CESAer

Canada – EU Student Exchange Program in Aerospace Engineering

Potential Thesis Areas
for Canadian Students at the European Partner Institutions:

Technical University of Munich, Germany
Delft University of Technology, the Netherlands
University of Glasgow, UK
Czech Technical University in Prague, Czech Republic

Compiled by

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Technical University of Munich
Munich, Germany

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TU Munich has 31 departments within the Faculty of Mechanical Engineering, from which the most relevant to Aerospace Engineering are listed below. Please visit the individual departmental websites for more details or to find out about the faculty members involved in the research.

Propulsion: http://www.lfa.mw.tum.de/en/forschung/schwerpunkte.html
Numerical Simulation of Complex Compressor Flows (G. Brignole, M. Hembera)
Operating Performance of Jet Propulsion and Gas Turbines (Dr.-Ing. W. Erhard)
Optimization of a Model Jet Engine (Dr.-Ing. W. Erhard, N. Spyra)
Experimental Investigations on LPP Aero Engine Combustors (A. Hupfer)
Hypersonic Propulsion Research (S. Rocci Denis, D. Maier)
Application of "Green Propellants" in Rocket Engines (S. Soller, R. Wagner)
Integrated Gap and Clearance Design Tools (Prof. Dr.-Ing. H.-P. Kau)
Methods for CAD-Based Statistical Tolerance Analysis (A. Stumvoll)

Flight Mechanics and Flight Control: http://www.lfm.mw.tum.de/
Analysis and utilization of vertical atmospheric wind shears for flight dynamics
On-board wind-measurement for General Aviation aircraft
Cockpit Instruments & Man-Machine Interface
Flight Path Prediction
3D Flight Guidance ("Tunnel in the Sky")

Gas Dynamics: http://www.lhm.mw.tu-muenchen.de/gd/frame_de.html
Gas Dynamics
Transonic flows with phase transition
Unsteady cavitating flows
Cavitation in injection nozzles
Cavitation in impellers

Lightweight Structures: http://www.llb.mw.tum.de/en/index_en.htm
Lightweight Structures for Aerospace, Vehicles and High-Performance Structures
Composite Structures
Health Monitoring
Smart Structures
Cryogenic Structures Structural Mechanics and Finite Element Method
Multiphysics
Multidisciplinary Optimization Composite Design
Hybrid Metal and Composite Design

Space Systems: http://www.lrt.mw.tum.de/en/lehrstuhl/forschungsgruppen.phtml
Human Spaceflight
Accelerator Laboratory (impact analysis of micrometeoroids and space debris, electromagnetic, electrothermal, and plasmadynamic accelerators)
Satellite Design
Systems Engineering

Numerical Engineering: http://www.lnm.mw.tum.de/research

- Computational fluid dynamics
- Computational solid dynamics
- Fluid-structure interaction
- Multiscale problems in engineering
- Free-surface flow simulation
- Biomedical flow simulation
- High-performance and parallel computing

Energy Systems: http://www.es.mw.tum.de/index_e.html

- Power Plant Technology
- Modeling & Simulation
- Renewable Energies
- Measurement Methods

Applied Mechanics: http://www.amm.mw.tum.de/index.php?id=21&L=1

- Fundamental Research
- Robotics and Walking
- Nonlinear Machine Dynamics
- Actuators

Aerodynamics: http://www.aer.mw.tum.de/forschung/index.en.php

- Aerodynamics of Aircraft and Ground Vehicles
  - Unsteady aircraft and vehicle aerodynamics
  - Innovative wing technology
  - Adaptive wings
  - Active and passive flow control
  - Flow-control devices and instabilities
  - Buffeting of agile aircraft
- Environmental aerodynamics
  - Unsteady pressure loads on large telescopes
  - Design of noise-protection hangars on large airfields
  - Aerodynamics of sporting devices
- Turbulent Flows and Laminar-Turbulent Transition
  - Large-eddy simulation of complex flows
  - Shock-turbulence interaction
  - Active and passive control of turbulent flows with separation
  - Unsteady hypersonics and re-entry aerodynamics
- Complex Fluids
  - Micro- and nano-fluidics
  - Interface phenomena and control of multi-phase flows
  - Bio-fluid mechanics and fluidic transport of macro-molecules

Thermodynamics: http://www.td.mw.tum.de/tum-td/en/forschung

- Reactive Flows
- Transport Phenomena
- Thermo Acoustics
- Energy and Environmental Technology

Delft University of Tehnology
Delft, The Netherlands

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Delft has an entire faculty on Aerospace Engineering, with about 180 faculty members in total. There are 16 research groups at the Faculty and they are grouped into 3 major departments. Again, please visit the individual departmental websites for more details or to find out about the faculty members involved in the research.

