FM TUL

# STRATEGY OF R&D AT FM TUL TO 2025 WITH VIEW TO 2030+

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Document annexes:

- Research team development plans
- SWOT analysis

# 1. Introduction

## a. Mission

"We create, disseminate and apply knowledge in the fields of mechatronics, computer science and applied sciences, and pass this knowledge on to anyone who wants to learn more."

- FM is a faculty with a strong focus on the fields of mechatronics and information technology and selected areas at the interface of natural and technical sciences. FM is an integral and recognized part of the University.
- The FM continuously strives for a close interconnection of educational and related scientific, research, development and innovation, artistic or other creative activities (hereinafter referred to as "creative activities") in these areas and its activities contribute steadily to the development of TUL. Scientific research and innovation activities are an integral part of the activities of the FM staff.
- FM provides and coordinates research in the field of information technology, mechatronics and applied sciences in engineering, development of the region in the field of R&D and support for the development of new technologies in these areas. It is a strong and stable partner in the development of the region and the region in educational, research and social roles.
- FM plays an important role in the field of knowledge transfer to industrial practice, not only in the form of teaching in accordance with current knowledge of R&D, but also in the form of cooperation with important industrial entities not only in the Czech Republic.

## b. Tradition, directions of development, basis for scientific, research, development and innovation, artistic and other creative activities

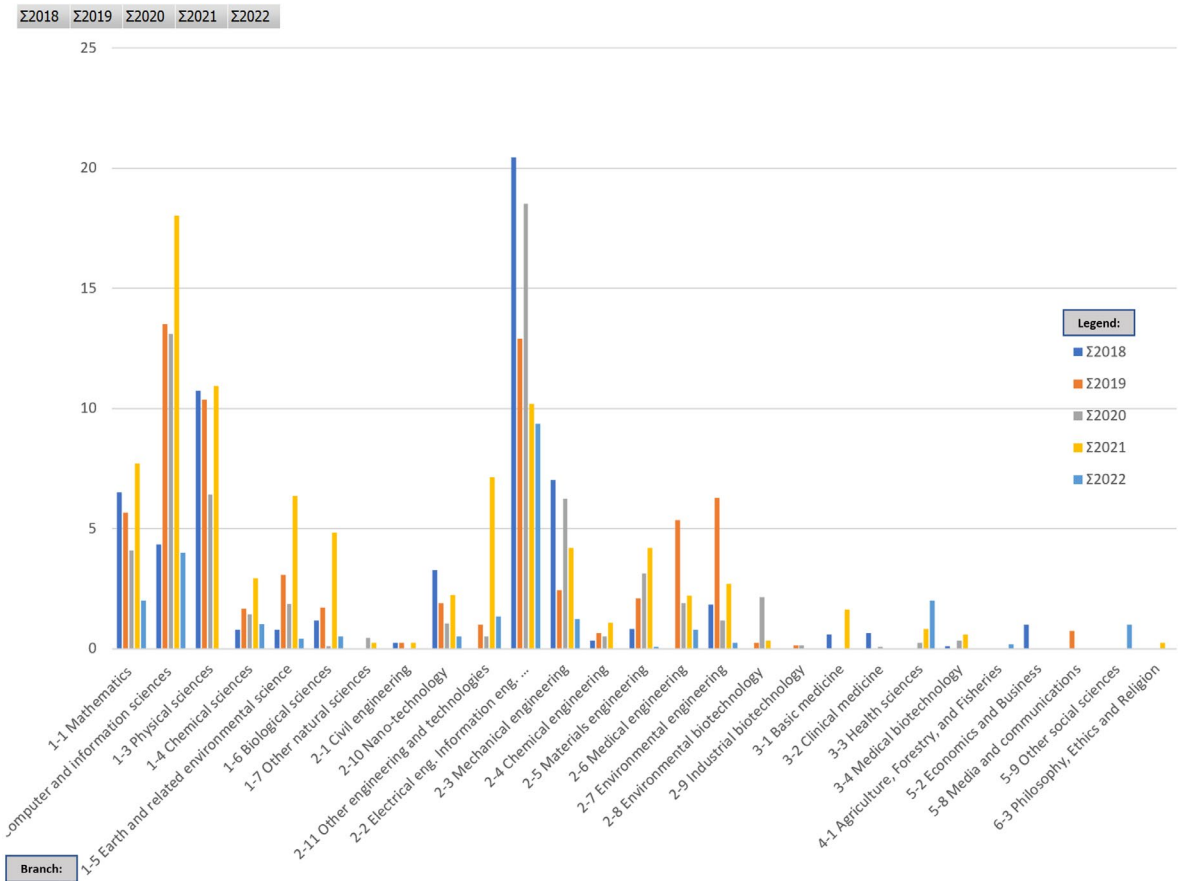
The Faculty of Mechatronics, Informatics and Interdisciplinary Studies was founded as a strongly interdisciplinary, scientific and engineering faculty, with close professional links to other parts of TUL. It has significantly contributed to the establishment of the Institute for Nanomaterials, Advanced Technologies and Innovations, not only through cooperation but also in terms of personnel. In addition to the traditional academic freedoms, these facts are also reflected in the structure of the results of the RDI in terms of FORD disciplines (see the following table and graph - including the actual contributions of the authors and with dedication to FM). Traditionally strong activities are in 1-1 Mathematics, 1-2 Computer Science and Informatics, 1-3 Physical Sciences and 2-2 Electrical, Electronic and Information Engineering and these disciplines will receive increased attention in the future with a view to strengthening the quality of outputs in the categories in which TUL is assessed under the M17+ methodology.

This strategy, in addition to the analyses of the evidence of the results of creative activities presented below, is also based on the results of discussions at meetings with the heads of individual FM teams, follows the Strategic Plan of Educational and Creative Activities of the Faculty of Mechatronics, Informatics and Interdisciplinary Studies of TUL for the years 2021-2025 and other Plans for the implementation of this Plan, and also follows the SWOT analysis, which is attached to this document.

The following table and graph shows the distribution of creative outputs by category of results; here we can see a significant proportion of outputs presented to the professional community in the context of professional conferences, i.e. papers in conference proceedings listed in the Scopus or Web of Science database. The second significant group is JI contributions, i.e. articles in journals listed in the Web of Science database; here the influence of the M17+ methodology is reflected and these publications will continue to be supported as a priority.

