



**2017 Annual Report
of the University Institute
New Technologies – Research Centre
University of West Bohemia**

26 February 2018

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1. Letter from the Director

Since the beginning of my career, international cooperation has always been a major challenge, and obtaining a foreign project has been a great motivation; not only because I can compare my knowledge, abilities and approaches with my foreign colleagues', but mainly because international contacts allow me to get acquainted with and understand global research in a broader context.



Due to my rich experience in international cooperation, after my appointment as a director, I have also given this goal to NTC because I want to motivate other colleagues and new teams to spread the reputation of NTC and the entire UWB around the world.

In 2017, it was crucial for NTC in terms of the development of internationalization. An important milestone was the launch of the project "Computational and Experimental Design of Advanced Materials with New Functionalities", thanks to which a foreign expert came to NTC and began to build an international research team in a promising area. NTC dealt with four projects supported by the Czech-Bavarian Cross-Border Cooperation in the ETC GOAL programme, and received two other projects from this programme for the following years. NTC has submitted six projects to the HORIZON 2020 programme and has also been involved in prestigious projects supported by the oldest European research programme titled COST. Finally, I also hold an important position in the International Federation of Automotive Companies FISITA; other colleagues of mine have also become prominent officials in Domestic, European and World Associations.

I think the year 2017 was crucial from the NTC's internationalization point of view. I personally thank all NTC employees for the excellent work accomplished, and hope that we will further leverage our results internationally.

Luděk Hynčík, NTC Director



2. NTC in the Year 2017

In 2017, NTC developed its activities in line with the Strategic Plan (formerly known as the Long-Term Plan) for the period 2016 - 2020, which is fully in line with the Strategic Plan of UWB. After the successful completion of the implementation phase of the CENTEM (Centre of New Technologies and Materials) infrastructure project, financed from OP RDI (Operational Programme Research and Development for Innovation), the key activity was, also in 2017, the implementation of the CENTEM+ project financed from the National Programme of Sustainability (NPU I), which successfully reached its second half.

In addition to CENTEM+, NTC has also dealt with a number of other projects from domestic providers such as: the Ministry of Education, Youth and Sports (MEYS), the Czech Science Foundation Grant Agency of the Czech Republic (GACR) and the Technology Agency of the Czech Republic (TACR). NTC also conducted the prestigious international project "HCENAT" that focused on the nature of improving human cognitive abilities, which was funded by the Czech-Norwegian Research Programme. As part of the research, the planned applied results were successfully passed on to industrial partners, and many high-quality publishing outputs relevant to the NTC evaluation from the point of view of research excellence were achieved.

NTC has been continuously developing research on electron structure and optical and mechanical properties of new materials. It includes basic research with a high level of publishing and cooperative potential. This topic is supported by the project "Computational and Experimental Design of Advanced Materials with New Functionalities", in the RDI Operational Programme in Call No. 02_15_003 Support of Excellent Research Teams in Priority Axis 1.

In addition to grant projects, an integral part of NTC is also a strong and long-built ties with industrial partners for the purpose of cooperation in the field of contractual problem-oriented research. NTC significantly strengthens its foreign activities, including the field of contract research.

The NTC is still located in four buildings in the Science and Technology Park (STP). It occupies half of the ground floor of the building of the Faculty of Education of the University of West Bohemia in Veleslavínová Street and uses pilot operation premises in Velenická Street in Pilsen. The total area used by the NTC is 2,302.14 m² in the UWB and VTP premises; NTC also externally leases 263.52 m² in Velenická Street in Pilsen. Additionally, NTC has modern instrumentation equipment worth over 380 mil. CZK.



Thanks to the upbringing of young researchers and a targeted strategy for attracting talented researchers/students from abroad, NTC has been gradually rejuvenating the age structure of its employees. Out of a total of 129 employees, 73, including 17 women, are under 40, which represents very promising human resources for further development. Emphasis is also placed on transparent processes of human resources management and non-discriminatory policy in all areas of management.

The NTC's personnel structure is shown in the table below.

Personnel capacities	Persons
Total	129
Professors	9
Associate Professors (Docent)	11
Ph.D.	60
Technical Staff	39
Overhead Staff	10

The NTC's organizational structure was based on research topics, with a substantial part of professional activities being integrated into CENTEM+.

The NTC's organizational structure in 2017:

- Deformation and Dynamic Processes Modeling (MDP)
- Modeling and Measurement of Interactions in Technical Systems (MIS)
- Centre of New Technologies and Materials (CENTEM) with the following research programmes:
 - Morphology and Surface Texture of Materials (CT1)
 - Engineering of Special Materials (CT2)
 - Laser Technologies and Thermomechanics (CT3)
 - Materials and Technologies (CT4)
 - Man Machine Interaction (CT5)
- Engineering of Condensed Phase (CT6)



NTC's organizational structure in 2017 is graphically displayed in the following picture (Fig. 1):