1. **Mechanics, Aerospace Structures and Materials (MASM)**

Engineering Mechanics www.em.lr.tudelft.nl
Numerical Methods
Micromechanics
Damage and Fracture
Fluid-Structure Interaction
High Temperature Coating for Engines
Delamination Buckling of Fibre-Metal Laminates
Optimized TRIP Steelshp-Adaptive Fluid-Stucture Interaction
Hard Coating-Substrate Systems
VMS-LES for Deforming Domains
Adaptive Multiscale Methods for RANS/LES
Explosive Loaded Composite Plates

Aerospace Structures www.lr.tudelft.nl/aes
Tailored Structures
Adaptive Structures
Structural Optimization
Stability and Vibrations of Shells
Thermal Loading of Structures
Inflatable Structures
Aircraft Crashworthiness

Design and Production of Composite Structures www.delftcomposites.com
Press Forming Technologies
Fibre Placement Technologies
Assembly Technologies
Liquid Moulding Technologies
Technology Demonstrator Programmes
Material Development
Inflatable Aerospace Structures
Bio-medical Applications
Intercontinental projects
Wind turbines
Hybrid composites

Fundamentals of Advanced Materials www.lr.tudelft.nl/~fam
Advanced Polymers
- Liquid crystal thermoset resins
- Carbon nanotubes

PPS thermoset resins
Morphing polymers
Metallic Systems
Formable Titanium alloys
Ultra high strength steels for aerospace
Statistical mechanics of deformation
Kinetics theory for phase transformations
Marageing steels
Steel band formation
Sensors and Actuators
Advanced functional materials
Radiation effects on materials & components
Self healing materials

Aerospace Materials and Structures www.vm.lr.tudelft.nl
Aluminium foam
DART (Delft Aerospace Re-entry Test)
DutchEvo (Sustainable Car)
Fiber Laminates
Joint Strike Fighter and FML's
Mechanically fastened joints
Restoration of Old Paintings
Rubber Forming of metal sheet
Safe Design (Patch Repairs)
Technology development reusable launchers

Delft Aerospace Structures & Materials Laboratory www.dasml.lr.tudelft.nl
Fibre Placement Technologies
Press Forming Technologies
Assembly technologies
Liquid moulding technologies
Technology demonstrator programmes
Material development
Inflatable aerospace structures
Bio-medical applications
Strengthening the Vietnamese composites industry
Wind turbine blade technology
Hybrid Structures; metal fibres, yarns and textiles for polymer composite structures
Design Methodology for Optimised Integrated Glare Fuselage Sections
Forming of Laminates
Safety design
Impact behavior of Fiber Metal Laminates; Impact and dent damage Resistance

2. Aerospace Design, Integration and Operations (ADIO)

Design, Integration and Operations of Aircraft and Rotorcraft www.lr.tudelft.nl/dar
Flight Operations
Air Traffic Management
Flight path optimization and flight guidance systems
Rotorcraft
Rotor Aerodynamics
Helicopter Flight Mechanics and Simulation Modelling
Rotorcraft Handling Qualities
Helicopter design
Knowledge Based Engineering

Aerospace Management and Operations www.lr.tudelft.nl/amo

Management and Operations in the Aerospace Industry

Aerodynamics www.lr.tudelft.nl/aerodynamics

- Aircraft Aerodynamics
  - Configuration aerodynamics
  - Unsteady Aerodynamics
  - Propeller theory
  - Theoretical investigations into aircraft aerodynamics
  - Numerical simulation of compressible flows
- Spacecraft Aerodynamics
  - Numerical simulation of Aerothermal effects in re-entry flows
- Boundary Layers, Wakes and Turbulence Modelling
  - Transitional turbulent boundary layers and wakes
  - Compressible boundary layers
  - Shock wave-boundary layer interaction
  - Combustion studies using flamelets
- Separated Flows and Vortical Flows
  - Low-speed vortical flow on delta wings
  - Compressible vortical flow on delta wings
  - Separation from smooth surfaces
  - Topology of 3D separated flow structures
  - Flow Induced Vibrations
  - Development of Experimental Techniques
  - Miscellaneous Fluid Dynamics Subjects
- Experimental Techniques (6 low-speed, 4 high-speed wind tunnels)
  - Laser-Doppler Anemometry (LDA)
  - Infrared technique for measuring the wall-shear stress
  - Electronically scanned pressure data acquisition and control system
  - Quantitative Interferometry in Compressible flow research
  - Development of a hypersonic test facility
- Miscellaneous Fluid Dynamics Subjects
  - Suppression of the sonic boom
  - Fast decompositions
  - Flows in pulmonary systems
  - Surface-tension-gradient driven phenomena
  - Unsteady rectilinear motion of an ideal gas

AeroSpace for Sustainable Engineering and Technology www.lr.tudelft.nl/asset

- Laddermill (set of “kiteplanes” to generate energy from winds at 30,000 ft)
- Superbus (super-fast bus capable of speeds of 250 km/h)
- Solar Racing (TUD’s entry into a solar powered car race in Australia)
- Kiteplane (TUD’s entry into a novel Kite design competition)
- KiteEYE (development of world altitude record kite)