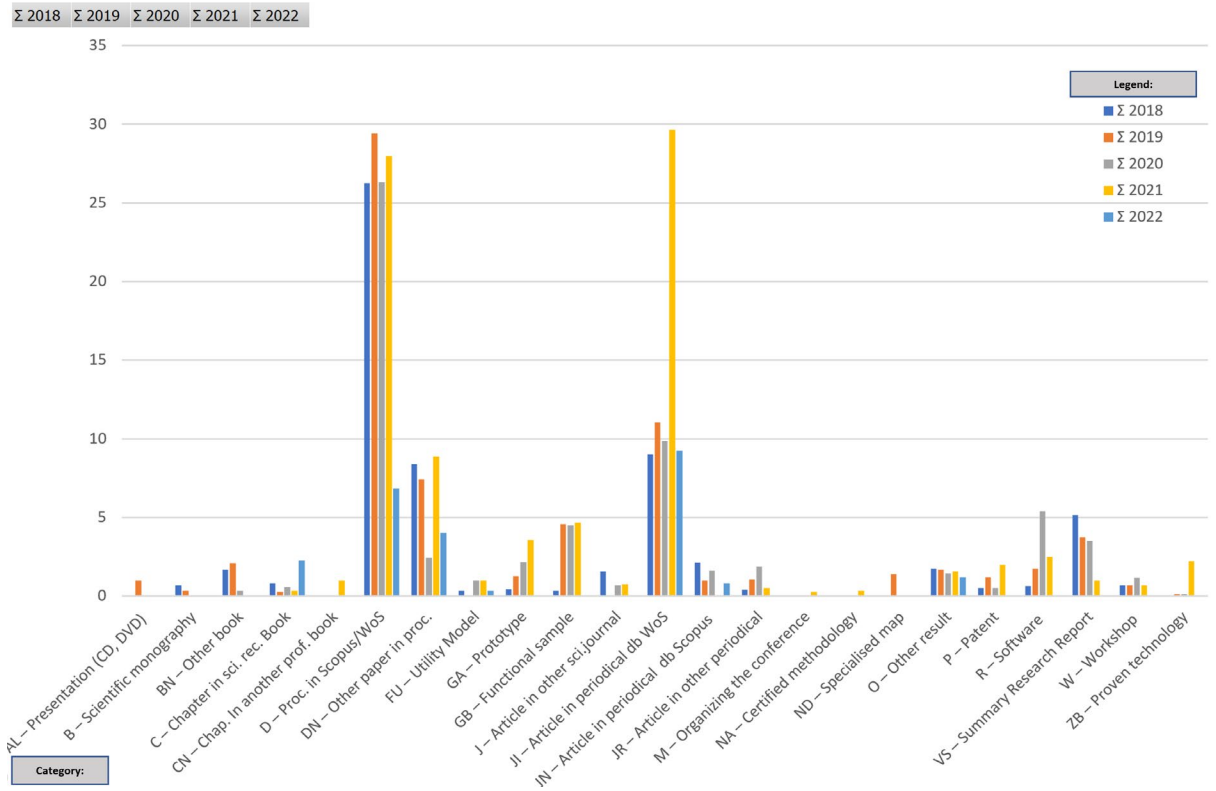
## Publication activity by FORD fields:

| Branch FORD | Σ 2018 | Σ 2019 | Σ 2020 | Σ 2021 | Σ 2022 |
|---|---|---|---|---|---|
| 1-1 mathematics | 6,5 | 5,66 | 4,08 | 7,7 | 2 |
| 1-2 computer science and inf. | 4,33 | 13,5 | 13,11 | 18,04 | 4 |
| 1-3 Physical Sciences | 10,75 | 10,37 | 6,41 | 10,95 | 0 |
| 1-4 Chemical Sciences | 0,81 | 1,67 | 1,44 | 2,93 | 1,02 |
| 1-5 Earth and life sciences | 0,81 | 3,07 | 1,86 | 6,37 | 0,42 |
| 1-6 biological sciences | 1,17 | 1,73 | 0,09 | 4,82 | 0,5 |
| 1-7 other natural sciences | 0 | 0 | 0,45 | 0,25 | 0 |
| 2-1 civil engineering | 0,25 | 0,25 | 0 | 0,25 | 0 |
| 2-10 nanotechnology | 3,27 | 1,89 | 1,06 | 2,23 | 0,5 |
| 2-11 other engineering and tech. | 0 | 1 | 0,5 | 7,15 | 1,33 |
| 2-2 electrical engineering, elec/inf inž. | 20,46 | 12,89 | 18,52 | 10,18 | 9,35 |
| 2-3 Mechanical Engineering | 7,03 | 2,43 | 6,24 | 4,19 | 1,23 |
| 2-4 chemical engineering | 0,33 | 0,66 | 0,5 | 1,08 | 0 |
| 2-5 materials engineering | 0,83 | 2,09 | 3,13 | 4,21 | 0,08 |
| 2-6 medical engineering | 0 | 5,36 | 1,9 | 2,2 | 0,79 |
| 2-7 environmental eng. | 1,82 | 6,27 | 1,16 | 2,71 | 0,25 |
| 2-8 environmental biotech. | 0 | 0,25 | 2,16 | 0,33 | 0 |
| 2-9 industrial biotechnology | 0 | 0,14 | 0,14 | 0 | 0 |
| 3-3 Health Sciences | 0 | 0 | 0,25 | 0,83 | 2 |
| 3-4 medical biotechnology | 0,11 | 0 | 0,33 | 0,6 | 0 |
| Total sum | 58,47 | 69,23 | 63,33 | 87,02 | 23,47 |



## Publication activity to date by result category:

| Category | Σ 2018 | Σ 2019 | Σ 2020 | Σ 2021 | Σ 2022 |
|---|---|---|---|---|---|
| AL - Presentations (CD, DVD) | 0 | 1 | 0 | 0 | 0 |
| B - Scientific monograph | 0,67 | 0,33 | 0 | 0 | 0 |
| BN - Other book | 1,67 | 2,08 | 0,33 | 0 | 0 |
| C - Chapter in the rec. book | 0,83 | 0,25 | 0,58 | 0,33 | 2,25 |
| CN - Chap. in another professional book | 0 | 0 | 0 | 1 | 0 |
| D - Proceedings in Scopus/WoS | 26,25 | 29,43 | 26,31 | 27,98 | 6,83 |
| DN - Other contribution in sb. | 8,38 | 7,41 | 2,45 | 8,88 | 4 |
| FU - Utility Model | 0,33 | 0 | 1 | 1 | 0,33 |
| GA - Prototype | 0,42 | 1,25 | 2,16 | 3,58 | 0 |
| GB - Functional sample | 0,35 | 4,56 | 4,49 | 4,67 | 0 |
| J - Article in another trade union. | 1,58 | 0 | 0,67 | 0,75 | 0 |
| JI - Article in periodical in db WoS | 8,99 | 11,03 | 9,87 | 29,64 | 9,24 |
| JN - Journal article in Scopus | 2,11 | 1 | 1,61 | 0 | 0,82 |
| JR - Article in other periodicals (rec.) | 0,4 | 1,05 | 1,87 | 0,5 | 0 |
| M - Conference organisation | 0 | 0 | 0 | 0,25 | 0 |
| NA - Certified Methodology | 0 | 0 | 0 | 0,33 | 0 |
| ND - Specialized map | 0 | 1,4 | 0 | 0 | 0 |
| O - Other result | 1,75 | 1,68 | 1,42 | 1,58 | 1,2 |
| P - Patent | 0,5 | 1,2 | 0,5 | 2 | 0 |
| R - Software | 0,66 | 1,76 | 5,38 | 2,5 | 0 |
| VS - Summary Research Report | 5,14 | 3,74 | 3,5 | 1 | 0 |
| W - Workshop | 0,67 | 0,67 | 1,17 | 0,67 | 0 |
| ZB - Proven technology | 0 | 0,14 | 0,13 | 2,23 | 0 |
| Total sum | 60,7 | 69,98 | 63,44 | 88,89 | 24,67 |



