IT4Innovations Centre of Excellence
March 31st, 2020

Research plan

2020

IT4Innovations
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Introduction

The research plan respects the goals and indicators planned for the sustainability period 2016-2020 in the latest version of the Technical Annex (TA) of the Centre of Excellence IT4Innovations (CE IT4I) project. This sustainability period is partially supported by the National Programme of Sustainability (NPS II) project "IT4Innovations excellence in science - LQ1602" of the Ministry of Education, Youth and Sports of the Czech Republic (MEYS) which specifies a part of all goals and indicators. The CE IT4I project was approved by the Managing Authority of the Operational Programme Research and Development for Innovation in late June 2011 and the NPS II project was approved by MEYS in December 2015. The research plan takes into account the experience and research results obtained in the previous years reported in the annual Research Reports for years 2012-2019. MEYS contribution to the NPS II project represents about a quarter of the total budget needed for the sustainability period. Other three quarters come from the obligatory co-financing of NPS II and other national sources, and institutional support. The detailed NPS II budget is in the table below.

Partner	2020		Total budget 2016-2020	
	Budget per partner	Contribution from MEYS	Budget per partner	Contribution from MEYS
VŠB	64 726	32 730	312 668	155 877
VUT	51 228	25 013	238 558	117 514
OSU	4 406	1 206	39 965	19 410
SLU	4 129	2 703	19 251	9 517
UGN	4 689	2 344	23 445	11 720
Total	129 178	63 996	633 887	314 038

Table I Financial support from NPS II per partner in 1000CZK

The objectives and outputs are specified in a form that allows assessment of their accomplishment. The work that leads to their accomplishment is described in the following part of the Research Plan, by individual research programmes. Each individual research programme (RP) has defined objectives and quantitative indicators for 2020 reflecting the latest update of the TA, NPS II project, and other project sources used within the sustainability period. The used indicators correspond to the current Czech R&D methodology published on http://vyzkum.cz. Research Plans of individual RP are outlined with detailed organizational structures, namely by assigning individual tasks to the teams and team key persons who will be responsible for the fulfilment of the research plan and its commitments.

The Research Plan is organized as follows. After this short introduction, the Research Plans of the individual research programmes will follow. The research plan of each RP has the following parts:

A. **Research programme annotation** – annotation is taken from the TA and updated to better correspond with current research activities.
B. **Research teams and objectives** – the research plan is described by research teams, their objectives, key persons, and team capacity.
C. **Research outcomes** – characteristics of verifiable outputs, such as a number and type of publications, applied research outcomes, planned organization of conferences, and some comments are listed.
D. **Project activity –** international, national, and contract research projects are summarized in tables, possibly with some comments.

1 IT for Disaster and Traffic Management

1.A Research programme annotation

The main objective of this research programme is providing advanced data analysis and simulations for industry and crisis management through an HPC platform and specialized programming models. This platform is provided as a service to internal and external users, and utilizes the computing power of HPC infrastructures, collects, stores, and pre-processes data into specialized data structures, and provides user-understandable visualization of results. Developed programming models allow the design of highly efficient parallel advanced data analysis methods, including statistical modelling, machine learning, and cross-validation. Proposed parallel implementations are tested on custom analytical problems, such as resource planning, production pipeline controlling, and research in bioinformatics. An important objective is also the research and development of scalable models to simulate the behaviour of dynamic systems. An example of such systems is modelling in crisis or traffic management. Simulations of such systems are often based on incomplete or inaccurate data and heuristics, therefore the developed models consider the probabilistic aspects of input parameters. Furthermore, implementation of the services for interactive providing and visualization of the results in an accessible and comprehensible form of different levels of detail is another objective. It is focused on providing user interfaces and a specialized application programming framework for specific groups of users. Finally, the application research of the research programme is extended by a topic focused on the combination of HPC, BigData, and Cloud Technologies. The collaboration with the ENET centre will continue focusing on solving the problems concerning the field of energy distribution management. The main focus in this area is the creation of algorithms for detection of faults in the energy networks and modelling the energy distribution networks.

Responsible partner: VŠB-Technical University of Ostrava
Head of research programme: Ing. Jan Martinovič, Ph.D.
Estimated personnel capacity (FTE): 37,5

1.B Research teams and objectives

- **HPC Platform and related tools and services**
  The main objectives of this research team:
  - Ongoing work on the HPC platform's tools and services with an emphasis on interoperability, management, deployment and security. HEAppE Middleware v3 will be released with various updates and improvements.
  - New version of the HEAppE adapter will be created to enable a seamless integration of HEAppE HPC capabilities into a hybrid cloud/HPC TOSCA workflow management system called Ystia Orchestrator.
  - New version of a web based interactive analytical application will be released to provide the expert users with an easy-to-use and comprehensible tool for data analytics and data visualization for geospatial data.
  - Extension of the application research by a topic focused on the combination of HPC, BigData, and Cloud technologies and the integration of models developed in basic research.
  - Extension of the Floreon+ system backend with relevant models and algorithms developed inside and outside of the research programme. New version of the Floreon+ system frontend will be released. Developed visualization framework and data management system will be further extended based on the expert's users requirements.

- Extension of the HPC Platform spatial database with new data sources and modules for communication with external tools will continue.
- Optimisation and extension of the developed programming model for executing different kinds of tasks on the HPC infrastructure. Continuation of improving scheduling algorithms and simulator for schedulers.
- Implementation of testing environment for schedulers and improving existing tools by transferring gained knowledge.
- Creating experimental graph neural network scheduler to efficiently schedule workloads without manual tunning of parameters
- Assessment of the technologies that enable secure, valuable and efficient collaboration of data and algorithms, specifically the Inter-Planetary File System (IPFS), the encryption and the Blockchain smart contract technology and use them together to prototype a distributed peer-to-peer Machine Learning training platform for space data while tracking ownership and preventing any unauthorized exploitation of both data and algorithms.
- The first version of the demonstrator platform that aims at helping the operators of emergency call centres during crisis situations by employing AI technologies into the process of handling the emergency calls.
- Providing applied research supported by industrial partners. These activities will follow on from new outcomes of basic research activities, with a view to their subsequent application in the field of crisis management and industry. The collaboration with industry partners will be built on contractual research in areas such as decision support in crisis management, machine learning, etc.
- An important activity in collaboration with the public sphere and industry will be the transfer of knowledge through seminars, training sessions and lectures on relevant HPC technologies, existing and developed application frameworks, data handling, HPC as a Service, and the requirements of an industrial partner.

Key persons: Ing. Jan Martinovič, Ph.D., Ing. Václav Svatoň, Ph.D., Ing. Böhm Stanislav, Ph.D., Doc. Mgr. Jiří Dvorský, Ph.D.
Estimated personnel capacity (FTE): 13

- **Data Analysis and Modelling of Dynamic Systems**

The main objectives of this research team:

- Design, implementation, and optimization of algorithms for transport optimization, machine learning, advanced data analysis, and dynamic systems modelling, with regard to the suitability of using heterogeneous HPC infrastructure.
- Development and optimisation of statistical and machine-learning algorithms for comparison, classification, and prediction of time series, especially uncertain time series, will continue.
- Design and study solutions for implementing, deploying and orchestrating the complex workflows containing HPC and Cloud tasks. Focus on extending the workflow capabilities with task triggering and continuous/repeated data flow capabilities.
- Solving the optimization of traffic with the help of heuristics and metaheuristic algorithms with the usage of HPC infrastructure and HyperLoom. Adaptation and evaluation of algorithms (heuristics, metaheuristics) for solving different variants of the Vehicle Routing Problem and their application to real-world cases.

- Examining the existence conditions and constructions of regular graphs with a given labelling, as well as with specific 1-factorizations. Determining necessary conditions and constructing infinite classes.
- Developing of a new time series forecasting method and its tuning on data obtained from IT4Innovations' infrastructures. Comparison of the success of IT4Innovations' infrastructures energy consumption forecasts generated using this new method and using machine learning models, nonlinear algorithms or statistical methods.
- To propose the methodology of chaos suppression and chaos stimulation of time series by perturbing periodically the state variable with constant shocks. For this purpose, the impulsive control systems will be introduced and tested on classical generic one and two-dimensional models. This technique will be applied to the real complex models, e.g., Cournot oligopoly one.
- Investigation of dynamic properties of biological systems and their applications for real problems. As an example, changes in the dynamic behaviour of cardiac tissue during pathophysiological conditions may be mentioned.
- The new topic of the quantum computing paradigm establishing. Practical testing of its principles by quantum programming the most famous quantum algorithms like Grover and Shor on external publicly accessible quantum computers and local emulators. Experimental testing with the size of a problem and the number of qubits used. Comparing the results of these quantum calculations with the results published by leading scientists in this field of quantum computing.
- Development of a methodology for data intensive processes by utilizing big data platforms. Examining and applying the techniques of machine learning algorithms in data streams with focusing on automation of certain aspects of the data decision-making process (multinomial classifier).

Key persons: Ing. Kateřina Slaninová, Ph.D., Doc. RNDr. Marek Lampart, Ph.D., Ing. Michal Podhorányi, Ph.D., Doc. Mgr. Petr Kovář, Ph.D.
Estimated personnel capacity (FTE): 12

- **Bioimage Informatics on HPC - „OP RDE IT4Innovations - Path to Exascale“**
The main objectives of this research team:
  - Develop a parallel version of EmbryoGen, a simulator of artificial time-lapse images from developmental biology. Images generated by EmgryoGen will be later used to train neural networks as there is a general lack of datasets with correct ground-truth and by extending the datasets by artificially created images we will significantly improve the training phase.
  - Provide a plugin for parallelization of macro scripts in ImageJ/Fiji. A macro is a simple program that automates a series of ImageJ commands. At this moment there is no interface to separate tasks inside the macro and run them parallely on multiple nodes. Our approach will provide an application interface enabling macro users to deploy parts of their scripts on different computational nodes.
  - Introduce an OpenMPI implementation of most common plugins, similarly to the CLIJ which provides OpenCL parallelization on single node.
  - Provide a user support for SPIM Workflow Manager for HPC and extend its user interface by introducing a new web interface for simple management and execution of SPIM workflow jobs.