Control and Simulation www.cs.lr.tudelft.nl

- Advanced Cockpit Displays
- Aeroservoelasticity
- Air Traffic Control Interaction
- DelFly I (Micro Vision-Controlled Flapping Wing Vehicle)
- Ecological Interface Design for Vessel Traffic Management
- Improving Operator Situation Awareness through EID.
- Fidelity
- Flight Simulation Models based on Computational Fluid Dynamics and Flight Test Identification
- Formation flying spacecraft guidance and control
- Handling Qualities

Human-Machine Interaction & Flight Deck Development (3D "Tunnel in the Sky")
Intelligent Control
Micro Aerial Vehicles
MiniSAR (coupled integrated IMU/GNSS navigation system)
Misat (Spacecraft attitude control with distributed sensor and actuators)
Motion perception
Multi-loop identification
Nissan IDSS (intelligent driver support systems)
Qualification of Flight Simulation Training Devices
Re-entry Flight Envelop Clearance
Reconfigurable Aircraft Flight Control
Situation Awareness for Agricultural Robots
Smart AHRS sensor integration
User-friendly Helicopter UAV Control
Vision-based Guidance for Autonomous UAV

Wind Energy www.lr.tudelft.nl/windenergy
Aerodynamic design of rotor blades
Airfoil Design and Testing
Wind Energy Conversion in the Built Environment
NewGUST, Modelling of extreme gusts for design calculations
Extreme Response of the offshore wind energy system
Airfoil Characteristics of Rotating Wind Turbine Blades
SWING4, Stochastic Wind Field Simulation
Rotor Wake Structure
Concerted Action on Offshore Wind Energy in Europe
Design methods for Offshore Wind Turbines at Exposed Sites

3. Earth Observation and Space Systems (DEOS)

Mathematical Geodesy and Positioning www.lr.tudelft.nl/mgp
Geo-infrastructure
- Active GPS Reference System (AGRS.NL)
- Virtual Reference Station (VRS)
- GPS meteorology
- The International GLONASS Experiment (IGEX)
- EGNOS System Test Bed (ESTB) - monitor-station

Georeferencing (development of three-frequency system for Galileo)
Geospatial modelling
- Monitoring land subsidence
- Modelling land subsidence
- Mathematical Geodesy
- Theory of integer inference
- The LAMBDA method
- Canonical theory for GNSS baselines

Astrodynamics and Satellite Systems http://www.as.lr.tudelft.nl
Satellite Altimetry;
Gravity fields;
Crustal dynamics;
Miscellaneous;
Orbital Science;
Space Instrumentation.

Physical and Space Geodesy www.lr.tudelft.nl/psg

Determination of the gravity field of the Earth and celestial bodies

Optical and Laser Remote Sensing www.lr.tudelft.nl/olrs

Airborne laser scanning
Full waveform analysis
Change detection
Digital Terrain Model Building reconstruction
Traffic monitoring
Terrestrial laser scanning
Reverse engineering
Tree reconstruction
Heritage and medical

Systems Integration/Space http://www.sis.lr.tudelft.nl

- Spacecraft engineering
- Mission concept exploration
- Mission operations
- Systems engineering
- Space propulsion
  - Advanced low thrust thermal rockets
  - Development of a microrocket test facility
  - Development of a low total impulse propulsion subsystem design tool
  - Tethered propulsion
  - Parabolic flight campaign
  - Development of a cold-gas microthruster

University of Glasgow
Glasgow, Scotland, UK

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The Department of Aerospace Engineering at the University of Glasgow has normally 18 faculty members (currently 16, with 2 to be hired by October 2006), forming about 7 research groups. For more information, please visit www.aero.gla.ac.uk or for specific research collaboration information, contact the corresponding faculty member.

Academic staff - Department of Aerospace Engineering

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Research Groups

Low-Speed Aerodynamics (Prof. Galbraith, Prof. Coton, Dr. Green, Dr. Gillies, Dr. Vezza)

Helicopter tail rotor blade vortex interaction
Analysis of three-dimensional dynamic stall
Analysis of pitching delta wing flows
Particle Image Velocimetry Studies
Aerodynamic modelling of wind turbines
Winglet studies
Active control of dynamic stall
Helicopter main rotor blade vortex interaction
Measurement and analysis of two-dimensional dynamic stall
Prediction and measurement of wind turbine flows
Discrete Vortex CFD Methods

Flight Mechanics (Dr. Thomson, Dr. Houston, Dr. Anderson)

Mathematical Modelling Requirements for Improved Helicopter Flight Control Systems.
Aerodynamics of Gyroplanes.
Helicopter Flight Mechanics in Autorotation.
Development and Application of a High Fidelity Inverse Simulation Technique for Helicopter Manoeuvring Flight.

Pilot Modelling for Control System and Handling Qualities Studies.
Martian Gyroplane Flight Mechanics.
The Gyrodyne - a Forgotten High Performer.

