

# SCIENTIFIC STRATEGIES OF ADAPTRONICS

GHEORGHE, I. G.; ISTRITEANU, S.; DESPA, V.  
& CONSTANTINESCU, A.

**Abstract:** *This paper deals with strategies and scientific methods of design, development and implementation of Adaptronics as part of key technology for the future, which will facilitate systems and high-tech micro-systems performance and know-how, and the relevance of most businesses. Design and application of Adaptronics were possible only because of Mechatronics and Integronics innovative developments, becoming active technology vector, structural and practical in most industries and hyper-intelligent products and systems, in technological purposes for change, improvement and evolutionary development of intelligent cybernetic manufacturing.*

**Key words:** *adaptronics, mechatronics, integronics, hyper-intelligent systems, key technology for the future*



**Authors' data:** Univ.Prof. Ph.D. Eng. **Gheorghe**, G[heorghe]\*; Ph.D. Stud. **Istriteanu**, S[imona]\*; Ph.D. Stud. **Constantinescu**, A[lexandru]\*; Ph.D. Stud. **Despa**, V[eronica]\*\*, \*INCDMTM Bucharest, Pantelimon Road, 6-8, Bucharest, Romania, \*\*VALAHIA UNIVERSITY of TARGOVISTE, Carol I Blvd., no. 2, 130024, Romania, geocefin@yahoo.com, simona.istriteanu@incdmtm.ro, dumiver@yahoo.com, ddnrmix@yahoo.com

**This Publication has to be referred as:** Gheorghe, G[heorghe]; Istriteanu, S[imona]; Constantinescu, A[lexandru] & Despa, V[eronica] (2012). Scientific Strategies of Adaptronics, Chapter 37 in DAAAM International Scientific Book 2012, pp. 427-444, B. Katalinic (Ed.), Published by DAAAM International, ISBN 978-3-901509-86-5, ISSN 1726-9687, Vienna, Austria  
DOI: 10.2507/daaam.scibook.2012.37

## 1. Introduction

Scientific strategy for design - realization - implementation of Adaptronics as part of the key technology for the future facilitates performance and know-how for systems and high-tech micro-nano-systems engineering and relevance to most businesses.

Therefore, Adaptronics and Adaptronics application, follows as advanced technology, as an intelligent innovative and multidisciplinary technology that brings together synergistically scientific discoveries news related to fundamental and applied knowledge in integronics and mechatronics science, intelligent structural mechanics science, intelligent materials science, intelligent architectural science of sensors and actuators, intelligent measurement and integrated control science, as well as computer and informatics science.

Adaptronic strategy follows as high-tech products, new and highly competitive products and systems that facilitate both performance and creation and evolution of know-how, adds active structural and applicable technological vector for technological purposes of change, improvement and sustainable development and developer vector for changing operating method of environment requirements and influencing and monitoring of all structures of any kind.

Adaptronics and Adaptronic strategy, as new methods and concepts that will promise a new design for products and systems, new potential for improving and upgrading the technical performance of products and systems as well as their extended profiles and a new role to meet growing and changing needs on modern and newly improved systems and products and enhanced simultaneously with the lowest development time and flexibility as possible and as efficiently as possible.

Moreover, the success of Adaptronics and adaptronic strategy is guaranteed by cooperating between many different scientific and technical disciplines, between technology and industry and between research-innovation and industrial application and commercial innovation, on national and international markets, supporting intensive technology transfer, information and knowledge to a competitive and with a high level of labour employment.

In brief, Adaptronics and Adaptronic strategy create and form an important international platform for key technology for the future, new adaptronic active technologies, structurally applicable in developing innovative products and systems, a new operating mode for change, a new construction of structures of any kind, a new approach to monitoring and influencing, a new form of energy recovery, a new real modelling of real-time control of phenomena and their effects, and a new implementation of competitive and highly competitive products and systems as a direct response to the more growing and changing needs.

The research and approach of this paper in the scientific strategies of adaptronics field, refers to the intelligent domain of mechatronics, integronics and adaptronics regarding intelligent systems for measuring, verifying, control integrated in intelligent manufacturing processes (ex. automotive industry and metrology).

## 2. ADAPTRONICS design

### 2.1 Optimization and Adaptability of mechatronic and integronic technologies and systems

By optimization and adaptability of mechatronic and integronic systems and technologies is synthesized the first concept of adaptronic design, through which is realized the modelling and simulation of parameterized applications and appropriate for structures and functions in order to meet measurable objectives and quantified requirements and corresponding to processes for all problems and solutions.

With this new concept, design and optimization, variables will be determined so that the objective function sets are minimized while constraints on system response variables must be satisfied.

The typical design variables are expressed in properties that define stiffness, by the typical control variables are represented gain factors and actuator/sensor system-specific properties, while goals are related to structural mass and control subsystems, of desired power, of full time response values, etc.

Often constraints are directly put on design variables, e.g. where structural rigidity and structures force must not exceed the limits imposed indirectly through constraints on response quantities, such as displacements or accelerations at specific points on a structure or limitations on their own frequencies.

In case of adaptronic structures derived from a mathematical perspective, the coupling of mechatronic, integronic and control subsystems, takes place in one of the system equations where the continuity of response are determined by the design variables and where they are spatial representations in which are involved equations of vibration and movement.

In terms of techniques for solving optimization problems is often used an overall strategy appropriate to deal with problems coupled structurally and of optimal control, such as:

- addressing fully coupled problem and solving problems simultaneously;
- using a decomposed or assembled approach, where an optimal structural design with constraints for achieving a good performance is performed first, followed by the design of optimal control with optimal constrains for consideration of structural requirements and followed possibly by a optimal structural design;
- heuristic decomposition method;
- mathematical techniques with and without optimization algorithms;
- etc.

The new concept mentioned, also calls for a package of software related to simulation of mechatronic and integronic systems, optimized and adjusted, which can be considered as representative, but not complete.

Many parts of the software package, participate in this new concept, for the dynamic and static analysis of optimized and adapted systems to determine frequencies and their own states, for multi-structural and multi-functional assemblies to reduce patterns, and for modal or condensed representations, including certain models of sub-systems.

Thus, in the software package, are observed programmes that are used in enhancing and adapting technical and technological systems, such as ANSYS, MATLAB, SIMULINK, etc.

By combining design software packages with industrial and commercial software packages, is offered a wide range of data acquisition and processing capabilities combined with graphical user interfaces in an engineering perspective on the future adaptronic system.

## *2.2 Technological and constructive adaptive fusion of mechatronic and integronic systems for industrial and commercial use*

Through the technology and constructive fusion adaptive to mechatronic and integronic systems is synthesized the second adaptronic construction concept, which is made and assembled as a synergistic combination of technical and technological solutions in mechanical engineering, electronics and information and respectively it is carried the material, structural and functional integration, of mechatronic and integronic components and sub-systems in a systemic mini-structural multi-functional and multi-adaptive compact whole.

With this new adaptronic concept, it is built a new inter-disciplinary mix compendium of several areas of engineering and intelligent manufacturing that supports the information revolution that marked the "intelligent switch" from post-industrialized society to information society.

This adaptronic concept uses the replacement of functional, structural and technological variables with new, optimized or upgraded variables, to complement other design variables, real-time response, efficiency, selection, metrological and technological parameterization, prevention defects, continuous evaluation of the adaptronic systems effects, etc.

In this context, the aggregate of variables considered, expresses in fact, the defining and behaviour of components and sub-systems resulted from applying the new adaptronic concept, characterizing the properties, the new functional and structural links, intelligent control of structural chain and of sensor-actuator system, any constraints occurring in the system and other phenomena caused directly or indirectly by any work environment of adaptronic system.

