Strategic Research Innovation Partnership
FACTORIES OF THE FUTURE

STRATEGIC RESEARCH INNOVATION PARTNERSHIP
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MISSION

The SPIP will **compile and integrate Slovenian research and innovation know-how, experience from the industrial and academic spheres**, and highlight the priority breakthroughs of new products, technologies and services for the Factories of the Future. This will enable the possibility of **efficient production in homeland with the introduction of production processes that are capable of automatic modification, adaptation and learning** to achieve the required quality at an acceptable price, which enables competitiveness and further development within the global economy.

The SRIP will set up a **supportive environment with professional services** for industry and research organizations that will address future human resource challenges at the corporate and academic level and will ensure a rapid transfer of knowledge into industry and new content into the education system. By **internationalizing the results of joint development, adequately protecting industrial property, promoting high-tech entrepreneurship and helping member countries tackle environmental challenges**, the SRIP will allow faster and easier transition of companies to the global market. At the same time, the support environment **will provide appropriate services to existing companies that are going on the path of transformation into the factories of the future,**according to their level of development and the desired dynamics.

RESEARCH AREAS

1) ROBOTIC SYSTEMS AND COMPONENTS

Robotics is one of the most important enabling technologies and the basic building block of the paradigm of factories of the future. Today's robotization is at a level that enables the automation of many industrial processes, but there is a shortcoming in flexibility, interoperability, connection with man and other devices in the system. Ensuring greater flexibility of robotic systems is the main motivation for many new research in the field of robotics. It is necessary to increase the flexibility of robots and to shorten the time needed for their layout and startup when the product changes. To this end, new mechatronics solutions must be found, for example, in the field of intelligent sensor-driven drives, automatic reconfiguration, robotic sensors, robotic vision and touch, guidance and learning.

The robotic systems and components are geared towards the development of new products and services in the following **three areas** of robotics within the framework of the "Factories of the Future":

- The field of **intelligent sensors** and **actuators** for the needs of robotics. The field covers both internal and external sensors for the needs of robotics (machine vision, position sensors, torque sensors) combined with software and information and communication technologies (ICT) in completed intelligent systems.
- The field of **development and production of new robots**. In this context, the SRIP highlight the anticipated needs of newly installed robot plants in Slovenia, where the accelerated flow of knowledge from research organizations into new industrial robots is expected, as well as the production of completely new robots for the agro-food and eco-industry and, last but not least, the contribution of service and humanoid robotics assemblies currently in its infancy.
- The field of development and marketing of **flexible and cooperative robot cells** is crucial for increasing the number of robots in production at home and abroad. These are interdisciplinary technological areas such as the development of new advanced and adaptive applications within robotic cells, the introduction of new concepts of reconfigurability, adaptability, modularity, introduction of concepts of desktop cells for installation in desktop factories, advanced systems of logistics and cell integration into systems. An important feature of these cells is also the ability to engage robots with humans, taking into account both the aspect of security and the synchronization of the work process with a person who will act as a colleague in such a cell. The characteristic of this field is interdisciplinarity and intertwining of technological areas and product directions with other value chains and other SRIP structures.

2) INTELLIGENT LASER SYSTEMS

With the emphasis on the development of intelligent, self-adaptive laser systems involved in the factories and clinics of the future through the Internet of Things, with the aim of enabling highly responsive and flexible production and therapy, the partners, based on their own competencies, are key to the development of the "Intelligent Laser Systems for Factories and Clinics future ", Slovenia has identified the following key development and innovation goals for digital laser-supported manufacturing machines and therapeutic devices with exceptional potential:

- additive and adaptive systems for digital laser transfer printing and systems for cold digital processing of advanced materials,
- innovative systems for laser processing of glass as an alternative silicon material in the semiconductor industry
- new prototypes of laser sources with emphasis on high-power ultra-short shock lasers and power lasers in the GHz modulation field
- New photon devices for regenerative medicine, contactless and non-destructive diagnostics and digital-controlled therapy of disease states
- Intelligent and adaptive teranostatic devices and entire value chains in the field of teranostics
- a multifunctional piconosecond laser system for treating pigmentary lesions
- Intelligent dermatological laser system with digital-controlled skin irregularity therapy
- Intelligent laser medical systems with simultaneous visual and thermal monitoring of therapy
- Medical combined multilevel laser systems
- innovative medical laser systems with timed output that adapts to the dynamic interaction between laser light and tissue
- Diode-pumped power laser systems for regenerative medicine of large skin and mucosal surfaces
- special active and passive optical fibers of the next generation
- smart, effective and safe therapeutic medical devices with integrated feedback loop detection systems
- New cost-optimized short-range lasers with high robustness
- a new generation of laser devices for ophthalmic procedures based on diode pumping