# 2. Vision in research, development, innovation

"FM's vision is to become a respected research institute, an attractive educational centre, a reliable technology partner and a pioneer of new ideas and technologies in the field of mechatronics, informatics and applied sciences."

In the period up to 2025 and then up to 2030, the Faculty aims to make significant progress in the following areas:

- FM is a respected faculty not only within the region but also internationally.
- The FM is a research faculty that achieves a standard level in its chosen specialisms, holding general expertise and knowledge in the 'core fields' of its operation. It trains PhD students in these areas, handles high-quality R&D projects and maintains active cooperation within TUL, the Czech Republic and abroad.
- The FM provides quality conditions for the work of its PhD students and researchers and visiting staff from foreign institutions.
- The faculty has made a disciplinary delimitation in science, research and applications in line with educational activities; it has adapted the organisation of R&D support, personnel policy and the structure of R&D at the faculty to the main disciplines and directions.
- The teams are creating a key knowledge portfolio of the fields, have made significant progress towards the European level in the intensity and quality of publishing, in the education of PhD students, in the staffing structure of the teams, international cooperation and projects (with emphasis on prestigious projects such as GACR, European research projects, etc.)
- Cooperation with industrial enterprises in the field of applied research is built to contribute to the development of the faculty and their key R&D areas; the legal and economic policy of both TUL and FM in terms of the management of intellectual property and work capacity is adapted to this goal.

# 3. Strategic areas of research, development, innovation

The Faculty's R&D strategic areas are divided into major and minor fields. The main field fulfils the conditions of the following definition:

- The field is staffed by at least five Ph.D. holders, of whom at least two meet the habilitation requirement (equivalent to doc/prof).
- A discipline includes the expertise of at least two standard teams (as defined in this document).
- The field is covered by an organisational unit whose budgeting includes explicit support for these teams.

Disciplines that do not meet these conditions are designated as minor disciplines.

In the programme period until 2025, the main R&D fields are:

- Technical Cybernetics - Mechatronics
- Technical Cybernetics - Computer Science and Electronics
- Applied Sciences in Engineering - Modelling

With a view to 2030, the following major industries are expected to become established:

- Applied Sciences in Engineering - Optics
- Applied Sciences in Engineering - Intelligent Materials

In the programming period until 2025, the following are minor fields:

- Environmental Engineering
- Nanotechnology

With a view to 2030, the faculty will support the activities of teams in promising areas of the main disciplines and will support the preparation and implementation of cross-cutting projects for staff with the same focus. These prospective areas include:

- Modern energy: green deal, renewables, energy storage, energy transformation
- Automation and artificial intelligence, autonomous secure mobile devices
- Expanding cooperation in applied research projects
- Greater promotion of Ph.D studies among Master's students.

# 4. Draft strategic measures

In the programming period until 2025, the FM supports the main fields of the RDI Strategy in a targeted manner so that they sufficiently fulfil the key qualitative and quantitative features of the definition of a main field (according to Chapter 3).

Interventions are needed in several areas to implement the measures. A key aspect is the existence and functioning of standard teams as defined, since the standard team is the basic unit of guaranteeing expertise in the R&D area on which it is primarily focused. It also serves as an incubator for new staff, new R&D topics and as staff support to the parent discipline.

The minimum parameters of a standard team are:

- A staff member with sufficient scientific erudition, with demonstrated ability to lead doctoral students and other team members, is habilitated or is expected to be habilitated within a maximum of three years.
- Intensive and high quality publication activity for the team: at least 2 publications Jimp quartile Q2 and above and 5 publications D at international conferences of generally recognized importance and quality by experts in the field within the last three years.
- Solving or co-solving at least one R&D project with a budget of more than CZK 4 million. CZK within the last five years.
- Supervision of at least one PhD student with a completed SDZ within the last five years.
- At least one Module 1 M17+ result with a grade of at least 3 in the last three years.

The following measures are related to ensuring the operation of the standard teams.

- Personnel:
  - Implementation of the Career Code and related guidelines for staff development and evaluation, and the TUL staffing strategy.
  - Updating of the rules for habilitation and appointment procedures - linking with the M17+ Methodology and career progression in the team system.
  - Introduction of rules to optimise the impact of recruiting own graduates into positions (so-called academic inbreeding).

- Organisational changes:
  - Development and implementation of rules for ensuring the activities of the teams in the funding of parent departments, or a proposal for intervention in the organizational structure of the faculty or its units.

- R&D:
  - Implementation of the rules for admission and funding of PhD students so that these rules preferentially support R&D majors and standard teams.
  - In the area of project applications, priority orientation to
    - individual projects, i.e. smaller and medium-sized projects that lead to greater motivation and responsibility of the researchers and to professional and personal development of team leaders,
    - participation in large projects as co-investigators or consortium members and long-term discussions creating the potential for larger interdisciplinary projects with a faculty centre.
  - Publication outputs (journals and conferences) specifically recommended by disciplinary councils.

- Cooperation with the application sphere:
  - Control of work capacity dedicated to commercially oriented projects where there is less contribution in terms of innovation and knowledge development.

- Internationalization:
  - Motivation and support for mobility projects (e.g. MOTUL, MSCA, etc.)
  - Active international cooperation with an institution or part of an institution in the field of R&D will only be understood as cooperation that is linked to an ongoing R&D project or regular outputs of at least one major publication per year.
  - The Faculty supports only those international collaborations that are active or have this perspective.

- R&D infrastructure development:
  - Funding for infrastructure development should primarily be addressed through regular and larger impact university projects. To this end, a forward planning system should be developed that takes into account simultaneously the needs of the main disciplines, research teams and the prospects for new research topics.

# 5. Research, development and innovation programmes

Below is the status of the main fields, i.e. the research areas they cover and their coverage by standard and other research teams in the programme period until 2025. The current status of these teams and plans for their current development are annexed to this document.