Adaptronic concept of technological and constructive fusion, adapted to mechatronic and integronic systems, synthesizes the full technical, technological, functional and decisional potential integrated in intelligent assemblies and always adaptive to new working and environment conditions, both by self-changing or self-implementing as:

- Innovative mechatronic and micro-mechatronic adaptronic ensemble (Figure 1)
- Innovative integronic and micro-integronic adaptronic ensemble (Figure 2)
- Innovative sensor/actuator and micro-nano sensor/actuator adaptronic ensemble (Figure 3)
- Innovative robotics and micro-nano-robotic adaptronic ensemble (Figure 4)
- Innovative mechatronic adaptronic integronic human adaptive ensemble (Figure 5)

- Adaptronic innovative ensemble (Figure 6)

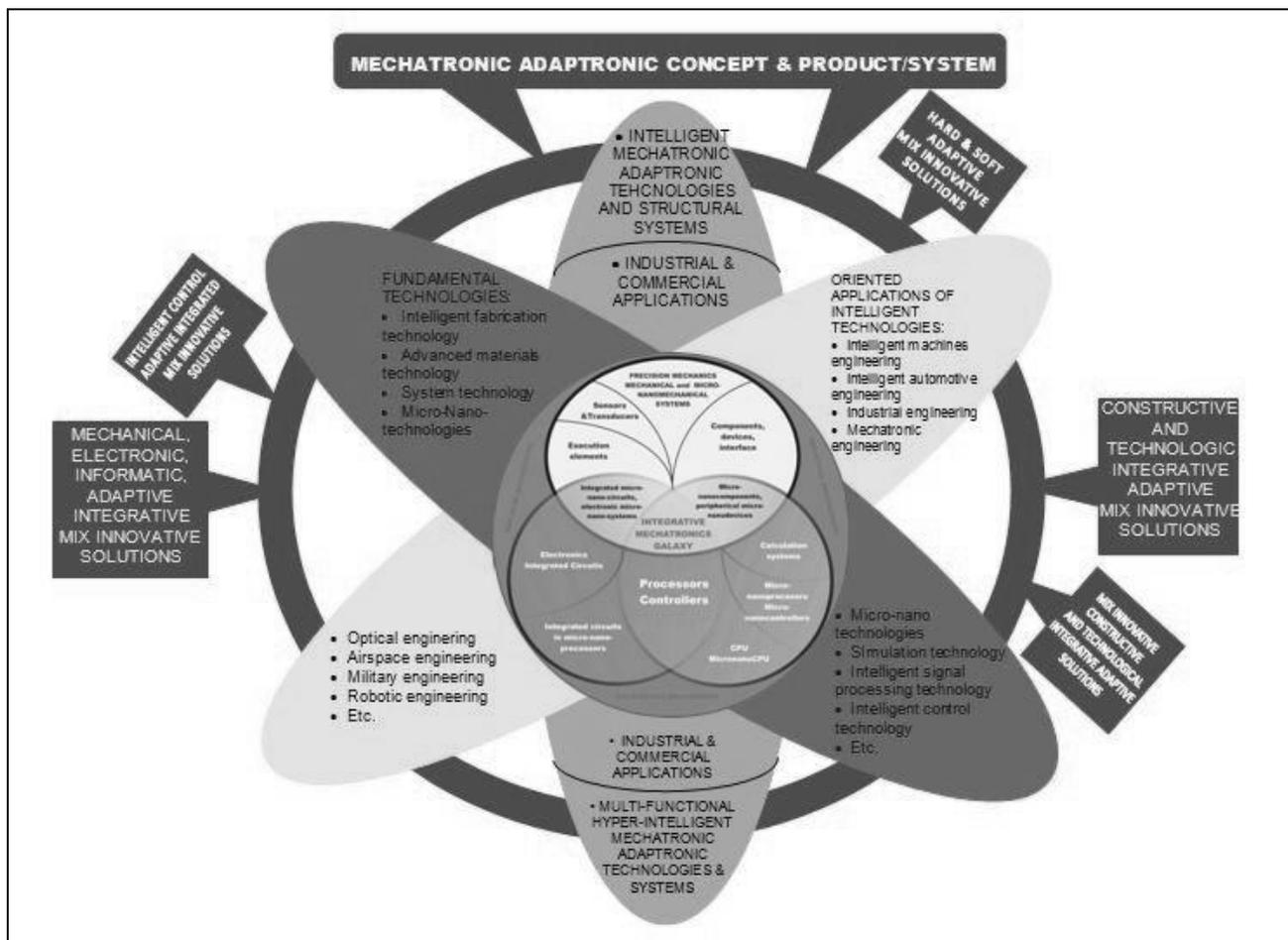


Fig. 1. Innovative integronic and micro-integronic mechatronic ensemble

According to the figure mentioned: innovative mechatronic and micro-nano-mechatronic adaptronic ensemble (Jacobs, 1997), as advanced and high-tech domain and as intelligent engineering, fusions synergistically and merging structural / material / technical / technological / operational and decisional the advanced mechatronics and micro-nano-mechatronics with adaptive mix-innovative solutions and constructive adaptive technology, mechanical, electronic and computer, hardware and software and intelligent control, this assembly uses innovative technology integrating core of intelligent manufacturing, advanced materials, systems, micro-nanotechnologies, simulation and modelling, intelligent signal processing, intelligent control, and so on, the results of these adaptronic assemblies are intelligent technology systems and structural hyper-intelligent adaptronic mechatronic, application of these results are identified in engineering-intelligent machines, smart cars, industrial, mechatronics, optics, aerospace, military, robotics, intelligent measurement, and so on; applications of results innovative domain and micro-mechatronic mechatronic adaptronic - systems and intelligent technology multi-functional structural and mechatronic hyper-intelligent adaptronic are found in industrial and commercial environment, now and in the future information society.

