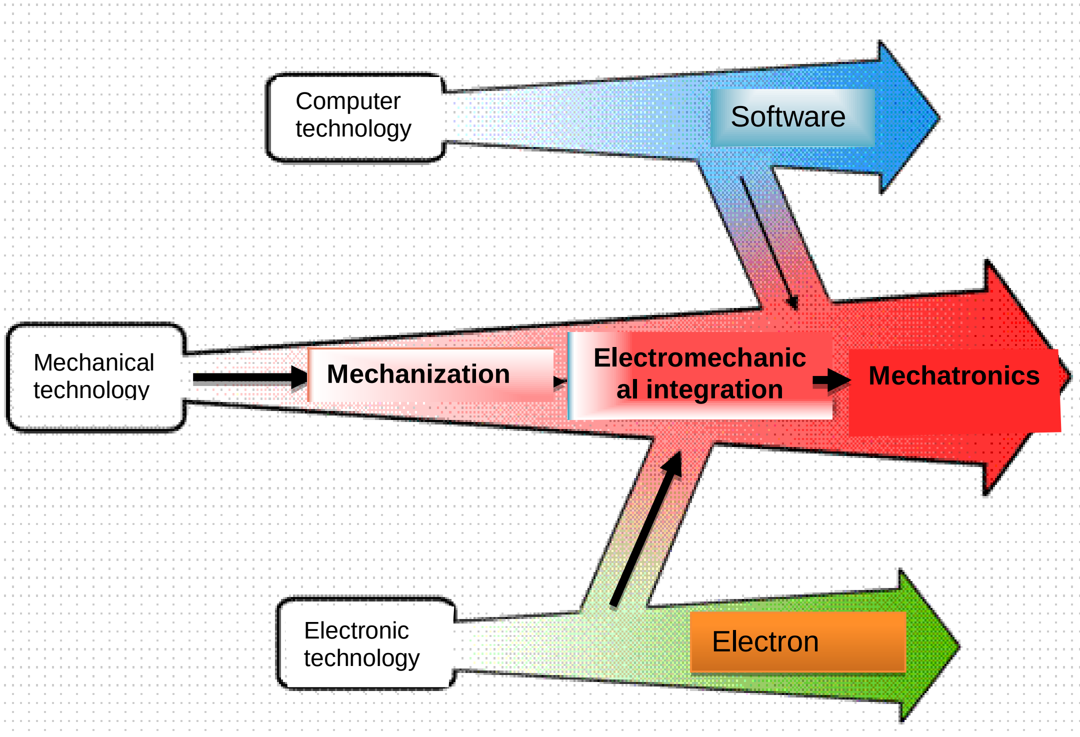


Fig. 3. Flow towards mechatronic integration.