## Technical Cybernetics - Mechatronics

- Control and optimization
    - **Research in the field of automatic control and optimization (standard team)**, head doc. J. Hlava, main collaborators. L. Tůma,
        - Publication activity 2019-2021: 8xJI ( 2xQ2, 3xQ3, 2xQ4), 1x JN, 11xD.
        - The research team of the Automatic Control and Optimization Laboratory is engaged in applied research in the field of automatic control and continuous optimization of a very wide range of technical equipment, technological processes and systems. The goal of the research team is to become a recognised centre for the application of advanced control methods in the fields of energy, autonomous mobility and robotics with a stable base of projects and new PhD students. In the future, the collaboration with Helmholtz-Zentrum Dresden-Rossendorf and other partners of the TOMOCON project (Horizon2020) will be further expanded.

    - **Research in the field of reliability and risk assessment**, leader J. Kamenický, Ph.D., main collaborator: J. Zajíček, V. V. Zajíček, V. Pelantová, J. Mokrá:
        - Publication activity 2019-2021: 1xJI, 5xD.
        - A current topic in the field of safety is the probabilistic risk assessment of major industrial accidents and their socio-economic impact on the population in the potentially affected zone. The team in this area plans to (co)develop a methodology for the so-called PSA-3 studies around nuclear power plants and to localise the computational algorithms for the conditions of the Czech Republic. Another highly topical issue is the replacement of energy transport to European countries due to the collapse of established natural gas supply chains. The team intends to contribute to this issue by investigating the level of risk in the vicinity of existing pipelines when the transported medium is changed to, for example, a mixture of natural gas + hydrogen or pure hydrogen.

- Electrical Engineering
    - **Research in the field of electric drives and industrial automation**, leader: M. Diblík, main collaborators: D. Kajzr, T. M. Didzil, M. Dizl, M. Myslivec;
        - Publication activity 2019-2021: 6×GB, 4×JI, 1×P.
        - Continuation of RDI activities in the field of electric drives for special applications with a focus on robotics, autonomous electromobility, textile and single-purpose machines. In the same areas we focus on the development and application of control algorithms for industrial control systems using modern and innovative sw tools and approaches.

    - **Research in robotics, battery systems and emobility (standard team)**, leader: P.Jandura, main collaborators: doc. J. Černohorský, prof. M. Vojtíšek, L. Dittrich, P. Bílek, J. Eichler;
        - Publication activity 2019-2021: 2xJimp(1xQ1, 1xQ2), 18xD.
        - The research focuses on key activities in the area collectively referred to as Green-deal. These include e-mobility, energy storage (lithium batteries), traction electric drives and advanced control techniques, AC and DC charging systems, mobile and stationary, infrastructure, automotive electronics development, HW and FW. In the context of I4.0, other activities are focused

on robotics, collaborative robots, data acquisition and evaluation in the field of industrial automation.

- **Research in the field of power quality assessment (standard team)**, leader: L.Kukačka, main collaborators: J. Kraus, M. Novák, L. Slavik:
  - Publications 2019-2021: 6xJI, 12xD.
  - Research and development will be focused on energy measurement and monitoring, power quality, power factor compensation, and flicker. The aim is to develop methods for archiving, analysing and displaying smart grid data, electromagnetic compatibility measurements, metrology according to relevant standards; analysis and modelling of electromagnetic measuring elements. Last but not least, the research will focus on the assessment of the impact of reduced power quality on lighting systems and their subsequent impact on humans. Cooperation with KMB systems s.r.o. in the field of measurement and monitoring of power quality, and with Université Toulouse III Paul Sabatier (France), TU Dresden (Germany) and the Brno University of Technology, especially in the field of lighting systems, will be further intensified. The results of the research will be validated at semi-operational level.

## Technical Cybernetics - Computer Science and Electronics

- Computer speech, signal and image processing
  - **Speech processing research - Speechlab (standard team)**, headed by prof. J.Nouza, main collaborators: doc. P. Červa, J. Žďánský, L. Matějů, O. Smola;
    - Publication activity 2019-2021: 2xJimp (1xQ1, 1xQ2), 9xD.
    - Research focuses on speech recognition primarily in Slavic languages, computational linguistics, continuous algorithm improvement, and computational infrastructure for media content monitoring and recognition. The main goals until 2025 are to complete the dissertation of the current PhD student F. Kynych and to recruit one or two new PhD students, as well as to obtain another TACR project in collaboration with a company. By 2030, the goal is to recruit 1-2 PhDs into stable employment also as a replacement for Prof. Nouza + further professional growth of the team members including habilitation of Lukáš Matějů. In addition, it is necessary to establish cooperation with new industrial partners in other areas of machine learning, to expand the portfolio of languages provided and to increase the number of publications recognizable in the individual modules of the M17+ methodology.

  - **Research in the field of acoustic signal analysis and processing (standard team)**, leader prof. Z. Koldovský, main collaborators J. Málek, V. Kautský, J. Čmejla;
    - Publication activity 2019-2021: 7xJimp (4xD1, 2xQ2, 1xQ3), 10xD.
    - The research focuses on the analysis and processing of multidimensional signals by blind signal separation and leads, for example, to improvements in the processing and separation of speech signals. In the coming years until 2025, the main focus will be on the development of new algorithms for blind separation based on specially structured mixing models that are designed for specific applications.

  - **Research in the field of machine vision**, head doc. J. Chaloupka, main collaborator. Paleček;
    - Publications 2019-2021: 8xD.
    - The research is focused on image data processing and recognition and on the use of machine learning and artificial intelligence methods, especially artificial (convolutional) neural networks. Given the size and focus of the team, it is largely a technical expertise in the field of "vision" systems for the activities of other research teams. The bulk of the results are applied.

- Electronics
  - **Research in hardware design**, head M. Rozkovec, main collaborators: prof. Z. Plíva, J. Jeníček, J. Čech, prof. O. Novák, M. Holada, L. Petržílka;
    - Publication activity 2019-2021: 16xD, 8xJI.
    - The aim of the team is to develop applied research in the field of machine vision, artificial intelligence and custom circuit design in synergy with international and local industry - this involves processing multispectral and hyperspectral photography on specialized hardware. Other activities will focus on non-linear codes for integrated circuit testing, hardware implementation of optimized test vector decompressors. Activities in the area of printed circuit board technology will be more focused on 3D printed circuits and in general on Printed Electronics (AME); close cooperation with Nanodimension in this area is to be established, and in 2023-24 to discuss the integration of FM into the "James" structure (in the form of partnerships) and to establish cooperation with other AME partners at this level.

