VSB TECHNICAL UNIVERSITY OF OSTRAVA
FACULTY OF MECHANICAL ENGINEERING

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LONG-TERM CROSS-SECTORAL COOPERATION STRATEGY FOR INNOVATIVE AND ADDITIVE MANUFACTURING TECHNOLOGIES

LONG-TERM CROSS-SECTORAL COOPERATION STRATEGY FOR INNOVATIVE AND ADDITIVE MANUFACTURING TECHNOLOGIES

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PREAMBLE

VSB – Technical University of Ostrava has been cooperating intensively with the application sphere for a considerable time, using various forms of collaboration in a number of areas across all sectors. In view of the market needs and the necessity of unique equipment and related technological know-how in additive technologies, which are characterized by multidisciplinary issues, the Department of Machining, Assembly and Engineering Metrology (hereinafter *„the Department"*) under the Faculty of Mechanical Engineering (hereinafter *„FME"*) started to build a platform with unique HW and SW equipment in 2016 in cooperation with application partners.

In 2017, our department was successful in submitting a project plan to the Call *No.02_17_049 Long-term cross-sectoral cooperation for ITIs* announced under the Operational Programme of Research, Development and Education. The project entitled ***Innovative and Additive Manufacturing Technologies - New Technological Solutions for 3D Printing of Metals and Composite Materials, reg. no. CZ.02.1.01/0.0/0.0/17_049/0008407*** (hereinafter referred to as *„the project"*) was recommended for implementation. The implementation of the project and the provided subsidy supports the two-way transfer of knowledge from scientific research activities, the transfer of demand and requirements from the application sphere towards research organizations, the development of specific expertise and skills of researchers in the field of 3D printing designed in the university environment in cooperation with experts from foreign universities, companies and other entities from the Ostrava conurbation.

The project provides a unique interdisciplinary platform across university research departments in cooperation with companies. Innovative and additive manufacturing, represented in particular by 3D printing technologies, is a multidisciplinary problem requiring joint solutions with contributions from designers, computer scientists, technologists, metrologists, metallographers, surface engineers and other specialists with a high level of technical education. 3D printing is also related to the necessary processes, represented in particular by a new creative approach in structural design (use of topological optimization and design of bionic structures, design of micro-routed structures, modern design proposals, etc.), preparation of production and manufacturing process and post-process modifications (heat treatment, chip formation on CNC machine tools, surface treatment, 3D measurement and 3D scanning).

One of the main outputs of the project is this strategic document, which aims to specify the priorities, tools and procedures for the development of long-term cooperation between the participating scientific research institutions and the application sphere, also after the project has finished.

Marek Pagáč
Executive Director of the Project

Jana Petrů
Project Director

ANNOTATION

Project name:	Innovative and additive manufacturing technologies – new technological solutions for 3D printing of metals and composite materials
Registration number:	CZ.02.1.01/0.0/0.0/17_049/0008407
Implementation period:	01 November 2018 – 31 December 2022
Project partners:	Polytechnic of Ślaska Gliwice University of Žilina, Fraunhofer, Institut für Werkzeaugmaschinen und Umformtechnik IWU V-NASS, a.s. BREBECK Composite s.r.o. Dk metal prominent s.r.o. Advanced Metal Powders, s. r. o. Klastr aditivní výroby, z.s.
Project Director:	prof. Ing. et Ing. Mgr. Jana Petrů, Ph.D.
Executive Director:	doc. Ing. Marek Pagáč, Ph.D.
Web:	3dprint-research.com
Funding sources:	European Regional Development Fund (ERDF) and the state budget of the Czech Republic (Ministry of Education and Science) through the Operational Programme Research, Development and Education and VSB-TUO

The aim of the project is to create a unique platform „Innovative and Additive Manufacturing Technologies“ addressing multidisciplinary issues that will support and deepen the intensity of long-term cross-sectoral cooperation. The main idea of the project is the development and establishment of new partnerships and cooperation between research organisations and the application sphere within the framework of jointly conducted research. The project addresses research activities in the areas of 3D printing from metal and polymer powders using Laser Powder Bed Fusion technology and composite materials using Fused Deposition Modelling and Continuous Fused Fabrication technologies through a newly built laboratory with available infrastructure located in the project applicant‘s laboratories.

The key activities of the project are the two-way transfer of unique knowledge, the establishment and development of a joint research workplace, the development of experience and know-how of the involved entities, the dissemination of the strategy of long-term cooperation between research organizations and entities from the application sphere, the implementation of joint research activities and projects, the deepening of existing cooperation and the development of new cooperation with the application sphere - with entities based in the Ostrava ITI conurbation and beyond.

