Bánki Donát Faculty of Mechanical Engineering

Institute of Mechanical Engineering and Safety Techniques

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Head of Institute: **dr. Sándor Horváth**

1 Introduction

The first predecessor of the Institute of Mechanical Engineering and Safety Techniques was the **Technical Department** which was established **on October 1, 1962** simultaneously with the Mechanical Polytechnic. A year later the name of the department was changed to the **Department of Technical Basics,** then in 1990 it was renamed **Machine Construction Department.** From the beginning to 1981 the department was headed by Professor dr. Ferenc Selmeczi while between 1981 and 1999 Professor dr Csaba Kósa was the head of department. **The Institute of Mechanical Engineering and Safety Techniques** was set up at the same time as Budapest Tech Polytechnical Institution so that it would continue the old traditions, however, its educational profile had substantially been extended if compared to the former institute.

The main activities of the Institute include the education of basics of sciences as well as foundational technical subjects (Physics, Chemistry, Mechanics, Drawing and Design of Mechanical Components, Communication in Engineering). Security Engineering subjects (Safety at Work, Security Engineering, Ergonomics) are taught in every specialisation. In addition, the Institute is the home institute for Machine Construction and Design Specification of the Faculty of Mechanical Engineering and co-ordinates the Security Engineering and the Military and Security Engineering BSc courses.

The total **headcounts** for the Institute is 24 people: 19 teachers, 4 institutional engineers and 1 assistant.

Seven teachers have acquired **scientific degrees**, four of them have already qualified as lecturers. One of our teachers is just preparing for his habilitation.

There are five PhD students at the department. Our aim is to reach 50% of the special **qualification ratio** by 2008.

The Institute is equipped with **4 laboratories** (Laboratory of Physics-Chemistry, Laboratory of Mechanics-Machine Construction, Laboratory of Security Engineering, Laboratory of Ergonomics) which contribute a great deal to hands-on training.

2 Educational Profile

The Institute is responsible for the **Military and Security Engineering Basic Course** as well as for the **Machine Constructor-Designer Specialisation** in the Faculty of Mechanical Engineering.

At Budapest Tech **the objective of the civilian basic course in Military and Security Engineering** is to provide professional training for security engineers in compliance with the general objectives of engineering training and provide a good foundation in science, technology, economics, organisation and law which will enable the students

- to identify, solve and deal with technical (electrotechnical or mechanical) and organisational problems regarding property and intruder alarm systems,
- to provide instant assistance in the event of fire or industrial accidents,
- to contribute to data security and data protection, etc.

Besides the basic technical subjects the following subjects are instructed among the others: Psychology, Law, Insurance, Fire Security, Security Engineering for Machines, Architecture, Civil Engineering, Civil Defense, Policing, Crisis Management, Security Systems, Property Defence-Weapons and Security Systems for Machines.

The Specialisation for Machine Design and Construction aims to train mechanical engineers who are supposed to have a solid grounding in theories of natural sciences and technology and who would like to gain substantial practical experience and be in possession of creative desinging skills. Due to the application of modern materials, technologies and construction, the students of this specification are expected to learn how to cope with projects involving modernisation, development and design.

The Institute of Mechanical Engineering and Safety Techniques instructs the following subjects for the Specialisation for Machine Design and Construction: CAD Technics, Machine Construction, Construction Analysis, Theory of Design, Theory of Mechanisms.

In addition to the above-mentioned courses the teachers belonging to the Institute instruct the following subjects in the three basic engineering courses (Mechanical Engineering, Mechatronics Engineering, Military and Security Engineering) as well as in the Mechanical Engineering Assistant Training courses: Communication in Engineering, Mechanical Components, Mechanics in Engineering, Physics, Chemistry, Safety at Work, Ergonomics and Ethics in Engineering. The Institute also provides engineering basic courses for Technical Management Training.

Owing to the co-operative courses, manufacturing plants and companies provide practical trainings for a great number of security engineering students, therefore they are enabled to gather hands-on experience, moreover to make preparations for their theses based on their practical experiences on the premises.

