McGill

Department of Mechanical Engineering

RESEARCH PROJECT OVERVIEWS

2015-16

McGill
Department of Mechanical Engineering

Department Overview

Overview

- McGill ranked #1 university in Canada (2015 QS World University rankings)
- Available grad programs: MEng (Thesis), MEng (non-Thesis), MEng (Aero), and PhD
- 240 students in Mech Eng graduate programs

Professors

•30 professors, including:

•8 Research Chairs

•4 Fellows of the Royal Society of Canada

Laboratories

Aerodynamics, Aerospace Mechatronics, Alternative Fuels, Biomechanics, Biomimetic Materials, Cardio Vascular Engineering, Computational Fluid Dynamics, Fluid Structures Interaction, Heat Transfer, MEMS/NEMS, Mechanics, Multiscale Mechanics, Robotic Mechanical Systems, Shockwave Physics, Space Flight Dynamics, Structures and Composites, System Optimization

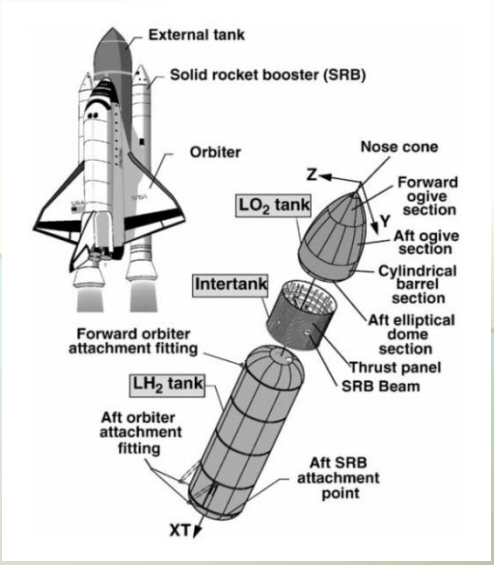
McGill
Department of Mechanical Engineering

Prof. Marco Amabili

(marco.amabili@mcgill.ca)

OVERVIEW

Modeling and experiments on nonlinear vibrations and dynamic stability of shell structures of traditional and advanced materials

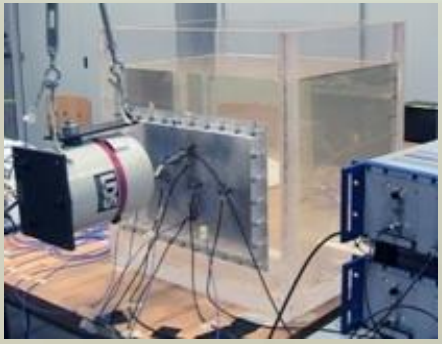


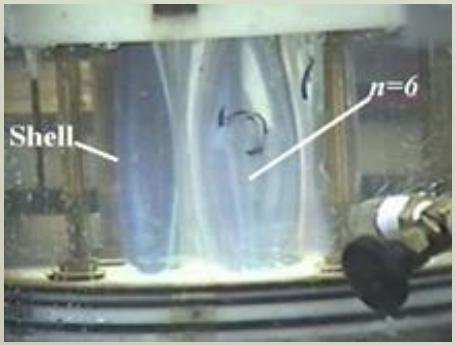
PROJECTS

- Large-amplitude vibrations of shell structures containing fluids
- Meshless discretization of shell structures
- Active vibration control
- Dynamic stability of supercavitating torpedos
- Development of a new Coriolis flowmeters for oil and gas industry

LABORATORY

ENGMD 052
ENGMD 259





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Prof. Jorge Angeles (angeles@cim.mcgill.ca)

OVERVIEW

- Research in the areas of design and control of mechanical systems

PROJECTS

- Design theory: Complexity measures for conceptual design
- PLATO: Design of multi-axis accelerometers and devising of algorithms for twist & pose estimation
- Design and control of fast pick-and-place robots
- Development of a simplified six-degree-of-freedom with a tripod
- architecture
- Development of a swift-shift transmission for electric vehicles

LABORATORY

- Robotic Mechanical Systems Laboratory, McConnell Engineering Bldg., Room 418

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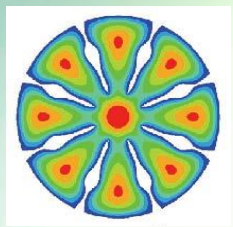
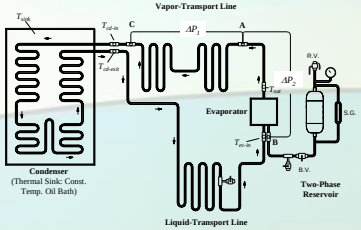
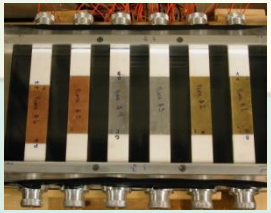