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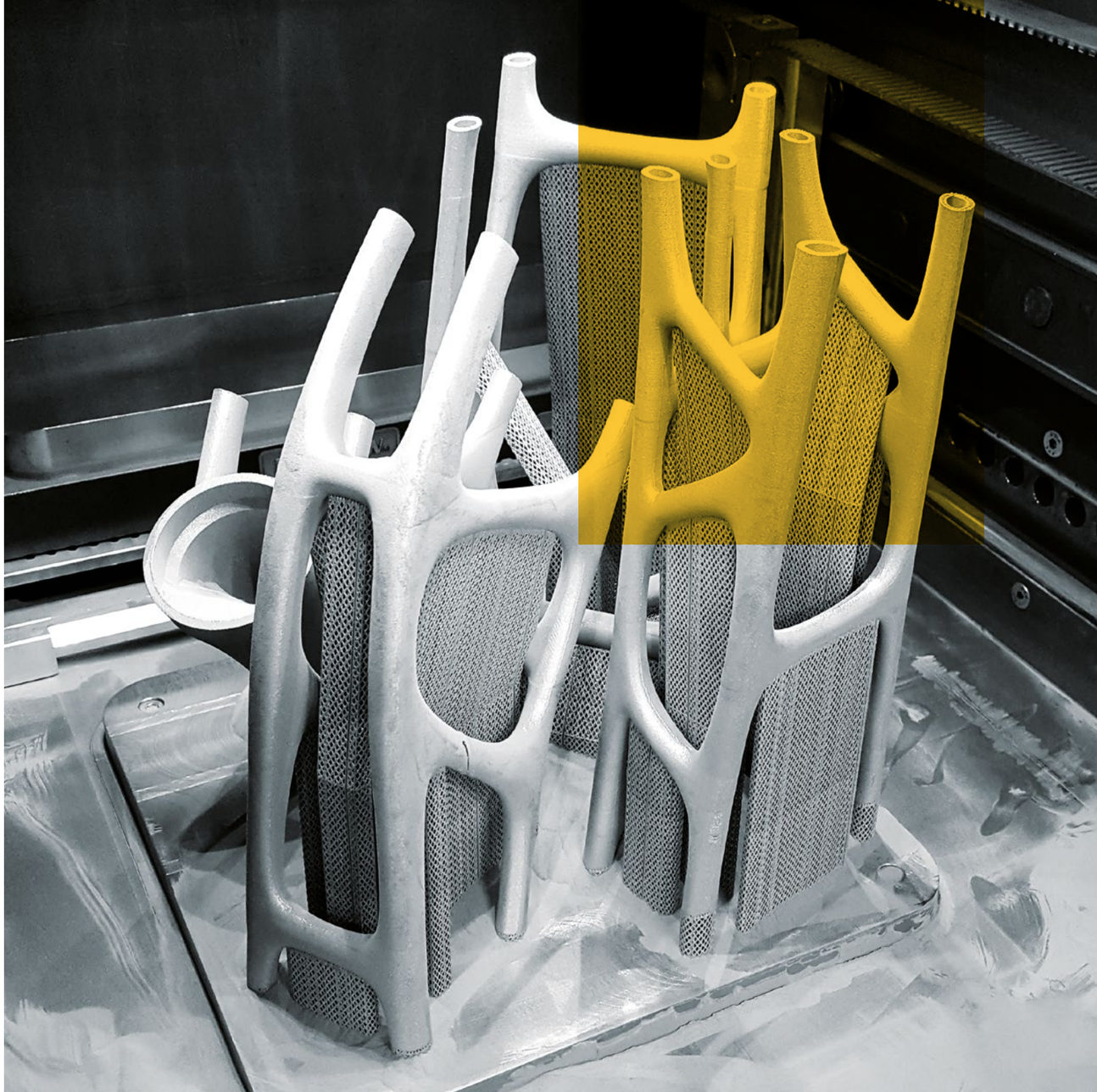
LONG-TERM CROSS-SECTORAL COOPERATION STRATEGY

Innovative and additive technologies are a dynamically developing field. The reason for the development of this strategy for long-term cross-sectoral cooperation is based on specific requirements from practical experience. VSB-TUO as a research institute is aware of the fundamental importance of national and international cooperation for the development of science and technology and the need for its institutional anchoring with regard to sustainability and funding. For this reason, this strategy document has been prepared as part of the implementation of the project *Innovative and Additive Technologies - New Technological Solutions for 3D Printing of Metals and Composite Materials*. The purpose of the strategic document is to set the essential manifestations of the university's internationalisation in the field of science and development in additive technologies and in other related processes such as machining, welding, metrology, surface treatment, inspection and measurement, etc. Furthermore, it is necessary to define the basic directions for its further development and to propose specific measures. Outside this framework, aspects in the areas of Bachelor, Master and PhD studies are important, as comparable attention is given to this part and students are involved in R&D activities. On the basis of the above information and according to the project plan, the strategic document is divided into an **analytical part** and **design part**.