Key persons: Mgr. Pavel Tomančák, Ph.D., Mgr. Ing. Michal Krumnikl, Ph.D., RNDr. Vladimír Ulman, Ph.D.

Estimated personnel capacity (FTE): 4

- **PERMED - Personalized Medicine - Diagnostics and Therapy**
  The main objectives of this research team:
  - Design and implementation of Python API for tunnel detection tool CAVER. CAVER provides rapid, accurate and fully automated calculation of tunnels and channels in static and dynamic structures. This API should allow the users to calculate, analyse and visualize their results.
  - Design and development of algorithms for simultaneous docking of more than one molecule using the program AutoDock Vina. Double docking is very important for the explanation of potential substrate and product inhibitions.
  - The development and implementation consensus-based prediction tool for protein aggregation. This new predictor will be used for both medical doctors (neurologists) and biotechnologists interested in the production of soluble non-aggregating proteins. The tool should be thoroughly validated using numerous data sets.

  Estimated personnel capacity (FTE): 3,5
  Key persons: Ing. Jan Martinovič, Ph.D., Ing. Ekaterina Grakova, Ph.D.

  Collaboration with ENET Centre
  The main objectives of this research team:
  - Optimisation of distribution networks using controllable components (shunt capacitors, on-load tap changers of transformers, topology control using switches). Research is also consulted with The Joint Research Centre of the European Commission.
  - Development and testing of classification algorithms for the detector of faults at insulated conductors of overhead lines. Analysing time series measured by a wireless antenna.
  - Distributed hyper-parameter optimization in the energy sector for above mentioned tasks.

  Key persons: Ing. Praks Pavel, Ph.D., Ing. Tomáš Martinovič, Ph.D.
  Estimated personnel capacity (FTE): 5

1.C Research outcomes

1. HEAppE Middleware v3.
2. Deployment of experimental LEXIS infrastructure with redundant 100 Gbps network, 6 virtualisation nodes, 120 TB of CEPH storage, gateway servers and two burst buffer servers.
3. Research paper publication on the implementation of the workflow/task trigger and repeated data flow in the LEXIS workflow.
4. Deep Learning model used for the Segmentation of Urban/non-Urban Areas and detection of Urban/non-Urban Changes from EO data
5. Parallel implementation of EmbryoGen, Parallel Macro Interface published on Fiji update sites, OpenMPI ImageJ/Fiji Plugins.
6. Pilot version of software: A stochastic model for identification of critical components of a power network (a cooperation with ENET Centre)
7. Pilot version of Software for prediction of energy consumption in a power grid from data.
8. A novel classificator for the wireless partial discharge detection.

9. PaReTran project (TRM SW) - The Transport Reaction Model (TRM) will be developed to include complex functionality that is necessary to solve specific transport-reaction issues.
10. Research and publication on topics that are related to the objectives of the research programme, such as chaos detection, graph analysis, traffic management, time series analysis, etc.

Type	Number
Journal papers (imp)	13
Other papers (proceedings, …)	20
Outcomes of applied research (patents, software, etc.)	5

Table 1 Key performance indicators of the research programme

1.D Project activity

International R&D projects:

Project title	**Grant agency**	**Total implementation period**	**Funds planned for RP in 2020 (CZK 1000)**	**Total funds planned for RP (CZK 1000)**	**Status (A-accepted, S-submitted, P-planned)**
ExaQUte	H2020	2018-2021	1 000	4 100	A
LEXIS	H2020	2018-2021	10 000	27 100	A
PRACE – 6IP	H2020	2019 - 2021	200	500	A
H2020-JTI-EuroHPC-2019-1	H2020	2020 - 2023	-	-	P

National grants / specific support:

Project title	**Grant**	**Total implementation period**	**Funds planned for RP in 2020 (CZK 1000)**	**Total funds planned for RP (CZK 1000)**	**Status (A-accepted, S-submitted, P-planned)**
Research Infrastructure (e-INFRA CZ)	MEYS	2020-2022	1 300	4000	A
Optimization of operating parameters of the electrical distribution system using artificial intelligence	TAČR	2019-2021	790	1802	A
Contactless partial discharge detector for HV distribution lines	TAČR	2019-2021	515	1257	A
IT4Innovations National Supercomputing Center – path to exascale (IT4I NSC - P2EX)	MEYS	2017-2021	3 812	19 957	A
Personalized Medicine - Diagnostics and Therapy	TAČR	2019-2020	3509	5986	A
National Center for Energy	TAČR	2019-2020	2100	3077	A
Smart energy management system for energy networks	TAČR	2019-2020	1201	1762	A
Involvement of artificial intelligence in emergency call reception	Ministry of Interior	2019-2022	1378	5060	A

INTant	Ministry of the interior	2019-2022	492	2 833	S
Energy System for Grids	TAČR	2019-2023	-	-	S
Research and development of an innovative agricultural machine with artificial intelligence for non-chemical weed control in sustainable and organic farming	TAČR	2020-2023	558	4567	S
Development of Expert System for Automatic Evaluation of Pathologies from Eye Images	TAČR	2020-2022	573	2465	S
Research and development of functional sample of railway vehicle with possibility of data collection and software - simulator with ability to generate data for training of obstacle detection in simulated conditions	TAČR	2020-2022	140	10147	A
High performance computing (HPC) with heuristic and evolutionary algorithms as a modelling service for smart energy and transport sectors in Danube region	MEYS	2020-2021	150	300	S

Contract research:

Project title	**Contracting authority**	**Total implementation period**	**Funds planned for RP in 2020 (CZK 1000)**	**Total funds planned for RP (CZK 1000)**	**Status (C-contracted, N-negotiated, P-planned)**
Contract Change Note N.2 to the Urban TEP (U-TEP)	The German Aerospace center	2019-2020	188	918	C
Cooperation in the implementation of technical consulting services	Bayncore Labs Limited	2020	306	306	C
Synergistic use of blockchain and Deep Learning technologies for space data	Space Applications Services	2020-2021	800	1961	C

2 Numerical Methods for Engineering

2.A Research programme annotation

Research programme in general aims at developing, testing, and application of numerical methods for the solution of complicated large-scale physical-engineering problems. The research focuses on methods for modelling coupled processes (multiphysics) and processes in heterogeneous environments (multiscale). Typical applications include the analysis of coupled thermo-hydro-mechanical (THM) processes related to the underground disposal of the spent nuclear fuel and high speed water jet simulations. The focus includes challenging simulations of flow in porous media and porous media with fractures, analysis of geotechnical stability problems, modelling of nonlinear processes in mechanics and flow, development of new algorithms for quantifying uncertainties and calibration of models. The research will also involve the use of parallel algorithms and computing capacity of IT4Innovations Centre.

Responsible partner: Institute of Geonics, CAS
Head of research programme: Prof. RNDr. Radim Blaheta, CSc.
Estimated personnel capacity (FTE): 7.5

2.B Research teams and objectives

- **Specific research aims for 2020 concern:**
  - The development and application of models including coupled physical processes, namely thermo-hydro-mechanical processes in porous continua.
  - Investigation of methods for simulation of hydro-mechanical processes in porous media with fractures.
  - The development of efficient and reliable computational techniques for determination of critical states of stresses in classical and gradient plasticity.
  - The development of efficient solvers based on Schwarz DD, FETI, PETSc, and deflation technique including parallel algorithms and iterative methods for solving problems of multiphysics.
  - Application of Bayesian inverse problems and methods for uncertainty quantification.
  - Preparation of final report for the sustainability period

  - In all cases a special attention will be given to the development of models and solution methods suitable for analysis of processes in heterogeneous media.

  Key persons: Prof. RNDr. Radim Blaheta, CSc., Mgr. Stanislav Sysala, Ph.D.
  Estimated personnel capacity (FTE): 7.5

2.C Research outcomes

The research outcomes will include **papers** in high quality journals and/or proceedings in the fields of mathematics, computer science, and engineering applications. We plan to attend and present results at several conferences including

1. PANM 20, Programy a algoritmy numerické matematiky 20, 21. - 26. června 2020, Hejnice,
   a. Numerical methods for Hydro-Mechanics in disturbed continua, R. Blaheta, invited lecture
2. Emerging Trends in Applied Mathematics and Mechanics 2020, ETAMM 2020, Dolní oblast VÍTKOVICE, Ostrava, Czech Republic, June 15 - 19, 2020
   a. Minisymposium MS8 Recent advances in plasticity D. Reddy (Cape Town), S. Sysala

3. International Association for Computer Methods and Advances in Geomechanics. Torino, Italy Jul 1 – 4, 2020 (R. Blaheta in Scientific Committee)
4. Int. Conf. on Spectral and High-order methods for PDE, ICOSAHOM 2020, TU Wien
    a. Invitation to minisymposium for O. Axelsson
5. Computational Methods in Applied Mathematics (CMAM-9), TU Wien, July 13-17, 2020
    a. Invitation to minisymposium for R. Blaheta and S. Sysala
6. IMACS Congress, Rome, October 6-9, 2020
    a. Minisymposium: Computational methods for simulation of coupled processes. Organizers: R. Blaheta, J. Kraus (University Duisburg-Essen)

For the contact with the professional community in the point of joint interest we plan to visit schools

7. Interplay of discretization and algebraic solvers: a posteriori error estimates and adaptivity. March 30 - April 1 2020 at Inria Paris (shifted to August 2020)
8. Mathematical Modelling, Numerical Analysis and Scientific Computing, May 24 - 29, 2020, Kácov, Czech Republic
9. The Fourteenth International Conference on Computational Structures Technology, 8-10 September 2020, Palma, Mallorca, Spain

Stays abroad: University of Jyvaskyla, June (shifted to November); Stays through the mobility projects – arrangement in progress (U Helsinki and U Edinburgh).