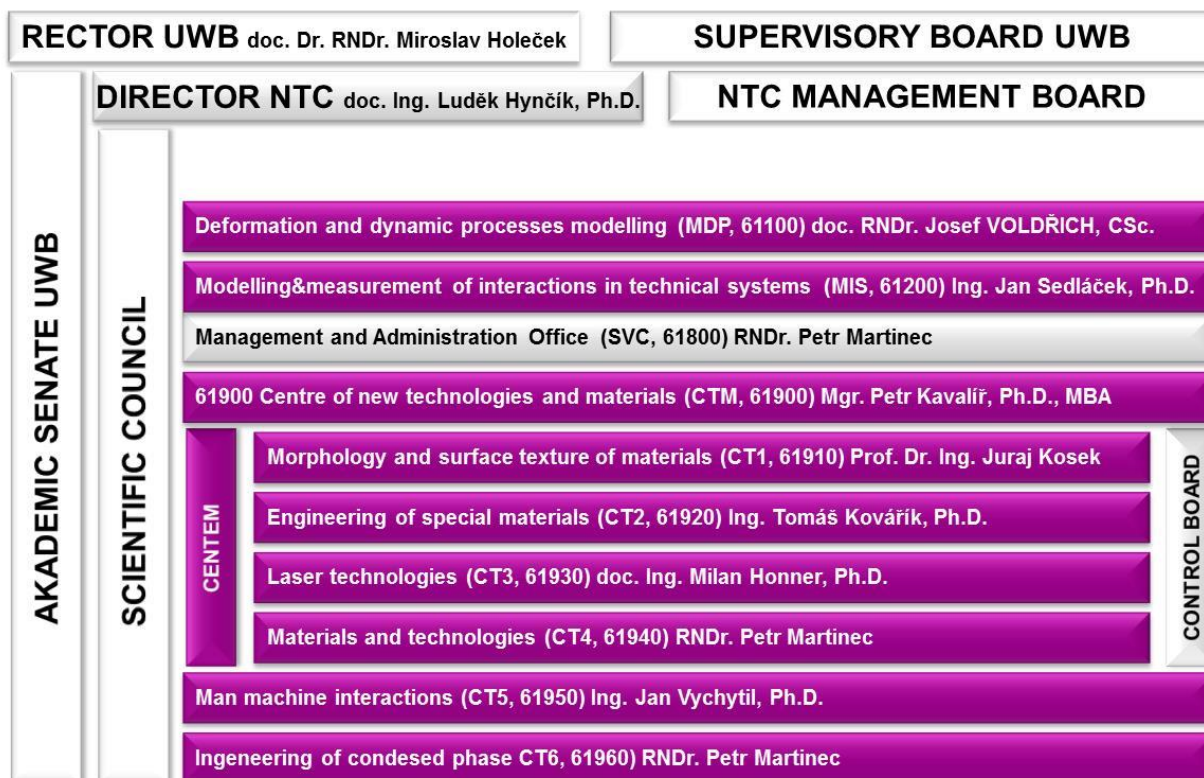


Fig. 1: Organization scheme of NTC

In 2017, the management system was further developed through the implementation of performance management processes, contributing to the fulfillment of objectives and overall higher motivation of employees. It is a system where, on the basis of joint meetings of individual departments, the objectives of the departments are set for a given year; they are checked regularly and their fulfillment is rewarded at the end of the year. It turns out that this system really motivates employees to produce quality outputs. An incentive system by which individual employees are financially rewarded for acquiring a project or contract research job and for creating excellent research results is implemented as the second pillar of the performance management system. Enhancing excellence in human resources development and performance-oriented organizational culture is a long-term process that will be developed by a university wide project that should result in obtaining the European certification, the so called *HR Award*.



3. Research and Development

Contract Research

As in previous years, in 2017 New Technologies – Research Centre was involved in solving problems and participating in activities together with commercial partners for whom research and service activities were predominantly addressed. These were research institutions and, above all, industrial enterprises with a total number of 62 entities. In 2017 were realized 78 contract research jobs and 54 contracts for complementary activities totaling 11.7 million CZK. The key partners were mainly the following companies: ŠKODA AUTO a.s., Adax S.A. (Switzerland), Redbull Technology (Great Britain), Ball Beverage Packaging Czech Republic s.r.o., ArcelorMittal Ostrava a.s., E.ON Czech Republic s. r. o., ZF Engineering Plzeň s.r.o., MAHLE Behr Holýšov s.r.o., Howden ČKD Compressors s.r.o., TEDIKO s.r.o., ZVVZ-Enven Engineering a.s., Škoda JS a.s., Honeywell International s.r.o., VZÚ Plzeň s.r.o., MECAS ESI s.r.o., Aremco Products Inc., COMTES FHT a.s., Continental Automotive Czech Republic s.r.o., JANTAR company s.r.o., TESLA Electrontubes s.r.o., Daikin Industries Czech Republic s.r.o., SHM s.r.o., SCG Chemicals Co. Ltd., Ghent University, Pilsen Urquell a.s., Whitford Corporation, Cheshire (Great Britain), Robert BOSCH s.r.o., as well as others. All of the above-mentioned contracts were always completed by the agreed dates and in line with the requirements of our clients.

CENTEM and the CENTEM+ Sustainability Project

After the end of the implementation phase of the CENTEM project from the OP RDI programme, the transition to the sustainability phase took place. The sustainability phase has been supported by the CENTEM+ project from the National Programme of Sustainability NPU I for the period 2015-2019. The eligible costs of this project are 60 million CZK, of which about 27 million CZK are subsidies from the MEYS. In the year 2017, attention continued to be paid to increasing prestigious R & D outputs, particularly in the area of impacted articles and outcomes intended for IP protection. Another requirement for 2017 was maintaining the performance in publishing activities with emphasis on improving its professional level.

In 2017, intensive negotiations were held with several investors aimed at commercializing the stationary energy storage using the technology of the Vanadium Redox Flow Battery, which is being developed in the Velenická Street laboratory. At present, a fully functional prototype of a 2 kW battery is developed and a prototype of a 5 kW battery is being developed. The form of commercialization is undergoing revision. Two scenarios come into play: the first is the sale of the license and the second one is the establishment of a spin-off company.



Projects

In 2017, NTC participated in the solution of 5 projects funded by the Grant Agency of the Czech Republic (GAČR). These were the following projects: "Electron Structure of Lanthanide-Doped Materials for Luminoform-Transformed White Electroluminescent Diodes", "Homogenization and Multi-Scale Computational Modeling of Flows and Nonlinear Interactions in Porous Intelligent Environments", "Polyolefin Particles Agglomeration Studied on a Meso-Scale", "Iron-Based Material and Machine Components Strength: Multiple-Scale Approach", and "Fluid Acoustics in Periodic Micro-Architectures". The total financial subsidy from the GAČR provider was 2.8 million CZK.

Significant group of NTC projects are application-oriented projects in cooperation with industrial partners. Above all, these are projects from the ALFA programme, where the provider is the Technology Agency of the Czech Republic (TAČR). Projects in the ALFA programme are aimed at supporting applied research and experimental development in cooperation with industry in the Czech Republic. The projects are focused on the development of active car hoods in cooperation with Vision Consulting Automotive s.r.o.; and the development of the technology of vegetable oil extraction with Farmet a.s.: research into a highly efficient catalyst and process for the degradation of resistant antibiotics in cooperation with PRO-AQUA CZ s.r.o, and also research on porous and macroporous titanium surfaces for improvement of adhesion of bone tissue with MATEX PM s.r.o. The total financial subsidy for the above listed projects from the ALFA programme is 2.3 million CZK.

Another group of projects comes from the TACR Centre of Competence programme. The NTC research Centre of Competence deals with two projects with a total financial subsidy of 2.9 million CZK under the name, "Centre for Research and Experimental Development of Reliable Energy" and "Advanced Technologies for Heat and Power Production".

The above applied research projects have been realised in close relation to industrial companies, which are usually the main beneficiaries of the projects; NTC acts as a research institution supporting these industrial partners.

In 2017, we also realized a project supporting active membership in the Council and the Education Committee of the International Federation of Automotive Companies, FISITA, where the NTC Director serves as Vice-President for Education. This activity was supported by the INGO II programme of the Ministry of Education, Youth and Sports with a financial volume of 0.1 million CZK.