- Informatics
  - **Research in Applied Informatics**, head J. Vraný, main collaborators L. Kosková Třísková, I. Kopetschke, doc. P. Satrapa, M. Volf, J. Hybš, T. Blažek, J. Kolaja, J. Kolaja Ehlerová;
    - Publication activity 2019-2021: 5xGB, 2xR, 2xBN, 3xD, 2xVS, 2xDN.
    - The team's long-term professional goal is to develop safe, sustainable and intelligent applications. In the coming years, the main research focus will be on Edge AI. In particular, the area of applications and systems for embedded devices, addressed in the acquired Horizon 4 / ECSEL-JU project. Within this project we will investigate the sustainability of applications and the possibilities of using machine learning methods on end devices. We will strive to deepen collaboration with ESA, UTIA CAS and other research teams as well as with existing industrial partners (IMA, Entry Engineering). We are continuously working on finding further opportunities to engage in international R&D projects.
  - **Research in software engineering and datamining**, leader M. Lamr, main collaborators: P. Svoboda, R. Špánek, P. Tyl, J. Vitvarová;
    - Publication activity 2019-2021: Jimp (6×Q1 + 4×Q2 + 4×Q3), 5×D.
    - The team's activities are focused on extracting knowledge and hidden dependencies from data, software development, web engineering, database systems, big data analysis and processing, analysis and design of IoT solutions for industry. Collaboration with the Liberec City Police or the Chief Prevention Officer for the Liberec Region on applications for crime data analysis. The team is addressing the preparation of TACR's Predicting Student Success project and research in the area of data-driven processes, e.g. data-driven decision-making in university or police environments (Data Driven Police or Data Driven University). Key partners include the Association of Driving Schools of the Czech Republic, and collaboration with the Road Safety Team and OLTIS Group is in the pipeline.

## Applied Sciences in Engineering - Modelling

- Modelling of coupled processes
    - **Research in the field of computation of coupled processes (standard team)**, leader: doc. J. Březina, main collaborators: doc. J. Stebel, P. Exner, M. Špetlík, D.Flanderka, R. Srb;
        - Publication activity 2019-2021: 2xQ3.
        - Research in the area of computation of coupled processes is primarily focused on mathematical models and software tools for computation of coupled processes in hydrogeology and geology with a focus on explicit description of fractures, stochastic description of fractures and homogenization of porous medium parameters. Links with application and research institutions will be strengthened in these areas.

    - **Research in the field of fluid mechanics and elastic bodies (standard team)**, leader: doc. P. Šidlof, main collaborators: M. Štěpán, M. Lasota, P. Tisovská;
        - Publication activity 2019-2021: 4x Jimp (3x Q2, 1x Q3), approx. 10x D.
        - The research will focus on fluid mechanics and elastic bodies - interaction of flow with elastic bodies, coupled problems, aeroelastic instability of airfoils and blade grids in turbines and compressors, biomechanics of human voice, pneumatic transport, multiphase flow. Closer cooperation will be established with the Institutes of the CAS, and with major centres abroad (Duke University N.C. USA, Ontario Tech University, FAU Erlangen and TU Graz.

- Computational mechanics
    - **Research in computational mechanics and biomechanics,** leader: P. Henyš,
        - Publication activity 2019-2021: 13 Jimp (5Q1 + 6Q2 + 2Q3)
        - The research is focused on bone tissue remodelling, and a cooperation with the Forensic Institute in Hamburg (UKE) has been established, which will supply the necessary clinical data (CT scans and other information). Furthermore, a collaboration with the University of Graz has been established in the field of anatomical and morphological integrity analysis of digital bone models. In the following period, the issue of random stochastic bone models (influence of ageing, gender, osteoporosis and drugs) will be addressed with the LFHK and the UK in order to replace the costly experimental tests (phase III) in the FDA/EMA certification process with a digital model.

For those fields that are expected to meet the conditions for inclusion as majors by 2030, the current status and outlook is as follows.

## Applied Sciences in Engineering - Optics

- **Research in the field of optical measurement methods (standard team)**, leader P.Psota, collaborators: V. Lédl, J. Kredba, M. Stašík,M. Mach;
  - Publication activity 2019-2021: 9xJimp (2xQ1, 4xQ2, 3xQ3), 7xD, 1xZtech, 1xFuzit, 1xGB.
  - The team's research activities are focused on the development of coherent measurement techniques, laser interferometry and digital holography. A one-way interferometric method for supersonic flow measurements will be developed to enable compact and simple measurements in aerodynamic laboratories, and a complete interferometric gauge for measuring the shape of optical elements will be developed to meet all the requirements of operation in an optical workshop and introduced into optical production (e.g. at aspericon cz).

## Applied Sciences in Engineering - Intelligent Materials

- **Research in the field of intelligent materials and structures (standard team)**, leader prof. P. Mokrý, collaborators: K. Steiger, P. Márton, M. Černík, J. Nečásek, J. Václavík, M.Mach, V. Lindauer;
  - Publication activity 2019-2021: 6xD, 5xJI.
  - Materials research is focused on the physics of dielectric, piezoelectric and ferroelectric materials; the study of semiconductor properties and domain phenomena in ferroelectric materials; and thermodynamics of ferroelectric materials, and related to this, the development of mathematical models describing physical phenomena in advanced dielectric materials; the development of mathematical models describing devices using ferroelectric materials, such as DRAM and FeRAM memory elements, or electric field-effect transistors. Other activities include the study of optical wave propagation in nonlinear optical materials; the interaction of optical materials with electric fields and mechanical stresses; and the research and development of optical methods for 3D imaging of domain walls in ferroelectric single crystals using digital holographic interferometry and digital holographic tomography. Finally, research is being conducted on methods for electronic control of acoustic and mechanical impedances and the use of metamaterials for active sound field control and for suppression of vibration transmission in optical systems. Key partners include the TOPTEC section of the CAS, FÚ AV ČR; the Department of Materials Science and Engineering, FNS, Norwegian University of Science of Technology (NTNU) and FSE, University of Limerick, Ireland.

# 6. Related documents, provision and implementation of the Strategy

The RDI strategy of the TUL FM, presented in this document, further elaborates the Strategic Plan of Educational and Creative Activities (hereinafter referred to as the "Strategic Plan") of the FM for the years 2021-2025, which is based on the Strategic Plan of the Ministry of Education and Science for the field of higher education for the period from 2021, is also in line with the Strategic Plan of Educational and Creative Activities and the Internationalization Strategy of the TUL for the period 2021 to 2025, with a view to 2030. Further background for this strategy is also the Innovation Strategy of the Czech Republic 2019-2030, the National Research and Innovation Strategy for Smart Specialisation of the Czech Republic 2021-2027, the National Policy on Research, Development and Innovation of the Czech Republic 2021+, Horizon Europe - 9th Framework Programme 2021-2027, the National RIS3 Strategy 2021-2027 and the corresponding regional documents. The activities of the FM will undoubtedly be shaped by the current M2017+ Evaluation Methodology, especially with regard to improving the quality of results leading to the evaluation of TUL for the next period.