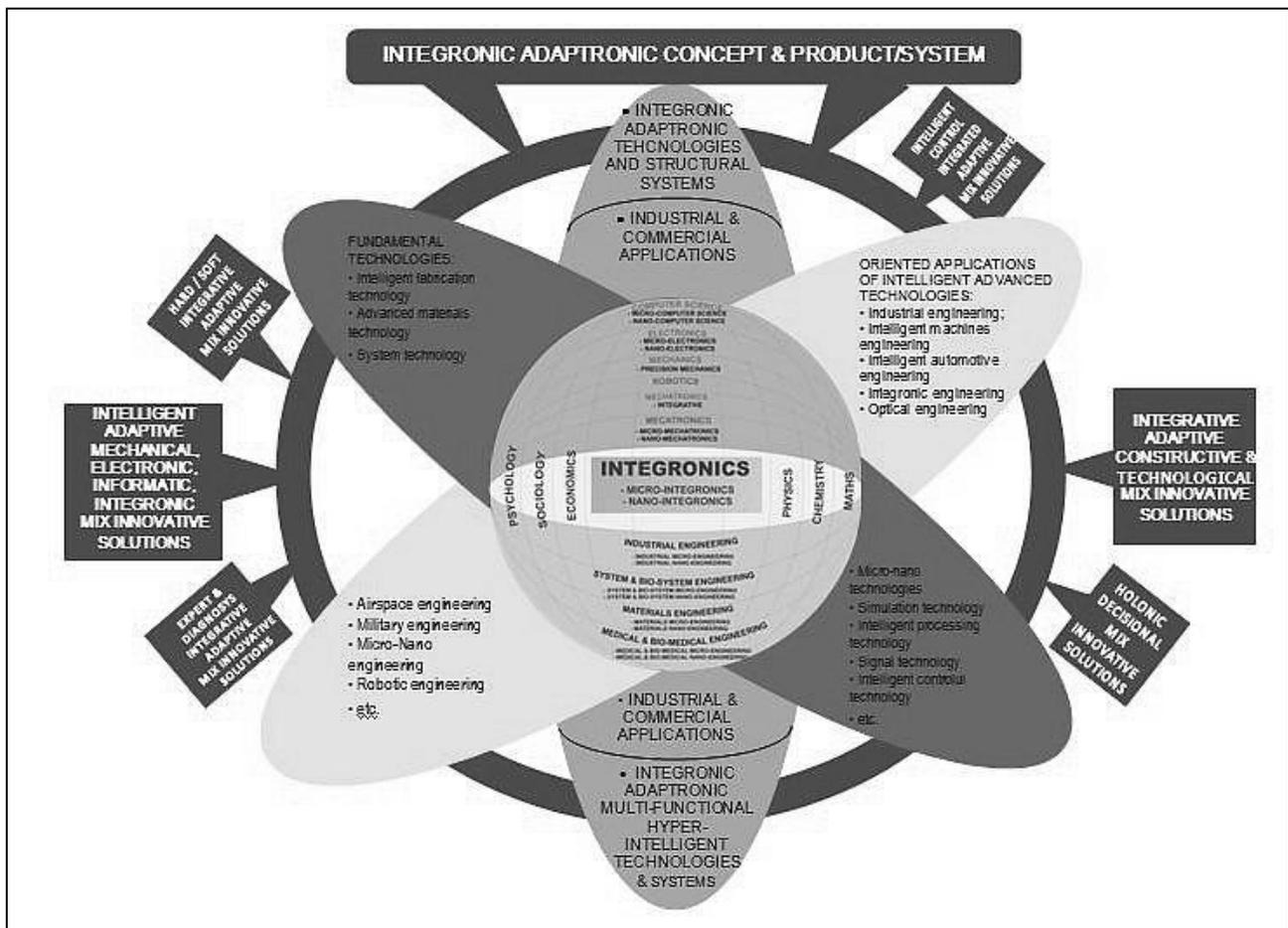


Fig. 2. Innovative integronic and micro-integronic adaptronic ensemble

According to the figure mentioned: innovative integronic and micro-nano-integronic adaptronic ensemble (Flemming, 1997) as advanced and high-tech field and as intelligent and hyper-intelligent engineering, merges and integrates synergistic - material / structural / technical / technological / functional / coordinator / decision and transport Information , the high-tech domain of Integronics and Micro-Nano-Integronics with mix-innovative solutions constructive adaptive and technological, integrative, mechanical, electronic and informatics integronic intelligent, integrative hard and software, integrated intelligent control, integrated expert diagnosis, this synergy and integration use innovative fundamental smart technologies of advanced materials, fabrication intelligent systems, micro-nanotechnologies, simulation, intelligent processing, signal, intelligent control, and so on, the results of this synergy of advanced high-tech areas are systems and intelligent technology multi-functional structured hyper-intelligent adaptronic integronic, applications of these results are identified in industrial engineering, smart cars, adaptronics, optics, aerospace, military, micro-nano-robotics, adaptronics, and so on; applications of results for the innovative domain integronic and micro-nano-integronic adaptronic - systems and intelligent technology multi-functional structural and micro-nano-integronic hyper-intelligent adaptronic integronic are found in industrial and commercial environments, the information society now and in the future.

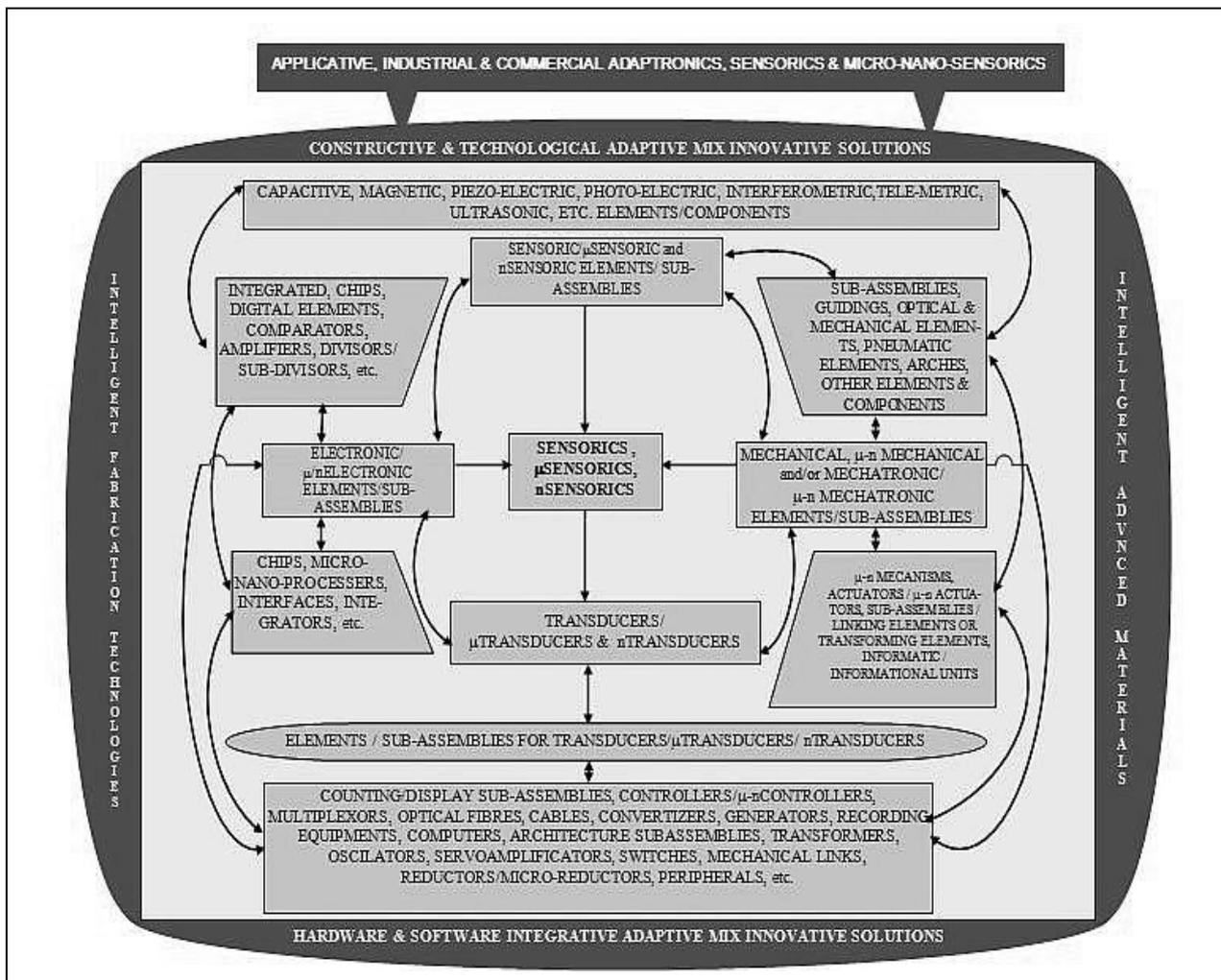


Fig. 3. Innovative sensor/actuator and micro-nano sensor actuator adaptronic ensemble

According to the figure mentioned: Innovative sensor/actuator and micro-nano sensor / actuator adaptronic ensemble, as intelligent and high-tech domain and as advanced engineering, fusions architectural and combinative - structural / material / technical / technological / decision making and informational, advanced domain of sensorics and actuatorics and micro - nano-sensorics and micro-nano-actuatorics, the solutions mix - constructive and technological innovative adaptive and mix solutions - innovative integrative adaptive hardware and software, this architectural fusion and combination use integrated intelligent manufacturing technologies and advanced smart materials, the results of these mergers is architectures integrating sensory system matrix and assembled actuator subsystem implementations in products and systems for intelligent manufacturing processes in the economy and industry applications of these results are found in many industrial and commercial environments.