In 2017, the project "Computational and Experimental Design of Advanced Materials with New Functionalities" was launched in the OP RDE Operational Programme in Call No. 02_15_003 Supporting Excellent Research Teams in Priority Axis 1. The aim of this project is to support research and development in the field of material structure, electrical and optical properties of new materials; the research will be carried out under the guidance of the key foreign researcher (KFR), Associate Professor Ján Minár, who came to NTC from Ludwig-Maximilian-Universität München. The first year of implementation was primarily focused on the establishment and stabilization of the research team. Another important activity in 2017 was realization of several public tenders for the purchase of software and hardware, such as: a computing cluster including UPS stations, a high temperature furnace and a chemical composition analyzer. A major challenge in the field of instrumentation was the completion of the tender for the supplier of the unique device "Spark and Angle Resolution Photoelectron Emission Spectrometer(SARPES) ", which is an exceptional device in the Czech Republic worth over 44 million CZK.

NTC increased its effort to submitting more international projects in 2017. NTC submitted six projects to HORIZON 2020 programme. Also submitted several projects, such as the project **PAPOOSE** - *Child Passengers on (Powered) Two Wheelers and Their Safety*", which will focus on the issue of children fellow passengers on two-wheelers. In particular, the research will focus on answering the question: "How shall we make transport of children on two-wheelers safer, healthier, sustainable and socially acceptable?"

In 2017, the research group of the Associate Professor Minár prepared the project **EUSpecLab** - *European Spectroscopy Laboratory to Model the Materials of the Future*", the aim of which is training students to be able to develop and use computer codes for the modeling of top spectroscopies, for example: time and spin-solved spectroscopies at the forefront of basic research in the characterization and design of new materials that will shape the future of our society.

In 2017, following projects were submitted but unfortunately, were not supported. These were the projects: **GETuP** - *Implementing Gender Equality Plans to Unlock Research Potential of RPOs and RFOs in Europe*", **IMGEP** - *Support to Research Performing Organizations (RPO) and Research Funding Organizations (RFO) in EU Member States, Associated Countries, and Neighboring Countries to Implement Gender Equality Plans*", and also the project **FINAICONST** - *Natural Fibre for Industry and Construction*". The aim of the **FINAICONST** project was to develop new bio-composite solutions based on the use of cannabis and esparto natural fibers. This new bio-composite solution will enable the production of innovative and competitive products for industry and the construction sector. The last project,



RAPIDSURF - *High Speed Laser Surface Texturing for Tribological Applications*, focused on the modeling of tribological processes on the textured surface allowing to determine the optimal geometry of the texture from a model; the advantage of which is minimal thermal degradation with efficient use of high performance pulsed lasers.

Another international project is the COST programme project, focused on theoretical spectroscopy of new materials based on cooperative use of multiple programmes with an emphasis on semiconductors and insulators.

In 2017, the international project "HCENAT" funded by the Czech-Norwegian research programme focusing on naturalness in improving human cognitive abilities was completed.

An important group of NTC projects are projects under the Czech-Bavarian Cross-Border Cooperation in the ETC GOAL programme 2014-2020, which is ensured by the Ministry for Regional Development of the Czech Republic. These projects are primarily focused on the cooperation of cross-border partners originating from the Czech Republic and the Free State of Bavaria in Priority Axis 1 "Research, Technological Development and Innovation".

The aim of the first project, "Virtual Human Model for the Prevention, Treatment and Rehabilitation of Shoulder Disease", is cooperating closely with the German partners OTH and FN Regensburg. Within the cooperation, a new musculoskeletal model of the shoulder joint will be developed in the AnyBody Modeling System programme, including its subsequent implementation into clinical practice.

Another project under the designation, "TheCoS - Thermoplastic Composite Structures", is designed to provide a reliable production chain for fibrous composite carrier structures with a thermoplastic matrix consisting of the component manufacturing process and laser beam welding, which is a joining technology.

The third project, "Cross-border Network for Research and Innovation in the Field of Energy Efficiency and Combined Heat and Power Production", is dealt with in cooperation with the Faculty of Mechanical Engineering (FME) - with cooperating entities FME/KKE, VVRC (formerly SUSEN), RTI. The aim of the project is to increase the competitiveness of small and medium-sized enterprises (SMEs) in the grant area.

The fourth project of the Czech-Bavarian Cross-Border Cooperation in the ETC GOAL programme 2014 – 2020 , focuses on creation of a joint research platform between NTC at UWB and the Technology Centre for Energy (TZE) at the Landshut Applied Sciences University focusing on research on energy storage and its integration with other technologies.



This research and cooperation takes place under the project "FSTORE: Cross-border Platform for Research on Future Energy Storage and its Integration".

For the year 2017, the total grant amount for these 4 projects was about 11.3 million CZK.

In 2017, this list of Czech-Bavarian projects was expanded by two other projects, the implementation of which will begin in the course of 2018. This is the project "Obstetrics 2.0 - Virtual Models for Prevention of Injuries During Childbirth", aimed at finding the optimal position and locomotion of the obstetrician during manual perineal protection for achieving maximum efficacy depending on the anthropometric data of the mother and the obstetrician. In order to achieve these goals, a computer musculoskeletal model of a human with a detailed developed submodel of the upper limb will be used.

The second project is "MATEGRA – Advanced Porous Biomaterials Functionalized by Stem Cells for Improvement of Osteointegration of Implants". The MATEGRA project is focused on the development, optimization and testing of new types of biocompatible surfaces in titanium implants for improvement of osseointegration and adhesion of bone tissue. Another main objective of the project is the interconnection of research institutions, expert groups and knowledge transfer in the development and testing of new porous biomaterials.

In 2017, the long-awaited call "Pre-application Research" was listed in the Operational Programme of OP RDE within the ITI programme. The first project, "LabIR-PAV – Pre-application Infrared Technology Research", was approved, but the corrected and completed project will be re-submitted in the upcoming call in April 2018. The LabIR-PAV project includes interdisciplinary pre-application research of measurement methods based on the use of infrared radiation for non-contact analysis of thermomechanical processes in laser technologies of materials processing, for the detection of optical, thermal and mechanical properties of materials and for non-destructive testing of materials and products.

The second project within this call, which is currently under preparation, is the "Application of Modern Technologies in Medicine and Industry" project. This project was submitted together with FAS of UWB and MF of Charles University; before the end of 2017 it was approved and recommended for funding. The project focuses on the creation of methodologies and algorithms for further refinement of mathematical and experimental modeling of selected types of tissues and biological fluids. This project targets in virtual, personalized and translational medicine. The project will also allow the development of biomechanical models of the human body with regard to anthropometry and biomechanical properties.