3) INTELLIGENT CONTROL SYSTEMS

The challenge of the field of control technology in the context of the Factories of the Future is mainly in the integration of existing support information products (sensors, actuators, I / O interfaces, SCADA, MES, ERP systems) and newly developed building blocks that will integrate this with the aim of increasing the overall efficiency of production intelligent communication interfaces, platforms for linking between different databases, data analysis agents, cloud architecture, etc.). The priority directions of research and development in the field of management technology are therefore directed towards the development of various building blocks for stronger integration of the physical and digital world in the factories of the future, the development of new procedures for automatic, comprehensive and depth analysis of product quality, the development of new procedures for the ongoing assessment of the "fitness" devices and the development of new powerful tools for mining information on production. Therefore, the development and use of management technology, as one of the most important ICT branches, is now integrated into practically all the global trends of development and innovation in the world.

The priority directions of development in the field of "Intelligent Control Systems for ToP" focus on the following technological areas:

- Intelligent Production Management Systems (MES – MOM). In this context, the emphasis will be on the development of methods of production analytics, the development of advanced modules for the MES-MOM system, support for decision-making in the management and scheduling of production operations, and the on-line optimization of server systems through on-line simulation.
- Diagnostics, prognostics and self-maintenance of smart machines. In this area, this is a direction for predictive maintenance, which, in comparison with periodic maintenance, ensures more cost-

effective equipment management and an increase in overall process efficiency. This can be achieved only by means of appropriate non-invasive control systems that generate real-time estimation of the state and remaining life of the devices (Prognostics and Health Management – PHM).

- Development of modern tools and building blocks for the management and control of systems and processes. The research and development focus will be on building blocks and services in factories for microelectronic lithography based on accelerators and high-performance security process systems.
- Distributed management systems and IoT. The currently envisaged guidelines relate to the development of various building blocks for remote sensing and control, sensor and actuator networks, IoT in industrial automation and infrastructure, and web management and control.
- Smart actuators. It is a direction that, on one hand, is connected with the installation of a higher level of intelligence into individual actuators (motors, valves, flaps, etc.), which increases their independence. On the other hand, it is about increasing the connectivity of actuators according to the IoT concept. The current research and development focus is on special valves and EC motors.

4) SMART MECHATRONICS TOOLS

In the framework of the vertical value chain "Smart Mechatronic Tools," the SRIP primarily want to increase the connection of Slovene toolmakers and prepare them for the challenges of the new industrial revolution – Industry 4.0. The goal is to actively involve all toolkit stakeholders as well as tool users to overcome problems and to find solutions in all areas where weaknesses are manifested. A joint appearance of key actors in the value chain in the field of tooling, which will integrate both stakeholders in vertical value chains and horizontal networks, will lead to a new product, i.e. smart tools that will represent the core of digitized production in companies and will, in the future, largely replace the current classic tools.

The main goal of integration in the value chains is to change the tool from the passive element into an active network element with its own artificial intelligence, which is fully integrated into the Industrial Internet of Things (IIoT). Such a tool will be able to actively monitor the production process in the tool at any time and actively activate the necessary solutions through integrated imaging intelligence, which will eliminate unforeseen events in real time in order to avoid stalled production. In addition to pursuing a key goal for the ultimate product of the smart mechatronics tool, one of the key strategic objectives will be the integration of the following critical development axes that will be faced by companies in the tooling chain in the next ten years:

- Production of micro products
- Production of micro tools
- Micro installation
- Microformation
- Distributed / integrated engineering
- In-Mold Technology (IML / IMD)
- Coatings and surface technologies
- Rapid production and prototype production
- Small-scale production
- New design techniques (Eco-Design)
- Advanced automation, remote monitoring and production cells
- New functional materials
- Innovative environmentally friendly materials (Bio- and Eco-materials)
- Nanotechnologies
- Production of structural composite parts
- Simulation methods and tools for consulting services
- Eco-friendly manufacturing processes

The existing cross-sectional areas have been concentrated mainly in tooling with nanotechnology, robotics and control technologies, but at basic levels.