In particular, the following financial resources are expected to be used to deliver this RDI Strategy:

● Contribution and subsidies from the state budget.

● Operational programmes.

● GACR, TACR projects, projects announced by ministries of the Czech Republic and other sources.

● University Infrastructure Development Investment Programme and Institutional Plan.

● TUL/FM's own resources.

● Foreign programmes and other programmes and funds.

The presented Strategy of the RDI FM TUL presents the current results of negotiations on the future direction of the FM; these negotiations have been ongoing since February 2022 and reflect the process of discussions on the structure of the RDI within the Faculty, in the context of cooperation with other components and external entities. As a result, an outline of the measures through which this Strategy will be implemented has been developed. During 2023 and subsequently by mid-2024, an ongoing evaluation of the implementation of the Strategy will take place so that this document can be updated, if necessary, not only in the context of the election of the Dean of the FM for the next term, but also in view of the next MEP evaluation. Indicators for the evaluation of the implementation of the Strategic Plan:

- Number of habilitated staff in the period under review.
- Publication activities of teams in the context of FM.
- The degree to which each team's goals are met.
- Number of standard teams in 2025.
- Number of majors.
- Number of submitted and successful R&D project applications.

Further steps will be part of the measures to implement the Strategy:

- Supporting the teams by distributing Bachelor Thesis, Diploma Thesis, Distation Thesis topics among students and establishing rules for priority approval of topics.
- Staff training for improvement.
    - the success rate of individual project submissions e.g. GACR, TACR, ERC, MSCA and
    - Ability to participate in larger projects and consortia, to seek information and contacts.
- Long-term discussion of potential content of large interdisciplinary projects with faculty teams.
- Further improving the work of the Grants Support Unit.
- Priority targeting of dedicated university support to core disciplines and emerging core disciplines through support for standard teams and emerging standard teams.
- Directing HR support (intake of new hires) to standard teams and established standard teams.

# 7. Authors

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**Abbreviations used:**

| | |
|---|---|
| FM | Faculty of Mechatronics, informatics and interdisciplinary studies |
| GACR | Grant agency of Czech republic |
| RDI | Research, Development and Innovation |
| TACR | Technology Agency of the Czech Republic |
| TUL | Technical university of Liberec |

# Annex of Strategy of R&D FM TUL until 2025 with a view to 2030+

# Research team development plans

## 1. Research Technical Cybernetics - Mechatronics

- Control and optimization
    - **Research in the field of automatic control and optimization (standard team)**, head assoc.prof. J. Hlava, main collaborators. L. Tůma.
        - Publication activity 2019-2021: 8xJI ( 2xQ2, 3xQ3, 2xQ4), 1x JN, 11xD
        - Main objectives by 2025:
            - Completion of thesis: Moezzi, Vedel
            - Opening of the habilitation (Hubka) and professorship (Hlava) proceedings
            - Admission of 1-2 PhD students
            - Acquisition of new applied research projects and collaboration with the commercial sector within the team's area of expertise
            - Publication activity IFAC/IEEE international conferences, impacted journals Q1 to Q3
        - Expectation to 2030:
            - Acquisition of other projects (TAČR or suitable international projects)
            - Recruitment of at least one additional PhD student

    - **Research in the field of reliability and risk assessment**, leader J. Kamenický, Ph.D., main collaborator: J. Zajíček, V. V. Zajíček, V. Pelantová, J. Mokrá.
        - Publication activity 2019-2021: 1xJI, 5xD
        - Inputs to Module 1 of the M17+ Methodology (grades): 1x4
        - Main objectives by 2025:
            - Opening of habilitation proceedings of Dr. Pelantová
            - retention of existing customers + expansion of services offered
            - personnel strengthening of the team
        - Expectation to 2030:
            - stabilisation of the number of students in the IT-IL specialisation
            - regular publications in Jimp (1xyear)

- Electrical Engineering
    - **Research in the field of electric drives and industrial automation**, head: L. Beran, main collaborators: M. Diblík, D. Kajzr, T. Myslivec.
        - Priority objectives:
            - complementary activities in cooperation with industrial partners
            - participation in projects in line with your specialisation
            - functional samples/models, machine control software, electrical documentation

- **Research in robotics, battery systems and emobility (standard team)**, leader: P. Jandura, main collaborators: assoc.prof. J. Černohorský, prof. M. Vojtíšek, L. Dittrich, P. Bílek, J. Eichler.
  - Publication activity 2019-2021: 2xJimp(1xQ1, 1xQ2), 18xD
  - Entries to Module 1 of the M17+ Methodology (grades): 1x2(2021)
  - Main objectives by 2025:
    - Completion of dissertation: Mach, Krčmář
    - Habilitation proceedings P. Jandura
    - Stabilization of 2 new PhD students admitted (2022)
    - New project of TAČR, cooperation on GAČR, OP JAK and OP TAK
  - Expectation to 2030:
    - Stabilization of the average annual publication activity to at least 1 article in Q1/Q2 rated journals and one output for Module 1 in two years
    - Recruitment of 1 PhD into a stable employment relationship + further professional growth
    - Obtaining stable funding for PhD students and postdocs

- **Research in the field of power quality assessment (standard team)**, leader: L. Kukačka, main collaborators: J. Kraus, M. Novák, L. Slavik.
  - Publications 2019-2021:
  - Inputs to Module 1 of the M17+ Methodology (grades):
  - Main objectives by 2025:
    - Admission of 1-3 PhD students
    - Habilitation of Miroslav Novák
    - Regular publishing activities in the range of 1-2 times a year conferences, 1x journal publication Q1 level
    - Intake of foreign trainees
    - Cooperation with commercial partner KMB systems s.r.o.
    - International cooperation (internships, joint publications): Université Toulouse III (France), TU Dresden (Germany)
  - Expectation to 2030:
    - semi-operational results
    - developing international cooperation (submitting joint projects)
    - search for new commercial partners
    - Habilitation of Leoš Kukačka

## 2. Research Direction Technical Cybernetics - Computer Science and Electronics

- Computer speech, signal and image processing
    - **Speech processing research - Speechlab (standard team)**, headed by prof. J. Nouza, main collaborators: assoc.prof. P. Červa, J. Žďánský, L. Matějů, O. Smola.
        - Publication activity 2019-2021: 2xJimp (1xQ1, 1xQ2), 9xD
        - Entries to Module 1 of the M17+ Methodology (grades): 1x2 (2018), 1x3 (2021)
        - Main objectives by 2025:
            - Completion of thesis: Kynych
            - Habilitation proceedings J. Málek
            - Admission of 1-2 PhD students
            - New project of TAČR
        - Expectation to 2030:
            - Recruitment of 1-2 PhDs into a stable employment relationship and as a replacement for Prof. Nouza + further professional growth
            - Habilitation proceedings of L. Matějů
            - Establishing collaboration with new industry partners in other areas of machine learning
            - Increase in journal publications, one output for Module 1 every two years