Cooperation within UWB

As in previous years, in 2017 NTC has continuously deepened cooperation with other UWB faculties as part of the Student Grant Competition (SGC). In total, four projects in the amount of 2.5 million CZK were supported in 2017, which was obtained in the framework of targeted support for specific university research from the Ministry of Education, Youth and Sports. Students of the Faculty of Mechanical Engineering (FME), the Faculty of Applied Sciences (FAS) and the Faculty of Education (FE) participated in these projects.

Professional Outcomes

In 2017, NTC focused on realization of contract research from commercial partners. NTC has also increased efforts to gradually improve the professional quality of publications results. The volume of the publication activity and the number of applied results, reported in the national register of RIV results, are presented in the summary tables below the text.

Publication results	No
Journal Articles	115
Conference Papers	47
Book Chapters	16
Technical Reports	98

Applied results	No
Functional Samples	8
Authorized Softwares	13
Verified Technologies	4
Prototypes	4
Utility Models	1
Patent Applications – National Phase	3*

** Patents filed in 2017 are still in the form of applications.*

Excellent Success in the Area of Publications in 2017

The Research Gate database awarded New Technologies – Research Centre for April 2017, as the most widely read part of UWB. Research Gate is the best-known social network for scientists and academics with about 12 million users (see Figure 2).

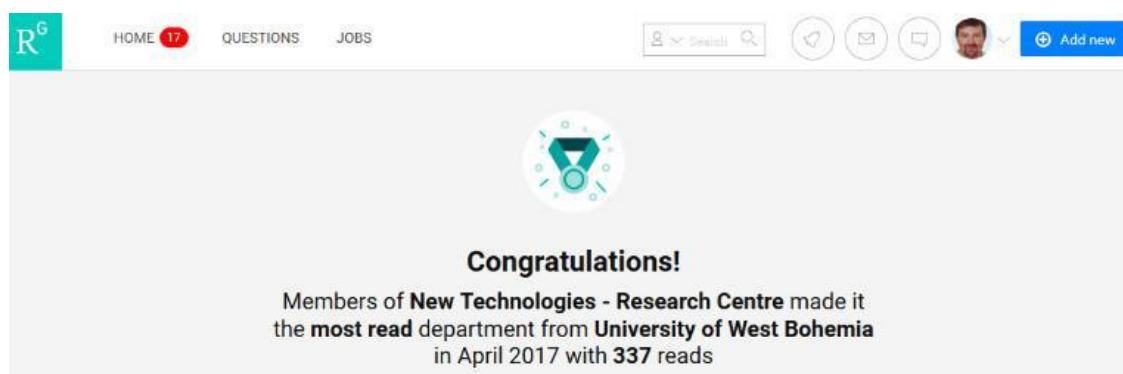


Fig. 2: Screenshot of ResearchGate Portal when NTC became the most read Part of UWB



The ten selected NTC results in 2017 are listed below:

1. **AL-JAARY, A. H. R.:** *METAL HYDRIDES: Electronic Band Structure*. In METAL HYDRIDES. Oxford : Elsevier, 2017, pp. 1-17. Book chapter. ISBN: 978-0-12-803581-8.
2. **MARŠÍK, F.; NOVOTNÝ, P.; TOMÁŠ, M.:** *What Is Entropy – A Generalized Outlook and Application to Living Systems*. In THERMAL PHYSICS AND THERMAL ANALYSIS. From Macro to Micro, Highlighting Thermodynamics, Kinetics and Nanomaterials. Cham, Switzerland: Springer International Publishing AG, 2017, pp. 79-108. Book chapter. ISBN: 978-3-319-45897-7.
3. **KOVÁŘÍK, T.; KŘENEK, T.; BĚLSKÝ, P.; ŠESTÁK, J.:** *Chapter 21 Biomaterials and Nanotechnology Approach to Medical Enhancement*. In THERMAL PHYSICS AND THERMAL ANALYSIS. Cham, Switzerland : Springer International Publishing, 2017, pp. 449-470. Book chapter. ISBN: 978-3-319-45897-7.
4. **KLIKA, V.; KUBANT, J.; PAVELKA, M.; BENZIGER, J. B.:** *Non-equilibrium thermodynamic model of water sorption in Nafion membranes*. JOURNAL OF MEMBRANE SCIENCE, 2017, Vol. 540, No. OCT 15 2017, pp. 35-49. ISSN: 0376-7388. **IF= 6.035.**
5. **AL-JAARY, A. H. R.:** *Spin-polarized Second Harmonic Generation from the Antiferromagnetic CaCoSO Single Crystal*. SCIENTIFIC REPORTS, 2017, Vol. 7, No. APR 13 2017, pp. not paged. ISSN: 2045-2322. **IF=4.259.**
6. **DERONDEAU, G.; BISTI, F.; KOBAYASHI, M.; BRAUN, J.; EBERT, H.; ROGALEV, V. A.; SHI, M.; SCHMITT, T.; MA, J.; DING, H.; STROCOV, V. N.; MINÁR, J.:** *Fermi surface and effective masses in photoemission response of the (Ba_{1-x}K_x)Fe₂As₂ superconductor*. SCIENTIFIC REPORTS, 2017, Vol. 7, No. AUG 18 2017, pp. not paged. ISSN: 2045-2322. **IF=4.259.**
7. **HONNEROVÁ, P.; MARTAN, J.; HONNER, M.:** *Uncertainty determination in high-temperature spectral emissivity measurement method of coatings*. APPLIED THERMAL ENGINEERING, 2017, Vol. 124, No. September 2017, pp. 261-270. ISSN: 1359-4311. **IF=3.444.**
8. **OČENÁŠEK, J.; NOVÁK, P.; PRUŠÁKOVÁ, L.:** *Kinetics of the laser-induced solid phase crystallization of amorphous silicon —Time-resolved Raman spectroscopy and computer simulations*. APPLIED SURFACE SCIENCE, 2017, Vol. 392, No. 15 January 2017, pp. 867-871. ISSN: 0169-4332. **IF=3.387.**
9. **KOVÁŘÍK, T.; KŘENEK, T.; RIEGER, D.; POLA, M.; ŘÍHA, J.; SVOBODA, M.; BENEŠ, J.; ŠUTTA, P.; BĚLSKÝ, P.; KADLEC, J.:** *Synthesis of open-cell ceramic foam derived from geopolymer precursor via replica technique*. MATERIALS LETTERS, 2017, Vol. 209, No. 15 December 2017, pp. 497-500. ISSN: 0167-577X. **IF=2.572.**
10. **HYNČÍK, L.; BOŇKOWSKI, T.; VYCHYTIL, J.:** *Virtual hybrid human body model for PTW safety assessment*. APPLIED AND COMPUTATIONAL MECHANICS, 2017, Vol. 11, No. 2, pp. 137-144. ISSN: 1802-680X.