Due to coronavirus epidemy, it is possible that some more events will be shifted or possibly cancelled.

Type	Number
Journal papers (imp)	3
Other papers (proceedings, …)	7
Outcomes of applied research (patents, software, etc.)	1

Table 2 Key performance indicators of the research programme

2.D Project activity

International R&D projects:

Project title	**Grant agency**	**Total implementation period**	**Funds planned for RP in 2020 (CZK 1000)**	**Total funds planned for RP (CZK 1000)**	**Status (A-accepted, S-submitted, P-planned)**
EURAD - DONUT	H2020 EU	2019 – 2023	500	2000	A
ESCOMOGRASs	H2020 Teaming	2020 - 2022	150	450	S

National grants / specific support:

Project title	**Grant**	**Total implementation period**	**Funds planned for RP in 2020 (CZK 1000)**	**Total funds planned for RP (CZK 1000)**	**Status (A-accepted, S-submitted, P-planned)**

Efficient and reliable computational techniques for limit analysis and incremental methods in geotechnical stability	Czech Science Foundation, No 19-11441S	2019 - 2021	1 581	4 743	A
Prediction of EDZ properties with influence on safety and reliability of deep radioactive waste repository	TAČR	2019 -2022	1 414	4 907	A

Contracted research:

Project title	**Contracting authority**	**Total implementation period**	**Funds planned for RP in 2020 (CZK 1000)**	**Total funds planned for RP (CZK 1000)**	**Status (C-contracted, N-negotiated, P-planned)**
Decovalex2019	TUL	2018-2020	129	947.5	C
Modelling of water flow in a nozzle					P

3 HPC Libraries and Supercomputing for Industry

3.A Research programme annotation

The first main objective of the research programme is to further develop in-house libraries of efficient parallel algorithms based on advanced computational techniques and HPC technologies (ESPRESO, scaDD, BEM4I, MULTIDYN, MCSIMUL, PIMCSIMUL, and LIB4NEURO). These libraries are used to solve complex and extremely difficult problems in engineering and molecular dynamics, and to support their respective communities. Their development is currently supported amongst others by the national projects funded by Ministry of Industry and Trade and EXPERTISE, PRACE-6IP, and CloudiFacturing international projects.

The second principal objective is collaboration with, and support of industrial partners. This goal is fulfilled through contractual research, joint research projects, and capability development. The above in-house libraries and selected commercial and open source third party software packages are applied to solve the challenging problems of our industrial partners. HPC services are offered to users from the application area with emphasis on Small and Medium Enterprises. Collaboration with SMEs is currently supported by the activities of Digital Innovations Hub Ostrava (DIH Ostrava) and CloudiFacturing project.

The third principal objective is development of tools and techniques that increase the quality of the service and the infrastructure of IT4Innovations. The team will continue to develop and optimize the in-house and other open-source tools such as MERIC, RADAR, and CyclesPhi and services such as Solver-as-a-Service and Rendering-as-a-service. Their development is currently supported amongst others by the national project e-Infrastructure CZ (LM2018140) within the Ministry of Education, Youth and Sports (MEYS) programme to support Large research infrastructures and H2020 Centre of Excellence project POP2.

Responsible partner: VŠB-Technical University of Ostrava
Head of research programme: Ing. Tomáš Karásek, Ph.D.

Estimated personnel capacity (FTE): 34

3.B Research teams and objectives

- **HPC libraries and scalable algorithms development**
  - Continuation of the development of optimization methods, mixed precision algorithms, non-symmetric system solvers, and the use of hybrid parallelization in the developed libraries.
  - Development and implementation of massively parallel algorithms for solving contact problems with discretized contact interface.
  - Implementation of solvers for solving different types of optimization problems.
  - Implementation of artificial neural networks methods for computationally fast representations of molecular interactions and their inclusion to Molecular Dynamic solvers and quantum/classical Monte Carlo methods. Implementation of general basis sets in the dynamical solvers.
  - The research team will work on the remaining activities of OP RDE project Math-In-HPC.EDU. In 2020, the main goal of this project is to establish a double degree doctoral study program jointly co-guaranteed with the University of Toulouse III. The research team will further participate in all the activities of the Math-In-HPC doctoral school established within this project in 2019.

- The activities corresponding to the PRACE-6IP, EXPERTISE, and ExaQUte international projects will continue as planned in the proposals.
- The research team will continue participation in HPC training activities.

Key persons: Prof. Ing. Tomáš Kozubek, Ph.D., Doc. RNDr. René Kalus, Ph.D.
Estimated personnel capacity (FTE): 14

- **Supercomputing for Industry**

  - The main goal of the research team is to continue collaboration with strategical industrial partners and research institutions. This will be done through offering customized tools and complex solutions for different problems in mechanics, contact problems, shape and topological optimization etc.
  - The research team will also prepare and conduct training courses focused on industrial end-users.
  - Another goal is the extension of in-house code ESPRESO with new capability modules and use of accelerators, and their incorporation into projects with industrial partners.
  - The research team will continue to work on activities of the ExaQUte and CloudFacturing international projects.
  - Work on project with Sigma Group funded by Ministry of Industry and Trade will continue as planned in proposal.
  - Work on project with Siemens s.r.o. funded by Ministry of Industry and Trade will continue as planned in proposal.

  Key persons: Ing. Tomáš Karásek, PhD., Ing. Tomáš Brzobohatý, PhD.
  Estimated personnel capacity (FTE): 10

- **Infrastructure Research**
  - The main goal of the research team is to develop tools and techniques that increase the quality of the service and the infrastructure of IT4Innovations. We will continue to develop and optimize our in-house and other open-source packages (ESPRESO, MERIC, RADAR, CyclesPhi) and services based on these tools such as Solver-as-a-Service and Rendering-as-a-service.

  - Within the ESPRESO library we will continue our work on following topics. Implementation, validation, and benchmarking of GPU acceleration of FETI and HTFETI solver. In particular, calculation/assembling of Local Schur Complement and Dirichlet preconditioner directly on GPU accelerators to be able to fully utilize multi-GPU systems, such as Nvidia DGX-2. GPU acceleration of FEM matrix assemblers for additonal physical solvers. Development and implementation of Solver-as-a-Service for IT4I infrastrucuture. In the newly developed parallel pre-processing module we will focus on improving the quality of decomposition by external tools (ParMetis, PTScotch, …) which generate non-contiguous domains.

  - Under the investigation of the H2020 project POP2 our team gained experience in optimization of parallel applications. This team will continue to support other groups that develop parallel applications at IT4Innovations and users of the IT4I infrastructure both from academia and industry. POP2 continously introduce new methodologies for evaluation of hybrid (CPU+GPU) HPC applications that are offered to all our users.

- The Visualization and Virtual Reality (VaVR) group has set up a service that provides rendering using cluster resources. It is continuation of our work in the area of parallel rendering. The plan is to advertise this service and offer it to potential users. Another aim in the parallel rendering topic is to provide better support and utilization of GPU accelerators with concern for both offline and interactive rendering. Within the topic of scientific visualization we want to utilize Vistle open-source, that uses parallel workflow for scientific data processing. In the area of medical data processing we will continue to bring more AI based data processing in the topic. The goal is to create also a simple platform for medical image processing in Blender where new algorithms would be deployed more easily. Our group has also started its participation in TACR TREND project focusing on development of a railway vehicle that is capable of object detection and condition monitoring in front of the vehicle. Essential part in the project is a development of a software simulator that will generate visual data to train the detection algorithm. Our team is responsible for the development of the software simulator until the end of the project in 2023.

- A group that focuses on energy-efficiency of HPC systems will further develop their in-house tools for parallel applications analysis and tuning. The tool-chain consist of (1) MERIC library that provides resource consumption monitoring and hardware parameters tuning, (2) a static binary instrumentation tool for automatic insertion of the tuning regions into the binary of the analyzed application, (3) MERICwrapper that analyze the instrumented application for various configurations and perform effective state-space search, and (4) RADAR visualizer for visualization of the application behavior based on measurements provided by MERIC. The road-map of the MERIC library focuses on support of GPGPU accelerated applications. The library will be extended with support for resource monitoring and GPU hardware tuning. Due to ever increasing list of tunable parameters that are supported, the MERICwrapper must be able to evaluate large multidimensional state-spaces. The same holds for RADAR visualizer that must provide new multi-dimensional charts. We would like to use our tools in the POP2 project to evaluate potential energy saving of POP2 customer applications. The method will be presented to potential customers using POP2 webinar.

Key persons: Ing. Lubomír Říha, PhD., Ing. Petr Strakoš, Ph.D.
Estimated personnel capacity (FTE): 10

3.C Research outcomes

1. Present newly achieved results at well-established HPC conferences and publish them in prestigious journals.
2. Extend and optimize versions of our in-house libraries ESPRESO, scaDD, BEM4I, MULTIDYN, MCSIMUL, PIMCSIMUL, LIB4NEURO, MERIC, RADAR, CyclesPhi.