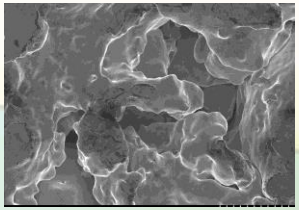
Prof. B. Rabi Baliga (rabi.baliga@mcgill.ca)

OVERVIEW

- Heat transfer in energy exchange, conversion, and storage systems





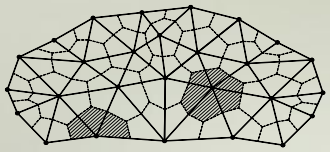


PROJECTS

- Loop heat pipes
- Compact heat exchangers and recuperators
- Heat transfer in slurries of microencapsulated phase-change materials
- Heat transfer enhancement using porous media
- Simulations and predictions of spot fires in forests
- Optimization of the thermal performance of internally-finned ducts
- Thermal energy storage in rock beds and phase-change systems
- Fluid flow and heat transfer in laptop and net-book computers
- Control-volume finite element methods for fluid flow and heat transfer

LABORATORY

ENGMD 54; ENGMC 12



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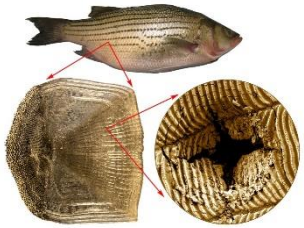
Prof. Francois Barthelat

www.barthelat-lab.mcgill.ca, francois.barthelat@mcgill.ca
Laboratory for Advanced Materials and Bioinspiration

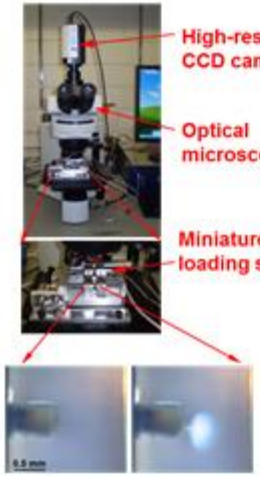
Missions: (1) Characterize the structure and mechanics of high-performance biological materials
(2) Design, fabricate and test novel bio-inspired high-performance engineering materials

1) Inspiration: bone, mollusk shells, teeth, fish scales

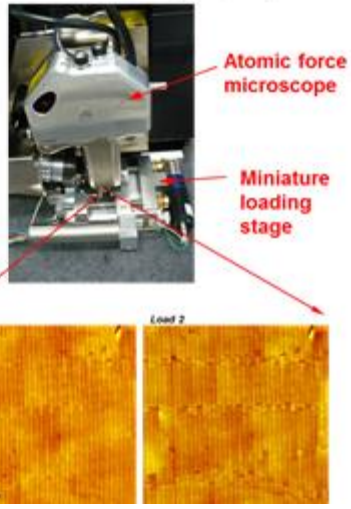


2) Experiments: small scale and in-situ testing, nano-indentation, fracture toughness, puncture, impact

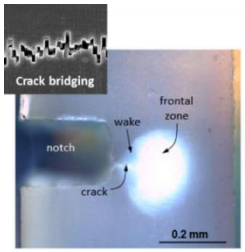
In situ optical testing: the sample is imaged as it is deformed and fractured

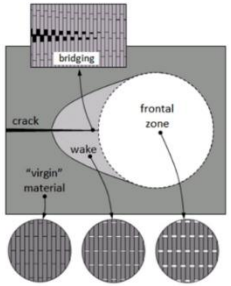


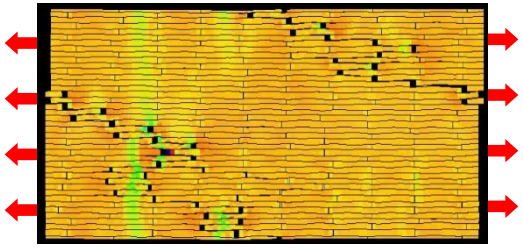
In situ Atomic force microscopy testing



3) Modeling: Micromechanics, fracture mechanics, finite elements, discrete element modeling, optimization

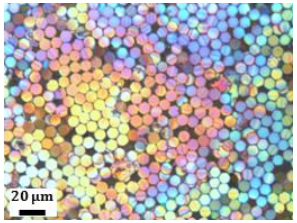






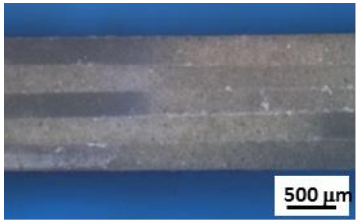
4) Fabrication: Doctor blading, self-assembly, three-dimensional laser engraving, 3D printing

Self-assembled composites



Hard / flexible glass

Toughened Bone graft material



5) Applications with industrial partners: toughened windows, coatings, flexible protective systems, impact-proof touch-screens, dental materials and bone graft materials for orthopedic applications