The **analytical part of the strategy** maps the situation in the general scale of the existing cooperation of partner entities. This includes collaborations in the areas of powder metals research, design, 3D printing of metals and composite materials, energy and mass flow, inspection and 3D measurement, surface integrity, heat treatment, finishing and surface treatments. The study highlights the use of common potential and location, including a SWOT analysis within the framework of partnership cooperation. The output is a mapping study focusing on all aspects of partnership cooperation with an emphasis on the main areas that were approved within the framework of the Long-Term Plan of VSB-TUO.

The **design part of the strategy** is conceived as a comprehensive plan for the development of long-term partner cooperation, including the global goal, strategic objectives and priorities of the partner entities (especially universities). The main output is a strategic plan with the identification of measures as specific activities/projects leading to the implementation of the strategy.



ANALYTICAL PART

RESULTS OF COOPERATION SO FAR

Within the framework of the intensive cooperation of the entities involved in the new *Innovative and Additive Manufacturing Technology* Platform created in the project, the following results have been achieved in the area of strategy focus:

Technical equipment of VSB-TUO

The analysis of the technical equipment focuses only on a selection of essential technologies of innovative and additive manufacturing available at the workplaces of the Department of Machining, Assembly and Engineering Metrology, Faculty of Mechanical Engineering, VSB-Technical University Ostrava.

In the field of **additive manufacturing technologies**, this concerns in particular the following 3D printers:

- Renishaw AM400 – SLM – metal alloys (316L material).
- Renishaw AM500 E – SLM – metal alloys (Maraging steel material).
- Trumpf TruPrint 1000 – SLM – metal alloys (materials AlSi10Mg, Ti6Al4V).
- EOS P396 – SLS – polymers (material PA2200).
- EOS P396 – SLS – polymers (material PA-640GSL).
- EOS P110 Velocis – SLS – polymers (materials PA2200, Alumide).
- Markforged X7 – FFF – composites (materials Onyx, Onyx + fiber).

In the area of **innovative production technologies**, this concerns the following equipment for final finishing and heat treatment after 3D printing, so-called postprocessing:

- WJ4025-1Z-Cobra-PJ5AX-60° – High pressure abrasive waterjet – 5-axis CNC cutting.
- Kovosvit MCV1270 POWER – 3-axis CNC milling center.
- DMG Mori DMU 50 – 5-axis CNC milling center.
- Rexim RMX 3500 – 3-axis CNC milling machine.
- DMG Mori NLX2500MC/700 M730BM – multi-axis CNC turning center.
- Tajmac KMX432 with bar feeder – multi-axis CNC automatic lathe.
- Rexim Proturn RLX1630 – 2-axis CNC lathe.
- OTEC CF1 × 32EL rendering machine – finishing and smoothing of surfaces on metal parts.
- Laser E4060 – engraving and cutting CO2 laser with Cosa.
- PEGAS 360x500 SHI-LR – semi-automatic band saw with hydraulic control.
- NABERTHERM NW 200 WITH REG. P470 – chamber furnace for heat treatment of materials.
- NABERTHERM NA120/64 WITH REG. B400 – circulating chamber furnace for heat treatment of materials.

In the field of **metrology, scanning, analysis and diagnostics**, the following equipment is used:

- Alicona Infinite Focus G5 – CNC optical scanning device with rotary unit (5-axis device).
- Wenzel LH 65 – X3Premium + Shapetracker II – CNC coordinate measuring with scan head option.
- HandySCAN 3D Black – laser scanning.
- HandySCAN 700 – laser scanning.
- BALLBAR RENISHAW QC-20-W – Diagnostic system for precision control of CNC machine tools.
- KISTLER dynamometers (type 9129AA, type 9255C, type 9272) – piezo-multicomponent dynamometers for measuring and evaluating force ratios during machining.