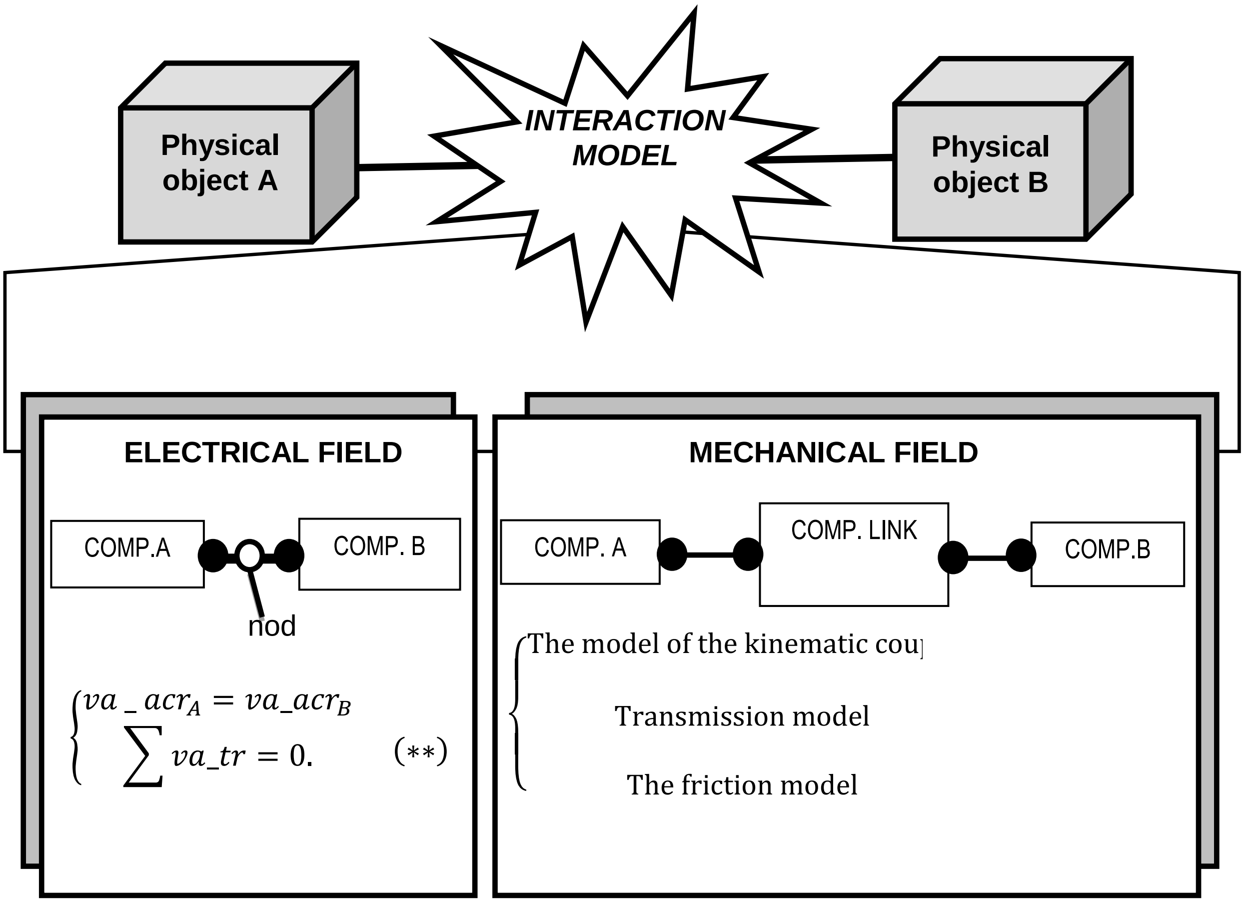


Fig. 4. Example of interaction of objects in a mechatronic system.

One can observe that the integration of the main components is carried out on the basis of efficient management, in accordance with the needs of the consumer. Mechatronics is the result of a transdisciplinary process, the result of the natural evolution in technological development. Electronic technology has spurred this evolution. The development of microelectronics has allowed electromechanical integration with microprocessors, so that electromechanical structures become intelligent, reaching mechatronics (fig. 3).

Mechatronic technology brings to the center of attention the problem of information, which is the dominant component in relation to the other components (material and energy). Arguments [2]:

- information ensures the satisfaction of man's spiritual needs;
- only information increases the newly added value of all things;
- information means culture.

The promotion of information links in the structure of technical systems ensures their flexibility and reconfigurability. Quantitative and qualitative evaluation of information is an essential issue in education, research and production activities [3]. In fig. 4. An example of the interaction of objects in a mechatronic system is presented.

4. Priority areas of use of mechatronic products

Starting from the premise that the consumer is increasingly demanding systems, not separate components, mechatronic products are increasingly widespread in all fields. The consumer no longer wants to purchase, for example, an electric motor, a gearbox, a working machine and the steering system produced separately. He wants a mechatronic product optimized in all aspects (efficiency, dimensions, ecological).

The nomenclature of mechatronic products is very large and varied (fig. 5): automobiles; toil; aircraft with ground infrastructure; satellite systems; computing; biomedical equipment; appliances; modern agricultural machinery; cine-photo and audio-video equipment; telecommunications technique; intelligent transport systems; research equipment etc. [4]. All are representative examples of mechatronic products. Practically everything we call a high-tech product is a mechatronic product. The modern car is getting smarter. Until around the 1970s-1980s, mechanical components, many of them true technical "jewels", represented an overwhelming weight in the whole of a car, the electrical part and electronics being limited to a limited number of engines (starter, alternator, windshield wipers) , sensors (for oil temperature, antifreeze, oil pressure, fuel level), relays (for signaling, ignition) bulbs. The development of microelectronics, materialized in logic and analog integrated circuits, power integrated circuits, digital processors (microprocessors, microcontrollers, DSPs), the realization of high-performance conventional and non-conventional actuation systems, new types of sensors, etc., have opened perspectives wide to satisfy some requirements, which were imposed more and more frequently, related to: traffic safety; economy; reliability; comfort; environment protection.