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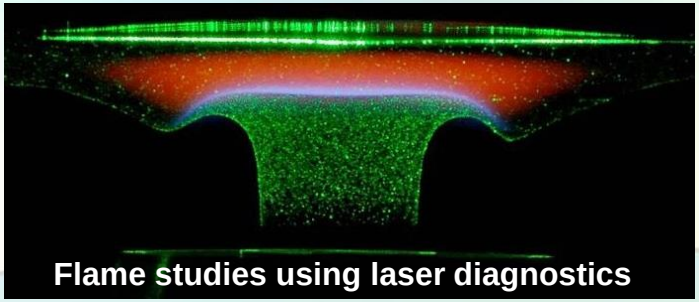
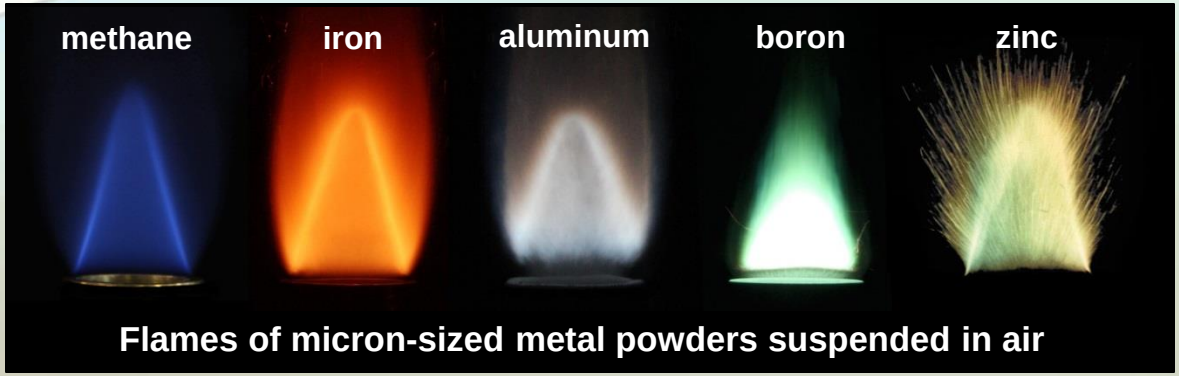
Prof. Jeff Bergthorson (jeff.bergthorson@mcgill.ca)

Alternative Fuels Laboratory (http://afl.mcgill.ca)



Flame studies using laser diagnostics



Flames of micron-sized metal powders suspended in air

Flame in mixture of nano-aluminum & water

PROJECTS

- Combustion and emissions properties of alternative gaseous and liquid fuels
- Novel low-emissions combustion technologies
- Metal powders as recyclable fuels produced from low-carbon primary energy
- Combustion of metal particles for zero-carbon power generation
- Metal-water reactions for in-situ hydrogen generation

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Department of Mechanical Engineering

Prof. Luca Cortelezzi

(luca.cortelezzi@mcgill.ca)

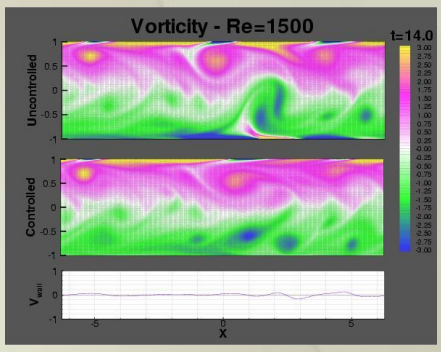
RESEARCH INTERESTS

- Optimization and Control of Unsteady Fluid Flows
- Theoretical Modeling and Numerical Simulation of Unsteady Flows

PROJECTS

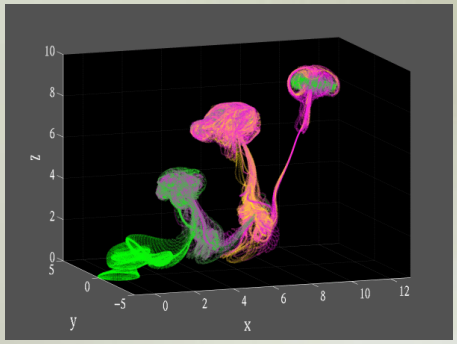
- Optimization and Control of Laminar Mixing with an Application to Biomedical and Pharmaceutical Processes
- Boundary Layer Control Using Realistic Actuators with an Application to Drag Reduction for a New Generation of Aircrafts
- Jets Manipulation and Control with an Application to Combustion Optimization and Temperature Pattern Factor Enhancement in Jet Engines

Boundary Layer Control



Mixing Optimization

Transverse Jet Manipulation



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Prof. James Richard Forbes

(james.richard.forbes@mcgill.ca)

OVERVIEW

- Dynamic modelling, estimation, and control of aerospace and robotic systems.