In the area of **software support** used **in the computation, design and production phase**, the following software is used:

- Computational software: Matlab, Statgraphics, ThermoCalc, Ansys Workbench, DS 3D Experience Platform, MSC Software Simufact Additive, MSC Software Digimat, Altair Inspire, Materialise Magics, Autodesk Netfabb, Geomagic Control X/Design X, nTopology and others.
- Tool for designing micro-structures with regard to topological rejuvenation of 3D metal printing - software developed within the project for defining lattice structures for their subsequent printing without the need to use CAD tools.
- CAD/CAM systems: WorkNC, Mastercam, SolidCAM, Autodesk Inventor, SolidWorks, Creo, and other CNC programming software: Mikronex - Mikroprog S, MAPPS dialogue programming, machine control systems: Mistubishi M730BM, Heideninhain iTNC 530 HSCI, Heideninhain iTNC 640.

Science and research results

In the period up to February 2022, the project involved experts in **publishing and creative activities** a total of **63 scientific publications** produced by the experts have been published in Q1 and Q2 impacted journals in close collaboration between the participating entities and their experts, focusing on highly specialised topics in the field of innovative and additive manufacturing technologies:

Table 1: Research results in impacted journals Q1 and Q2 (as of 2/2022)

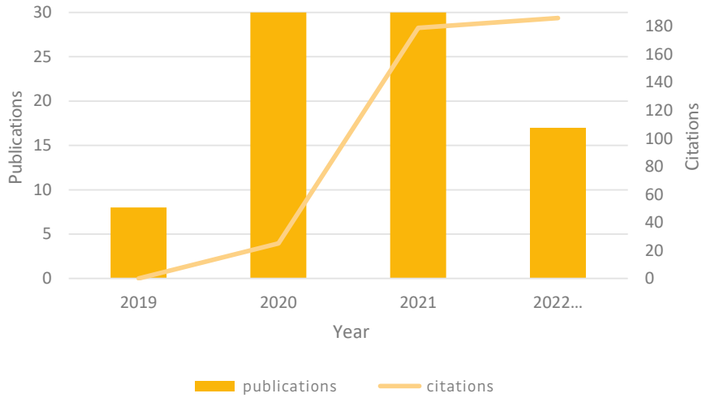
Year of publication	Total number of publications	of which	
		with foreign co-authorship	in co-authorship with the application sphere
2019	3	1	1
2020	24	7	3
2021	27	15	4
01-02/2022	9	6	6

Analysis of published results (includes proceedings) with affiliation to the project[1]:

Number of publications/citations:

- 2019 8/0
- 2020 30/25
- 2021 30/179
- Until 9/2022 17/186
- Total number of publications/citations: 85/391
- Number of citations without self-citations: 327
- Average number of citations per result: 4,6
- H-index: 10
- Highly Cited Paper: 1
- Review: 2
- Open Access: 68
- Enriched Cited References: 40

Graph 1:
Evolution of published papers and citations from 1/2019 to 8/2022

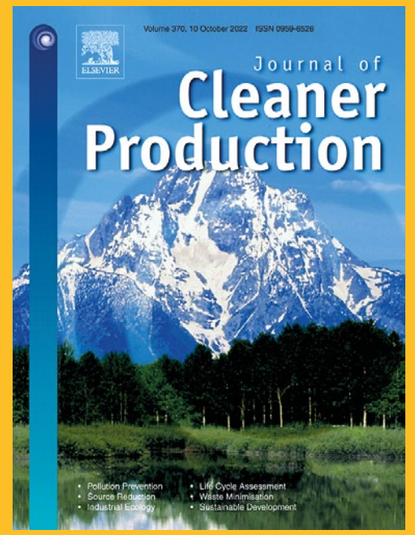


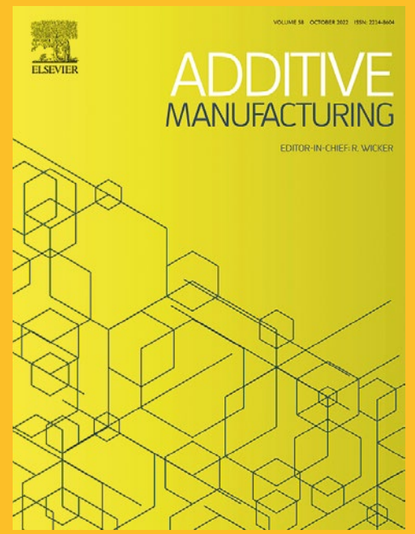
[1]*Source: webofscience.com; 9/2022*

Research categories

Publications in prestigious scientific journals:

- Additive Manufacturing (IF 11.632)
- Composites Science and Technology (IF 9.879)
- Sustainable Materials and Technologies (IF 10.681)
- Journal of Cleaner Production (IF 11.072)
- Alexandria Engineering Journal (IF 6.626)
- Nanomaterials (IF 5.719)
- Polymers (IF 4.967)
- Scientific Reports (IF 4.996)
- Materials Characterization (IF 4.537)
- Archives of Civil and Mechanical Engineering (IF 4.042)
- Sustainability (IF 3.889)





Highly Cited Paper – 60 citations

Pagac, M. ; Hajnys, J.; Quoc-Phu, M.; Jancar, L.; Jansa, J., Stefek, P.; Měsíček, J. A Review of Vat Photopolymerization Technology: Materials, Applications, Challenges and Future Trends of 3D Printing. Polymers. 2021, 13, 598. https://doi.org/10.3390/polym13040598; **60 citations**[1]

Chapter in the book

Radim Halama, Kyriakos Kourousis, Marek Pagáč, and Zbyněk Paška, Cyclic Plasticity of Metals Modeling Fundamentals and Applications. Elsevier Series on Plasticity of Materials. 2022. 11. Kapitola: Cyclic plasticity of additively manufactured metals. Cyclic Plasticity of Metals. ISBN: 978-0-12-819293-1. https://doi.org/10.1016/B978-0-12-819293-1.00010-3. Series Editors Frédéric Barlat, Oana Cazacu, René De Borst, A. Erman Tekkaya. Editor: Hamid Jahed Ali A. Roostaei.

A more detailed analysis of the publication activity in the project in the individual years of implementation shows a clear increasing trend of joint research and publication activities of scientific research with foreign partners, but also with companies, which also confirms the positive effect of the created platform *Innovative and Additive Manufacturing Technologies*.

Results of applied research

Over 30 results of applied research in the field of additive and innovative technologies. These include functional samples, prototypes, industrial designs and utility models.

Another major result of the cooperation within the established project platform are 2 international patent applications that are currently under international search:

- *Platform for 3D print*, patent originator: doc. Ing. Marek Pagáč, Ph.D.
- *A program-controlled system of a slotting tool and a lathe machine for forming an internal spiral grooving*, patent originator: Ing. Jiří Hajnyš, Ph.D.

Number of joint events held

Within the framework of the established project platform, a total of **17 joint events** including workshops, expert discussion forums and conferences were held in the period until June 2022 with the participation of partners, where specialised topics from the innovative and additive manufacturing segment were presented and discussed:

- Research, development and modern trends in additive manufacturing
- Topological optimization and simulation of 3D printing
- The Material Basis of 3D Printing
- Multi-laser 3D printers and R&D solutions
- Potential for additive manufacturing in the engineering, automotive, energy, aerospace and medical industries.

Participation in conferences, trade fairs and exhibitions

- **Formnext (Frankfurt am Main, Germany)** – the leading international industrial exhibition and conference focused on the next generation of intelligent industrial manufacturing, additive manufacturing and industrial 3D printing.
- **Additive Manufacturing Forum (Brno, Czech Republic)** – international conference focused on information about the latest technologies and practical knowledge of professional 3D printing.
- **Next 3D (Czech Republic)** – conference focused on new trends and best practices in additive manufacturing in companies and with creative professionals.
- **CIMT 2019 (Beijing, China), Material technologies in Silesia 2019 (Zawiercie, Poland), ASME 2019 (San Antonio, Texas, USA), Engineering 2020 (Sydney, Australia).**

[1]*Source: webofscience.com; 9/2022*

SWOT ANALYSIS WITHIN THE FRAMEWORK OF PARTNERSHIP COOPERATION

S STRENGTHS

- State-of-the-art infrastructure and equipment of the specialized workplace of VSB-TUO in the field of 3D printing in the Czech Republic and Slovakia.
- Highly qualified scientific research team of VSB-TUO - knowledge in multidisciplinary issues in the field of additive and innovative manufacturing.
- Publications in prestigious scientific journals Composite Science and Technology, Sustainable Materials and Technologies, Polymers, Archives of Civil and Mechanical Engineering, Nanocomposites, etc.
- Personal invitations to professional conferences on additive and innovative manufacturing (Next3D, Additive Manufacturing Forum, ICMEM 2022, etc.).
- Intensive professional cooperation with foreign scientific institutions in Central Europe (Poland, Slovakia, Germany), but also domestically in the Czech Republic (cooperation with the Academy of Sciences of the Czech Republic).
- Increasing interest in studying in the fields of additive technologies from abroad (India and Erasmus students).
- Long-term intensive cooperation with companies in the field of additive and innovative manufacturing (science, research, innovation).