The Specialisation for Security Organisation also means a relevant field in the education of the Institute, in which 183 degrees have been issued so far. Furthermore, the Institute has organised advanced courses and examinations which have been completed by more than a thousand students who therefore have obtained OKJ certifications in Security Organisation.

3 Research and Development

The main fields of Research and Development in the Institute include the following:

3.1 Development and test of characterization technique of surface microtopography, focusing on filtering and waviness (Project leader: Dr. Sándor Horváth, associate professor)

The development and research have been going on continuously with Institute of Material Sciences and Technology till 1975. The research were supported by Hungarian National Scientific Research Foundation (OTKA) between 1998-2001 (T026117), and 2003-2006 (T 043151) with Institute of Machine Design, BUTE.

The surface waviness, which plays an important role in operation (Fig. 1), is one of most significant part in our research activity. The relevance, role and applicability of waviness parameters are not well-known. It is true especially in case of 3D microtopographies, where the definition of waviness, using filtering techniques, has not been clarified yet (Fig. 2).

Our Institute tries to give suggestion in field of explanation and applicability of waviness for industry and research. Our measuring experience based on Perthometer Concept, 3D stylus instrument, accessible in Faculty.

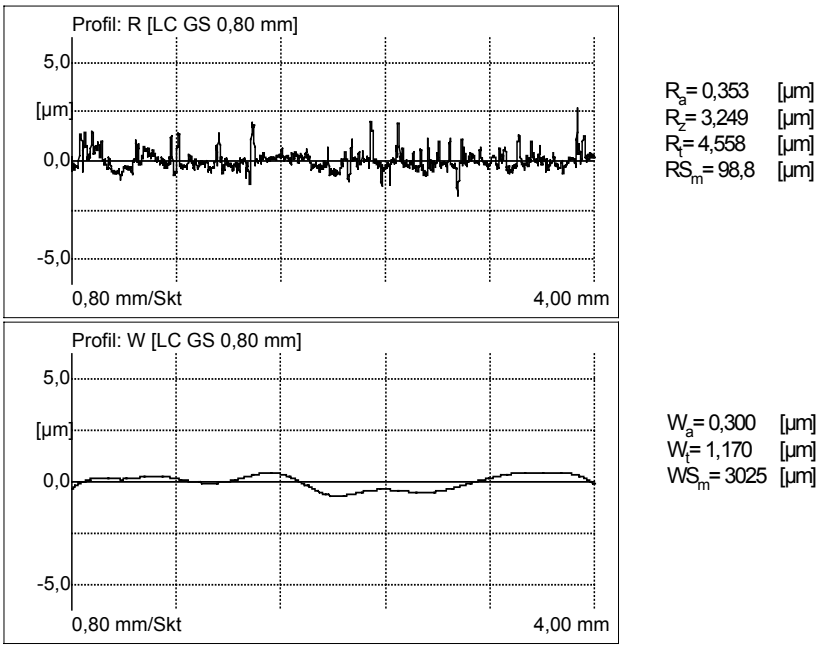

Figure 1
Report of measurement of camshaft sliding bearing: roughness and waviness profiles with some parameters

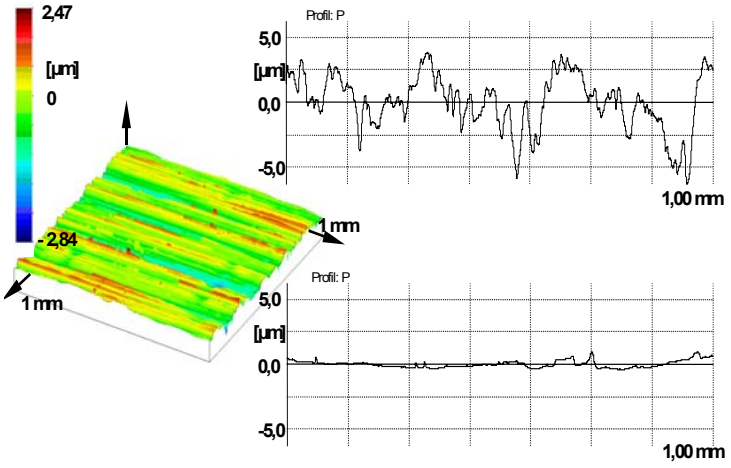

Figure 2
Topography of grinded surface with parallel and perpendicular profiles of machining direction