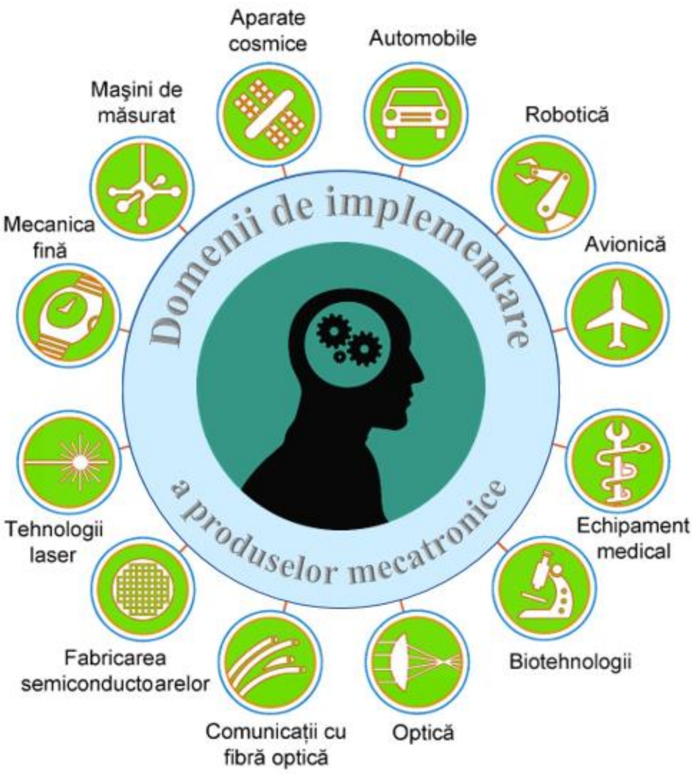


Fig. 5. Priority areas of use of mechatronic products

In addition to mechatronic systems for engine management, ABS, ESP, active suspension, interconnection of subsystems with appropriate buses – for example, CAN-Bus, navigation systems, X-by Wire, telematics, etc. A modern car of a medium class includes about 60 - 70 mechatronic products (electric motors, reducers, execution mechanisms, equipped with sensors and sensory systems. An eloquent example is the major differences between the highly successful "frog" of the Volkswagen company, from the 1960s (136 W–maximum power consumed; 150 m of electrical cables and about 80 electrical contacts) and its successor from 2001, the "New Beetle" car (2050 W, 1500 m of cables and 1200 electrical contacts). Robots, in general, are the systems that include the most advanced mechatronic products. Mobile robots (wheeled, humanoid and animaloid), in addition to the mechatronic products characteristic of stationary robots, which include a "brain", made up of one or more processors to control the entire system, also include sensors and mechatronic systems that allow it to orientate, identifying or avoiding obstacles. A particularly dynamic field of mechatronic applications is that of micro-robots, which are in a continuous race of miniaturization worldwide: walking micro-robots; micro-robots for inspections in hard-to-reach areas; micro-robots for military applications; magnetic micro-robots for the body etc. According to researchers from the Massachusetts Institute of Technology, by 2020, there will be micro-robots capable of uniting with each other to form tools or tools and then separating again. To demonstrate this, they created test modules with microprocessors and magnets. Mechatronic systems are becoming more intelligent as artificial intelligence advances.