4. On Departments and Sections

Deformation and Dynamic Processes Modeling (MDP)

In 2017, the Department's research staff (6 FTEs in total) participated in the TACR Alfa TA04010992 project together with the company FARMET a.s., and contributed to the solution of the Centre of Research and Experimental Development of Reliable Energy TE01020068 project, a CENTEM project, EVT 615019/1536, and GACR 616037/1613.

Our researchers were co-authors of two publications in impacted journals, namely in the prestigious journal *Acta Materialia* and *Applied Surface Science*. They also produced a contribution to the proceedings of the ASME 2017 *International Design Engineering Technical Conferences and Computers and Information in Engineering Conference*.

Javier Varillas, graduate from Universitat Politècnica de Catalunya (UPC), Barcelona, successfully continued his doctoral studies in the field of "Engineering of Special Technologies and Materials"; his supervisor and specialist consultants were from the MDP.

The cooperation with industrial enterprises in the form of contract research amounted to 129.5 thousand CZK. This was a research for E.ON Czech Republic s.r.o., and for Škoda JS a.s.

The Head of the Department was appointed Professor in the field of Mechanical Engineering by the President of the Czech Republic on December 13 2017.

Modeling and Measurement of Interactions in Technical Systems (MIS)

The MIS Department traditionally focuses mainly on applied research and cooperation with industry. In 2017, its staff participated in two research projects: the project of the TACR Competence Centre called "Advanced Technologies for Heat Production" (the main beneficiary is the Faculty of Mechanical Engineering of CTU Prague; 15 partners in total), and the Czech-Bavarian Cross-Border Cooperation in the ETC GOAL programme entitled Cross - Border Network for Research and Innovation in Energy Efficiency and Combined Heat and Power Production" (the main beneficiary is OTH Amberg – Weiden; a total of eight partners).

At the same time, direct cooperation with industrial partners has also been developed. This activity was directed mainly towards the energy and automotive sectors. For 2017, it is necessary to point out in particular cooperation with the following companies: Howden ČKD Compressors s.r.o.; ŠKODA AUTO a.s.; ZVVZ-Enven Engineering a.s.; and ŠKODA JS a.s.. In addition to traditional partners, new promising collaborations were established in 2017, for example with the company ZF Engineering Pilsen s.r.o.



In collaboration with other research groups, the CT1 Section published, in 2017, a total of 10 high-impact articles. Three publications were accepted in prestigious journals with Impact factor 6+ (Journal of Membrane Science, Journal of Power Sources, and Chemical Engineering Journal). Each of these three prestigious publications is from different research areas of the CT1, which shows a high level of research in all topics.

The volume of contract research in 2017 amounted to 1.5 million CZK. Most of this volume was generated by micro-tomography. The majority of customers recruit from companies from the automotive industry. At the end of the year, hosted a visit from an American multinational corporation.. They were interested in the tomographic analysis of monolith samples of automotive catalysts with activated layers of precious metals. The order for these analyzes was promised for the following year.

The department continues to regularly participate in activities aimed at bringing scientific issues closer to the general public.

Engineering of Special Materials (CT2)

The research team of the CT2 Section, in 2017, continued to address individual research goals in the area of *Advanced Technologies Based on Polymer Materials, Microcomposites, Laser Chemistry* and in the area of study of *Thermodynamic Processes of Materials*.

In the reporting period, research activities focused on the development of a hydrogen fuel cell prototype applicable in the commercial sphere. For this purpose, new materials were developed - PVA membranes, copolyamide membranes, modified GDL and a Nafion membrane with controllable porosity. In the framework of international cooperation, an article was published in the prestigious *Journal of Membrane Science*, titled *Tuning the Ion Channel Network of Perfluorosulfonated Membranes via a Facile Sacrificial Porogen Approach*.

In the theoretical part of research, the theoretical model was extended and is currently confronted with data from degradation experiments. The scheme of the prepared functional sample from the non-conductive PMMA plates and the deposited platinum layer is presented in Figure 4A.

The research group *Microcomposites* developed issues of thermally resistant composites and ceramic carriers. The effect of ceramic filler on dimensional stability was published in the journals *Construction and Building Materials* and *Materials Letters*. Measurement results using a thermomechanical analyzer and macroscopic porous ceramic substrates are presented in Figures 4B and 4C. During the course of 2017, a project was submitted within the framework of the Czech-Bavarian cooperation, which follows the activities of the Laser





Laser Technologies and Thermomechanics (CT3)

In 2017, the main activities of the CT3 Section were focused on the development of international cooperation. Their result is the representation of our staff in the management structures of international institutions, which will bring new possibilities for addressing international projects in the key directions of the Department's development. Head of Laser Microscopy Research Team, Ing. Jiří Martan, Ph.D., became the second representative of the Czech Republic in the Board of Stakeholders of the European Platform Photonics21. Head of the research team Laser Processing and Tribological Properties of Surfaces, Ing. Šárka Houdková Šimůnková, Ph.D., was appointed Vice-President of the European Thermal Spray Association (ETSA).

In 2017, the Section's staff published 10 contributions in professional journals, among which the most significant are the following publications: Moskal D., Martan J., Lang V., Švantner M., *The Stamp Method for Processing of High Noise Data From Infrared Sensor in Harsh Environment in the journal Sensors and Actuator A-Physical*; Honnerová P., Martan J., Honner M. *Uncertainty Determination in High-Temperature Spectral Emissivity Measurement Method of Coatings*, in the journal *Applied Thermal Engineering* and, last but not least, Honnerová P., Martan J., Veselý Z., Honner M. *Method for Emissivity Measurement of Semitransparent Coatings at Ambient Temperature in Nature Scientific Reports*. Besides professional articles, Ing. Marek Vostřák presented an invited lecture at the *International Thermal Spray Conference ITSC 2017* in Düsseldorf.

The second main focus was the development of products for commercialization. There was a further expansion of the portfolio of unique finished products ready for sale under the LabIR's own label. By bringing research from the CESEN WP9 project into a form that can be used by a wider public, three types of special colours for thermographic measurement are now available for sale. In addition to colour for common use, washable colour and high temperature paint are also available.