Design and modellization techniques – based on the surface microtopography – are in the focus of international research. Contact, thermal, adhesion and lubrication models require information about the microtopography. In most cases the parameter-based techniques can not suit these requirements. Therefore in our institute the development and improvement of asperity-, correlation- and frequency-based techniques have begun (Fig. 3).

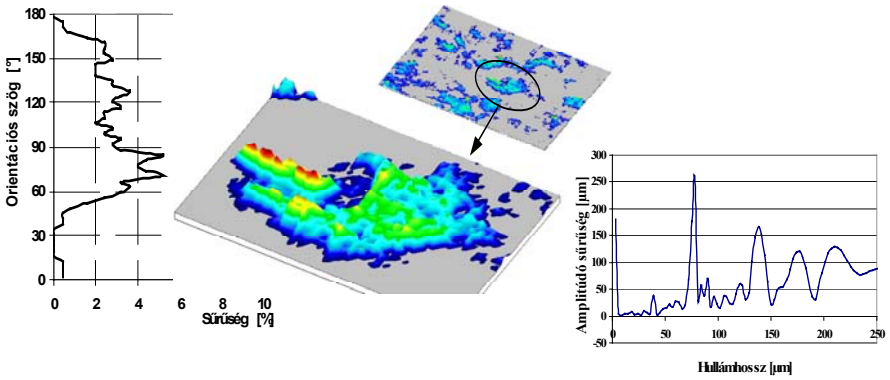

Figure 3

Asperity and frequency analysis: orientation and wavelength-spectrum

3.2 Mechanical Investigations of Layered Composites and Sandwich-Constructions at Nonlinear Geometric and Physical Circumstances

(Project leader: Dr. Lajos Pomázi, retired Professor, CSc, Professor Emeritus)

The research – which in 1987-91 under the No. I/1./1483 and in 1995-99 under the No. T01641 was supported by the Hungarian Scientific Research Found (OTKA) - is continuos beginning from 1984.

Subject of the research is to take into account the geometric and physical nonlinearities in the mechanical (elastic, stability, vibration) investigations of multi-layered sandwich-constructions and composites with the aim of optimal constructions. For the basis of the research and modelisation methods of anisotropic plate- and shell-theory, derived from the continuum-theory and the adequat finite element numerical methods (FEM) were taken.

In the frame of the research an analytical and FEM model was elaborated for the investigations of the stability of multi-layered sandwich plates built with constructionally anisotropic hard and transversally isotropic soft layers. For the nonlinear FEM investigations the COSMOS/M program-package was used. Verifying each others analytical and numerical investigations for the stability of 3-5 layered plates – according to which in the OTKA I/1./1483 with the firm of Hungarian Automobile Research Institution (AUTOKUT) experiments also were done – shows well the ‘sensitivity’ of the in-plane loaded plate to the – often