    - **Research in the field of acoustic signal analysis and processing (standard team)**, leader prof. Z. Koldovský, main collaborators J. Málek, V. Kautský, J. Čmejla.
        - Publication activity 2019-2021: 7xJimp (4xD1, 2xQ2, 1xQ3), 10xD
        - Entries for Module 1 of the M17+ Methodology (grades): 2x2 (2019), 1 (2020), 3 (2021)
        - Main objectives by 2025:
            - Completion of dissertation: Janský, Čmejla
            - Habilitation proceedings of J. Malek
            - Admission of 1-2 PhD students
            - New project of GAČR, NSF or ONR Global, cooperation at TAČR
        - Expectation to 2030:
            - Stabilization of the average annual publication activity to at least 2 articles in IEEE Q1-Q2 journals and one output for Module 1 in 2yrs
            - Acceptance of 1-2 PhDs into a stable employment relationship + further professional growth
            - Obtaining stable funding for PhD students and postdocs

    - **Research in the field of machine vision**, head assoc.prof. J. Chaloupka, main collaborator. Paleček.
        - Publications 2019-2021: 8xD
        - Entries to Module 1 of the M17+ Methodology (grades): 3 (2021)
        - Main objectives by 2025:
            - D publications at prestigious international conferences, publications in Q1-Q2 journal
            - Admission of 1-2 PhD students
            - New project of TAČR, cooperation at TAČR
        - Expectation to 2030:
            - Habilitation proceedings - K. Paleček
            - Appointed Professor - J. Chaloupka
            - Recruitment of 1 PhD into a stable employment relationship + further professional growth
              Obtaining stable funding for PhD students and postdocs

- Electronics
  - **Research in hardware design**, head M. Rozkovec, main collaborators: prof. Z. Plíva, J. Jeníček, J. Čech, prof. O. Novák, M. Holada, L. Petržílka.
    - Main objectives by 2025:
      - Completion of dissertation J. Čech, habilitation M. Rozkovec
      - Report patents in Module 1 M17+
      - After ITMA 2023 journal articles on patented technologies
      - Continued cooperation with Rieter CZ s.r.o. on cotton quality sensors
      - Deepening of inter-laboratory cooperation with K. Palecek
    - Expectation to 2030:
      - Continued cooperation with Rieter CZ s.r.o.
      - Establishment of cooperation with Université Grenoble Alpes in the form of a postdoc internship on HW development and image analysis for space applications
      - Establishing cooperation with CSO and commercial entities on the topic of HW development and image analysis for space applications

- Informatics
  - **Research in Applied Informatics**, head J. Vraný, main collaborators L. Kosková Třísková, I. Kopetschke, assoc.prof. P. Satrapa, M. Volf, J. Hybš, T. Blažek, J. Kolaja, J. Kolaja Ehlerová.
    - Publication activity 2019-2021: 5xGB, 2xR, 2xBN, 3xD, 2xVS, 2xDN
    - PhD students 2017-2021: 2x defended dissertation - P. Ječmen, Lenka Kosková Třísková
    - Entries for Module 1 of the M17+ Methodology (grades): 1xR 2020 (3)
    - Main objectives by 2025:
      - Thesis defence: M. Křepelka
      - Composition of SDZ: L. Mázl, M. Blažek
      - Cooperation on projects OP TAK, OP PIK, TAČR, Horizon-KDT-JU
    - Expectation to 2030:
      - Stabilization of the average annual publication activity to at least 1 single output for Module 1 in two years
      - Obtaining additional funding from projects to stabilize the team
      - Participation in international research projects
  - **Research in software engineering and datamining**, leader M. Lamr, main collaborators: P. Svoboda, R. Špánek, P. Tyl, J. Vitvarová.
    - Main objectives by 2025:
      - to implement TAČR requests
    - Expectation to 2030:
      - publications at international conferences (Scopus, WOS)
      - foreign journal articles

# 3. Research Direction Applied Sciences in Engineering - Modelling

- Modelling of coupled processes
  - **Research in the field of computation of coupled processes (standard team)**, leader: assoc.prof. J. Březina, main collaborators: assoc.prof. J. Stebel, P. Exner, M. Špetlík, D. Flanderka, R. Srb.
    - Publication activity 2019-2021: 2xQ3
    - Entries to Module 1 of the M17+ Methodology (grades): 2x2 (2018, 2019)
    - Main objectives by 2025:
      - more precise definition of the team, evidence of results
      - Dissertation Špetlík (2024)
      - Completion of the Endrse TAČR project (2022)
      - Completion of the EURAD project (2023)
      - publications from projects: 6x IMP (2023, 2024)
      - obtaining at least one major project (also necessary for funding PhD students)
      - min 1 new PhD student
      - continuing applied research for repositories
      - Beginning to collaborate on continuous hydrological models and incorporating uncertainties
    - Expectation to 2030:
      - Collaboration and problem solving using multiphysics, multiscale and stochastic calculations for poroelasticity and transport processes in at least three application areas: storage, hydrology, composite materials;

  - **Research in the field of fluid mechanics and elastic bodies (standard team)**, leader: assoc.prof. P. Šidlof, main collaborators: M. Štěpán, M. Lasota, P. Tisovská.
    - Publication activity 2019-2021: 4x Jimp (3x Q2, 1x Q3), approx. 10x D
    - Main objectives by 2025:
      - defence of the dissertation V. Vomáček, and in case of return from maternity leave also Petra Tisovská
      - admission of 1-2 PhD students
      - new projects of GAČR, Inter-Excellence, Horizon or TAČR
      - acceptance of one postdoc
    - Expectation to 2030:
      - maintain a close link between research and teaching in the Master and the Doctoral Study programs of AVI
      - stabilise the workload and funding of the team so that it is not subject to sharp annual fluctuations
      - Deepen active international cooperation (Duke University N.C. USA, Ontario Tech University, FAU Erlangen, TU Graz)

- Computational mechanics
    - **Research in computational mechanics and biomechanics,** leader: P. Henyš.
        - Publication activity 2019-2021: 13 Jimp (5Q1 + 6Q2 + 2Q3)
        - Main objectives by 2025:
            - Completion of dissertation: Gleb Pokatilov
            - Admission of 1-2 PhD students
            - New project of GAČR, TAČR or OP JAK
        - Expectation to 2030:
            - Stabilization of average annual publication activity to at least 2 articles in Mechanics/Biomechanics Q1-Q2 journals and one output for Module 1 in two years
            - Acceptance of 1-2 PhDs into a stable employment relationship + further professional growth
            - Obtaining stable funding for PhD students and postdocs

For those fields that are expected to meet the conditions for inclusion as majors by 2030, the current status and Expectation is as follows.