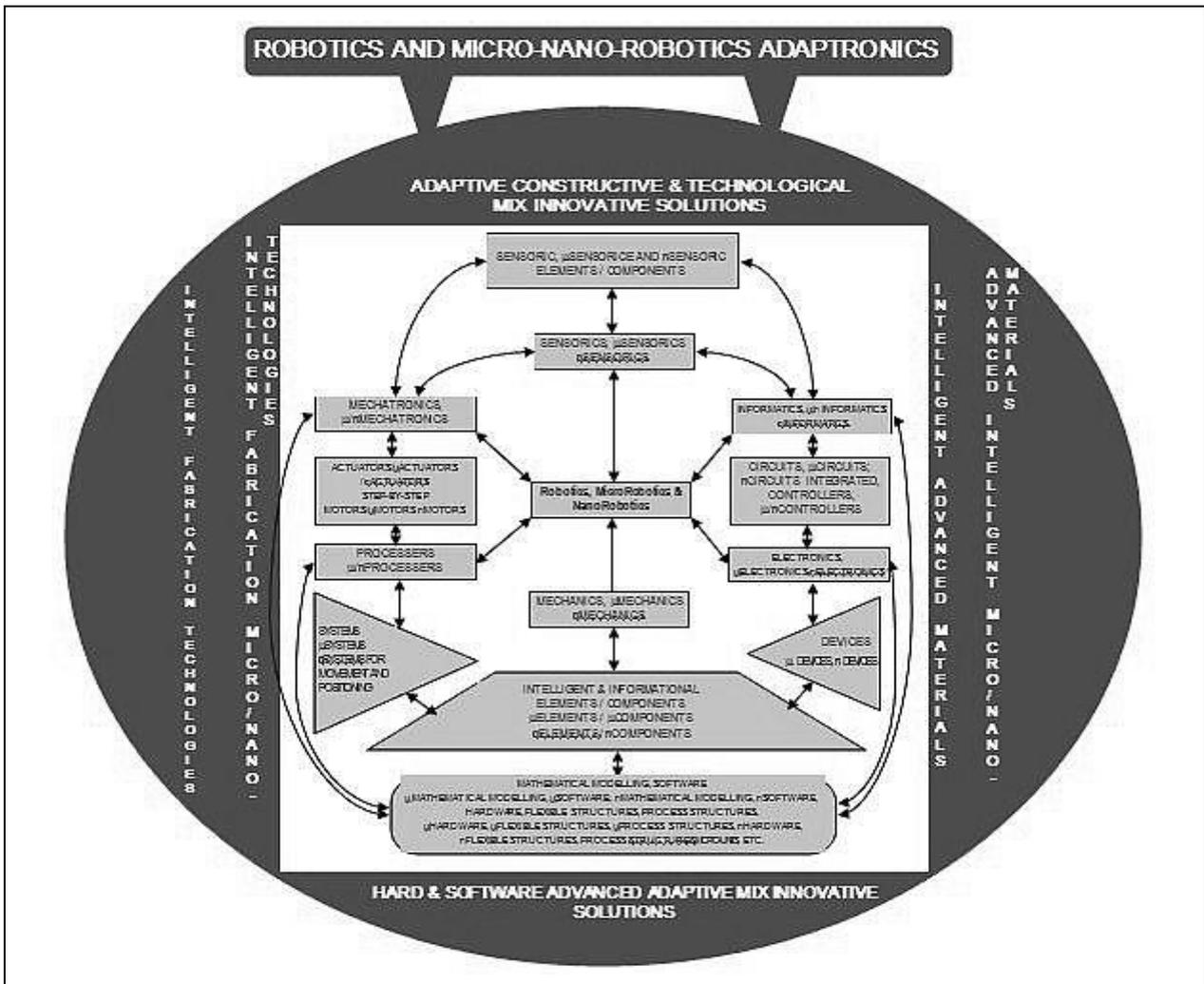


Fig. 4. Innovative robotics and micro-nano-robotic adaptronic ensemble

According to the figure mentioned: Innovative robotics and micro-nano-robotic adaptronic ensemble (Thrashers et. al, 1996), as advanced intelligent field and as a intelligent engineering, fusions structural and vectored - technical / technological and decision-making, high-tech robotics and micro-nano-robotics domain with innovative solutions mix constructive and adaptive technology and innovative solutions mix adaptive hardware and software technologies; this vector and structural fusion uses intelligent manufacturing technologies and micro - nano manufacturing and advanced intelligent and smart materials and advanced - intelligent micro-nano-materials; the results of such vectorial and structural fusion are robotic and micro-nano-robotic products and systems with direct implementation of industrial and commercial products that supports intelligent manufacturing processes; applications of these results are found in many locations in business, using their own or other multi-structural and multi-functional complex structures.