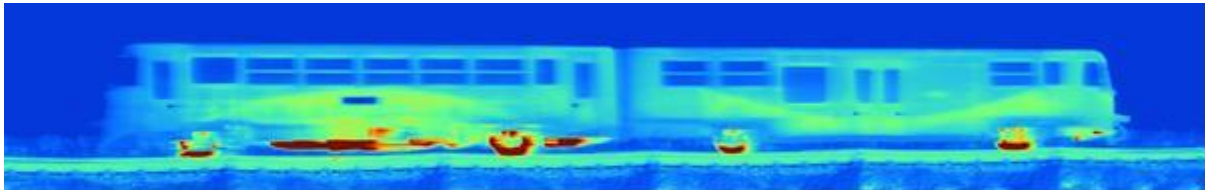
Pict. 5: thermografic spray

During the second half of 2017, 13 Czech and 16 foreign companies bought these colours.

The LabIR software was expanded by two modules. The first is the NDT module designed to evaluate active thermography measurements. The module contains, in addition to standard evaluation functions, also its own methods and procedures. The second module is *Thermostitch*, which is used for composing thermographic images. The module was developed based on the requirement of IR camera users. The module also combines



sequences such as records from an IRNDT inspection (Figure 5). Immediately after being introduced at the user conference Thermography in Practice in Hustopeče, several companies showed interest in the software.



Pict. 6: Composed Thermografic Picture of Running Train

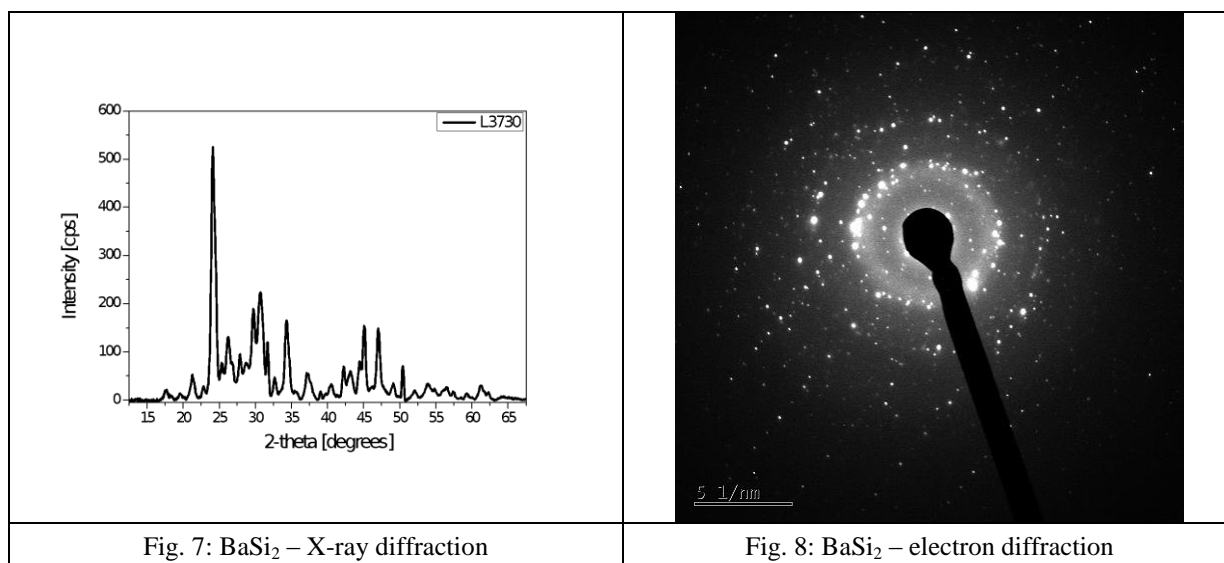
In the course of the year, the Section won and began the realization of the OP EIC project together with the Eurometal Group company. The aim of the project is developing a new test stand for fireplace stoves and subsequently carrying out measurements in the chimney flue gas temperatures, the surface temperature of the measuring area, flue gas analysis, and fuel mass loss during combustion.

Materials and Technologies (CT4)

In 2017, the Section continued to research and develop the technology of ferroelectric materials based on perovskite structure (BaTiO_3 and BaSrTiO_3) investigated as antireflection layers in solar cells and for the needs of the EVT project. In addition, aluminum doped ZnO layers with different interstitial oxygen content and its influence on the formation of mesh tension in the layers were investigated. In the framework of the ongoing bilateral cooperation agreement with the International Laser Center in Bratislava, the research continued in the field of ZnO : Ga layers prepared by laser pulse deposition to optimize deposition parameters.

In cooperation with *Photovoltaic Materials and Devices Laboratory* of the University in Delft Holland, we especially researched, through X-ray diffraction and transmission electron microscopy, the BaSi_2 thin layer microstructure, which appears to be a promising absorbent material for tandem thin-film photovoltaic cells. The results of the work were presented at two major conferences (EU PVSEC 2017 in Amsterdam and MRS Fall Meeting 2017 in Boston); an article is currently being prepared for a major journal. In Figures 7 and 8, "cooperation" of X-ray and electron diffraction is presented.





Last but not least, we intensively researched photovoltaic materials prepared on five-chamber apparatus to obtain optimal deposition parameters of silicon layers for tandem photovoltaic cells, including simple p-i n structures. This activity resulted in the form of one presentation at an international conference in Poland and several other professional publications are being prepared.

The year 2017 was also the last year of the international COST project, completed by a successful evaluation on 19 January 2018 with a "V" rating. Within this project, cooperation of our department (CT4) with the ERT (Excellent Research Team) project based on combining theoretical calculations and experiments started to successfully develop.

In addition, previously concluded bilateral cooperation with several foreign institutions is taking place, in particular with: the Institute of Electronics and Informatics of FEI STU in Bratislava, the Institute A Stodol of the Faculty of Electrical Engineering of the Žilina University in Žilina, the International Laser Centre in Bratislava, the School of Engineering and Material Science, and Queen Mary University of London, UK. These joint activities included active participations in conferences and publications in professional journals.

Also, cooperation with the Institute of Nuclear Fuels (UJP) Prague, with which we have signed a bilateral research cooperation agreement, continued successfully. This year, cooperation took place, in addition to EDS experiments on a scanning electron microscope (detecting the amount of oxygen in zirconium alloys) also in the field of chromium and chromium nitride structures covering zirconium tubes using the methods of X-ray diffraction, whilst also in situ X-ray diffraction at high temperatures was used to detect phase transformations in the coating material. This cooperation will continue in 2018. We already have specified experimental procedures and sample preparation is being carried out at UJP.