PROJECTS

- Linear and nonlinear controller analysis using input-output stability theory.
- Robust controller synthesis using convex optimization and linear matrix inequalities.
- Attitude control and estimation of spacecraft and aerial vehicles using the rotation matrix directly.
- Modelling and nonlinear control of flexible structures and robotic manipulators.
- The dynamics and control of Martian ``tumbleweed'' rovers.

McGill

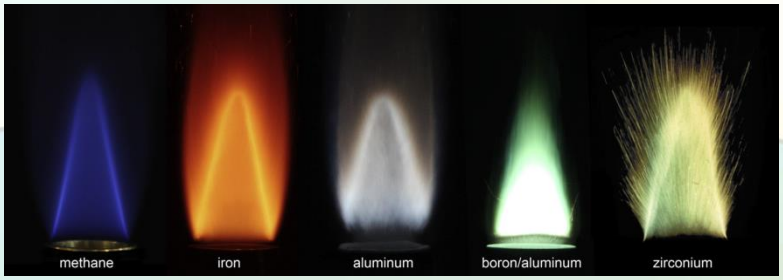
Prof. David Frost (david.frost@mcgill.ca)

OVERVIEW

Multiphase Combustion Processes, Explosions, and Shock Wave Physics

PROJECTS

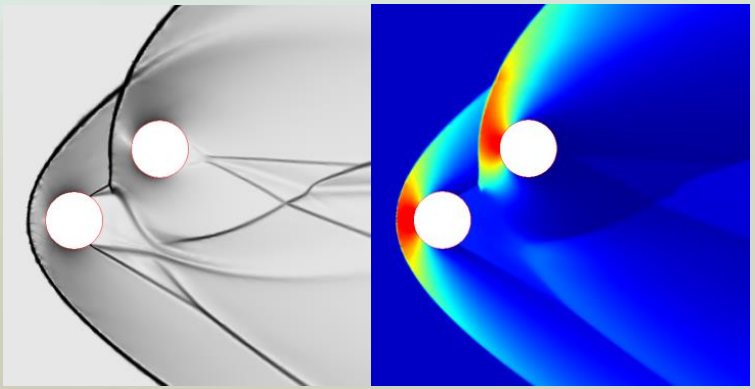
- Metal particle combustion
- Hybrid gas/particle flames
- Explosive particle dispersal
- Ballistic impact of shear-thickening fluids



Bunsen burner: gas and dust flames compared

Titanium particle combustion

Explosive particle jet formation



Interacting spheres moving at supersonic speeds

LABORATORIES

- Macdonald-Harrington B30/32; Macdonald 055

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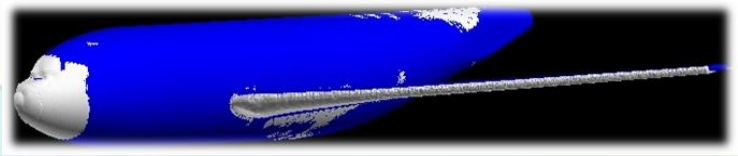
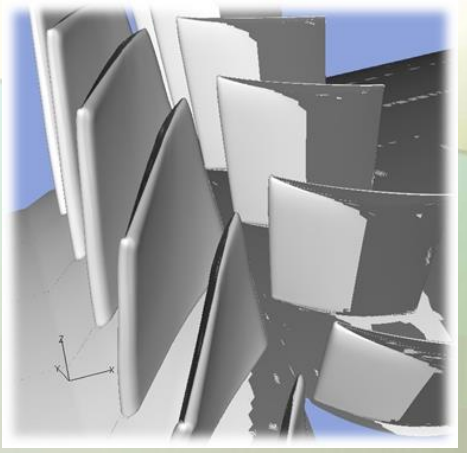
Department of Mechanical Engineering

Prof. Wagdi Habashi (wagdi.habashi@mcgill.ca)
Director CFD Lab, Chairholder NSERC - Lockheed Martin - Bell Helicopter IRC

OVERVIEW

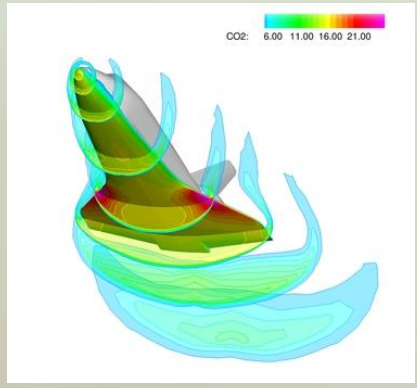
Development of advanced Computational Fluid Dynamics methods for aircraft, rotorcraft and jet engines.