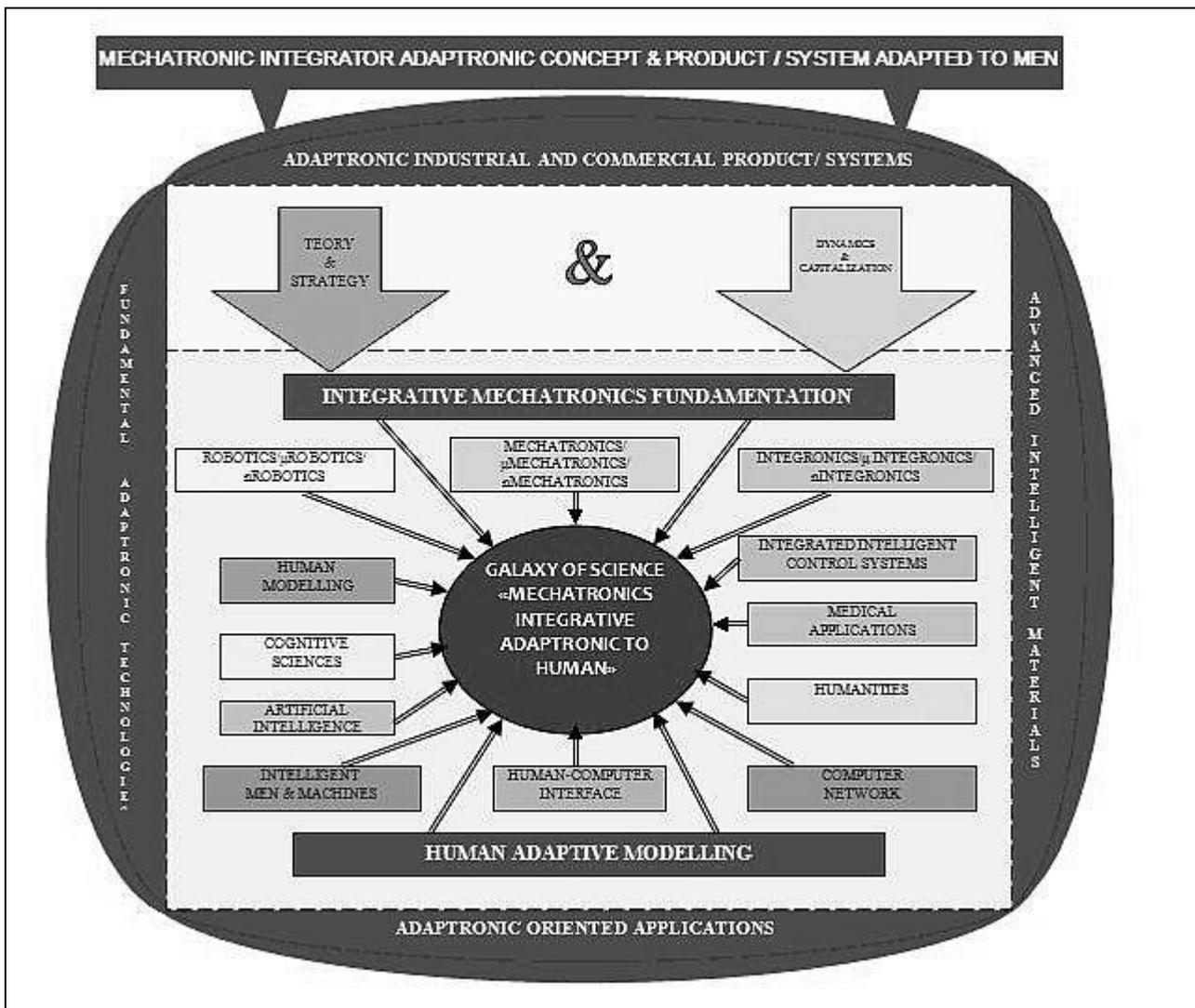


Fig. 5. Innovative mechatronic adaptronic integronic human adaptive ensemble

According to the figure mentioned: Innovative mechatronic adaptronic integronic human adaptive ensemble (Gheorghe et. al, 2012), as intelligent high-tech domain and as advanced intelligent engineering, fusions structural, functional, decisional and informational, high-tech domain of mechatronic integronic adaptronic products human adaptive with solutions mix - constructive and innovative adaptive and technology adaptive and solutions mix - innovative adaptive hardware and software technologies; this fusion structural - functional - decision - information using intelligent manufacturing technologies and micro-nano-manufacturing technologies and intelligent materials and advanced intelligent smart micro-nano advanced materials; results of this mix fusion are mechatronic products and systems adaptronic integronic adaptive to man with industrial uses, multiplication and implementations in manufacturing, processing and commercial applications; applications of these results can be found in the economy, industry and society, with direct effects on economic life - social, now and in the future.

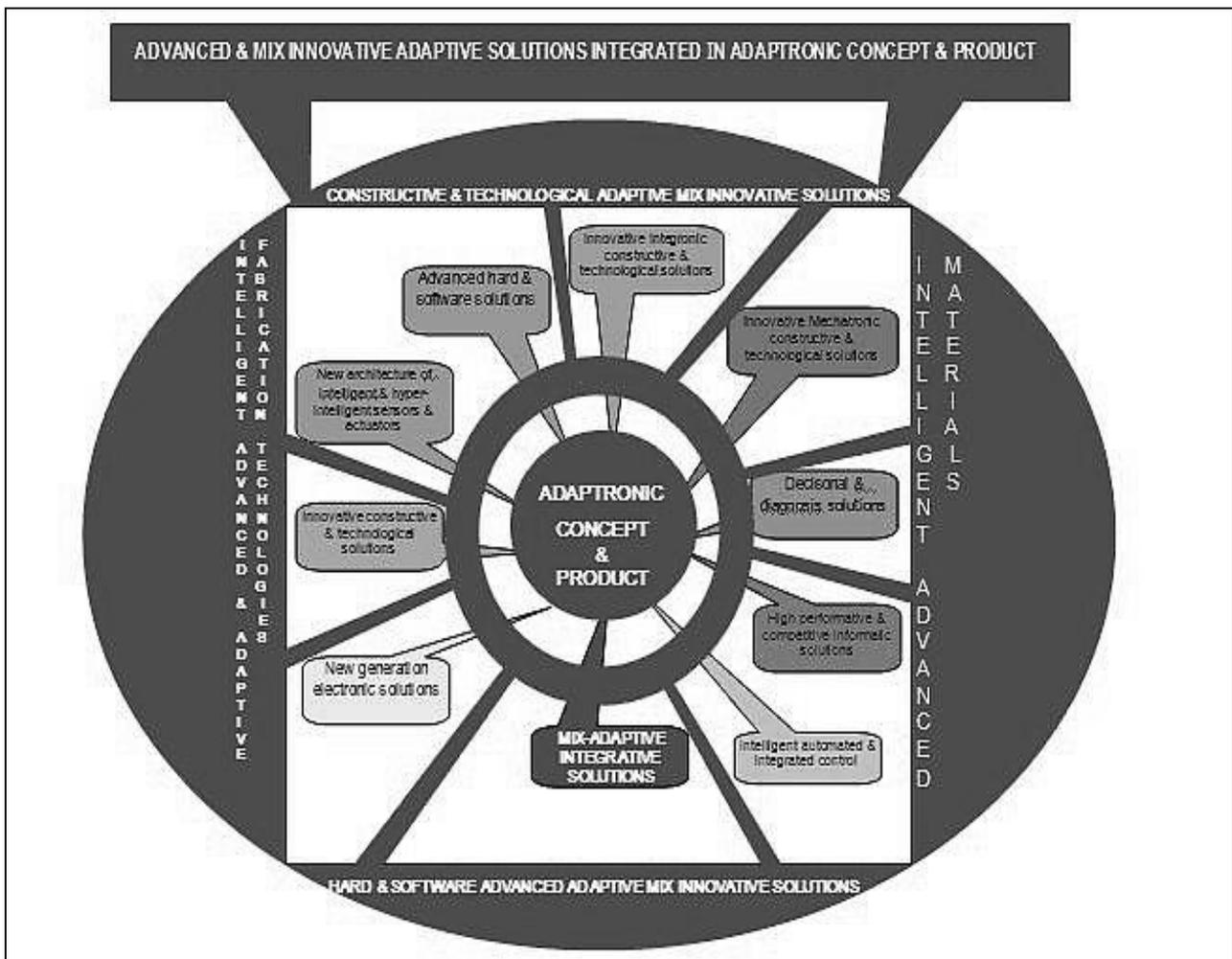


Fig. 6. Adaptronic innovative ensemble

According to the figure mentioned: adaptronic innovative ensemble (Gheorghe et. al, 2011), as intelligent and hyper-intelligent advanced field, as sophisticated and high-tech field as intelligent and hyper-intelligent engineering, fusions synergistically and combinative, technical and technological, structural and functional, decisional and informational advanced sophistication domain of adaptronics built on integrative fields of mechatronics and integronics with mix-innovative solutions technological and constructive integrative adaptive, adaptive mix - intelligent integronic innovative solutions, adaptive mix innovative adaptive intelligent mechatronic solutions, solutions mix - innovative mechanical / electronic and adaptive integrative, solutions mix - innovative smart integronic adaptive, mix solutions - innovative adaptive and intelligent control solutions integrated mix of innovative hardware and software performance and highly competitive, this synergistic fusion and high combination of adaptronic use basic technologies such as intelligent manufacturing technologies, structural mechanics, systems, micro-nanotechnology, sensors and actuators architectures, advanced materials, signal processing, intelligent control, and so on, the results of this merger are highly combinative adaptronic structural and multi-functional products and intelligent hyper-intelligent adaptronic systems, applications of these results are identified and used in engineering-smart cars, smart advanced materials, smart car, medical, mechanical, mechatronic, integronics, optical

communications, robotics, and so on; these applications are numerous in industrial and commercial environments, now and in the future information society.

### 3. ADAPTRONICS – key technology for the future

**Adaptronics – key technology for the future**, is based since 2000, on Mechatronics and Integrative Mechatronics and Integronics, when it was designed and implemented as advanced high-tech field. Adaptronics - is an innovative intelligent and multi-interdisciplinary technology that brings together synergistically inter-disciplinary scientific discoveries news related to fundamental and applied knowledge in the science of structural mechanics, materials science, sensors and actuators architectural science, the science of measurement and intelligent control as well as computer and information science. Adaptronics as key future technology facilitates both the performance and the know-how of mechatronic and integronic, micro and micro-nano-integrionic nano-mechatronic systems and micro-systems and development of products and systems and competitive products, being found more and more effective in relevance to most businesses. Thus, Adaptronics is reflected both as a new technology for the future as well as products and systems for new, intelligent informatic products. Adaptronic design and application were possible only because of innovative developments of Mechatronics, Integrative Mechatronics and Integronics potential providing future improvements and significant upgrades of technologies and systems for the advanced high-tech field. Currently, Adaptronics - as new concept for the future - is the best science and the best new area for national and international markets and industries particularly: aerospace, automotive industry, railway technology industry, shipping industry, medical technology industry, acoustic industry, industrial measurement technology and automatic intelligent control integrated mechatronic measurement industry, mechanical industry, process industry, engineering industry manipulation and automation of production. In the scientific development of the descriptor: <<Adaptronics>> is added the structural active and applicable technological vector in most industries and system innovative vector of products, intelligent materials, intelligent sensors and actuators and measurement control and regulation functions, all in changing, improvement and evolutionary development technological purposes. Therefore, Adaptronics – as vector for developing new in the high-tech advanced domain by adapting complex scientific, conceptual / structural / functional and decisional structures, products, systems and technologies, can be **used to change the operating environment requirements to actively control vibration, noise and distortion, to recover energy from vibrating systems and mechanical inertia and influence and monitor** all structures of any kind. In addition, **Adaptronics** will allow the **new design of mechanical and integronic systems and a new potential for improving and upgrading the technical performance** of products and systems as well as of the extended profile of products and systems. **Adaptronics - a new science, was designed and developed** for the first time in the world in **Germany** by Fraunhofer, since **2000** and **gradually more European countries** have began to modernize and develop this advanced high-tech field **and especially countries that have developed and applied mechatronics, Integrative Mechatronics and Integronics**, among these countries **being Romania**