Control Theory (Dr. McGookin)
Marine Vehicle Navigation and Control
Aerospace Vehicle Navigation and Control
Gas Turbine Engine Control
Sliding Mode Control and Observers
Evolutionary Optimisation

Space Systems (Dr. Radice, Dr. Vasile)
Space Mission Analysis and Design
Global Optimsiation Methods
Autonomous Systems

Design and Structures (Dr. Smrcek, Dr. York)
Development of a UAV laboratory for in-flight airfoil testing.
General Aviation Aircraft Structural Wing Design and Optimisation.
Instability in skew and tapered plan-form wing panels with implications for design.
Natural frequency calculations for skew plates with continuity and rotational edge restraint.
Buckling interaction in regular arrays of distorted Hexagonal plates.
Elastic buckling analysis of skew plates with planform taper.
Advanced concept designs on Micro Air Vehicles (MAV), High Altitude Aircraft (HAA), Wing-In-Ground-Effect (WIG), sailplane winglets and flying wings.

Rotorcraft CFD Group (Prof. Brown)
(Moving with his entire group from the Imperial College to Glasgow in April 2006. For now, please follow the old link to his group website http://www.ae.ic.ac.uk/research/rotorcraft/index2.html)

3D CFD modeling of rotorcraft aerodynamics based on Vorticity Transport formulation
Vortex Ring Aerodynamics – Dynamic and Operational Effects
Helicopter/Aircraft Wake Interaction
Vibration Prediction
Advanced Configuration / Gyroplane

Avionics and Aerospace Systems (Dr. Goodchild, Dr. Anderson)
Development of an aircraft and operations simulation to evaluate and test ACAS/TCAS II and IV logic.
Integration of flight plan information into ADS-B, Mode-S data in Free-Flight CNS/ATM.
ACAS/TCAS error and failure modes analysis.
Development of a multiple-station aircraft and operations simulation extension to ATSSET.
Study on the application of Genetic Algorithms in CNS/ATM simulations.
ATSSET Inverse simulation to determine the cause of Air Traffic Conflicts.
Safety and Risks Analysis with high air-traffic density, variable and curved approach finals, and multiple runway operations.
Development of a Passive Aircraft-Wake-Turbulence Avoidance System (PAWTAS).

Czech Technical University (CTU) in Prague

Prague, Czech Republic

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Aerospace Engineering can be studied at the CTU as a stream within the "Department of Automotive and Aerospace Engineering". Correspondingly, the academic staff is relatively modest, but with concentrated specialization in internal and external aerodynamics:

Doc. Ing. Luboš Janko, CSc. [Head of Department] lubos.janko@fs.cvut.cz
Aircraft aerodynamics, Flight mechanics, Gas turbine aerodynamics (experimental)
Prof. Ing. Václav Brož, CSc. brozv@fsik.cvut.cz
Low-speed and high-speed aerodynamics
Doc. Ing. Daniel Hanus, CSc. daniel.hanus@fs.cvut.cz,
Aircraft propulsion, Aerodynamics and thermodynamics of gas turbines and jet engines
Doc. Ing. Svatomír Slavík, CSc. svatomir.slavik@fs.cvut.cz
Aerolelasticity, Propeller aerodynamics (experimental), Aircraft design
Ing. Robert Theiner robert.theiner@fs.cvut.cz
Aircraft design, Wind tunnel testing of propellers, Propellers for UAVs

There are 2 specialization streams available at the MSc level, "Aircraft Design" and "Aircraft Propulsion".

Examples of research projects completed or currently underway at CTU:
Inlet duct optimization for turbojet engines
Supercritical airfoil design for the Aero L-159 jet trainer
Two-stage compressor design for turbojet engines
Improving the safety of VLA (Very Light Aircraft)
Development of a new Structural Life Monitoring unit for aircraft
Modal analysis and testing of VLA airframes
New composite fan for enhancing the performance of VLA and UAV engines,
etc.

Other research related to Aerospace Engineering is performed at the **Department of Fluid Dynamics and Power Engineering** at the CTU (Head of Department: **Professor Dr.-Ing. Jiri Nozicka** Jiri.Nozicka@fs.cvut.cz) who also agreed to participate in the CESAer exchange program:

Research Facilities available for the CESAer exchange students at the Dept. of Fluid Dynamics and Power Engineering at CTU are:

PIV system containing modules for:

2D PIV (Particle Image Velocimetry), "low-cost" 2D PIV system for flow visualization and measurement in fluids, **Stereo PIV for 3D** measurement in fluids and gases, IPI for measurement of 2phase flow, LIF for measurement in fluids allowing measurement of flow velocity and temperature or concentration, HWA system, Temperature and pressure sensors, DAS computer controlled systems (based on National Instruments lab PC cards.

Wind tunnels

Low speed wind tunnel ca 550 x 900 mm,
"2D" wind tunnel for research of airfoils 400 x 1200 mm
Small high speed and supersonic wind tunnel,
Wind tunnel for research of blade cascades
Special facilities (low Re wind tunnel, wind tunnels for demonstration of experimental methods ...)

HW and SW

PC with SW based on Microsoft products, SW for PIV (Flow Manager) SW for DAS control (LabWiew) CFD SW Fluent Other typical SW: MatLab, AutoCad, ...