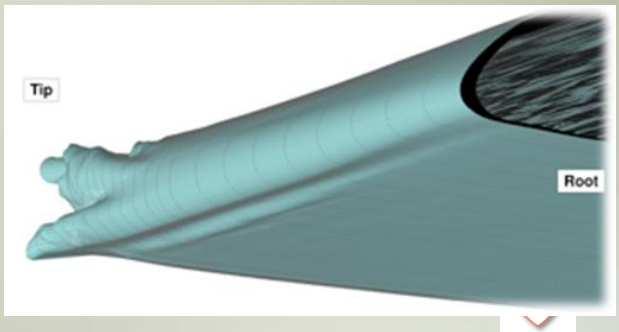




PROJECTS

- In-flight Icing Simulation (ICE):
  - 3D Ice Accretion Modeling
  - Supercooled Large Droplets Modeling
  - High Altitude Ice Crystals Engine Ingestion Modeling
  - Droplet Deformation and Breakup Modeling
- High-Mach Flows (HMF):
  - Transonic
  - Supersonic
  - Hypersonic
- Reduced Order Modeling for CFD (ROM)
- High-Performance Computing (HPC)





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Prof. Andrew Higgins

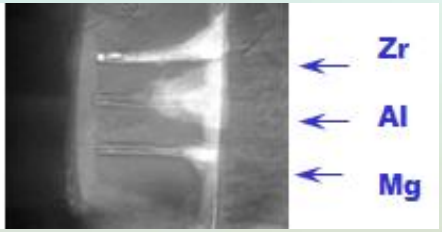
(andrew.higgins@mcgill.ca)

OVERVIEW

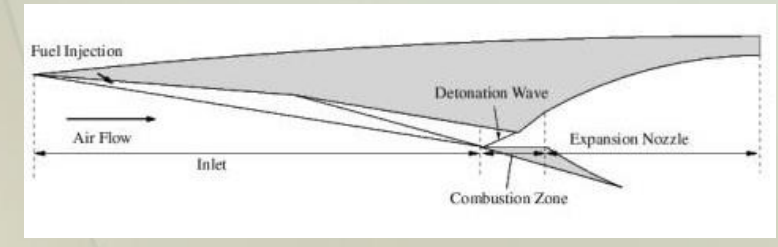
- High-speed, reacting fluid dynamics as encountered in detonation, energetic materials, and high-speed propulsion

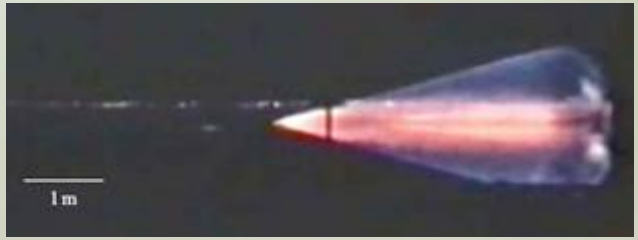
PROJECTS

- Combustion of Bulk Metals in Supersonic Flow



- Existence and Stability of Oblique Detonation





LABORATORY

- Macdonald-Harrington B30/32

McGill
Department of Mechanical Engineering

Prof. Pascal Hubert

Werner Graupe Chair on Sustainable Composites Manufacturing
(pascal.hubert@mcgill.ca)

OVERVIEW

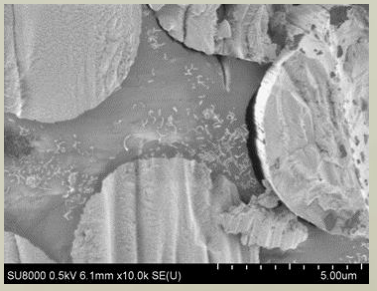
- Development new processes, material systems and design tools in order to reduce manufacturing costs and improve the environment impact of composite materials manufacturing.

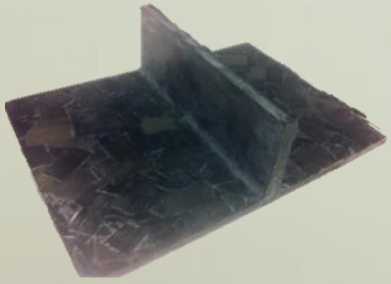
PROJECTS

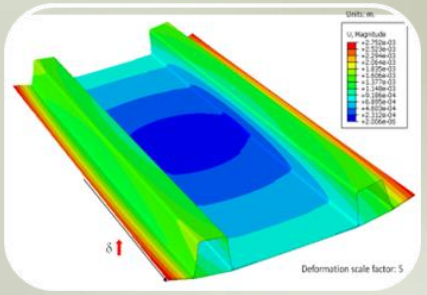
- Process modelling of polymer matrix composites
- Development of out of autoclave and thermoplastic composites processes
- Recycling of composite materials
- Development of multi-scale composites for structural health monitoring