5) ADVANCED SENSORS

Besides the development of computer technologies, sensory technologies are fundamental for the development of autonomous and smart systems, industrial automation systems, modern transport systems, medical systems, security systems, etc. Modern sensors and sensor systems are crucial for the development of the concept of smart (autonomous) factories, smart (autonomous) production processes and all smart (autonomous) products. Without sensor technologies, autonomous systems cannot be created, and their autonomy will in many cases depend on the quality and extent of the parameters that can be detected in the future.

Managing sensory technologies will be crucial for industrial stakeholders, both from the point of view of establishing intelligent production systems as well as from the point of view of controlling end products, as sensory technologies will be those that will enable the production of complex products with new features and capabilities.

The "Advanced Sensors" vertical chain will seek to consolidate and link the knowledge, experience, competencies and interests of individual companies and knowledge institutions in the field of sensor technologies with the aim of creating a high-competence core capable of providing key knowledge, ideas, personnel and intellectual property needed for the effective development of sensor technologies and systems.

Focused points are directed to:

- development of miniature advanced sensors for measuring process quantities. This would include the development of sensors for monitoring various industrial and other processes, including sensors for use in advanced systems and products, namely:
- sensors for smart cooking appliances,
- sensors for the analysis of industrial fluids,
- sensors for measuring surface temperature,
- sensors of components of gas mixtures,
- gas nanosensors.
- development of advanced sensors for measuring mechanical quantities, focusing on the following specific sensors:
- miniature pressure sensors,
- sensors and measurement methods for quality control of aluminum castings
- special optical fibers for the production of optical elongation sensors,
- semiconductor sensors for measuring rotation and linear displacements.
- development of advanced sensors for measuring chemical and bio-chemical parameters, in particular:
- Bionanosensors for rapid biomedical diagnostics, food analysis and monitoring of production processes (modular components of bionanosensors, electric bionanosensors, immunochromatographic bionanosensors, microfluidic bionanosensors, auxiliary components)
- smart (Nano) Kemo / Bio sensor systems for the environment, home and health
- optical sensors for bio-detection.

6) SMART PLASMA SYSTEMS

Plasma technologies represent one of the key technological breakthroughs in the modern industry. The use of plasma technologies worldwide increases from about 15% per year. The driving force is the need for innovative products that can not be manufactured without the use of plasma (eg in microelectronics), ecological integrity of technologies and high added value. Plasma technologies were initially established in microelectronics, later in tooling, chemical and automotive industries, and the current challenges are the use of plasma in medicine and agronomy.

The purpose is to develop, implement and market specialized lines that combine all the horizontal technologies listed in the Smart Specialization Strategy (SPS):

- plasma technologies for nano structure and functionalization of modern materials,
- processing of materials with UV radiation (photonics),
- Automation with robotization and
- process management technology.

The vertical chain of values is shown top-down:

- Production and marketing of special lines for the plasma processing of products and semi-finished products in the automotive, textile and chemical industries.
- Development, manufacture and implementation of production lines for processing of products in large industrial partners with the close cooperation of smaller companies and academic spheres. These lines will represent demonstration products.
- To achieve this level, the SRIP will intelligently integrate components and sensors to allow fully automated lines.
- Some components are already available in industrial and academic partners, and specific components and sensors that will be integrated into the lines will be developed and manufactured. This work will be done by specialized SMEs.
- The academic sphere will explore optimal process parameters, take care of personnel training in industry, weigh out environmental aspects and prepare appropriate patent applications.
- Incorporate modern business and adaptive process concepts with IoT elements to create a smart integrated line of plasma technology as part of a future factory.