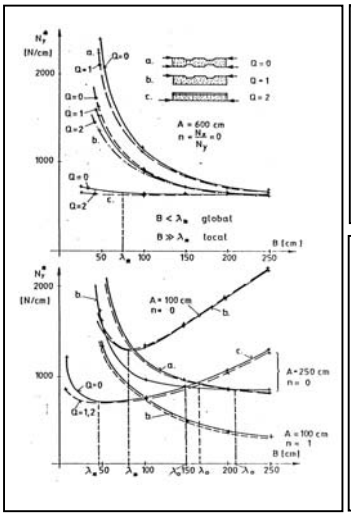

Figure 4

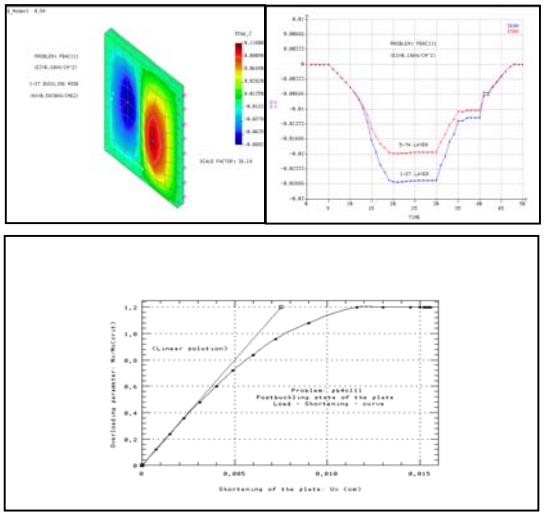

Figure 5

technological origin - effects done by the different structural and loading asymmetries of the hard layers. Figs. 1 and 2 show results of the analytical, and of the COSMOS/M investigations , accordingly.

In the frame of research special attentions was oriented to the correct formulation of the corresponding boundary-values problems and the clearing up the anomalies arisen, so results of the theoretical investigations of the number of boundary conditions and of the basic equations of the stability of layered sandwich-type circular plates were cleared up and published. Results of the whole research were summarized in the Dr. Habil. Thesis of the Project-Leader: ‘Contributions to the Theory of Layered Sandwich-Type Plates’ (BUTE, 2004).

In the research of OTKA-I/1./1483 in addition of the co-workers of the Bánki Faculty of Budapest Polytechnic co-workers of Technical University of Budapest (BME) and of AUTOKUT also were taken part. In the research of OTKA/T01641 a fruitful collaboration was founded and is supported with the Department of Applied Mechanics of BME by Dr. József Új and Dr. Gábor Vörös (Assoc. Professors), taking part in the research and by the Project-Leader, being part-time Assoc. Prof. of the Department. Professional contacts with departments abroad have personal character, founded by the Project-Leader on his scholarships in Japan (Japan Cultural Association, University of Tokyo, Department of Aeronautics and Astronautics, head: Prof. K. Kondo, 1990, 1 month) and in USA (Senior Fulbright Scholar Program, Stanford University, Department of Aeronautics and Astronautics, head: Prof. G. Springer, 1992, 12 months).

3.3 Numerical Modelling of Frictional Behavior and Wear Mechanics of Polymers and Elastomers (Project leader: Dr. Tibor Goda, PhD, associate professor)

At the design of different machine parts subjected to sliding friction, in most cases, the constructor leans on experiences of tribology and experimental results. Contrary to this experiment-oriented, traditional design process, nowadays an innovative approach stands in the centre of interest of tribologists. The main of the latter is to observe and model tribological phenomena. Our research follows this approach. The overall aim of the research is to study sliding friction of polymers, polymer composites and elastomers experimentally and numerically. Within this, the research concentrates, first of all, on the finite element (FE) modeling and experimental investigation of tribological phenomena and wear mechanisms. In order to achieve these objectives we deal with the observation of tribological phenomena, the development of mechanical models as well as the experimental verification of numerical results in details.

The main results of the research achieved up to now are as follows: (a) FE micro/macro-models have been developed to model the characteristic wear mechanisms and to determine the contact pressure distribution and the stress-strain states; (b) a computer program cooperating to a commercial FE software has been developed to model both the tension and shear type debonding of fibre-reinforced polymer composites; (c) an FE-model has been developed for the calculation of hysteresis component of friction force; (d) adhesion models hav been applied to study the adhesion component of friction force.

In the last few years, a close cooperation was formed with the Institute of Machine Design, Budapest University of Technology and Economics (IMD BUTE) in the scope of this research topic.