LABORATORY

FDA 015
FDA 012
FDA 012B





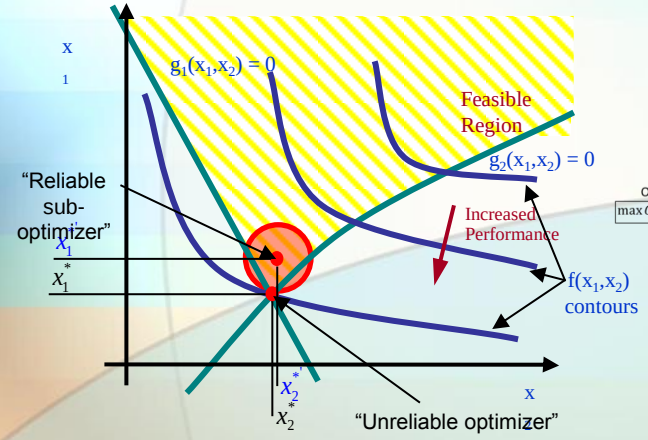


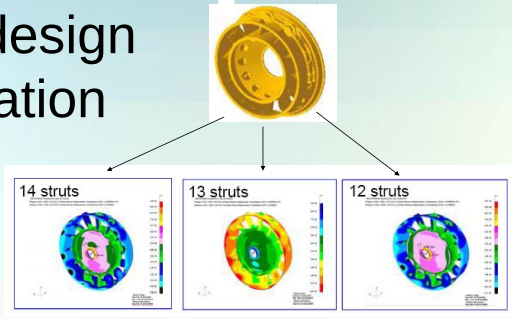
Prof. Michael Kokkolaras

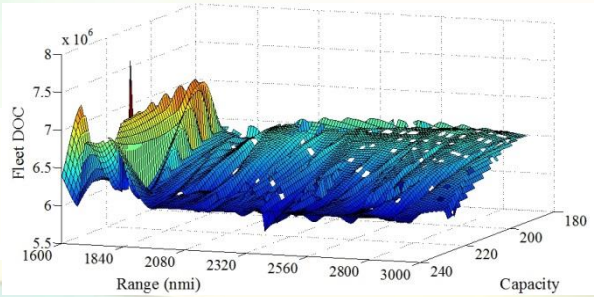
(michael.kokkolaras@mcgill.ca)

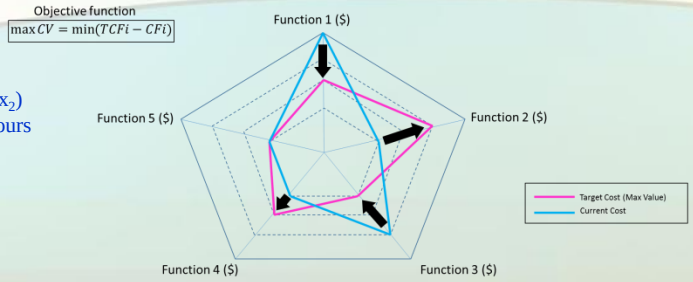
Overview

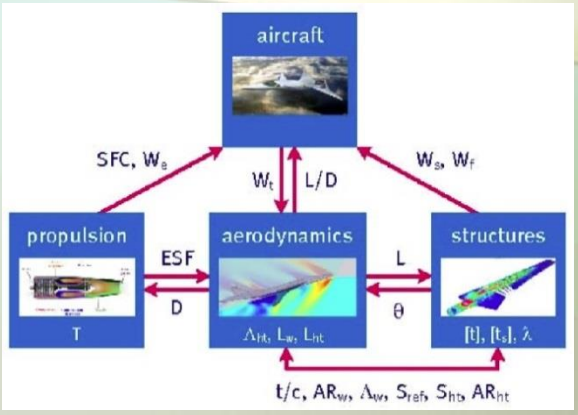
- Simulation-based engineering design
- Multidisciplinary design optimization





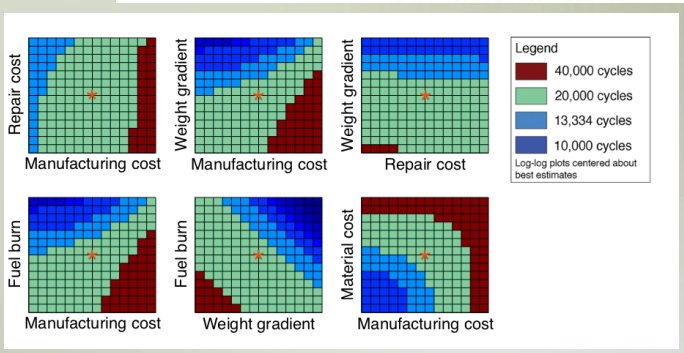






Projects

- Modeling and optimization of systems of systems, including using bio-inspired approaches
- Robust design optimization under uncertainty
- Modeling and design of product-service systems with emphasis on aerospace applications
- Blackbox optimization using rigorous surrogate-assisted strategies and derivative-free algorithms



McGill
Department of Mechanical Engineering

Prof. Jozsef Kovecses

(jozsef.kovecses@mcgill.ca)