Type	Number
Journal papers (imp)	12
Other papers (proceedings, …)	10
Outcomes of applied research (patents, software, etc.)	5

Table 3 Key performance indicators of the research programme

3.D Project activity

International R&D projects:

Project title	Grant agency	Total implementation period	Funds planned for RP in 2020 (CZK 1000)	Total funds planned for RP (CZK 1000)	Status (A-accepted, S-submitted, P-planned)
EXPERTISE	H2020-MSCA	2017 - 2021	1 600	5 900	A
PRACE – 6IP	H2020	2019 - 2021	1 200	3 000	A
CloudiFacturing	H2020	2016-2021	2 100	6 500	A
ExaQUte	H2020	2018-2021	1 450	4 100	A
LEXIS	H2020	2019-2021	1 200	3 000	A
POP2	H2020	2018-2021	3 200	11 233	A
H2020-JTI-EuroHPC-2019-1	H2020	2020 - 2023	-	-	P

National grants / specific support:

Project title	Grant	Total implementation period	Funds planned for RP in 2020 (CZK 1000)	Total funds planned for RP (CZK 1000)	Status (A-accepted, S-submitted, P-planned)
Research Infrastructure (e-INFRA CZ)	MEYS	2020-2022	5 700	17 000	A
Sigma Lutin, Inflow and outflow objects in pumping and turbine stations	MIT	2018-2021	1 927	3 890	A
Math-In-HPC.EDU	MEYS	2017-2022	207	2 450	A
Technology for the future	MEYS	2016-2022	500	1 940	A
Artificial Intelligence Methods for Process Control in Glass Industry	TAČR	2020-2022	1079	5020	S
Inlet and outlet objects of pumping and turbine stations	Ministry of Industry and Trade	2018-2021	1307	3921	A
Digital twin product at Siemens manufacturing plants	Ministry of Industry and Trade	2019-2022	3651	8373	A
Space-time methods of boundary elements for solving the heat conduction equation	GAČR	2019-2021	1266	3573	A

Optimization of operating parameters of the electrical distribution system using artificial intelligence	TAČR	2019-2021	223	1802	A
Contactless partial discharge detector for HV distribution lines	TAČR	2019-2021	223	1257	A
Research and development of functional sample of railway vehicle with possibility of data collection and software - simulator with ability to generate data for training of obstacle detection in simulated conditions	TAČR	2020-2022	2650	10147	A

Contract research:

Project title	**Contracting authority**	**Total implementation period**	**Funds planned for RP in 2020 (CZK 1000)**	**Total funds planned for RP (CZK 1000)**	**Status (C-contracted, N-negotiated, P-planned)**
Creation of automated workflow for CFD simulation based on OpenFOAM	Hanon	2020	250	250	P

4 Modelling in Nanotechnology

4.A Research programme annotation

Research programme activities are oriented towards HPC applications in theoretical and experimental aspects of nanotechnologies. The research branches are as follows:

- Electronic structure modelling of solid states based on quantum mechanics.
- Theoretical and experimental study of new materials and surface structures for next generation photovoltaic cells.
- Research and development of spin lasers for electronics applications.
- Nonlinear optical effects in nanostructures.
- Nanocomposites modelling and design for broad applications.
- Terahertz photonic structures and plasmonics.
- GMR based THz source.
- Next generation SPR sensors.

Responsible partner: VŠB-Technical University of Ostrava
Head of research programme: Prof. Ing. Jaromír Pištora, CSc.
Estimated personnel capacity (FTE): 18

4.B Research teams and objectives

- **Modelling in Nanotechnology**

  Modelling of diffraction on pyramidal structures using the Straton-Chu-Silver method, behaviors of metallic nanolaminates under shock loadings, electronic, elastic, phonon, and thermodynamic properties in terms of the importance of the spin-orbit coupling acting on the 6d and 5f states, investigation of the polar antiferromagnets Ni_2CoTeO_6 and $NiCo_2TeO_6$, modelling of spin polarization, description of interactions for two component nanocomposites with liquids, modelling of fano-resonance in surface plasmon resonance x waveguiding systems, description of magneto-optical effects in periodical structures.

  Key persons: prof. Ing. Jaromír Pištora, CSc., Ing. Dominik Legut, Ph.D.
  Estimated personnel capacity (FTE): 4.0

- **New materials and surfaces for nano-optics**

  - Electronic structure modelling of solid states based on quantum mechanics
  - Sensitivity enhancement of nanosensors based on fano-resonance
  - Plasmonic nanostructures with waveguiding effect
  - Surface plasmon resonance modulation

  Key persons: Prof. Ing. Jaromír Pištora, CSc., Doc. Dr. Mgr. Kamil Postava
  Estimated personnel capacity (FTE): 3.5

- **Nanocomposites modelling and design for broad applications**

  - Preparing nanocomposites by reactive milling
  - Development of highly photoactive nanocomposites for sanitary use
  - Pre-treatment of nanocarbons
  - Multiplecomponent nanocomposites

Key persons: Doc. Ing. Gražyna Simha Martynková, Ph.D., Doc. Ing. Jonáš Tokarský, Ph.D.
Estimated personnel capacity (FTE): 3.0

- **New terahertz sources and spintronics**

  - Modelling of spintronic structure for THz sources
  - Design and computer optimization of the diffraction structure for THz emitter
  - Surface-emitting lasers with vertical architecture (VCSELs)
  - Mueller matrix ellipsometric study of multilayer spin-VCSEL structures with local optical anisotropy

  Key person: Dr. Mathias Vanwoleghem, Dr. Henry Jaffrés
  Estimated personnel capacity (FTE): 3.0

- **Plasmonics and non-reciprocal photonic structures**

  - Semiconductor plasmonics and magneto-optically active materials and structures
  - Modelling of non-reciprocal and isolation parts
  - Magnetoplasmonic nanograting geometry for optical nonreciprocity sign control
  - Silicon slot waveguide electro-optic Kerr effect modulation
  - Closed-form approximations to solutions of plasmon dispersion at a dielectric/conductor Interface
  - High sensitive Z-shaped fiber interferometric refractive index sensor

  Key person: Prof. Michael Cada
  Estimated personnel capacity (FTE): 2.5

- **Photovoltaics and security diffraction structures**

  - Modelling of functionality of security holograms
  - Modelling of advanced surface structures for efficient photovoltaic cells
  - Optical properties and performance of pyramidal texture silicon heterojunction solar cells: Key role of vertex angles
  - Optical activity temperature-dependent measurements of chiral solutions using Mueller matrix spectroscopic ellipsometry
  - Modeling of Mueller matrix response from diffracting structures

  Key person: Doc. Dr. Mgr. Kamil Postava
  Estimated personnel capacity (FTE): 2.0

4.C Research outcomes

1. The proposed activities are divided into fundamental and applied research. In the frame of optical measurements, and diagnostics and nanocomposites modelling, fundamental research will be dominant. In these cases, the research outputs will be published in excellent journals.
2. During 2020 we plan to attend the MMM, NANOCON, Workshop of Ellipsometry 2020, and Intermag 2020 conferences.
3. Research topics and journals: SPR in semiconductors (Optics Express, IEEE Transactions, Thin Solid Films, JOSA), Terahertz photonic structures (Thin Solid Films, Optics Express), Nonlinear optical effects in nanostructures (Journal of Physics D, Physical Chemistry Chemical Physics, Computer Physics Communications, Physical Review B).
4. Types of applied research outputs: Magnetic field source for magneto-optics, Development of highly photoactive nanocomposites for sanitary use, SPR sensorics based on plasmonics effects.

Type	Number
Journal papers (imp)	17
Other papers (proceedings, …)	5
Outcomes of applied research (patents, software, etc.)	1

Table 4 Key performance indicators of the research programme

4.D Project activity

International R&D projects:

Project title	**Grant agency**	**Total implementation period**	**Funds planned for RP in 2020 (CZK 1000)**	**Total funds planned for RP (CZK 1000)**	**Status (A-accepted, S-submitted, P-planned)**
s-NEBULA (project at the Center of Nanotechnology, VŠB-TUO)	H2020	2020-2023	1500	8440	A

National grants / specific support:

Project title	**Grant**	**Total implementation period**	**Funds planned for RP in 2020 (CZK 1000)**	**Total funds planned for RP (CZK 1000)**	**Status (A-accepted, S-submitted, P-planned)**
Photonic structures in safety holography	MIT	2017-2021	700	5 808	A
Modification of thermal stability of W-Cr based alloys for fusion applications reactors	GAČR	2020-2022	2589	7967	A
IT4Innovations National Supercomputing Center – path to exascale (IT4I NSC - P2EX)	MEYS	2017-2021	13 860	40 000	A

Physics of phonon interactions in solids for terahertz radiation generation	MEYS	2019-2020	78	156	A
Multi-level design of new permanent magnets without rare earth elements	MEYS	2020-2021	120	240	S

Contract research:

Project title	**Contracting authority**	**Total implementation period**	**Funds planned for RP in 2020 (CZK 1000)**	**Total funds planned for RP (CZK 1000)**	**Status (C-contracted, N-negotiated, P-planned)**
Nanobricks		2020-2021	150	250	P

5 IT for Knowledge Management

5.A Research programme annotation

The research programme is divided into three major research areas. The first area of interest is the usage of artificial intelligence and modern data processing and analysis methods, especially with the focus in the field of big data problematics. The enormous number of data nowadays obtained almost from every part of human activities is a big challenge for researchers. Big data has their specific, and according to this, they demand particular approaches. The knowledge gained from big data could help us to optimize, energy-efficient power control systems and with it connected reduction of greenhouse gas production, etc. We also deal with processing provisional and location data of mobile operators to extract knowledge on movements in the territory. In cooperation with T-Mobile CZ, we have launched a Mobility Atlas of the Czech Republic as a web portal with remote access and processed data in pseudo realtime.

The second field of interest is the Internet of Things. Our research is focused on green communication in new emerging 5G and future 6G mobile networks. We deal with energy harvesting via radio-frequency signals in wireless relay networks. Moreover, we continue in our two national applied research projects; the first one is funded by the Ministry of Trade, where we develop equipment for an industrial partner and the second by the Ministry of Interior, where we deal with security in IoT networks. The last activity in this is low-power IoT networks in the H2020 project Tetramax, which is concentrated on IoT and a cross-border technology transfer.