W WEAKNESSES

- Very high financial intensity of research and development in the field of 3D printing (investment in infrastructure including maintenance and fees for software, materials and tools, energy).
- Unstable operational funding for science and research and the administrative complexity of project funding (from European sources).

O OPPORTUNITIES

- New areas of application of innovative and additive manufacturing - entry into the aerospace segment (including the possibility of certification of the workplace for the production of components).
- New cooperation topics and research projects in innovative and additive manufacturing:
  - 3D bioprinting, 4D printing, 3D printing in microgravity
  - 3D printing of difficult to produce materials such as ULTEM, PEEK with high temperature resistance, etc.
  - Multimaterial engineering for the production of models with multi-physical properties.
- Development of cooperation in science and research with the University of Defence.
- Development of international scientific research cooperation with a focus on Western European and Asian countries.
- Growing interest of companies in additive and innovative technologies.
- The planned expansion of the infrastructure of VSB-TUO with a focus on the development of 3D printing of metal alloys.

T THREATS

- Very rapid development in the additive and innovative manufacturing technology segment - infrastructure obsolescence, necessary reinvestment and technology innovation.
- Negative changes in financing due to, for example unfavourable macroeconomic developments.

DESIGN SECTION

STRATEGIC OBJECTIVES AND PRIORITIES

The design part of the strategy for long-term cross-sectoral cooperation consists in the further development of a multidisciplinary platform that includes researchers engaged in R&D activities for the development and generation of results and outputs in innovative and additive technologies. The plan for the development of cooperation is structured in accordance with the global targets and selected relevant objectives of the current **Implementation Plan of the Strategic Plan of the VSB-TUO** as well as the **Strategic Plan of Educational and Creative Activities for 2021-2027 at FME VSB-TUO** as the main initiator of the platform). The cross-sectoral cooperation strategy also takes into account the long-term strategic objectives and development priorities of the partners. The Principal Investigator and partners have thus set the following global goal/vision as part of this Strategy:

To be a Central European research and innovation leader in the multidisciplinary field of innovative and additive technologies and multimaterial 3D printing.

The following 9 strategic objectives aimed at developing long-term partnership cooperation in the field of innovative and additive manufacturing technologies will contribute to the achievement of the global goal/vision:

Strategic objective 01: **To be a centre with a high applicability of R&D results**
Strategic objective 02: **To be a recognised centre of targeted research**
Strategic objective 03: **Efficiently manage and use the capacity of technological infrastructure**
Strategic objective 04: **Internacionalizace**
Strategic objective 05: **Vytvářet motivační prostředí pro rozvoj osobností a týmů**
Strategic objective 06: **Synergie projektů a nové projektové záměry**
Strategic objective 07: **Smart Materials and Sustainability Additive Manufacturing: 3D Printing and 4D Printing**

Strategic objective 08: **Infrastructure sustainability and modernisation**
Strategic objective 09: **Being an incubator for promising students and researchers**

Fig. 1 – Structure of strategic objectives and priorities of the long-term cross-sectoral cooperation on the Innovative and additive manufacturing technologies platform- new technological solutions for 3D printing of metals and composite materials

These strategic objectives have a clear meaning and can be achieved through well-defined sub--activities. The strategic objectives are set according to the current situation and based on the set cooperation across the platform – between universities and partners of the unique platform. The objectives are achievable and the implementation team is aware of the risks involved in achieving the objectives.

STRATEGIC OBJECTIVE 01

TO BE A CENTRE WITH A HIGH APPLICABILITY OF R&D RESULTS

The aim is to support the creation of quality publication applied outputs through the use of motivational tools and the corresponding salary level. High-quality publications, produced in international author teams, will become a natural part of the way to present the results of research and development carried out at VSB-TUO.

- Targeted applied research and publication of R&D results in prestigious scientific journals Q1 and Q2.
- Cohesion and competitiveness in multidisciplinary issues.
- Potential of publication in prestigious journals in terms of partial research and scientific activities.
- Providing excellent scientific research know-how to companies.
- Transfer of knowledge, expertise and prudence in publishing trends.
- Stabilization of publication and citation trends.
- Predicting the development of cited topics and searching for publication context in multidisciplinary issues.
- Make effective use of the University‘s technology transfer tools.
- Build on the Research Portal database for efficient management and work with R&D results.
- Deepen knowledge of scientometrics and trend tracking in the given field and focus on cited topics in the areas of additive technologies and related multidisciplinary issues.
- To carry out R&D activities within the projects with a connection to the issue of interest worldwide and according to its citation.
- More effectively exploit the potential of protected intellectual property results, which will be reflected in increased revenues from commercialisation activities.