However, the major advantage of CTU is its close links with

- the **Aeronautical Research and Test Institute** (VZLU, the Czech equivalent of NRC's Institute of Aerospace Research) and
- the **Czech Academy of Sciences** (the top research establishment of the country, composed of a number of "research centres of excellence"),

Both these institutions are located in Prague and they confirmed their willingness to participate in the CESAer program, kindly offering their facilities for visiting Canadian exchange students. This opens new opportunities to top research expertise and outstanding research facilities in virtually every area of Aerospace Engineering. Please see below for an overview of the research areas available at these partner institutions:

VZLU – Aeronautical Research and Test Institute

The main research activities within VZLU are (please see http://www.vzlu.cz/activity.php?cid=11 for more details):

AERODYNAMICS

Measurement of aerodynamic characteristics of aircraft, land transport vehicles and engineering products or their models
Measurement of flow characteristics of parts of turbomachines
Wind engineering - dynamic effects on buildings and their parts and other building structures
Ecologically oriented experiments - dispersion of gaseous and dust emissions, infiltration into buildings
Computational Fluid Dynamics (CFD) - application and code development
Design of wind tunnels and their parts

STRUCTURAL ANALYSIS AND TESTING

Static and fatigue tests of aircraft airframes (full-scale), aircraft and other technology parts and other structures and samples, landing gear fatigue and crash tests
Combined strength tests (temperature, humidity)
Tests of residual strength of structures
Analysis and prediction of fatigue crack propagation
Strength analyses of structures - calculations and experiments
Experimental strain analysis of structures (surface measurement of stress and strain)
Structural flaw detection

AEROELASTICITY AND MODAL ANALYSIS

Modal tests of full-scale structures, dynamic models, and structural parts
Calculation of modal characteristics, analysis of static and dynamic aeroelastic phenomena
Design and production of (dynamically similar) aeroelastic models, aeroelastic experiments
Updating computational dynamic models according to experimental data
Evaluation of flight and taxiing tests data

TEST OF SYSTEMS

Climatic resilience tests - temperature-humidity tests, corrosion tests, simulated solar radiation tests, tests of ozone effects, tests of the effects f liquids (water, fuel, hydraulic liquids, oils, and various chemicals), dust and sand tests

Tests of mechanical resistance - vibrations, shocks, linear acceleration, vibration and thermal combined tests, special tests of crash flight-recorders

Tests of electrical systems - LF and HF interference, radiated HF energy, indirect effects of lightning, electrostatic discharge, tests of aircraft electrical systems

Acoustic tests and noise measurement - measurement of acoustic pressure level, estimation of workplace noise exposure, indoor and outdoor noise measurement, test of resistance to acoustically induced vibrations, measurement of indoor and outdoor aircraft noise, measurement and analysis of aircraft propellers

Hydraulic and pneumatic tests - certification tests of instruments and equipment for alternative fuelling of motor vehicles powered by LPG and CNG, tests by hydrostatic and hydrodynamic pressure, destructive hydraulic tests, calibration of liquid and gas manometers

Measurement and analyses - measurement of contamination of working liquids, chemical and spectral analyses

COMPOSITE STRUCTURES

Development and tests of composite parts of aircraft and other applications

Design and implementation of technology of composite structure production, infusion technology (RTM, VARTM, RFI, etc.)

Numerical simulation and optimization of technological processes of composite production

Radio-transparent and electrically conductive composite structures, structural adhesive bonding of composites

Aircraft propellers, aircraft parts, spinners, propeller agitators for sewage treatment plants and others

Composite products of primary and secondary structure, aircraft and other applications

AIRCRAFT PROPELLERS

Development and test of aircraft propellers, axial fans, rotors of axial wind turbines, axial propeller agitators for sewage treatment plants and others

Certification tests of aircraft propellers (FAR part 35, CS-P, UL-2, and others)

Tests of propeller and engine control systems on ground test rig, including stability tests in wind tunnel

ENGINES

Developmental work for aircraft, land vehicles, and special engines, aircraft engine combustion chambers, gas turbines and cogeneration units, gearboxes of turbine engines

Technical diagnostics without disassembly

Engine control systems

DESIGN

Design of rescue devices - ejection seats, aircraft seats, parts of aircraft airframes and power unit installations

Test system design, rig design and mock-up design

Design of aircraft propellers, rotors of wind turbines, axial fans

Design of structures made of isotropic and anisotropic materials

SERVICES FOR SPACE INDUSTRY

Mechanical tests, electromagnetic compatibility, dynamic loads of structures, modal analysis

Design and production of composite parts and large segments

Devices for measuring micro-acceleration (10-4 - 10-9 ms-2)

Czech Academy of Sciences - Institute of Thermomechanics
Department of Fluid Mechanics

Current projects related to aerospace engineering

- **Bypass transition of a boundary layer to turbulence**
  Study of bypass transition of a boundary layer subjected to disturbances. Disturbances introduced either into incoming flow or using surface roughness. Influence of intensity and type (scale) of disturbances on transition process. Flow physics studies.