The last research area is cybersecurity, where we have several activities. The first is participation in the H2020 project OpenQKD, where we provide simulations in IT4I of QKD use cases for the entire consortium, and we have several tasks origin from the project proposal. The other important activity is contractual research for the National Authority for Cybersecurity. Unfortunately, the contract is under NDA, and we are not eligible to provide the content of our applied research and individual tasks within this activity, the amount of the contract is 4.3 mil. CZK.

Responsible partner: VŠB-Technical University of Ostrava
Head of research programme: Prof. Ing. Miroslav Vozňák, Ph.D.
Estimated personnel capacity (FTE): 10

5.B Research teams and objectives

- **Artificial Intelligence in Complex Systems, Big Data, and Scheduling and Combinatorial Optimization**
  - In 2020, our primary goal is to continue in current research - optimization of robotics movements with various algorithms. Our goal is to find new ways of trajectory optimization and energy-efficient path planning. We will continue the research on the placement of the robotic arm in the workspace. Another part of the research will focus on energy consumption estimation, preparing a simple model without using a complex set of kinematic variables. We will also explore the possibilities and improvements in optimization algorithms. Selected algorithms will be fully optimized and tuned for specific problems they solve. The last part of the research will focus on the effective parallel execution of the aforementioned bioinspired algorithms. All the research results will be published in Q1 journals.
  - In the next operational period, the researchers in the Big data analysis group plan to add prediction and anomaly detection features to the traffic data model. The next idea

is to implement the modification of the Self-Organizing Migrating Algorithm to current a model as the parameter optimization method. Further, their goal is to apply these methods for flight data analysis. The next scientific plan is to use machine learning techniques in school-aged children's specific study for a better understanding of young's behavior and habits and present the results to policymakers and the Czech community.

Key person: Prof. Ing. Miroslav Vozňák, Ph.D., Ing. Jakub Šafařík, Ph.D.
Estimated personnel capacity (FTE): 3

- **Internet of Things**
  - The individual aims of the research are defined in one industrial project of MIT for the period 2017-2020 and MI 2017-2020. The primary goal is to finish both projects successfully.
  - The next aim is to realize technology transfer in the field of IoT, which is our task in the H2020 project TETRAMAX for this year.
  - The last domain in IoT, which we deal with, is energy harvesting in mobile 5G/6G networks. The topic attracts the interest of many researchers, and energy harvesting is useful, especially for supplying the energy to relay nodes in IoT systems. We try to analyze the performance of a novel energy harvesting scheme for a two-way half-duplex relay sensor network, and we investigate various relay strategies in 2020.

Key persons: Prof. Ing. Miroslav Vozňák, Ph.D.
Estimated personnel capacity (FTE): 5

- **Cybersecurity**
  - We launched a new project gained in the H2020 call on security SU-ICT-04-2019. In 2020, we are responsible for one task where it will be developed web application in which various use cases should be simulated. We will also realize one use-case this year; it is HPC over QKD between IT4I and PSNC.
  - The second aim is defined by conditions of contractual research for the National Authority for Cybersecurity.

Key persons: Prof. Ing. Miroslav Vozňák, Ph.D.
Estimated personnel capacity (FTE): 2

5.C Research outcomes

1. Continue the work on projects and finish all the activities connected with it according to the projects' plan.
2. Research of IoT is focused on experimental development and applied research and also on fundamental problems of energy harvesting in emerging new sensor networks.
3. The results of the research will be submitted for publication in journals.
4. The members of the team will cooperate with other research teams within the IT4Innovations centre.
5. The team members will continue in international collaboration within the projects, which are solved under the research programme.

Type	Number
Journal papers (imp)	4

Other papers (proceedings, …)	6
Outcomes of applied research (patents, software, etc.)	0

Table 5 Key performance indicators of the research programme

5.D Project activity

International R&D projects:

Project title	**Grant agency**	**Total implementation period**	**Funds planned for RP in 2020 (CZK 1000)**	**Total funds planned for RP (CZK 1000)**	**Status (A-accepted, S-submitted, P-planned)**
Tetramax	H2020	2017-2021	400	2 300	A
OpenQKD	H2020	2019-2022	1 400	6 100	A

National grants / specific support:

Project title	**Grant**	**Total implementation period**	**Funds planned for RP in 2020 (CZK 1000)**	**Total funds planned for RP (CZK 1000)**	**Status (A-accepted, S-submitted, P-planned)**
AI&Reasoning	MEYS OPVVV	2017-2022	2 214	12 175	A
SIoT, Solidus, SAMMWAP (projects of the Faculty of el. engineering and comp. science)	MIT CR, MI CR, TA CR	2017-2021	2 223	-	A
Smart energy management system for energy networks (project of the Faculty of el. engineering and comp. science)	TAČR	2019-2020	170	1762	A

Contract research:

Project title	**Contracting authority**	**Total implementation period**	**Funds planned for RP in 2020 (CZK 1000)**	**Total funds planned for RP (CZK 1000)**	**Status (C-contracted, N-negotiated, P-planned)**
Research in field of cybersecurity (under NDA)	Organizational unit of the state (under NDA)	2019-2021	3 178	3 595	C

6 Soft Computing Methods with Supercomputing Applications

6.A Research programme annotation

In 2020, we will continue our research following on from the results of 2019, and focus among other things, on the open problems that have appeared. Following the general aim of our institute, we will continue development of special fuzzy modelling methods, their software implementation, and possibly realize real-life applications for companies with whom we have signed contracts. The research will be based on the development of fundamental theories that later stand behind the considered methods in applications. The essential goal is to apply original methods developed in our institute, the functioning of which is scientifically justified. In 2020, we will focus especially on the development of methods belonging to the area of artificial intelligence. The main strategic goals are the following:

- Modify our research focus towards research and development of methods of artificial intelligence.
- Search other areas of mathematics and computer science that have the potential to enrich fuzzy modelling.
- Develop new methods, algorithms, and software that have potential for real applications.
- Search partners from industry that are interested in application of our methods.
- Research of multi-agent biologically inspired systems.
- Development of AI methods applied to medical information systems,

Responsible partner: University of Ostrava, Silesian University in Opava
Head of research programme: Prof. Ing. Vilém Novák, DrSc.
Estimated personnel capacity (FTE): 27.5

6.B Research teams and objectives

6.B.1 University of Ostrava

- **Theoretical Research Department**

  Main objectives: continue the study and theoretical development of existing as well as new methods and their foundations to be able to justify scientifically their use:
  - Join of mathematical tools of fuzzy modelling with probabilistic methods and tools of classical mathematics (e.g., numerical or functional analysis, optimization tasks, and others).
  - Selected problems in fuzzy natural logic and its theoretical foundations (focus especially on other intermediate quantifiers, square and cube of opposition, development of algorithms for their computation).
  - Theoretical foundation of methods for computer vision on the basis of fuzzy modelling.
  - Theoretical foundations of methods for mining information from data and forecasting of future development of systems on the basis of the prinicples of fuzzy modelling.
  - Further development of the theory of dynamical systems from the point of view of topology and its generalization.
  - Combination of neural networks with tools of fuzzy modelling (for example, fuzzy transform).

  Key persons: Prof. Irina Perfiljeva, Prof. Jiří Močkoř, Prof. Vilém Novák

Estimated personnel capacity (FTE): 8.3

- **Applied Research Department**

  Main objectives: development of algorithms on the basis of the theoretical results in synergy with special nature inspired algorithms (especially neural networks):
  - Realizing special theoretically justified methods for computer vision.
  - Data mining (including incomplete and big data).
  - Automatization of decision-making.
  - Machine learning of expert knowledge.
  - Forecasting and mining information from data of dynamical systems.
  - Other selected tasks of artificial intelligence.

  Key persons: Doc. Martin Štěpnička, Doc. Michal Holčapek, Doc. Antonín Dvořák
  Estimated personnel capacity (FTE): 8.4

- **Software Development Department**

  Main objectives: effective implementation of the theoretical and application results obtained in Theoretical Research and Applied Research departments. Improvement of the existing software systems:
  - Development of LFL Forecaster and LFL Controller as WEB service. Implementation of new techniques based on the F-transform in R-system, improvement and implementation of new algorithms in computer vision tasks, and implementation of the special numerical methods based on the F-transform.
  - Extension of the functionality of LFL forecaster to provide information in natural language and detect structural breaks in them.
  - Continue the development of the special software for solution of differential and integro-differential equations.
  - Development of new methods for detection of objects using neural nets in combination with fuzzy transform technique.

  Key persons: Dr. Viktor Pavliska, Dr. Michal Burda, Mgr. Radek Valášek
  Estimated personnel capacity (FTE): 5.8

6.B.2 Silesian University in Opava

- **Autonomous Agent Research Team**

  Main objectives:
  - research of medical risk evaluation of atherosclerotic plagues from b-images and histological patterns.
  - Bio-inspired multi-agent computing models (membrane computing, P colonies).
  - Theoretical research and computer modelling of morphogenetic systems capturing growth of organisms with explicit spatial and geometric arrangement, with possible application to systems biology/artificial life.

  Key persons: Doc. Ing. Petr Sosík, Dr., Prof. Ing. Dušan Marček, Ing. Jiří Blahuta, Ph.D., RNDr. Lucie Ciencialová, Ph.D., Doc. RNDr. Luděk Cienciala, Ph.D.
  Estimated personnel capacity (FTE): 5

6.C Research outcomes

6.C.1 University of Ostrava

1. Our research outcomes will be especially scientific papers in journals with IF and algorithms implemented in the software developed on the basis of the results of our theoretical research.
2. Due to the corona-virus crisis, we either have to move or cancel the International student conference ISCAMI 2020 (International Student Conference on Applied Mathematics and Informatics), Malenovice, Czech Republic that is organized by us.
3. We plan to attend several international conferences, e.g., IPMU Lisbon, WCCI 2020 Glasgow, FLINS Koln, FCTA Budapest and few other ones (provided that they will not be canceled due to corona-virus).
4. Research topics of the planned publications: image processing, data mining, analysis and forecasting of time series, fuzzy natural logic, theory and applications of fuzzy transform.
5. Types of applied research outputs: software.