by the **National Institute of Research - Development in Mechatronics and Measurement Technique - INCDMTM Bucharest**, which has already created an **<<Adaptronics Centre>>** since 2010. In this respect, INCDMTM, **works since 2010 in the development and implementation of "Adaptronics"**, with more involvement in intelligent measuring engineering and particularly in intelligent mechatronic and integronic measurement and integrated control system in the intelligent car industry, by designing adaptronic systems and equipment in new and with much improved structural and functional architecture, and with much improved technical performance and technology. Therefore, there is the belief that this new " adaptronic technology " is of major importance for the implementation of competitive and hyper-intelligent products, and is necessary to meet growing and changing requirements of modern and improved new systems and products, at the same time with developing the smallest and largest possible and more efficient flexibility. In fact, the success of "Adaptronics" is guaranteed by the cooperation between many different scientific and technical disciplines and expertise in science, technology and industry and is understood by a leading research unit and oriented towards applications as is INCDMTM in Romania.

**The further expansion of "Adaptronics" in INCDMTM and Romania, in Europe and in the world market**, will focus on the integrative dialogue between research - development - innovation and industrial and commercial application.

Currently, **Adaptronics** - as an inter-multi-disciplinary science, is dynamically expanding, including significant national and international markets, branch industries and in particular mechanical process industry, mechatronic and integronic industry, airspace industry, medical technology industry, automobile industry, etc.

As innovative science, **Adaptronics** intensively supports and transfers technology, information and knowledge, leads to competitive growth and increased level of employment.

As science vector, **Adaptronics** creates and forms a major "international key adaptronic platform technology for the future."

As an integrative synthesis, structural **Adaptronics is an active technology** - applicable in most branches of industry, **it is an opening of completely new possibilities** for the development of innovative products and basic innovative systems, **it is a new change in operating mode, it is a new construction** of structures of any kind, **is a new approach** to monitoring and influencing, **it is a new form of energy recovery** from mechanical energy and inertia, **is a new active control modelling of real phenomena** and their effects, **it is a new design** of mechanical systems, **it is a potential of new products and systems** to improve performance and extend their profiles, **it is a new implementation** of competitive and highly competitive products and systems, **it is a direct response** to the ever growing and changing demands, **it is the lowest time lowest** for adaptronic development, **it is the optimal cooperation** between multi-and inter-disciplinary experts in science and industry and **it is a complex interaction** between research - innovation and transfer and commercial application. However, **Adaptronics, develops the latest solutions for systems with adaptronic components as well as the latest trends in the advanced high-tech field.**

**In Adaptronics integration as future technology, are set several new principles and ideas that need to be developed:**

- **predictive creation of intelligent adaptive systems engineering**, using the approach of model-based systems engineering;
- **implementation of new findings** on the electro-rheological effect, in intelligent damping systems;
- **implementation of new** intelligent piezoelectric "inchworm" and inertia **actuators**;
- **implementation** of new advanced materials and composites for electro-active polymer actuators and smart sensors;
- **implementation of the new architecture** for adaptive control signal processor component, based on floating point arithmetic, for adaptronic applications;
- **implementation of intelligent manufacturing of adaptive components** by selective laser sintering;
- **implementation of intelligent sensory analysis** to study the robustness of an intelligent control system;
- **using a finite element model** for beam type structure with piezoelectric intelligent components derived using RL circuits;
- using **adaptronic intelligent control** of sound and vibration in engineering and nature;
- **intelligent sensor-actuator integration for the control** of static and quasi-static forces;
- very excitable serial dynamic structure **performance optimization** by adaptronic methods;
- **and so on.**

#### **4. Adaptronic application for design and implementation of a high-tech positioning and micro-positioning mechatronic / micro-mechatronic system**

Applying Adaptronics - by adaptronic concepts and structures, has been implemented for the <<experimental model of high-tech positioning and micro-positioning mechatronic / micro-mechatronic system>> to be integrated in the following applications: precision positioning in measuring, characterizing surfaces in complex vector space and temperature; intelligent mechatronic complex system for determining global constants measurements of optical systems with software algorithms, system calibration of inductive displacement sensors and pneumatic-electrical sensors.

##### *4.1 General description of the high-tech positioning and micro-positioning mechatronic / micro-mechatronic system*

The product is a flexible, multi-functional, adaptronic micro-mechatronic product, integrated into technology platforms, placed on the border of micro-mechatronic adaptronic products.

The main part of the adaptronic micro-mechatronic flexible positioning system consists of two electric linear axes.

In general, submicron precision linear axes have limited linear cycles, to avoid aggregation errors. The adaptronic micro-mechatronic micro-system consists of two linear axes and two controllers.

Apart from the possibilities for positioning / micro-positioning, was studied using the adaptronic system and measurement and calibration activity, of sensors, cameras measuring equipment, and complex surface morphological characterization equipment.

Adaptronic system flexibility stems from the possibility of mounting two axes both horizontally and vertically, correcting displacement errors by dedicated software.

The adaptronic positioning sub-system consists of two linear axis mounted vertically, so to form a Cartesian XZ system.

The electro gripper sub-system mounted on the vertical sled, securing the piece to be micro-position, allowing it to support a piece of up to 0.5 kg. Gripper fingers are individualized according to the type of parts to be positioned.

To ensure modularity of the adaptronic system, the panel of the table that supports the micro-mechanic system is made from cellular micro-mechatronic is made of aluminium profiles with T-slots on both sides.

Control wiring of the adaptronic system is located in an accessible panel. The electronic computer that provides the hardware is a laptop or desktop.

Since the positioning accuracy is submicron size, a temperature sensor mounted near the system is used, included in the control in order to warn or stop the system in case of over temperature, which could compromise accuracy.

Piece presence inductive sensors provide full automation of the whole technological process.

Linear axis drive is ensured by CF motors, while screw-nut type transmission ensures safety and positioning accuracy.

The schematic representation of the adaptronic mechatronic system is shown in Figure 7.