STRATEGIC OBJECTIVE 02

TO BE A RECOGNISED CENTRE OF TARGETED RESEARCH

The aim is to support R&D activities and the implementation of applied research results into practice with practical application and with the aim of optimizing and rationalizing existing technological production processes. The goal is that the 3D printing centre and the implementation team are seen and recognized as an indivisible whole and that the public understands that multidisciplinary issues must be addressed across all related disciplines.

- Providing active support to the Faculty's academic and research workers in the preparation and execution of projects in the sphere of research and development (R&D).
- Strategic assistance in setting up a scientific research consortium for various targeted projects.
- Targeted transfer of information on current national and international project calls to the faculty.
- Identifying opportunities and providing information to academic and research staff of the faculty in the field of international cooperation.
- Transfer of technological and scientific research know-how, knowledge and expertise across long-term cross-sectoral cooperation.
- Implementation of activities to increase the participation of faculty research teams in collaborative international projects.
- Analysis of the possibilities of establishing motivational support for publishing authors leading to an increase in the number of quality publications in key areas of faculty R&D.
- Evaluation of the trend of citation response of publications across the university in relation to multidisciplinary issues.
- Promotion and popularization of the quality R&D results of the faculty to the public, industry and students of bachelor, master and doctoral studies.
- Offer international cooperation to scientific teams that have expressed interest in published R&D results through citations.

STRATEGIC OBJECTIVE 03

EFFICIENTLY MANAGE AND USE THE CAPACITY OF TECHNOLOGICAL INFRASTRUCTURE

The aim is to promote and popularise the unique infrastructure with the aim of its maximum, rational and efficient use for R&D purposes and cooperation in practice and for the implementation of national and international projects.

- Strategic planning of experiments and continuity of sub-research activities.
- Design of Experiment planning and rationalization of experimental activities with respect to R&D results and outputs of the project.
- Implementation team meetings and mutual consolidation of sub-research capacities.
- Preparation of a proposal for the renovation and expansion of the existing unique technological facilities.
- Planned maintenance and calibration of unique technological facilities and certification for automotive and aerospace purposes.
- Interconnection and mutual synergy between activities in the projects of OP VVV and OP PIK, GAČR, TAČR, SGS, etc.

STRATEGIC OBJECTIVE 04

INTERNATIONALISATION

The aim is to build international relations and strengthen the capacity for scientific research.

- Continuous research activities of joint international teams leading to joint publications and other scientific results.
- Supporting the stay of PhD students, postdocs, associate professors, professors and R&D staff in third countries as a suitable opportunity for the development of dissertation, habilitation and professorship procedures.
- Supporting the arrival of high quality staff, mentors and experts from key R&D multidisciplinary areas.
- Transfer of unique knowledge and expertise for further development of cross-sectoral cooperation.
- Sharing international experience across the implementation team.
- Using a combination of virtual and physical mobility.
- Building quality international networks with partner institutions and planning foreign business trips of employees to third countries.

Regarding international relations, we are currently focusing on strengthening international scientific research cooperation in the segment of additive and innovative technologies with scientific and academic institutions in Western Europe (Germany, France) and Asia (India, China and Vietnam).

STRATEGIC OBJECTIVE 05

TO CREATE A MOTIVATIONAL ENVIRONMENT FOR THE DEVELOPMENT OF INDIVIDUALS AND TEAMS

The aim is to motivate researchers to investigate current trends and technological challenges with a view to the vision and future in the fields of additive technologies. Motivation must be directed towards research on multi-material and multi-physical properties.

- Introduction of an evaluation system for the implementation team and emphasis on mutual cooperation in individual sub-activities.
- Motivation of researchers, students and collaborating companies to perform new tasks that are based on the requirements in practice and have application potential.
- Visibility and popularization of significant R&D results for career and personal development.
- Supporting educational and promotional events for the development of staff and faculty leaders.
- Career progression in relation to building new research capacity with the academic ranks of Ph.D., Associate Professor and Professor.
- Building a unique environment with unique infrastructure and being a leader in areas related to additive technologies.
- Strengthening excellence in key areas of targeted research.
- Motivation to attract and deal with international projects with the aim of involving different university departments.