## 4. Research Direction Applied Sciences in Engineering - Optics

- **Research in the field of optical measurement methods (standard team)**, leader P. Psota, collaborators: V. Lédl, J. Kredba, M. Stašík,M. Development of coherent measurement techniques, laser interferometry and digital holography;
    - Publication activity 2019-2021: 9xJimp (2xQ1, 4xQ2, 3xQ3), 7xD, 1xProvTech, 1xFsamp, 1xGB
    - Main objectives by 2025:
        - Habilitation: P. Psota
        - Defence of PhD: F.Kaván, M.Stašík, J. Kredba
        - Admission of one PhD student
        - New project of GAČR, TAČR or other provider (MIT,...)
    - Expectation to 2030:
        - Stabilization of the average annual publication activity to at least 2 articles in Q1-Q2 journals in three years.
        - Recruitment of 1-2 PhDs into a stable employment relationship
        - Obtaining stable funding for PhD students and postdocs
        - Habilitation of V. Lédl

# 5. Research Direction Applied Sciences in Engineering - Intelligent Materials

- **Research in the field of intelligent materials and structures (standard team)**, leader prof. P. Mokrý, collaborators: K. Steiger, P. Márton, M. Černík, J. Nečásek, J. Václavík, M. Mach., V. Lindauer. Specialization:
- The mission of the Laboratory of Intelligent Materials and Structures (LIMS) is to push the frontiers of knowledge in the field of advanced dielectric materials and to find applications for them in a wide range of devices, technologies and scientific fields.
- The key activities of LIMS include:
    - Materials research focused on the physics of dielectric, piezoelectric and ferroelectric materials; the study of semiconductor properties and domain phenomena in ferroelectric materials; and the thermodynamics of ferroelectric materials;
    - Creation of mathematical models describing physical phenomena in advanced dielectric materials; creation of mathematical models describing devices using ferroelectric materials such as DRAM and FeRAM memory elements or electric field-effect transistors.
    - Study of optical wave propagation in nonlinear optical materials; interaction of optical materials with electric field and mechanical stress; research and development of optical methods for 3D imaging of domain walls in ferroelectric single crystals using digital holographic interferometry and digital holographic tomography.
    - Basic research on active acoustic metamaterials and metasurfaces based on the use of piezoelectric materials; in particular, research on methods of electronic control of acoustic and mechanical impedances and the use of metamaterials for active sound field control and for suppression of vibration transmission in optical systems.
    - Study of the role of piezoelectric materials in biological systems and application of piezoelectric materials in biomedical applications.
    - Key partners of LIMS include TOPTEC Section, Institute of Plasma Physics, CAS; Department of Dielectrics, Section of Condensed Matter Physics, Institute of Physics, CAS; Department of Materials Science and Engineering, Faculty of Natural Sciences, Norwegian University of Science of Technology (NTNU), Trondheim, Norway; Faculty of Science and Engineering, University of Limerick, Ireland.
    - Publication activity: team members are authors of 78 articles with TUL affiliation (49 of them in journals with IF)
    - Main objectives by 2025:
        - Defence of PhD: M. Mach, V. Lindauer
        - Habilitation: P. Márton
        - New GACR project, H2020 MSCA
        - Admission of 2 new PhD students
        - Involvement of the team in active long-term international cooperation
    - Expectation to 2030
        - Habilitation: J. Václavík
        - Long-term financial security of the team through long-term projects in basic research

# Annex of Strategy of R&D FM TUL until 2025 with a view to 2030+

## SWOT analysis

*The points of the SWOT analysis quoted below contain all the collected opinions of individual FM staff members, these comments were obtained as a basis for the preparation of the R&D Strategy document at the Faculty of Mechatronics, Informatics and Interdisciplinary Studies of TUL and were only formally edited or concentrated in the case of the same comments. This analysis follows the SWOT analysis compiled during the preparation of the Strategic Plan of Educational and Creative Activities of the Faculty of Mechatronics, Informatics and Interdisciplinary Studies of TUL for 2021-2025.*

### *Strengths*

- Relatively high success rate in smaller projects.
- Teams focused on basic and applied research and the potential to address these topics.
- Free choice of topics.
- Experience with the application of automatic control methods in a number of very different application areas.
- Great flexibility in the choice of objectives of modern management methods, which allows participation in projects focused on current topics (energy optimization, smart grids, electromobility, etc.).
- Availability of excellent software facilities.
- Close cooperation with the CAS and a diverse range of PhD studies.
- Thanks to the interdisciplinary focus of the faculty, the opportunity to assemble a comprehensive team.
- Good reputation of the faculty among potential Ph.D. students.

### *Weaknesses*

- The project teams do not have a long-term research vision that would allow them to profit from long-term projects that would enable long-term stability of research.
- Research teams are mainly focused on applied research and do not define their vision in the field of basic research, which limits their ability to successfully apply for basic research projects.
- Relatively small team size or fragmentation.
- Lack of contacts to industry partners who are willing to participate in project submissions.
- The quality of R&D results assessed under M17+ lags behind.
- Insufficient support and motivation for Ph.D. students to complete their studies.

## *Opportunities*

- The existence of current research topics, e.g. electricity storage, gas storage, electromobility, artificial intelligence, Smart technologies, etc., fall within the expertise of the research teams at FM.
- Current emphasis on green energy or transport and related upcoming project calls. The demands for optimisation and management and the need for methods from these fields are clearly higher in the use of renewable energy than in the conventional energy sector.
- Willingness of research teams at TUL to collaborate with the FM and thus enable the involvement of FM teams in large long-term projects.
- Growing interest of foreign students in Mechatronics studies; this creates a certain chance to attract motivated foreign students who can then go on to pursue a DSP.
- Opening of the Master's degree in Information Technology in English.
- Further development of active international cooperation (USA, Argentina, Germany).
- Expanding cooperation in applied research projects.
- Implementation of a unifying project, for workers with the same focus.
- Greater promotion of Ph.D studies among Master's students.

## *Threats*

- The outflow of other faculty personalities and entire research topics to research centers. Transfer of selected topics to research centres, e.g. CxI and Toptec, unequal opportunities in terms of administration, opportunities, equipment and salaries.
- Competition from research teams at other TUL units working on similar topics.
- Separatism of individual teams, fragmentation of time/work activities.
- The current problematic situation in obtaining projects for the next years and longer solution periods.
- Lack of people interested in studying for a PhD, or engaging in R&D.
- Declining number of PhD graduates in post-doctoral positions - weakening of teams.
- The departure of skilled workers to the private sector for financial reasons.