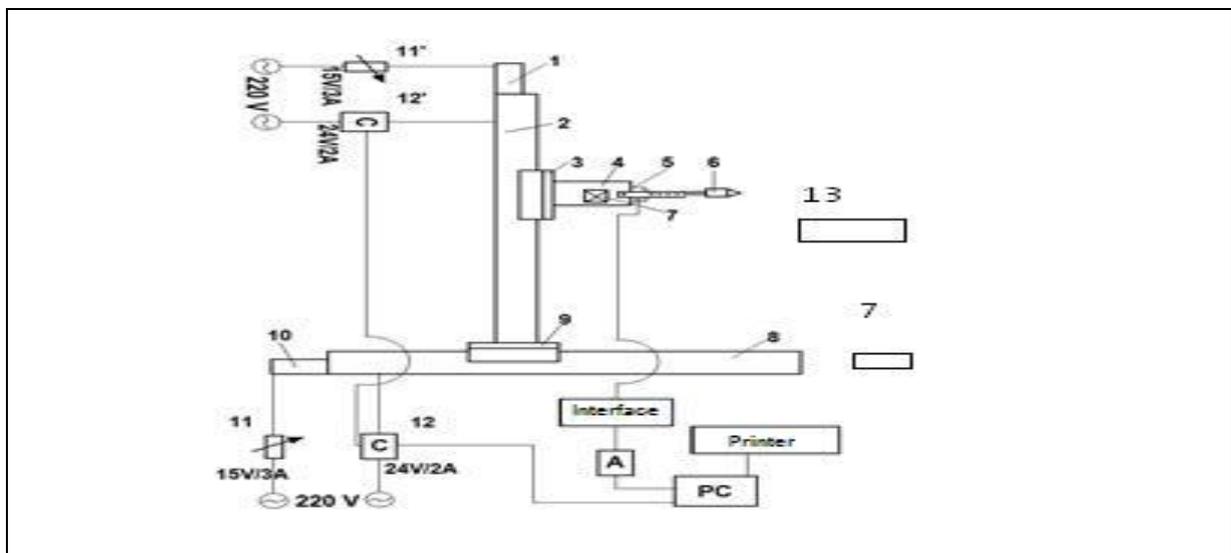


Fig. 7. Schematic representation of the mechatronic system

Composition of mechatronic system adaptronic:

- 1.10 - CF motors
- 2.8 - linear axes
- 3.9 – linear sleds axes
- 4 - electric gripper
- 5 - shaped fingers
- 6 - piece
- 7 - temperature sensor
- 11, 11 - electricity supply
- 12, 12 - controllers
- 13 – piece presence sensors

### Specifications:

- work table: 1250x780x750 (mm)
- sled race: 0-200 mm in x axis and z axis
- transport load on x axis: 100-200 N, on z axis: 25-50 N
- positioning accuracy:  $\pm 0.00025$  mm;
- (electric or pneumatic) gripper, with the possibility of trapping and positioning parts up to 0.5 kg.
- power supply: 220 Vca/50 Hz (-15V CF motors, 24V - gripper and controller)
- automatic loading and unloading of parts.

In Figure 8 is shown the overall representation of the positioning and micro-positioning mechatronic/micro-mechatronic system.

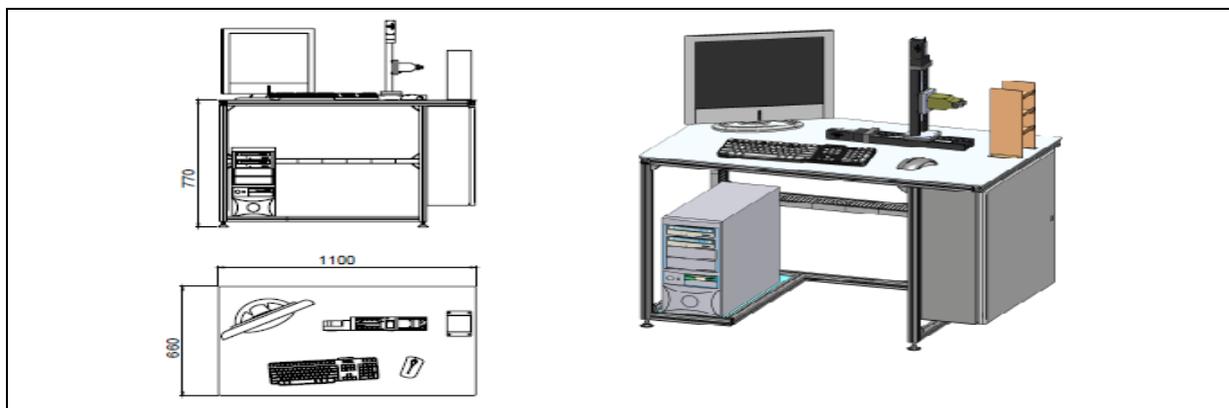


Fig. 8. Overall representation positioning and positioning micro-mechatronic system

In Figure 9 is shown a detail of the virtual mechatronic system, highlighting x and z axes and micro-gripper mounting location.

In Figure 10 is shown the micro-gripper of the adaptronic micro-mechatronic flexible positioning system.

In Figure 11 are shown the linear x and z axes and the gripper adaptronic micro-mechatronic system.

In Figure 12 is shown the electric linear screw-nut drive.

In Figure 13 is shown the electrical control of the adaptronic mechatronic system.

In Figure 14 is shown the flexible adaptronic mechatronic system, integrated in the technology platform.