In 2017, the Section's staff published 12 articles in professional journals (others are in the preparatory phase), and participated in eleven contributions to ten international and domestic conferences. Last but not least, contract research activities worth 360,000 CZK were carried out.



Man and Machine Interactions (CT5)

The main activity of the Section in 2017 was realization of the current research projects in cooperation with Czech and foreign partners. The TACR Alfa project "Development of an Active Car Bonnet System with Regard to the Diversity of the Human Population and the Implementation of the Biomechanical Model of the Human Body", was completed in September 2017. The results of this project included: a functional sample of an optimized active system, traffic accident simulation software, methodology for collecting and analyzing traffic accident data, and professional publications. The project will be evaluated by the Technology Agency in 2018.

In April 2017, the **HCENAT** - "Naturalness in Human Cognitive Enhancement" project was completed. Besides the CT5 Section, two Czech and two Norwegian partners (the National Institute of Mental Health, the First Medical Faculty of Charles University Oslo, Akershus University College of Applied Sciences, and the Norwegian University of Science and Technology) participated in this project. The main results of the project include: an online expert database of new technologies available at <http://hcewiki.zcu.cz>, a software designed to facilitate communication in the hospital environment titled *Key-to-Voice* and, of course, professional publications. The results of the project were, on the professional level, evaluated as "outstanding". Between January 2017 and April 2017, CT5 also addressed the HCENI project "Human Cognitive Enhancement: New Issues", focusing on bilateral cooperation with the Norwegian partner Oslo and Akershus University College of Applied Sciences.

International cooperation was further strengthened through the Czech-Bavarian Cooperation Project entitled "Virtual Human Model for Prevention, Treatment and Rehabilitation of Shoulder Disease". The partner of the project is Ostbayerische Technische Hochschule Regensburg. The project focuses on the design of a strategy of prevention, treatment and rehabilitation of the shoulder joint using modern approaches of medicine including computer modeling of the human body (Fig.9).





Fig. 9: Jan Špička (NTC) and Pavel Jedlička (FAS) are presenting the development of a new model of the shoulder complex to the State Secretary of the Free State of Bavaria Bernd Sibler and the President of OTH Regensburg Wolfgang Baier

In order to further expand international cooperation, another project of the Czech-Bavarian cooperation entitled "Obstetrics 2.0 – Virtual Models for Prevention of Injuries During Childbirth" was submitted. This project was granted support and will begin in 2018. Other projects that were submitted in 2017 include the TAČR Éta project called "Intelligent Personal Assistants – Facilitating and Monitoring Everyday Life", as well as a large international project PAPOOSE under the framework programme EU H2020 Marie Curie (ITN). In this project focusing on the safety of children in transport, CT5 is a co-researcher.

In 2017, the CT5 team published 21 articles in professional journals and proceedings; another 8 articles are under review procedures. In the context of contractual research, the team continued the long-term cooperation with MECAS ESI s.r.o., for whom contract research in the field of transport safety was implemented.

Condensed Phase Engineering (CT6)

In 2017, a new CT6 Department was established. This Department focuses on theoretical and experimental research of the electron structure of solids and the low-dimensional system with an emphasis on electron spectroscopy. The uniqueness of this Department lies precisely in the interconnection of the theoretical plane with the experimental plane and is the basis of the OP RDE project CEDAMNF: "Computational and Experimental Design of Advanced Materials with New Features" with web pages <http://www.cedam.ntc.zcu.cz>. This issue is addressed through cooperation with several workplaces, such as CT4 and MDP. The project focuses on the research and design of new materials and, in a narrower focus, also on the ecological use of energy in various aspects. The CT6 Department is also involved in the GAČR project, whose Head Researcher is the CT4 workplace: "Electronic Structure



of Lanthanide-doped Materials for Luminophores-Transformed White Electroluminescent Diodes."

Both of these projects were successfully launched in 2017 and their results were published in several prestigious impacted journals and international conferences in Europe, Japan and the USA where Professor Minár presented invited lectures (11 times).

Published articles also show that key collaboration has been established and developed with Professor Hubert Ebert (LMU, Munich), Professor Karol Hricovini (Uni Cergy-Pontoise), Professor Chuck Fadley (University of California), Professor Hugo Dile (EPFL Laussane), and Professor Stefanie Scheu (MPI Düsseldorf).

Another significant scientific result is the study of ultra-short (attosecond) electron processes without the use of clocks.

In collaboration with colleagues from the Swiss university EPFL in Lausanne, we managed to find a description of the processes in the photoemission without using ultra-fast lasers by measuring the spin polarization of electrons.

This significant discovery is also published in the journal *Physical Review Letters*. The discovery has significant implications for both basic research and the latest technologies.

Another two important results were obtained on the basis of understanding photoemission with modern high-temperature superconductors, which are on the basis of iron and chromium. These two papers were published in the journal *Scientific Reports* and in the *Proceedings of the National Academy of Sciences (PNAS)*, where authors can only publish on special invitations.

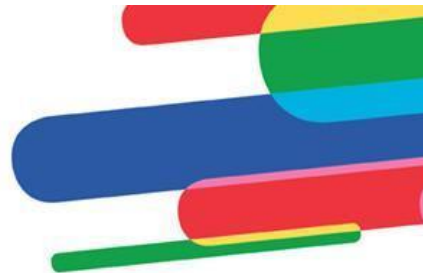


5. Other Activities

International Cooperation and Popularization

International cooperation is one of the key strategic directions of NTC development. In the framework of international cooperation and expansion of activities within the European Research Area, the NTC Director continued his long-term work for the automotive industry as Vice-President for Education of the International Federation of Automotive Companies FISITA (*Fédération Internationale des Sociétés d'Ingénieurs des Techniques de l'Automobile*).

NTC also succeeded in its efforts to have its representative in the European Technology Platform Photonics²¹. Ing. Jiří Martan, Ph.D., a CT3 researcher, was elected member of the *Board of Stakeholders*.



Head of the research team Laser Processing and Tribological Properties of Surfaces, Ing. Šárka Houdková Šimůnková, Ph.D., a CT3 member, gained another important post and became Vice-President of the *European Thermal Spray Association* (ETSA).



NTC cooperates very closely with the Federation of Industry and Transport. Mgr. Petr Kavalíř, Ph.D., MBA, thanks to his activities within the R & DI expert team, became a member of The Business and Industry Advisory Committee to the OECD.