- **Active flow control**
  Flow Control of boundary layer transition and separation, shock waves and body drag. Several active flow control techniques considered, such as continuous suction and/or blowing and periodic excitation by synthetic jets. Sailplane airfoil optimization and comparison of passive and active control devices.

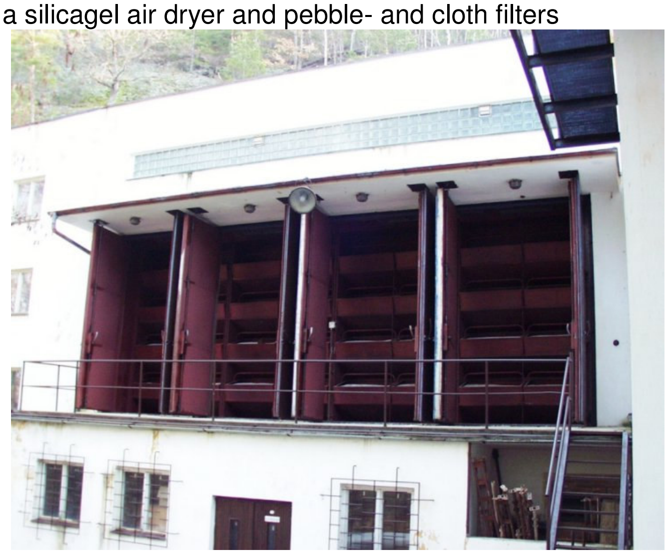
- **Turbulent mixing**
  Experimental study of turbulent mixing mechanisms in the mixture of two gases. Mixtures of air and helium or CO_2 are considered using a unique method for the simultaneous point evaluation of instantaneous velocity and concentration (based on hot-sensors technique). The method allows direct study of turbulent fluxes. Various configurations of turbulent mixing are studied and optimized.

- **Transonic flow in blade cascades**
  Both turbine and compressor blade cascades are tested. For experiments optical and pressure measuring methods are used. The airflow is transonic with both subsonic and supersonic regions. Study of shocks wave–boundary layer interactions. Blade optimization for improving stage efficiency.

Research Facilities:

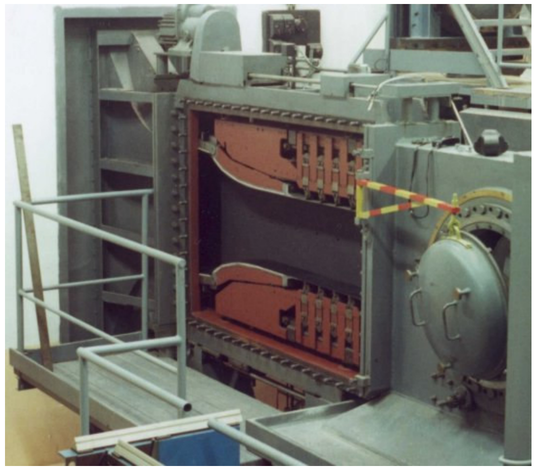
Aerodynamics Laboratory in Nový Knín

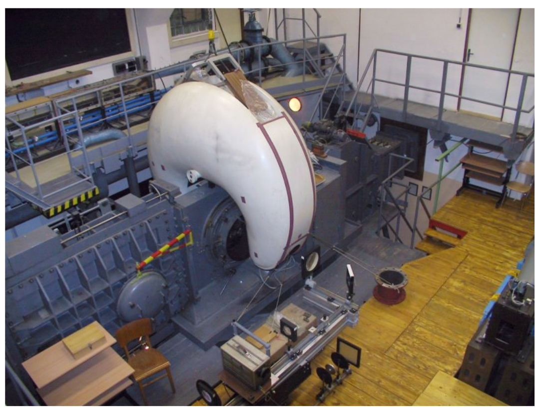
The detached Aerodynamics Laboratory in Nový Knín was founded in 1964, as a High Speed Laboratory of the Institute of Thermomechanics. Two of the abandoned galleries of former gold-ore mines are used as a vacuum storage of the total volume of 6500 m^3 to drive the high speed blow-down wind tunnels. 3 sliding-vane vacuum pumps 80 kW each can evacuate this volume to the lowest pressure 0.1 x 105 Nm^{-2}. Quick acting control valves make possible an economic operation. The high speed wind tunnels are breathing atmospheric air through a silicagel air dryer and pebble- and cloth filters

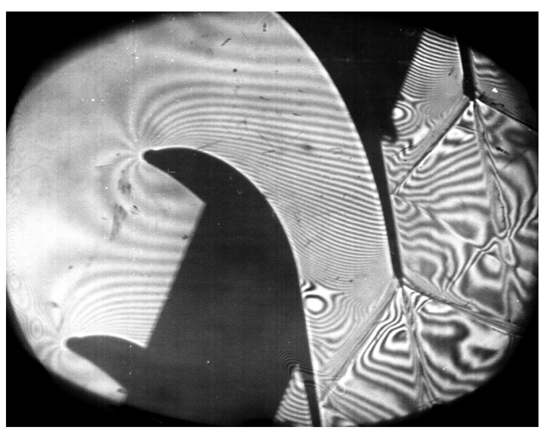


Cascade wind tunnel (built in 1965)