Type	Number
Journal papers (imp)	10
Other papers (proceedings, …)	15
Outcomes of applied research (patents, software, etc.)	1

Table 6.1 Key performance indicators of the research programme

6.C.2 Silesian University in Opava

1. Most of the planned research centres around theoretical properties and applications of a) AI methods in medical image recognition and processing, and b) biologically inspired multi-agent systems (P colonies, morphogenetic systems), including their computer modelling. Concerning publications as the main visible outcomes, examples of journals where we publish/plan to publish are: Information Science, Natural Computing.
2. Participation is planned at research events such as the 21st Conference on Membrane Computing, the Conference on Machines, Computing and Universality (MCU) and others. Due to the Coronavirus pandemic, however, these plans may have to be changed.
3. Research topics of the planned publications: membrane computing, P colonies, image processing (ultrasound images), morphogenetic systems.

Type	Number
Journal papers (imp)	2
Other papers (proceedings, …)	4
Outcomes of applied research (patents, software, etc.)	1

Table 6.2 Key performance indicators of the research programme

6.D Project activity

6.D.1 University of Ostrava

International R&D projects:

Project title	Grant agency	Total implementation period	Funds planned for RP in 2020 (CZK 1000)	Total funds planned for RP (CZK 1000)	Status (A-accepted, S-submitted, P-planned)
Erasmus+ CBHE	EC, House of international collaboration	2018-2021	375	1,15	A

National grants / specific support:

Project title	Grant	Total implementation period	Funds planned for RP in 2020 (CZK 1000)	Total funds planned for RP (CZK 1000)	Status (A-accepted, S-submitted, P-planned)
AI-Met4AI Artificial Intelligence Methods for Automotive Industry	OP RDE MEYS	12/2018-12/2022	7500	29500	A
Complex topological structures	MEYS - IRP	2018-2020	1,146	5,720	A
Utilization of transdisciplinary synergy data science and tools of fuzzy modeling and social work: Multidimensional Evidence Informed Practice	MEYS – IRP(s FSS)	2018-2020	675	2,025	A
New approaches to financial time series modelling based on soft computing	GA CR 18-13951S	2018-2020	952	2,856	A
New approaches to aggregation operators in analysis and processing of data	GA CR 18-06915S	2018-2020	803	2,397	A
Fuzzy Relational Structures in Approximate Reasoning	GAČR 20-07851S	2020-2022	1,710	5,149	A
Social Adjustment of Homeless Children with Domestic Violence Experience in the Territory of the City of Ostrava	GA CR (s FSS) 18-10233S	2018-2020	122	366	A

Contract research:

Project title	Contracting authority	Total implementation period	Funds planned for RP in 2020 (CZK 1000)	Total funds planned for RP (CZK 1000)	Status (C-contracted, N-negotiated, P-planned)
Kasandra	EAGO Systems s.r.o.	2019-2021	1000	3000	C

6.D.2 Silesian University in Opava

International R&D projects:

Project title	Grant agency	Total implementation period	Funds planned for RP in 2020 (CZK 1000)	Total funds planned for RP (CZK 1000)	Status (A-accepted, S-submitted, P-planned)
ERASMUS+ 2016-1-CZ-01-KA103-XXXX (tba)	EC, House of international collaboration	2020-2021	486	486	S

National grants / specific support:

Project title	Grant	Total implementation period	Funds planned for RP in 2020 (CZK 1000)	Total funds planned for RP (CZK 1000)	Status (A-accepted, S-submitted, P-planned)
Development of Methods of Theoretical and Applied Comp.Sci.	MEYS	2019-2021	374	1350	A
Usage of information sources in society	MEYS	2019-2021	70	232	A

Contract research:

Project title	Contracting authority	Total implementation period	Funds planned for RP in 2020 (CZK 1000)	Total funds planned for RP (CZK 1000)	Status (C-contracted, N-negotiated, P-planned)
Data processing for autonomous vehicles	LPP, s.r.o.	2020	540	540	N

7 Multimedia Information Recognition and Presentation

7.A Research programme annotation

The Multimedia Information Recognition and Presentation research programme continues to have one principal research objective, which is getting closer to robustness and applicability of the developed methods; that remains true throughout the whole funded period of the project. In 2020, while the applicability of the methods in real life applications remains the focus of the research programme. The main goal in the upcoming period is to continue with multimedia data keeping in mind its properties starting from the signal level. The activity remains connected to other research activities (most closely specifically to RP8). Further research goals include research of efficient and/or high performance computations (HPC) in applications and robust algorithmic solutions. The emphasis remains on image, video, and speech analysis, mining of the knowledge from documents and multimedia data, presentation, visualization and modelling, acceleration, as well as techniques of semantic web, languages, and grammars which corresponds to the structure of the RP. The results of the research programme include new procedures and understanding of the above area in new types of applications which, as also mentioned in the previous reports and plans, have not been possible or feasible for technological or economic reasons so far but that are now start to be developed. The results will be published at conferences and in journals and it will be applied mostly in the form of software, and/or functional models, and services (including contractual research).

Responsible partner: FIT, Brno University of Technology
Head of research programme: Prof. Dr. Ing. Pavel Zemčík
Estimated personnel capacity (FTE): 20.5

7.B Research teams and objectives

- **Processing of information from multimedia data within NPS II**
  In the next research period of the year 2020, the focus will be on the following aspects of information from multimedia data processing:
  - Further research of algorithms covering extraction and understanding of multimedia data, visualization, data mining, and visualization/rendering in selected applications.
  - Analysis of video footage of unknown source with the aim to understand the scene contents and camera placement/orientation. Detection, recognition and orientation of objects present in the video footage and their motion for statistical purposes and for the purposes of understanding the scene as a whole and understanding the camera placement in the scene as well as activities taking place in the scene.
  - Similarly to the previous period, the research will be executed with focus on non-supervised robust methods that have the best potential to avoid of human work.

  Key persons: Prof. Ing. Adam Herout, Ph.D., Prof. RNDr. Alexander Meduna, CSc.

- **Industrial applications of advanced information technologies within NPS II**
  In the next research period, the focus will be on the following aspects of industrial applications of advanced information technologies:
  - We will continue work in the field of CPS and IoT in applications, such as “Smart Cities”, traffic, and “Smart Homes”. The most actual areas will be speech data mining in transportation with particular forcus on aviation (such as assessment of pilot training, partially funded by a new TACR project and potential cooperation with Honeywell).

- We will continue work with Ericsson, NTT, and we will actively seek other cooperation opportunities. A new area (link analysis based on multimodal information) that was open in the previous period in synergy with newly accepted EU H2020-Security project Roxanne will continue.
- In all scenarios relevant for industrial applications, the CPU/GPU/memory needs and possibility to apply HPC and non-conventional platforms will be evaluated.

Key persons: Doc. Ing. Lukáš Burget, Ph.D., Prof. Ing. Miroslav Švéda, CSc.

- **Video sequence processing and speech recognition**

In 2020, research of techniques for multi-lingual robust data mining from speech data in adverse conditions will continue. In speaker recognition (SR), we expect to continue activities in NIST 2020 Speaker recognition evaluation. We will extend investigation of performance of i-vector and x-vector models as started in the previous period. In automatic speech recognition, we will still focus on basics of neural ASR systems (temporal resolution, representation levels, and fusion with other modalities). This work is running concurrently with a newly started NEUREM3 project funded under the GACR "EXPRO" scheme and also H2020 ROXANNE and CleanSkyATCO2 and DARPA Lorelei and IARPA Material. In addition to basic research, we expect providing a set of applicable results, mainly acoustic models for ASR, some for new languages, in some of them upgrade of existing language models. We also expect at least an article published in a journal or renowned international conference.

Key persons: Doc. Dr. Ing. Jan Černocký, Ing. Ondřej Glembek, Ph.D., Ing. Pavel Matějka, Ph.D.

- **Computer vision and recognition**

The research to be executed in 2020 will keep the focus on acceleration of new and robust algorithms of scene understanding and object detection/recognition on modern platforms such as embedded platforms, multi-CPU and/or GP-GPU, and also FPGA combined with CPUs and possibly also Xeon Phi architecture. The research will continue to use non-traditional image sources, such as multiexposure HDR and multispectral images, potentially we expect also ToF systems (Time of Flight). Experiments and evaluation of the algorithms and the acquired data will continue to be carried out, as well as further refinement of the methods. We expect at least an article published in a journal or renowned international conference, possibly also an open source software package and/or preparation of a functional sample.

Key persons: Prof. Dr. Ing. Pavel Zemčík, Ing. Tomáš Starka, Ing. Jan Pečiva, Ph.D., Ing. David Bařina, Ph.D., Ing. Markéta Juránková, Ph.D., Ing. Michal Kula, Kolář Martin, M.Sc.

- **Knowledge Mining from Documents and Multimedia**

In 2020 period, we will continue research in the document information extraction area started in the previous periods. The focus will continuously be given to experimental evaluation of the proposed methods and the proposed improvements of the methods on large data sets. The research will also keep focus on linking the data contained in web documents to existing semantic databases such as DBPedia, as a continuation of 2019 activities. We will keep the research focus on the area of querying and mining data extracted from video with the focus on supporting infrastructure. We will further focus

on the hidden sub-process analysis with the use of advanced techniques, such as declarative mining approach. We expect to publish at least one conference paper on a renown international conference or a paper in an international journal.

Key persons: Doc. Ing. Jaroslav Zendulka, CSc., Ing. Radek Burget, Ph.D., Ing. Vladimír Bartík, Ph.D.