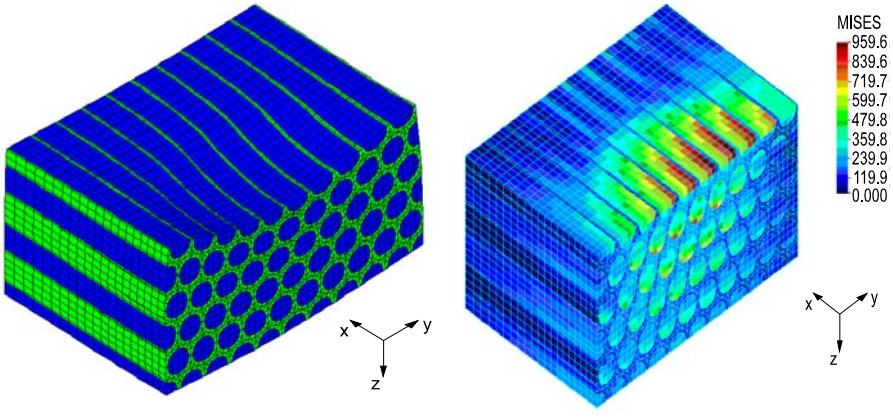

Figure 6
Deformed shape and equivalent stress distribution of a fibre-reinforced polymer composite

Benefits of the research can be summarized as follows: (a) reducing friction the energy consumption and operational costs can be decreased; (b) decreasing the wear rate the life-time of the component can be increased and, at the same time, the costs can be decreased; (c) reducing wear and friction the environmental impact (noise, vibration, lubricant) can be minimized; (d) the models and methods worked out can be built in the design process thus products with more advantageous operational parameters can be developed as well as the optimization of the product considering tribological guidelines can be performed; (e) the knowledge generated can be transferred into the education directly.

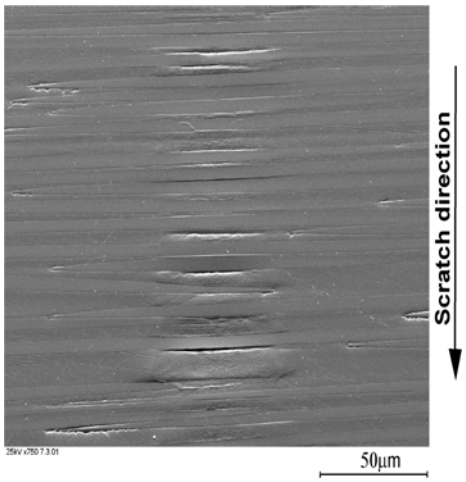

Figure 7
SEM (Scanning Electron Microscopy) photo from the worn surface of a polymer composite scratched by a diamond pin

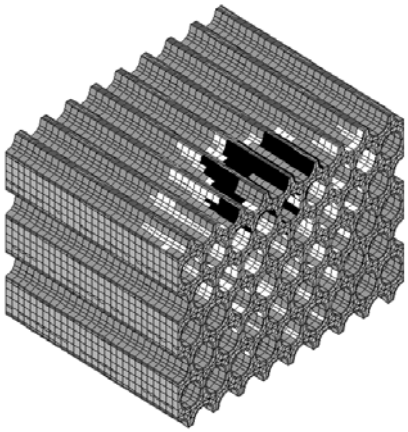

Figure 8
FE modeling of the fibre/matrix debonding

3.4 Numerical modeling and investigation of the mechanical behavior of granular materials (Project leader: Dr. Tibor Goda, PhD, associate professor)

At the design, development and optimization of devices be suitable for storage and transport of granular material it is of primary importance to know beforehand the magnitude and variance of forces arising in the course of operation with acceptable accuracy. To model and study the mechanical behavior of granular materials, researchers use continuum mechanical models in several cases. The different analytical and FE models are such ones. Their common characteristic is that the granular material is substituted by an equivalent continuum one during the analysis. However, in several cases, the continuum mechanical models prepared in this way are able to describe the global behavior (e.g. pressure distribution) of granular materials with appropriate accuracy, for the investigation of local phanomena (e.g. interfacial adhesion, particle-particle interaction, mixing of

particles etc.) they are not suitable. For the simultaneous investigation of the local and global phenomena, nowadays, the so-called discrete element method (DEM) is used. The latter is an efficient numerical method which investigates the movement of each particle separately on the basis of forces acting on the particles.