Designed for investigation of all types of turbine and compressor cascades up to Mach ~ 2 (at inlet or outlet). With the test section 0.16 x (0.2 to 0.45) m, depending on the stagger angle, and typoval blade chord 0.08 to 0.12 m (i.e., number of blades in the cascade tested 6 to 12), the wind tunnel running time is from 10 to 50 s, depending on the type of experiment. There is an adjustable nozzle with parallel side walls and flexible Foelsch-type upper and lower walls, servo-driven to any desired Mach between 1.1 and 2.0 and to any test section height. Back pressure is controlled by a second throat at the settling chamber outlet.





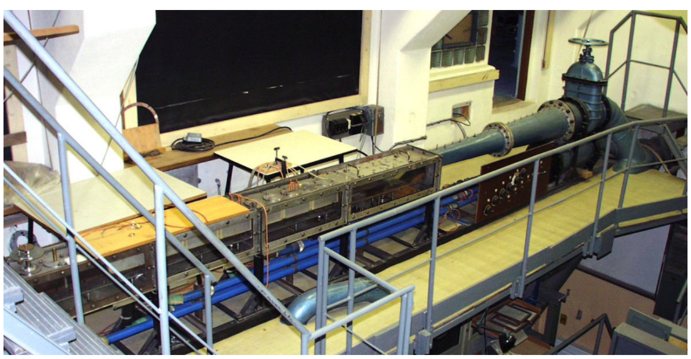


Modular wind tunnel (construction started in 1998, operational only in selected versions)

The modular concept makes possible various experiments at **transonic** velocities in interchangeable test sections, as, e.g., transonic flow in radial inflow cascades or in relatively narrow and curved channels, transonic turbulent flow in channels, **aeroelastic** investigation of profiles and bodies at transonic velocities, etc. The entrance part of the wind tunnel consists of an entrance nozzle, honeycomb and turbulence-control screens, settling chamber and a sine-shaped contraction. The contraction is designed so that at a distance of two hydraulic cross sections the mean velocity profiles are uniform, and the turbulence intensity up to the velocity 60 m/s amounts 0,1% Minimum controllable velocity at inlet of the contraction is approx. 4 m/s, running time at constant controlled velocity is about 180 s

Small high-speed wind tunnel for boundary layer and turbulence research

Test section 0.1 x 0.1 m, length 2.25 m, with controlled auxiliary suction from 3 walls, subsonic operation up to Mach ~ 0.83, running time about 3 minutes, turbulence level can be set in the range 0.1 to 12% by inserting turbulence grids.



Single-purpose test sections

Various single-purpose test sections can be attached to the vacuum storage as, e.g., test section for studies mainly of shock wave-boundary layer interaction in internal transonic/supersonic flows. The test section is *a* x 0.15 m, where *a* can be adjusted stepwise from 0.01 to 0.12 m, length is 0.9 m, velocities in the range 0.2 to 1.8 Mach, incl. transonic (slotted walls).

Aerodynamic Experimental Facilities in Prague

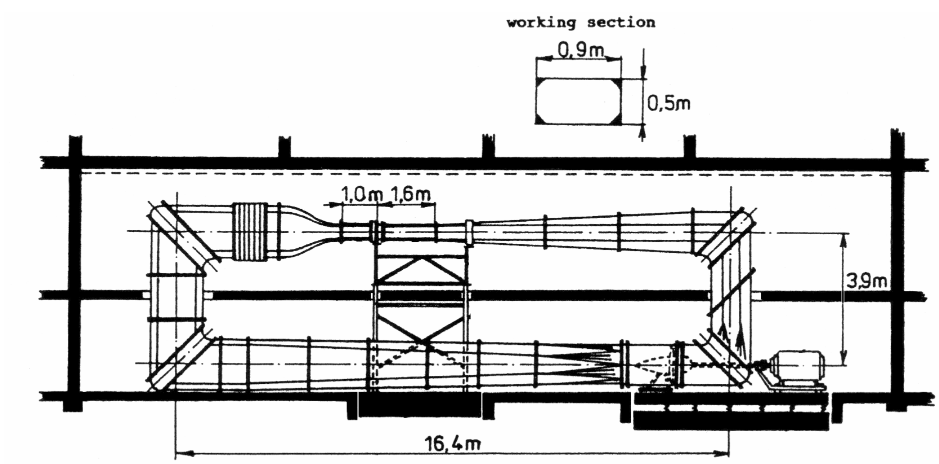
Close-circuit wind tunnel

The investigations of turbulent flows and boundary layers, the force measurements of various models (incl. vibrating models) and the development of the measurement methods of the flow parameters are performed mostly in the closed-circuit wind tunnel (C.A.T.).