7) NEW MATERIALS

New materials play an important role in improving the quality of life. They enable technological progress in all areas of society, industry and domestic living environment, in transport, food, health care and information processing. The development of new materials also enables the use and exploitation of harmless, ecological and renewable sources and thus forms a basis for the sustainable development of the whole society. Industrial modern materials are classified as extremely high added value. For example. ceramics is one of the main areas of materials that is facing extremely rapid development in many new areas, for example, nanomaterials, biomaterials and materials with special optical properties. In Slovenia, modern inorganic materials at the research level are an important place and they are already ranked high on a global scale with their achievements. In addition, there are many companies in Slovenia that produce inorganic materials, components with different functional properties. These range from electronics, energy to engineering materials and represent an important production program of Slovenia, which covers in particular numerous niche product lines.

The vertical value chain “Advanced materials” derives from cross-sectional areas between materials, nanotechnologies, photonics and plasma, as well as processes of process control technologies. It focuses primarily on the field of inorganic non-metallic materials, where the SRIP wants to connect Slovenian manufacturers of materials, components and products, research institutes and universities. Our main goal is thus to build a platform of knowledge and experience that will serve to effectively transfer information on specific materials and technologies. Furthermore, our objectives relate to the development of joint research and development strategies in the fields

- Replacements of rare earths (eg neodymium and disproportion), which are currently the key elements in the production of certain permanent magnets, must be effectively replaced with less scarce raw materials due to the sensitivity of supply from the Asian markets.
- Implementation of the RoHS and the WEEE Directive, where the common market regulation under the RoHS Directive requires the replacement of harmful materials in various electronic components and electrical equipment. The main use of lead is the use of lead, which is a major element in many piezoelectric and ferroelectric materials, and effective substitution has not yet been developed by the actors. Furthermore, the WEEE Directive relates to recycling, which intends to recycle efficiently electronic components at the end of functional use and return them to the secondary raw material market. From these, in the final stage, it will be possible to produce products with properties that are comparable to products made up of primary raw materials.
- Identification and applications of joint research and development projects, development of new products and solutions in the field of key advanced materials.

Based on competence and capacity analysis, the SRIP identified the following focus areas:

- materials for electronics,
- materials for energy and
- engineering materials that are further subdivided into different product lines, such as, for example, varistors, PTCR thermistors, permanent magnets, piezoelectrics, etc.

The existing cross-sectional areas have been concentrated mainly within advanced materials, nanotechnologies, photonics and plasma.
In the SRIP Factories of the Future area, new horizontal networks cross-sectional areas such as robotics, control technologies, as well as vertical value chains, such as smart mechatronic tools, smart factory, advanced sensors are detected.
The cross-sectional areas possible within other SRIPs such as Materials Development as Final Products, Smart Buildings and the Wood Chain and Smart Cities and Communities (ICT).

8) SMART FACTORY

Digitalization, Industry 4.0, smart factories, etc. for Slovenian industrial and export-oriented companies, are a description of the ongoing evolution that they themselves experience and can be summarized in the form of strategic orientations in the following three points:

- **Uniformly designed umbrella processes** with precisely defined contact points and control points that will enable digitization of the most important processes of the company and their connection with the support processes and processes of business partners.
- Use of the **most modern and optimal technologies** both in the analysis and layout of processes and the concept of a smart factory as in the implementation of processes.
- Significantly **increase the added value** of these processes.

The concept of managing a smart factory should be based on the simultaneous development of all the components needed to build a smart factory:

- **“smart products”** … that can communicate with equipment, people and provide information for guidance,
- **“smart equipment”** … that can communicate with products, people and provides information for guidance

- **“smart people”** … who are trained to manage smart equipment and products, and use information to manage processes,
- **“smart” concepts,** that enable the rational operation and use of technologies with clearly defined inputs / outputs and characteristics, so that digitization is possible,
- **“smart management”**, based on the minimum number of data for maximum effect (added value). The primary aim of the **vertical value chain smart factory** is to address the challenge of the Smart Factory in the framework of SRIP ToP with the active involvement of all stakeholders in Slovenia and build a functioning support environment that will enable companies to integrate at different stages of their digital and technological maturity.

The key building blocks of this support environment, which will be provided by the vertical value chain Smart Factory are:

- linking and **upgrading the support to already established value chains** for the provision of four (4) step-by-step “smart turnkey” services,
- establishing a **single network of knowledge and information** on factories of the future,
- the establishment of a **three-level demo infrastructure** (Smart Factory model), according to the Open innovation model,
- the **establishment of an internal market for real industrial scenarios** of collected data for verifying the power and real useful value of artificial intelligence methods.