- **3D Geometric Modelling**
  Further research in 2020 will keep focus on development of robust algorithms and applications of 3D environment perception and modelling in robotics, especially focusing "teaching of robots" for shared workspace applications where humans and robots collaborate. We will also keep working on 3D geometry modelling from CT scans with applications in medicine. Novel approaches based on deep learning techniques will be explored with regard to 3D structures with a long term goal of optimization of 3D models related to human tissues. We will also keep collaborating with our industrial partners, such as TESCAN 3DIM and GEODROM. At least one paper in a journal and/or some papers at international conferences will be published, and we plan to release a software in the form of an open source.

  Key persons: Ing. Michal Španěl, Ph.D., Ing. Zdeněk Materna, Ing. Martin Veľas, Ing. Oldřich Kodym

- **Data presentation and visualization**
  In 2020, we will attempt to continue the progress with the algorithms of real-time rendering of realistic visual effects, such as rain, snow, or hail. We will also progress the research of automatic calibration procedures for cameras for the purpose of visualization of data using augmented reality in the scenes observed by the cameras. We will further investigate the possibility of calibration using cameras with radial image distortion and possibly other types of geometrical image distoritions. The applications which are targeted will be mostly traffic surveillance, but we will investigate the possibility to apply the techniques in other domains. At least one article is expected to be published in an international journal, several papers at renowned conferences, and we plan to release also an open source software and/or publicly available mobile application(s).

  Key persons: Prof. Ing. Adam Herout, Ph.D., Ing. Vítězslav Beran, Ph.D., Ing. Michal Matýšek

- **Acceleration in specialized hardware**
  In 2020, we will perform further research in acceleration of algorithms both from the point of view of high performance using heterogeneous architectures and energy consumption efficiency. We will continue to study algorithms used in real applications, specifically we will keep in our focus mapping algorithms on FPGA and CPU in "connected" architectures and structures. The main focus of applications will further involve real-time image processing and signal/object recognition in FPGA. In 2020, we will pay increasingly more attention to High Level Synthesis (HLS) approaches in order to increase productivity of work and to allow to pay more attention to "manual" optimization in the most critical parts of the systems. The results of the activity will be presented at good international conferences and possibly a functional sample or software will be prepared as well.

Key persons: Doc. Dr. Ing. Otto Fučík, Doc. Ing. Richard Růžička, Ph.D., MBA, Ing. Václav Šimek

- **Semantic web technologies**
  In 2020, our research will further focus on efficiency of the parallel and distributed machines learning. We will address advanced on-line learning mechanisms that can continuously update the models based on newly available data in steps consisting of fast update procedures. We will also attempt to work with stream processing linked to distributed messaging platforms such as Aeron or Apache Kafka and will interconnect the results with advanced machine learning frameworks involving neural networks of Transformer type in frameworks, such as Facebook PyTorch, Google TensorFlow. We will also keep targeting target advanced question answering (QA) methods that take advantage of contextual document embeddings and will explore novel strategies for the retrieval component of the QA systems. The attention will be kept on HPC and specifically on GPU implementation of the algorithms described above.

  Key persons: Doc. RNDr. Pavel Smrž, Ph.D., Ing. Lubomír Otrusina, Ing. Jaroslav Dytrych, Mgr. Petr Škoda

- **Formal languages and grammars**
  In 2020, our research will further focus structures investigated in the previous periods. We will keep addressing yet new coding of context dependencies in order to decrease the number of necessary context-sensitive rules without a drop of the expressiveness in the studied formal models, such as scattered context grammars and tree-controlled grammars. In addition to this research, we will continue the investigation of non-continuous processing of context information using jumping and regulated formal models. At least two papers in journals with impact factor will be released and at least two conference papers will be presented at international conferences. Possibly we will release some open software tool(s).

  Key persons: Prof. RNDr. Alexander Meduna, CSc., Doc. Dr. Ing. Dušan Kolář, Ing. Zbyněk Křivka, Ph.D.

7.C Research outcomes

The expected research outcomes include especially:

1. applications of the investigated algorithms to industrial, traffic, and possibly other real life applications, possibly also through contractual research,
2. improvements of the algorithms and solutions based on practical experience of users and industries,
3. preparation of software (open source and/or other) and investigation of protected IP.

Type	Number
Journal papers (imp)	5
Other papers (proceedings, …)	23
Outcomes of applied research (patents, software, etc.)	6

Table 7 Key performance indicators of the research programme

7.D Project activity

International R&D projects:

Project title	Grant agency	Total implementation period	Funds planned for RP in 2020 (CZK 1000)	Total funds planned for RP (CZK 1000)	Status (A-accepted, S-submitted, P-planned)
MegaMaRt2	H2020 ECSEL	2017-2020	477	5,721	A
ETE SPEAKER	H2020	2019-2021	1,885	3,142	A
ECoWeB	H2020	2018-2021	98	375	A
Cross-CPP	H2020	2018-2020	2,952	8,856	A
SAUCE	H2020	2018-2020	3,120	9,360	A
OCCAM –OCR	CEF	2019-2021	4,074	10,865	A
COMP4DRONES	ECSEL	2019-2022	4,915	14,746	A
Cross-CPP	H2020-ICT	2018-2020	2,952	8,856	A
ATCO2	H2020	2019-2022	1,857	3,714	A
ROXANNE	H2020	2019-2022	2,585	7,755	A
FITOPTIVIS	H2020 ECSEL	2018-2020	2,856	9,134	A
WELCOME	H2020	2020-2023	1,804	5,411	A

National grants / specific support:

Project title	Grant	Total implementation period	Funds planned for RP in 2020 (CZK 1000)	Total funds planned for RP (CZK 1000)	Status (A-accepted, S-submitted, P-planned)
CPK - Using Semantic Technologies to Access Cultural Heritage Through The Central Portal of Czech Libraries	MC	2016-2020	3,591	17,581	A
Information Mining in Speech Acquired by Distant Microphones -DRAPÁK	MIT	2015-2020	1,524	10,020	A

VRASSEO - Tools and Methods for Video and Image Processing to Improve Effectivity of Rescue and Security Services Operations	MIT	2017-2020	6,049	22,176	A
PERO - Advanced content extraction and recognition for printed and handwritten documents for better accessibility and usability	MC	2018-2022	4,078	19,700	A
Neural Representations in multi-modal and multi-lingual modeling	GA CR	2019-2023	4,735	24,328	A
BOREC - Colour Image in "Realtime Embedded Computing"	TAČR	2018-2020	1,368	4,116	A
SMARTCarPark - Surveillance Monitoring, Analysis and Re-identification of Traffic for Enhanced Car Parking	TAČR	2018-2020	2,687	8,145	A
Employment of artificial intelligence into an emergency call reception	Ministry of Interior of the Czech Republic	2019-2020	1,766	5,343	A
MuSiC - Multi-level Security for Critical Services	MEYS CZ INTER EXCELLENCE	2018-2020	1,964	5,073	A
enetCollect- Large-Scale Information Extraction and Gamification for Crowdsourced Language Learning	MEYS CZ INTER COST	2018-2021	1,361	3,888	A
Distant Reading for European Literary History	MEYS CZ INTER COST	2018-2021	1,298	4,666	A
Computer-Aided Analysis and Prediction of Child Growth and Development	TA CR	2018-2021	448	1,350	A
Progressive Image Processing Algorithms	TA CR	2018-2021	1,112	3,138	A
SECUre SENsors and data	TA CR	2019-2020	5,897	6,908	A
TRACTOR: TRaffic Analysis and seCuriTy OpeRations for ICS/SCADA	TA CR	2019-2020	1,914	3,191	A
Artificial Intelligence Driven Autonomy - NaCCAS - AIDA	TA CR	2019-2020	6,058	11,140	A
AI for Traffic and Industry Vision - AITIV	TA CR	2019-2021	2,111	4,750	A
Flight Training Evaluation Software	TA CR	2019-2021	3,072	9,183	A
Development of indoor software for cycling - Rouvy AR	Ministry of Industry and Trade of the CZ	2017-2020	2,159	3,883	A
Deep-Learning Approach to Topographical Image Analysis-ACTION	Ministry of Education, Youth and Sports CZ	2019-2022	1,300	3,900	A

Research and development of the monitoring part of forging presses –Sensory	Ministry of Industry and Trade of the CZ	2019-2022	725	2,800	A
Test-it-off: Robotic offline product testing- RoboTest	Ministry of Industry and Trade of the CZ	2019-2021	2,646	6,110	A
Multi-linguality in speech technologies	Ministry of Education, Youth and Sports CZ	2020-2022	1,973	5,919	A
Embedded Intelligence Based on Advanced Methods of Machine Learning for Edge-Computing Systems with an Application in Livestock Management	TA CR	2020-2022	1,745	5,235	A

Contract research:

Project title	**Contracting authority**	**Total implementation period**	**Funds planned for RP in 2020 (CZK 1000)**	**Total funds planned for RP (CZK 1000)**	**Status (C-contracted, N-negotiated, P-planned)**
Research and development for CadWork Informatik a.g.	CadWork Informatik a.g.	ongoing	1,620		C
Research and Development	Raytheon BBN Technologies	ongoing	3,000		C
Speech enhancement front-end for robust automatic speech recognition with large amount of training data	NTT Corporation	1/2020-12/2020	664	664	C
Deep learning methods for 3D image processing	TESCAN 3DIM, s.r.o.	1/2020-12/2020	540	540	C
Configuration and security of an embedded sensor data acquisition system	CAMEA spol. s r.o.	11/2019-12/2020	900	1,500	C
Development of VRUT application for Škoda auto	ŠKODA AUTO a.s.	1/2020-6/2020	473	473	C
Exploiting Language Information for Situational Awareness (ELISA)	LORELEI	ongoing	2,120		C

8 Secure and Safe Architectures, Networks, and Protocols

8.A Research programme annotation

Research is focused on advanced methods of modelling, design, validation, verification, simulation, adaptation, and testing of computer-based systems (including embedded systems), primarily considering the aspects of safety and security, and accenting parallel processing (multi- and many-core systems, accelerators based on specialized chips and FPGAs), high speed communication (high speed networks, Internet of Things), smart and adaptive systems, and low power solutions. Particular goals will be formed from the goals of the research projects the team members are involved in. Applied research and development will be conducted under the umbrella of contract research. For 2020, the research objectives are formulated via the research objectives of NPS II, 14 national projects (**including a new ERC CZ project "Efficient Finite Automata for Automated Reasoning"**) and four EU projects – PAMMOTH, AQUAS, Arrowhead Tools, and TETRAMAX.