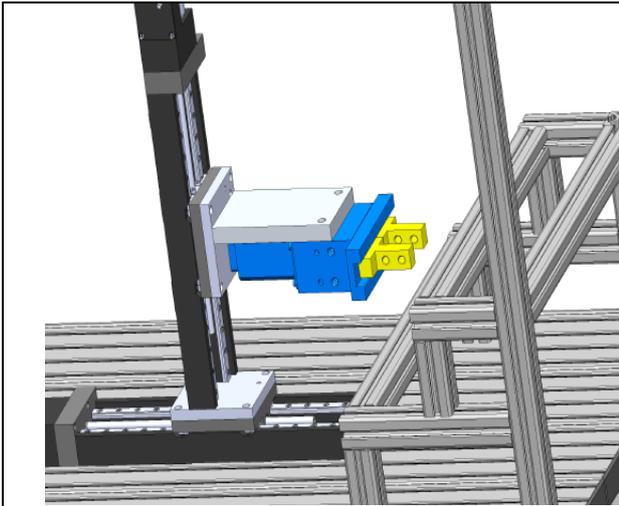


Fig. 9. Highlighting axes x and z and micro-gripper mounting location

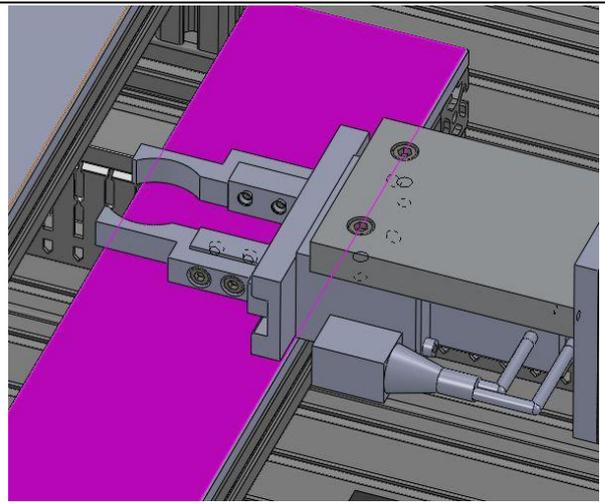


Fig. 10. Flexible adaptronic mechatronic system gripper

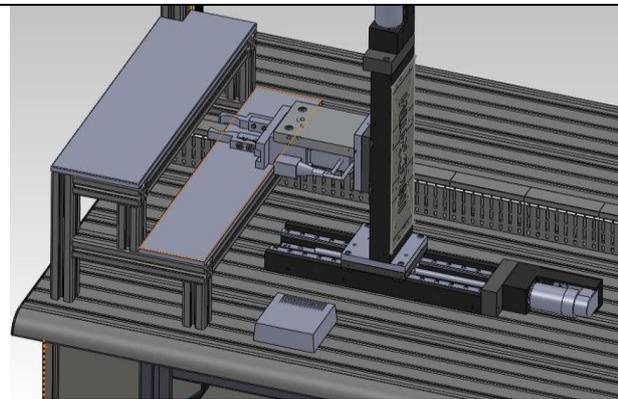


Fig. 11. Representation of linear axes x and z and of gripper

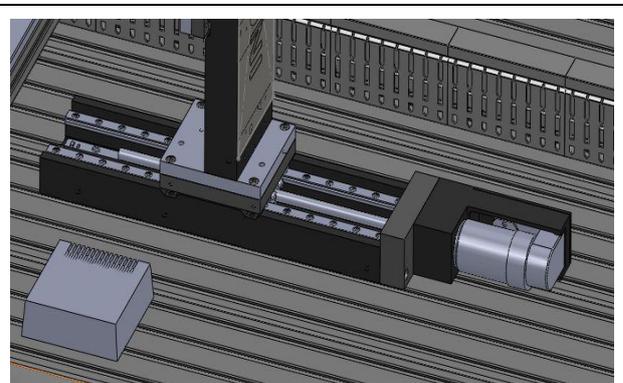


Fig. 12. Linear electric axis – screw-nut transmission



Fig. 13. Electrical control system



Fig. 14. Flexible adaptronic mechatronic system, integrated technology platform

#### 4.2 Tests and experiments of flexible positioning adaptronic micro-mechatronic system

Tests were designed to highlight the operating parameters for the components of the flexible adaptronic micro-mechatronic positioning system, to achieve characterization of system components in terms of construction, functional accuracy and reliability of operation. **Programme** activities include **experiments** that rely on functions that must be satisfied by the adaptronic components of the mechatronic equipment, in order to exploit them in micro-positioning and micro-measuring applications. There have been performed checks and tests for structural and functional characteristics of the micro-mechatronic system, respectively trials and testing of programmes that generate the X and Z movements, gripper operation and control and safety of the adaptronic micro-mechatronic system.

In Figure 15 is shown the Cyclogramme of the adaptronic mechatronic system.

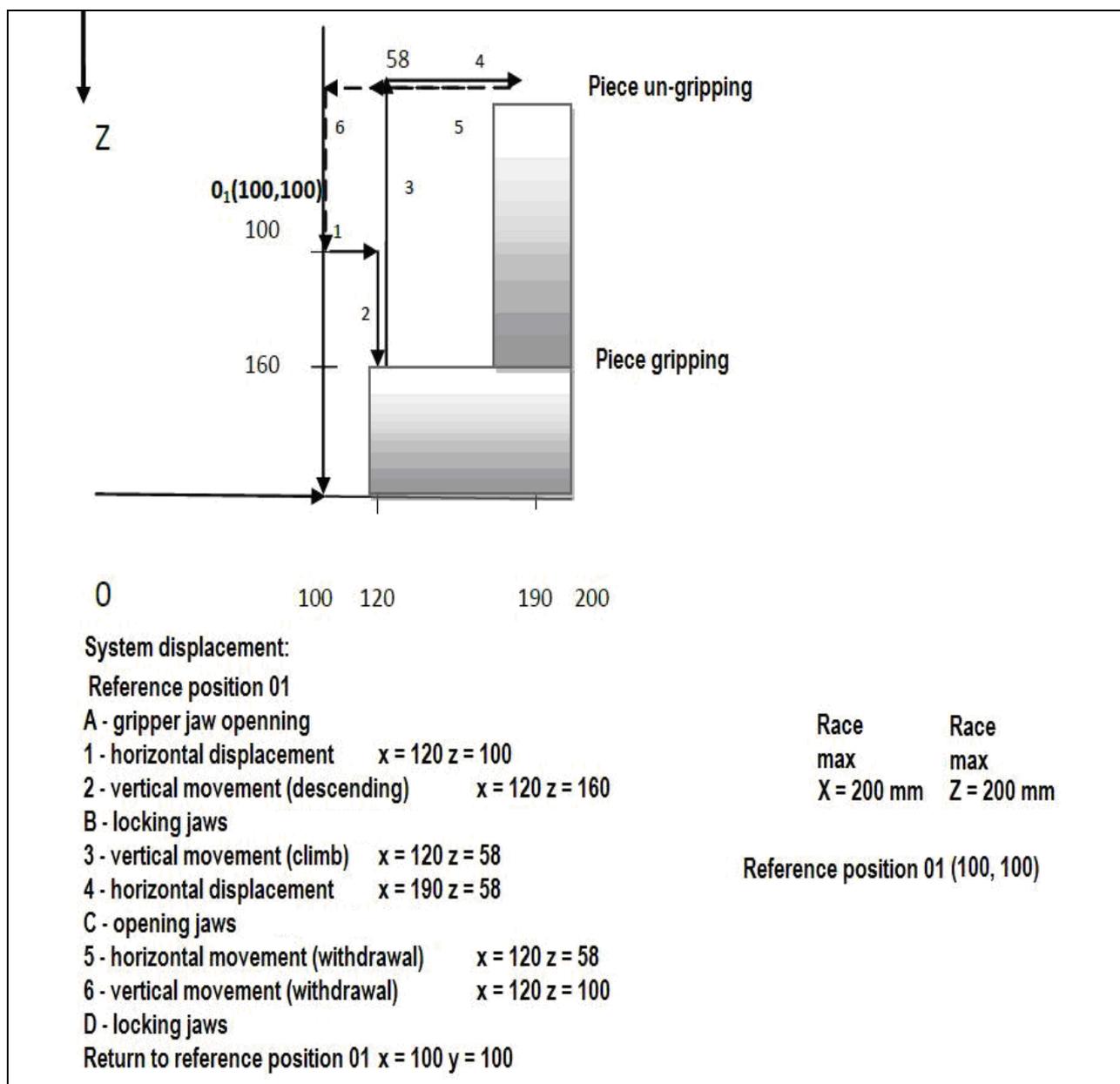


Fig. 15. Cyclogramme

## 5. Future Research Plans

The future research plans in adaptronics field, based on development and evaluation of adaptronics mechatronics and integronics adaptronics and based on the fundamental and applicative researches, realised and presented in this paper, include:

(a) structural and functional development of adaptronics concepts with implementations for intelligent systems and micro-nanosystems for measuring and intelligent control engineering for integration in intelligent manufacturing processes;

(b) structural assembling of adaptronics modules of mechatronics and integronics construction, to realise assembly systems with integrative and adaptive functions, required to new conditions and environment and working effects.

Fundamental and applicative research, addressed in the next period, follows the next steps to be realised:

Step 1: researches and laboratory tests, on functional and experimental models, dedicated to modules or adaptronics systems, constructed by structural completion with intelligent innovative elements from the chain sensor-actuator-integrated control;

Step 2: assembled construction by fusion, simulation and intelligent modelling, of prototypes and unique adaptronics products and adaptive to tehnico-technological goals and objectives, from present and future.

## 6. Conclusions

**Adaptronics**, as a scientific strategy and an integrative multi-inter science, is used as a cutting edge opening new possibilities for design, construction and implementation of innovative adaptronic products and systems, a new approach to monitoring complex interactions and cooperation in the value chain of research - innovation - technology transfer - industrial and commercial application.

## 7. References

- Flemming, E. (1997). *Tactile sense in minimal invasive surgery: the tamic-project. mst news*, vol 19, VDI / VDE, p.13
- Gheorghe, G. & Stiharu, I. (2011). *NanoEngineering*. Cefin Publishing House, ISBN 978-606-8261-15-7, pp. 9-140
- Gheorghe, G. & Istrateanu, S. (2012). *Adaptronic microtechnologies nanometer micro-mechatronic regarding nnaosystems for micro-micro-and nanopositioning nanodisplacements*. 8<sup>th</sup> International DAAAM Baltic Industrial Engineering Conference, 19-21 April 2012, Tallinn, Estonia
- Jacobs, R. (1997). *Control model of human stance using fuzzy logic*, *Cybern Biol*, 77 (1), pp. 63-70
- Thrashers, A.; Wang, F. & Andrews, B. (1996). *Safe adaptive neuro-fuzzy control of neural prostheses using reinforcement learning*, pp. (CD-ROM version) I8 / IEEE Conf IEEE EMBS Amsterdam PT)