The main goal of the research is the development of a general, three-dimensional computer program using the discrete element method which, thanks to its structure, may be suitable to take both the interfacial adhesion and real particle shape into consideration in the near future. As a result of the research work carried out up to now its first three-dimensional version with a graphical user interface is available. The program has already proved its ability to solve different engineering problems many times. Thanks to the continuous development the current version of the program is able to handle particles that are constructed from two or more spheres.

The research is carried out in a close cooperation with the chair of Particle Technology and Fluid Mechanics, Technical University of Kaiserslautern.

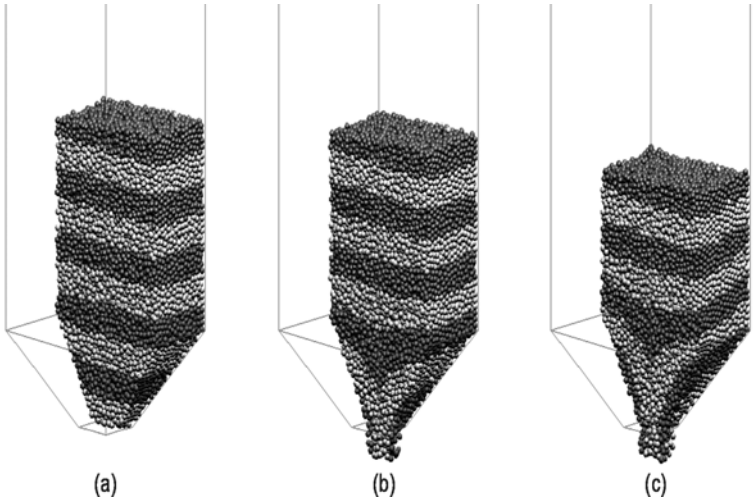

Figure 9

Flow patterns at different simulation times in case of silo: (a) at t=1.5 s (static state at the end of the filling process), (b) at t=2 s, and (c) at t=3.25 s

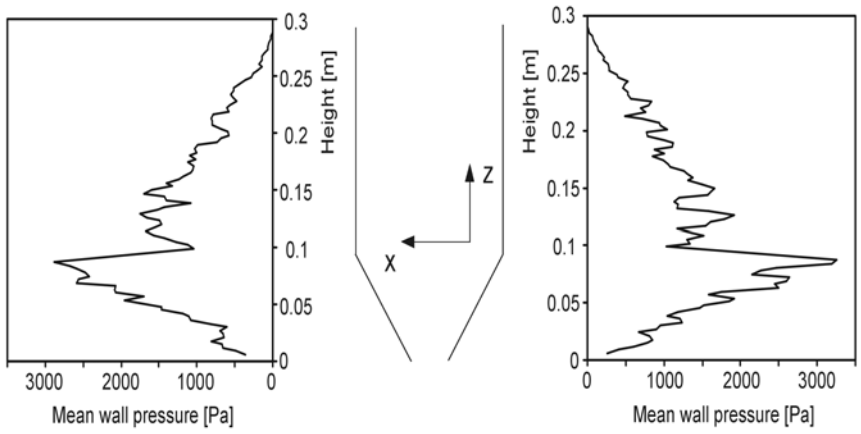

Figure 10
Mean wall pressure distribution along the walls in the case of silo outflow (t=1.8 s)