5. Mechatronic education

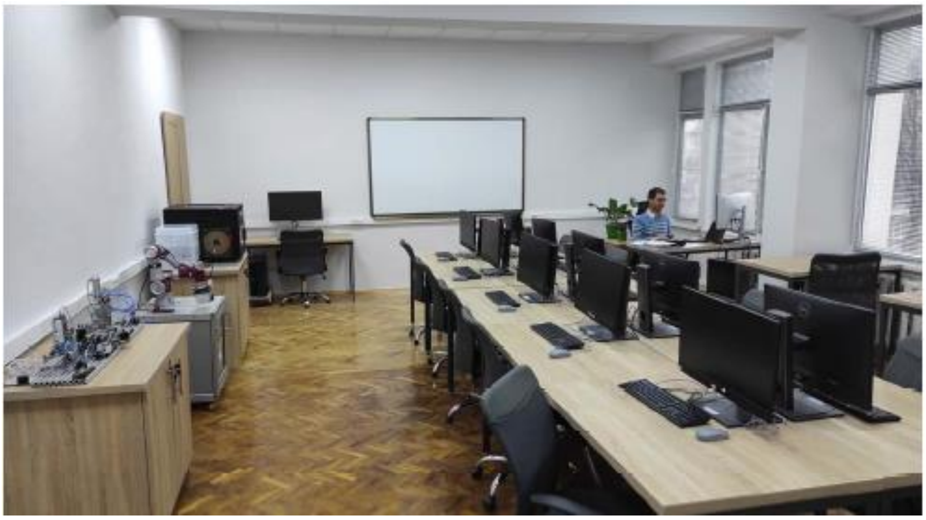
Developing systems thinking is especially important for today's engineers. For the training of mechatronics specialists in accordance with the requirements of new technologies, the basic mechatronic principles in education were outlined, aiming [5]:
- *development of systemic thinking;*
- *training skills to work in a team.*

This is largely achieved through mechatronic education, which ensures flexibility in action and thought. By offering effective solutions to promote interdisciplinarity, mechatronics has become the support of efforts to stimulate initiative and creativity. The interdisciplinary mechatronics laboratories constitute the basis for the materialization of the principles: "education through practice", "education through research", transferring the emphasis from the information side to that of training skills at all stages of the educational process. The first graduation of mechatronic engineers took place in Great Britain in 1989. The content of the term mechatronics has been continuously enriched as a natural consequence of the evolution in technological development. Mechatronics became philosophy. For engineering practice, the mechatronics philosophy marked the leap from traditional, sequential engineering to simultaneous or concurrent engineering.
Mechatronics is a high degree of integration of disciplines synthetically called transdisciplinarity, a term introduced in 1970 by Jean Piaget who defines it as "what is at the same time between disciplines, within different disciplines and beyond any discipline", its purpose being the understanding of the world through the unity of knowledge. "Because today we are in the midst of an intellectual revolution, we must understand that transdisciplinarity reveals to us the poetic dimension of existence, crossing, as I said, all the disciplines, beyond them. Not to be confused, however, with multidisciplinarity and interdisciplinarity" says Basarab Nicolescu. Transdisciplinarity is seen as a superior form of integrated learning and involves concepts, methodology and language, which tend to become universal (systems theory, information theory, cybernetics, mechatronics, integronics, etc.). The interpenetration of disciplines and the coordination of research can end up with the adoption of the same set of fundamental concepts or general methodical elements, that is, a new field of knowledge or a new discipline.
Starting from the premise that today engineers must be trained at a high interdisciplinary level at the Technical University of Moldova within a cross-border project, a Mechatronics Laboratory was created (fig. 6), and the education plan for engineering specializations completes a discipline nine - "Applied Mechatronics".

Extensions of mechatronics in other fields such as: hydronics, pneutronics, thermotronics, autotronics, agromechatronics (precision agriculture) are increasingly common. The evolution in the micro- and nano-fields means: micromechatronics, nanomechatronics, and at the junction of the fields of natural and artificial systems - biomechatronics. The general trend is to "intellectualize machines and systems".

6. Conclusions

- The integration of electronics and computer technology has led to the substantial simplification of mechanical components and cheaper systems. Mechanical parts have been replaced by electronic components, cheaper, more reliable, more precise and easier to maintain.



Robotic arm JAKA

3D printer Raise 3DE2

Modular training equipment in mechatronics for Industry 4.0

Assistance, safety and control systems for motor vehicles

Modular system for rapid prototyping of flight mechatronic system (drone) Aircraft Kit F450-V2

Fig. 6. Mechatronics Laboratory: Technical University of Moldova

- In the perspective of lighter constructions, relatively elastic systems were made, with a reduced mechanical damping, but in which a command with adequate reaction, based on electronics, sensors and adequate actuators, ensures an electronic damping.
- Introduction of regulation systems for position, speed, force, etc. it allows not only to maintain the programmed quantities within reasonable precision limits, but also to obtain a quasi-linear behavior, even if the mechanical system is non-linear.
- Mechatronic products are increasingly ubiquitous in all fields: aerospace, robots, industry, medicine, domestic, etc.

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