OVERVIEW

- Dynamics and Control of Mechanical Systems

PROJECTS

- Dynamics of Multibody Systems: Modelling, Analysis, Simulation, Design
- Dynamics and Control of Haptic Mechanical Systems and Interactions with Virtual Environments
- Robotic Systems for Space and Terrestrial Applications, Rovers on Unstructured Terrain
- Contact and Interaction Problems in Mechanics
- Modelling and Simulation of Directional Drilling

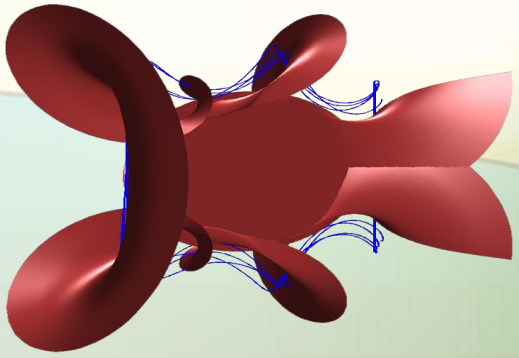
McGill
Department of Mechanical Engineering

Prof. Mathias Legrand

(mathias.legrand@mcgill.ca)

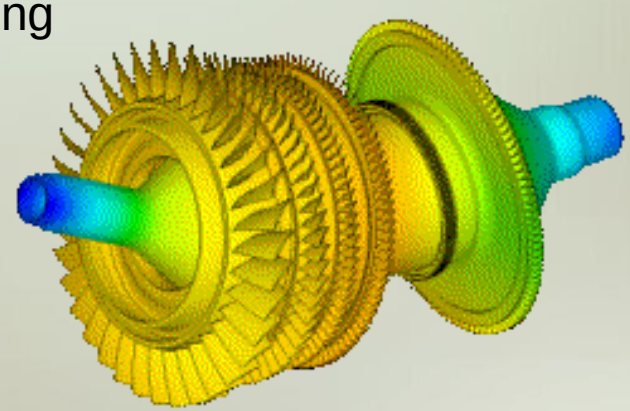
NONSMOOTH DYNAMICS OF COMPLEX SYSTEMS

- Nonsmooth Modal Analysis
- Reduced-order modeling of large-scale systems
- Advanced time-marching techniques



AEROSPACE APPLICATIONS

- Blade/casings unilateral contact and friction mechanisms in turbomachinery
- Wear of abradable coatings
- Analysis of bladed disks featuring mistuning



PARTNERS

NSERC, Pratt & Whitney Canada, Safran Group, FQRNT

LABORATORY

MC122

McGill
Department of Mechanical Engineering

PROF. JOHN H.S. LEE

(john.lee@mcgill.ca)

SHOCK WAVE PHYSICS GROUP

OVERVIEW

Combustion and Shock Wave Physics: Combustion is an amalgam of thermodynamics, heat and mass transfer and fluid dynamics and deals with the conversion of chemical to thermal energy by oxidation of fuels. Shock wave physics investigates the thermodynamics of the adiabatically compressed shocked state and the dynamics of the non-steady shock propagation. These research topics find extensive practical applications in energy conversion and propulsion systems.

PROJECTS

Current projects are mainly in the study of the fundamental propagation mechanisms of detonation and high-speed deflagration waves. These phenomena are the manifestation of the non-linear interactions between chemical kinetics, turbulence and shock waves. The projects all involve experimental, analytical, as well as numerical simulations.

LABORATORY

MD 271

McGill
Department of Mechanical Engineering

Prof. Timothy Lee

(tim.lee@mcgill.ca)

OVERVIEW

- Experimental Aerodynamics and Fluids Mechanics

PROJECTS

- Dynamic-stall flow control
- Wingtip vortex measurement and its control
- Rotorcraft blade-vortex interaction and its control
- Flow over oscillating circular cylinder

LABORATORY

ENGMD 152

McGill
Department of Mechanical Engineering

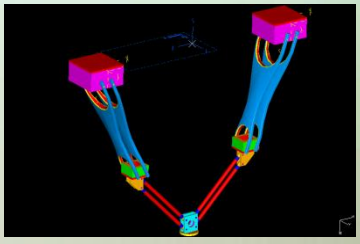
Prof. Larry Lessard (larry.lessard@mcgill.ca)

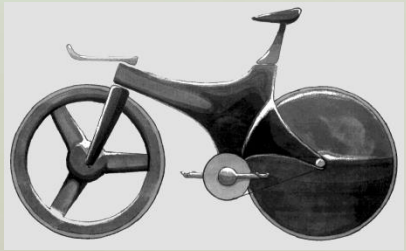
OVERVIEW

- Design, analysis, manufacturing and testing of advanced composite materials and structures.