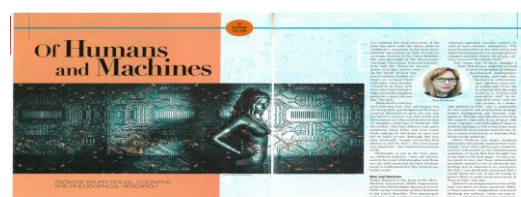
On October 28, Professor Jaroslav Šesták took over, from the hands of the President of the Czech Republic Miloš Zeman, the First Grade Merit Medal, for merits for the State in the areas of science and education. Jaroslav Šesták became the guarantor of a number of institutions such as the School of Energy Science of Kyoto University in Japan, the Faculty of Humanities at Charles University in



Prague and the Czech Branch of the University of New York in Prague where he taught, for twenty years, the interdisciplinary course "On the Border of Science and Philosophy of Nature". His greatest career success is the publication, as a co-author, of a triptych of professional publications in the renowned Springer Publishing House: *Glassy, Amorphous and Nano-Crystalline Materials* (2011), *Thermal Analysis of Micro, Nano- and Non-Crystalline Materials* (2013) and *Thermal Physics and Thermal Analysis* (2017). These books are among the twenty most successful titles published by the Springer Publishing House.

In 2017, NTC organized a number of international events. Among other things, it hosted more than 40 experts from ten countries of Europe and America in the two-day workshop CSPES-2017. The list included several lectures by the world's leading experts in photoemission. They were Charles Fadley from the Lawrence Berkeley National Laboratory of the University of California, Vladimir Matolin from the Faculty of Mathematics and Physics of Charles University in Prague and Didier Sebillé from the University of Rennes.

Other events included, for example, a working session of the Ballistics Section of the Scientific Board of the Criminal Institute Prague, which NTC hosted in the spring of 2017. Furthermore, NTC organize an event focused on energy saving for teachers from the Secondary Industrial School of Mechanical Engineering in Pilsen.



**Státní tajemník Bavorska
jednal o Virtuálním modelu
člověka pro léčbu a rehabilitaci
onemocnění ramene**

**KAM S ELEKTRINOU? ŘEŠENÍM MOHOU BYT
VANADOVÉ PRŮTOČNÉ BATERIE**

ro firmy, ne do šuplíku



In cooperation with the UWB Technology Transfer Department and the EECB platform, NTC participated in an event titled "How to Innovate in Cooperation with the University".

NTC also contributed to the popularization of science not only in the form of lectures and expert conferences, but also through active media coverage.

Education

NTC participated closely in teaching in bachelor, master and doctoral study programmes and supervising bachelor, master and doctoral theses in cooperation with FAS, FEE, FE and FME. In cooperation with the KMM Department of the Faculty of Mechanical Engineering, the doctoral study programme "Engineering of Special Technologies and Materials" is accredited and provided by NTC. NTC participated in activities of UWB, the City of Pilsen and the Pilsen Region in order to support the motivation of applicants for study of technical fields; this activity focused mainly on high school students. In the context of lifelong learning, NTC cooperates with commercial entities on further educating their staff.

Thanks to the CT3 Department, NTC was also the local partner for the Czech Republic in the development of the "*Photonics Explorer*" educational kits; experimental kits designed for the needs of optics education at elementary or secondary schools. The kit was developed in 2014 by an international team of teachers and pedagogical experts from 11 countries. CT3 continues to spread the kit to other schools; the number of students and positive feedback from teachers testify to the success and usefulness of this project.



6. Budget

An important income source for NTC was from institutional funds amounting to 29,675,715 CZK in 2017, which was 9.5 CZK million more than in the previous year. This resource is directly related to the reporting of research and development results in RIV.

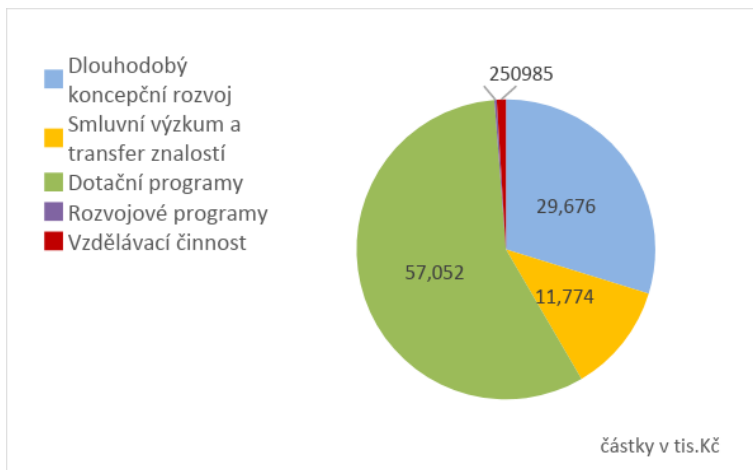
In the field of contract research and transfer of knowledge, in 2017, NTC received an amount of 11.7 million CZK, i.e. about 0.5 mil. CZK more than in the previous year.

Revenues from grant projects for basic and applied research from providers: Ministry of Education, Youth and Sports, GACR and TACR reached almost 53 million CZK. Of this, NTC received almost 18.2 million CZK from the EU structural funds (cross-border cooperation between Czechia - Bavaria and OP RDE).

In 2017, the prestigious foreign project HCENAT supported by the Norwegian funds completed; its last subsidy was over 4 million CZK.

The contribution for educational activity in 2017 amounted to 985 thousand CZK. We received 250 thousand EUR for development projects.

The fund of operating costs was not used in 2017. On the contrary, an amount of 985,000 CZK was transferred into it. NTC transferred 3 million CZK to the Fund for the Reproduction of Investment Assets from its own income.



7. Conclusion

In 2017, NTC successfully completed several projects and many contract research tasks. New and ongoing projects and contract research have been realized as planned. NTC continues to strengthen its competitiveness in the area of excellence and internationalization. NTC is intensively preparing several projects for the HORIZON 2020 calls. One of the key activities for the next period is the re-submission of the project under the ITI Pre-application Research Integrated Projects call. Intensive development in the sphere of management and excellence of human resources is taking place. These activities are backed by an all-university project that, in 2018, will lead towards obtaining a European HR Award certification. Internationalization is key to maintaining NTC's competitiveness in Europe and globally. In this respect, language skills of all NTC employees are being significantly improved.

With respect to the fulfillment of the Long-term Plan 2016 - 2020, meeting all NPI I monitoring indicators of the CENTEM+ project and obtaining financing for other projects not only from domestic but mainly from foreign sources will be key tasks for 2018.

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