The tunnel was built from wooden material, and began to work in the year 1958. Before moving it to the new building of the Institute of Thermomechanics in 1985, the tunnel had been modernized.

The settling chamber to the working section area ratio is roughly 10. The working section (area: 0.5 x 0.9 m^2) is divided into two parts. The first one is designated to control the oncoming flow - field by means of passive devices (grid/screen turbulence generator, generator of mean shear etc.) The second part with the wooden plate is the working section, where objects of experimental study (boundary layer) take place. With the tested body-model attached to the five-component wind-tunnel balances, the section is suitable for measurement of varying forces up to 150 Hz. The support of this part of the working section has special grounds isolated from all parts of the wind-tunnel supporting structure. The 50 kW drive motor with a fan has its grounds isolated too. Flow speed in the test section could be within the interval from 5 m/s up to 70 m/s.

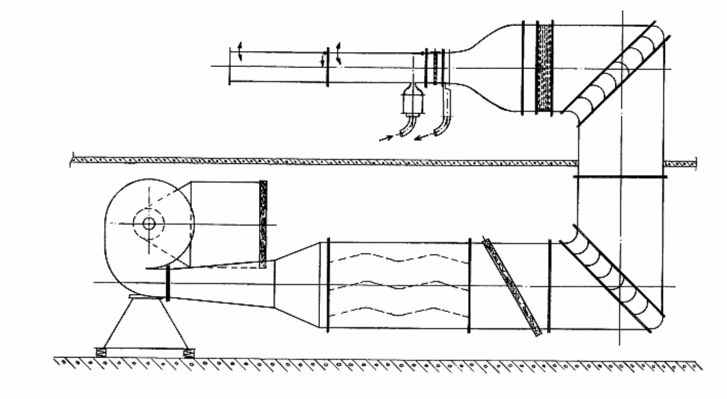
The developed grid-screen system allows the control of turbulence levels in the working section from its natural level, Iu = 0.3% up to 12% with various turbulence length-scales.



Blow-down rig

The test rig is supplied by air from a radial compressor ČKD with the maximal air flow capacity 2520 m^3/h (measured on intake). The anti-dust filter (Firon) is placed on the suction of the compressor. The electric DC drive motor (power of 11 kW) is electronically controlled using the back step derived from the shaft rotational speed. The facility consists of the three branches: lower and upper horizontal branches and a vertical one between them. The output of the compressor (section 160 x 160 mm) is funnelling into main tubing (section 520 x 810 mm) by means of a wide-angle diffuser of 2100 mm length. Then, a horizontal part of lower branch main tubing follows, filled by anti-noise filters (length 3 m). The tubing continues by the filtering section equipped by inclined anti-dust Firon filter. The inclination angle of 45° was chosen for increasing of the filter surface. The filter is followed by two corners connected by vertical branch (the length of 2 m). The two abrupt corners are used, their losses are kept to a minimum by means of proper turning vanes. The settling chamber, contracting nozzle and the test section forms the upper horizontal branch. Cross-section of the rig including the settling chamber is of 510 x 820 mm^2.

Three contraction nozzles of various output cross-sections are available with circular output ø100 mm or rectangular 250 x 250 mm^2 and 100 x 200 mm^2 respectively. Output velocities are within the range from 5 m/s up to 100 m/s, depending on the chosen nozzle.



Close-circuit overpressure aerodynamic facility

Multifunction calibrating device is destined for calibration of the hot-wire and hot-film probes as well as small pneumatic probes in a stream of air or another non-corrosive gas. It can be used also as a source of accurately measured flux of air for charging other aerodynamic facilities.

Modes of operation:

- as a small closed circuit variable density tunnel, which can be filled by air as well as by various non-corrosive gases or gas mixtures. In this arrangement movement of medium involved is caused by hermetically built-in small side-channel compressor,
- as an open circuit small wind tunnel supplied from a pressure vessel volume about 16 m^3 and maximum pressure 0,8 MPa,
- as a source of accurately measured flux of air.

Dimensions of measuring sections:

- in a closed circuit arrangement two cylindrical measuring sections with diameters of 14 mm and 25 mm are available. Each measuring section follows one of two contraction cones, that can be interchanged,
- in an open circuit arrangement the above mentioned contraction cones can also be used and in addition to contraction cone with exit diameter of 50 mm can be used for generation an axis-symmetrical jet of air

Ranges:

- in a closed circuit arrangement with air filling under normal pressure and temperature conditions in the measuring section of 14 mm in diameter the flow velocity can be varied and measured with the accuracy better then ±0,5% in the range from 0,1 m/s up to more then 100 m/s, pressure level adjustable by means of a vacuum-pump or compressor in the limits from 5 kPa up to 1,6 MPa,
- in an open circuit arrangement achieved velocity range is from 0,1 m/s to Mach number of about 0,95,
- in an air supply arrangement the mass flux can be adjusted and measured in the range from about 0,1 g/s. to 0,3 kg/s,