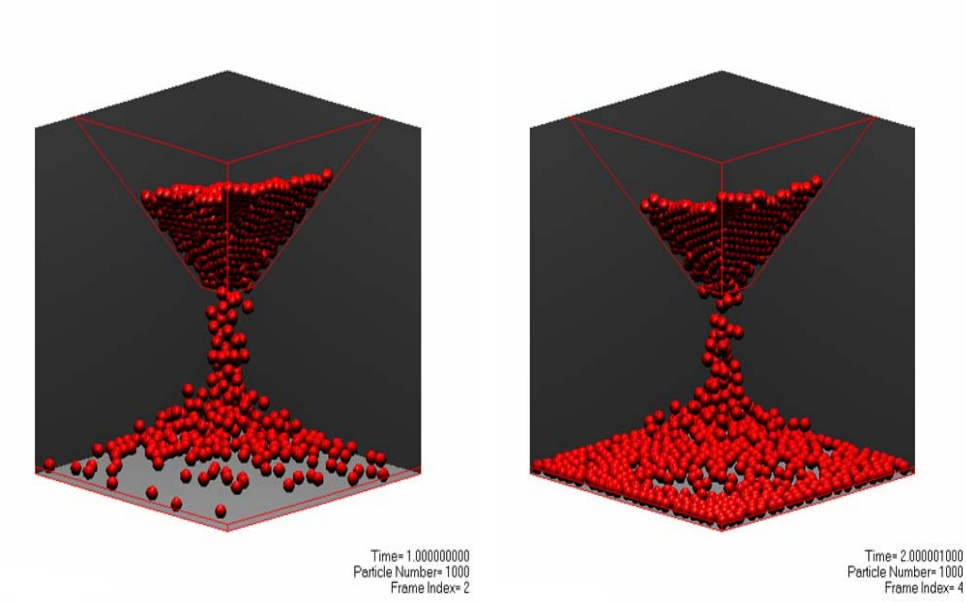

Figure 11
Simulation of outflow from a hopper

3.5 Current Tasks in the Field of Environmental Protection and Security Technique of the National Defense (Project leader: Dr. habil. Ákos Simon, CSc, professor)

The aim of the research pursued from 1999 to introduce and apply results of the security technique in the field of national defence. The most important projects until 2006:

- Analysis of the control-possibilities of the radiation dose received by personnel and employees of the Hungarian Defence Forces working with radioactive materials. Analysis of the real NBC hazard and environmental risks appeared in peacekeeping operations.

- Work out the proposition for the developed physical detection-instruments of chemical agents used currently in monitoring systems in Hungary.

Researches run in close cooperation with 'Miklós Zrínyi' National Defence University and many considerable Hungarian security companies.

3.6 Private Security Researches (Project leader: Dr. habil. Tibor Kovács PhD, professor, leader researcher: Dr. József Kaló, associate professor)

A contract of cooperation was signed in December, 2004 by Bánki Donát Faculty of Mechanical Engineering of Budapest Tech and Sectoral Social Dialogue Committee on Hungarian Private Security Industry where the representative of emloyers is the Employers' Association of the Hungarian Security Companies and the representative of employees is the Federation of Trade Unions on Private Security Industry.

The main goal of agreement to develop this sector on national and European level by a cooperation of science and the private security industry and establish a R&D base to promote this intention.

Confederation of European Security Services – CoESS and Union Network International encourage the development of European private security model. The development can only be successful if that is well-grounded, for that reason it is definitely necessary scientific searching of possible impacts of the planned arrangements.

Therefore the organizatons above mentioned proposed establishing an European and national R&D centers.

In consequence of these within the Bánki Donát Faculty of Mechanical Engineering of Budapest Tech was established the Science Centre for Private Security Services in 2005.

The main activity of the Centre to be known and received European experiences and to carry researches and analysis in the field of the development of private-security-model out.

Accomplishments:

- Study on ‘Actual Situation and Development of the Labour Safety and Health Protection in the Personal Security Sector’.
- Comprehensive study on biometrical detection possibilities. Work out of propositions to ameliorate the availability of iris scanner BM-ET330 by hardware-software developments. Attitudes and aversive reactions tests generated by an iris scanner detection system.
- Analysis of the international and national law-background of the bank security. Analysis of the bank-security-instruments used in the practice in Hungary and abroad.