STRATEGIC OBJECTIVEL 06

PROJECT SYNERGIES AND NEW PROJECT IDEAS

The strategic objective is to use the results of basic research in applied research and development of functional samples, industrial designs, utility models and patents. The aim is to use the acquired technological know-how and experience with the acquired infrastructure and its capitalization within the framework of the provided services, consultations and in cooperation with practice and teaching.

- Monitoring the coherence of key activities in long-term cross-sectoral cooperation and their mutual evaluation.
- Implementation of new research projects based on requirements from practical experience.
- Continuous development of the multidisciplinary Innovative and Additive Manufacturing Technologies platform and dissemination of R&D results within national and international scientific institutes.
- Expanding the platform to new partner companies and scientific research institutions that lack technological know-how, experience with additive technologies and unique infrastructure.
- Monitoring of modern trends and tracking of announced project calls and continuous preparation of project applications that relate to these calls.

STRATEGIC OBJECTIVE 07

SMART MATERIALS AND SUSTAINABILITY ADDITIVE MANUFACTURING: 3D PRINTING AND 4D PRINTING

The strategic objective is to develop and research technological processes of additively manufactured materials with multi-physical properties and unique chemical composition for application in automotive, aerospace, energy, petroleum, engineering and food industries, etc. The point of this is to extend the research objectives to 4D printing and its application use in industrial practice.

- Focused research on multi-physical properties in the areas of multi-material 3D and 4D printing.
- Research on mechanical properties of metal, polymer and composite materials for actuators, Smart Robotics, Smart Flexible Electronics and Shape Memory Polymers.
- More sophisticated production processes with respect to Product Lifecycle Management (PLM) and the inclusion of the entire life cycle (from design to recycling) in the development of prototypes.
- Environmental sustainability of additive technologies and green waste management and promotion of environmental aspects on a global scale.
- Savings on energy costs and energy recovery.

STRATEGIC OBJECTIVE 08

INFRASTRUCTURE SUSTAINABILITY AND MODERNISATION

The eighth strategic objective is the sustainability and modernisation of infrastructure in line with trends in additive technologies. The specific objective is to acquire new equipment with a higher level of performance (more lasers, 3D printers with more print heads) from the project plans. An integral part of this is the updating of computational software and software for topological optimization, bionic model construction, STL model repair, print job preparation, open platform for process parameter optimization, multimaterial property analysis, etc.

- Keeping up with modern trends in 3D printer development and design, and options for add-on devices to monitor scan speed, acoustic emission, meltpool, CT measurements and defect scanning after each layer.
- Modernization of post-processing machinery including machining, welding, welding, painting, lacquering, plating, steaming, heat treatment, 3D scanning and production accuracy measurement.
- Modernization of instruments and equipment for chemical analysis, evaluation of microstructural and macrostructural properties and non-destructive evaluation of defects.
- Updating SW for the needs of technological processes of additive manufacturing.

Among the key infrastructure investments currently planned are the following acquisitions:

- An atomizer for the production of powder mixtures with unique chemical composition,
- Equipment for additive Direct Energy Deposition technology (3D printing from powders and wires fused by laser beams),
- Powder Bed Fusion Selective Laser Melting 3D printers for laboratory use and for 3D printing of precious metal alloys with process monitoring, thermal imaging, CT scanner, acoustic emission and high-speed camera.

STRATEGIC OBJECTIVE 09

BEING AN INCUBATOR FOR PROMISING STUDENTS AND RESEARCHERS

The aim is to motivate promising students and researchers to study and perform R&D activities related to additive technologies, to integrate them into the existing implementation team and to build a unique scientific and research facility in terms of human resources. Human capacity is indispensable for R&D purposes and there is a risk of staff turnover within the context of multidisciplinary issues.

- Accreditation of the study specialization entitled Additive Technology as part of the Mechanical Engineering Bachelor's degree program, with the start of teaching expected from 9/2022.
- Implementation of workshops, expert discussion forums and open days and popularization of R&D activities related to multidisciplinary issues.
- Promoting case studies and spreading awareness of the potential of additive technologies with links and connections between R&D activities and practice.
- Popularisation of additive technologies in primary and secondary schools through cooperation with the Moravian-Silesian Innovation Centre.
- Creation of interactive teaching aids for dissemination of knowledge, awareness and applicability of additive technologies in practice.

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LONG-TERM CROSS-SECTORAL COOPERATION STRATEGY
FOR INNOVATIVE AND ADDITIVE MANUFACTURING TECHNOLOGIES

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