Responsible partner: FIT, Brno University of Technology
Head of research programme: Prof. Ing. Lukáš Sekanina, Ph.D.
Estimated personnel capacity (FTE): 20.5

8.B Research teams and objectives

- **Safe and secure systems within the NPS II project**
  The strategic scientific objective is the research and development of automated methods of design, analysis, and verification of modern computer-based systems.

  Key persons in NPS II: Prof. RNDr. Milan Češka, CSc., Prof. RNDr. Josef Šlapal, CSc.

- **Security of multi-agent systems, wireless sensor networks, and biometric systems**
  Objectives: Research in the area of biometric systems, especially in recognition of fingerprints, faces and retina, where efficient generating of synthetic images, detection of skin diseases, pathologies in retinal images and 2D/3D face detection are main research targets.

  Key persons: Prof. Ing. Martin Drahanský, Ph.D., Doc. Ing. František Zbořil, Ph.D.

- **Embedded systems, networks, and protocols**
  Objectives: The main focus of the research will be on methods of monitoring and analysis of threats hidden in encrypted network traffic, both in the Internet environment and in networks of industrial systems. This will primarily involve the application of machine learning methods, data mining, and rule systems. A combination of different approaches seems to be promising to achieve greater detection accuracy. The other research area considers Internet privacy. This will involve creating methods that can be used, for example, as a web browser extension to prevent automated user information retrieval and the study of data leaks in existing Internet Advertising Systems.

  Key persons: Doc. Ing. Ondřej Ryšavý, Ph.D., Ing. Petr Matoušek, Ph.D., M.A.

- **Computer architectures and diagnostics**
  Objectives: Research on hardware acceleration of pattern matching and encrypted traffic analysis, particularly optimization of existing hardware architectures, with the use of

approximate computing techniques. We shall deal with the evaluation, testing and ensuring fault tolerance of electronic systems implemented into FPGAs. Particularly fault tolerance evaluation of cyber-physical systems with the usage of artificial fault injection and fault-tolerant system design will be investigated. A stochastic model of the behaviour of digital circuits aiming to analyse and optimize their dynamic properties as well as the ways of their control and test will be developed.

Key persons: Doc. Ing. Zdeněk Kotásek, CSc., Ing. Jan Kořenek, Ph.D., Ing. Josef Strnadel, Ph.D., Ing. Tomáš Martínek, Ph.D.

- **HW/SW co-design**
  Objectives: Research on search algorithms capable of ensuring that an optimal processor configuration is reached for a set of applications, including selection of clusters of instructions.

  Key persons: Prof. Ing. Tomáš Hruška, CSc.

- **Evolvable Hardware**
  Objectives: Research on machine learning for approximate circuit design, evolutionary design of cryptography-relevant logic functions and hash functions, evolutionary re-synthesis of combinational networks and efficient search operators for genetic programming.

  Key persons: Prof. Ing. Lukáš Sekanina, Ph.D., Doc. Ing. Zdeněk Vašíček, Ph.D., Ing. Michal Bidlo, Ph.D., Ing. Vojtěch Mrázek, Ph.D.

- **Automatic verification**
  Objectives: Research on advanced static as well as dynamic analysis and verification methods, development of the needed background automata and logic technologies, as well as applications of these methods for optimisation. In more detail, the areas covered by the research will include efficient methods of analysing low-level memory-manipulating programs, applications of formal verification methods in approximation of arithmetic circuits with guaranteed error bounds, and methods for analysing string-manipulating programs.

  Key persons: Prof. Ing. Tomáš Vojnar, Ph.D., Mgr. Lukáš Holík, Ph.D., Doc. Mgr. Adam Rogalewicz, Ph.D., Ing. Ondřej Lengál, Ph.D., RNDr. Milan Češka, Ph.D., Ing. Bohuslav Křena, Ph.D., Ing. Aleš Smrčka, Ph.D.

- **Modelling, simulation, and optimization**
  Objectives: Research in the area of formal models and simulation-based software design using a combination of high-level Petri nets and UML. Another research will deal with applications of high-level Petri nets in distributed control systems.

  Key persons: Doc. Ing. Vladimír Janoušek, Ph.D., Ing. Radek Kočí, Ph.D.

- **Supercomputing technologies**
  Objectives: Research in real-time evaluation of photoacoustic and ultrasound data from a photoacoustic breast scanner, multi-resolution models for distributed ultrasound simulation, coupling of different method of wave propagating (finite elements, boundary elements,

spectral, etc.), evolutionary design and optimization of ultrasound treatment plans, and development of a framework for automated job execution and monitoring on supercomputers.

Key persons: Doc. Ing. Jiří Jaroš, Ph.D.

8.C Research outcomes

1. The main research outcomes will be in the form of journal and conference scientific papers. Applied research outputs are expected from EU projects, contract research, and projects supported by the Technology Agency and the Ministry of the Interior of the Czech Republic. The NPS II project expects both types of outcomes.
2. Scientific papers will be published at international conferences, e.g.: the Design, Automation and Test in Europe, Design Automation Conference, International Workshop on Biometrics and forensics, IEEE International Conference on Network Protocols, ACM Symposium on SDN Research, International Symposium on VLSI Design, Automation and Test, ACM SIGSIM Conference on Principles of Advanced Discrete Simulation, ACM SIGHPC Conference on the Platform for Advanced Scientific Computing, International Conference on Tools and Algorithms for the Construction and Analysis of Systems, EvoStar and IEEE Congress on Evolutionary Computation.
3. Articles are planned for the following journals: IET Biometrics, Journal of Network and Systems Management, Microprocessors and Microsystems journal, IEEE Transactions on VLSI Systems, Applied Soft Computing and IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control.

Type	Number
Journal papers (imp)	5
Other papers (proceedings, …)	23
Outcomes of applied research (patents, software, etc.)	7

Table 8 Key performance indicators of the research programme

8.D Project activity

International R&D projects:

Project title	**Grant agency**	**Total implementation period**	**Funds planned for RP in 2020 (CZK 1000)**	**Total funds planned for RP (CZK 1000)**	**Status (A-accepted, S-submitted, P-planned)**
AQUAS: Aggregated Quality Assurance for Systems	ECSEL JU	2017-2020	3,343	22,995	A
PAMMOTH: Photoacoustic/Ultrasound Mammoscopy for evaluating screening-detected lesions in the breast	H2020	2017-2020	1,819	10,395	A
Arrowhead Tools - Arrowhead Tools for Engineering of Digitalisation Solutions	ECSEL	2019-2022	3,536	11,494	A
TETRAMAX: TEchnology TRAnsfer via Multinational Application eXperiments	H2020	2018-2021	1,152	3,937	A

National grants / specific support:

Project title	Grant	Total implementation period	Funds planned for RP in 2020 (CZK 1000)	Total funds planned for RP (CZK 1000)	Status (A-accepted, S-submitted, P-planned)
Designing and exploiting libraries of approximate circuits	GA CR	2019-2021	2,312	6,936	A
Automata for Decision Procedures and Verification	GA CR	2019-2021	1,846	5,538	A
CAQtuS: Computer-Aided Quantitative Synthesis	GA CR	2020-2022	2,070	6,210	A
Scalable Techniques for Analysis of Complex Properties of Computer Systems	GA CR	2020-2022	1,855	5,565	A
DEMOS - Possibilities for creation of community genealogical database with semantic information and uncertainty	TA CR	2018-2021	1,157	3,471	A
Integrated Platform for Analysis of Digital Data from Security Incidents-TARZAN	MIT	2017-2020	2,547	16,302	A
Security monitoring of ICS communication in the smart grid - BONNET	Ministry of the Interior CZ	2019-2022	3,679	11,195	A
Flexible probe for lawful interceptions - FlexProbe	Ministry of the Interior CZ	2019-2022	5,515	17,958	A
Advanced Methods of Nature-Inspired Optimisation and HPC Implementation for the Real-Life Applications	MEYS CZ – INTER COST	2018-2021	120	1,381	A
AuFoVer - Automated Formal Verification	TA CR	2019-2021	1,499	4,497	A
National Center of Competence for Cybersecurity	TA CR	2019-2020	8,034	16,068	A
Efficient Finite Automata for Automated Reasoning - ERC_CZ FINITING	Ministry of Education, Youth and Sports CZ	2020-2024	7,117	35,584	A
Survey and education of citizens of the Czech Republic in the field of biometrics	TA CR	2019-2021	1,002	2,480	A
Validated Data Storage	Ministry of Industry and Trade of the CZ	2019-2021	1,408	2,818	A

Contract research:

Project title	Contracting authority	Total implementation period	Funds planned for RP in 2020 (CZK 1000)	Total funds planned for RP (CZK 1000)	Status (C-contracted, N-negotiated, P-planned)
Research and Software Services	RedHat CZ	ongoing	1,560		C

Implementation and Debugging of Systems	Cesnet	ongoing	1,000		C
Electromobile charger	KPB Intra s.r.o.	2020	370	370	C
Acceleration of the DNS collector	CZ.NIC	ongoing	500		C