PROJECTS

- Design of sports equipment (bicycle, hockey, etc.)
- Development of models for static and fatigue failure analysis
- Design and Manufacture of Composite Parts by RTM process
- Design of Composite Musical Instruments
- Optimization of Composite Design and Manufacturing
- Design of Helicopter and Robotic Composite Structures
- Natural Fiber Composite Materials



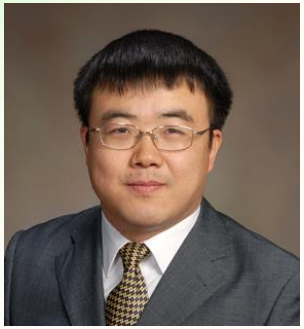


LABORATORY

FDA 015; FDA 012; FDA 012B

McGill
Department of Mechanical Engineering

Prof. Xinyu Liu (xinyu.liu@mcgill.ca)

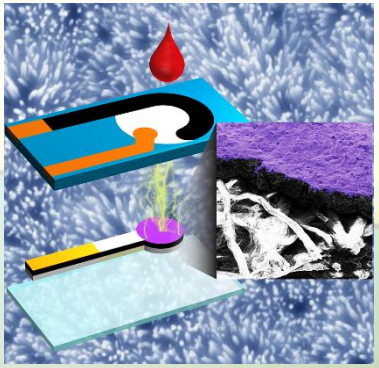


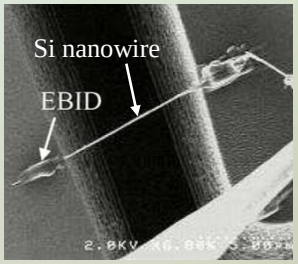
OVERVIEW

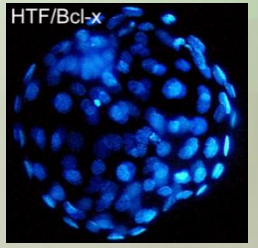
- Microfluidics, bioMEMS, and micro/nanorobotics

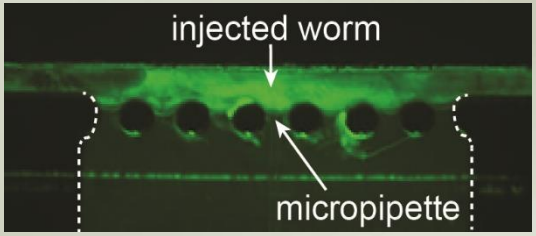
PROJECTS

- Paper-based microfluidic biosensing for low-cost molecular diagnostics
- Development of automated microfluidic systems for worm biology studies
- Robotic micromanipulation and characterization of biological samples (cells, tissues, and small organisms)
- Robotic nanomanipulation inside electron microscopes
- Design, microfabrication, and control of MEMS end-effectors for micro and nanomanipulation









LABORATORY

MD 357, Macdonald Engineering Building

McGill
Department of Mechanical Engineering

Prof. Arun Misra

(arun.misra@mcgill.ca)

OVERVIEW

- Study of the dynamics and control of satellites and space structures

PROJECTS

- Dynamics and control of Lagrangian point satellites
- Capture of space debris using tether-nets and space manipulators
- Dynamics and control of tethered satellites
- Formation flight of satellites
- Dynamics of satellites orbiting asteroids

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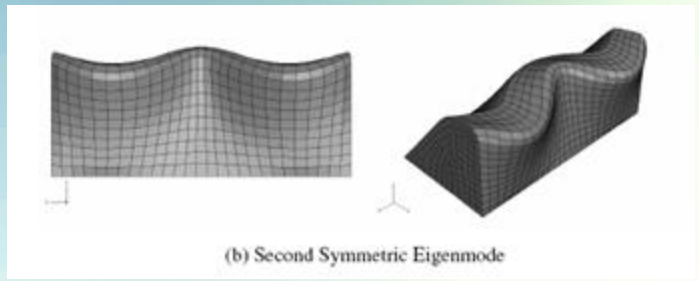
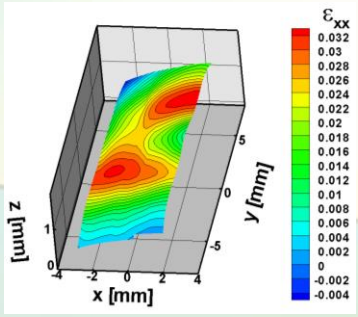
Department of Mechanical Engineering

Prof. Luc Mongeau

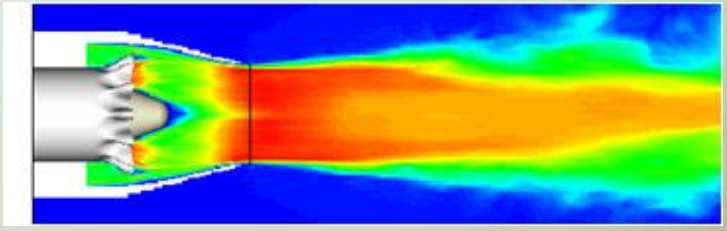
(luc.mongeau@mcgill.ca)

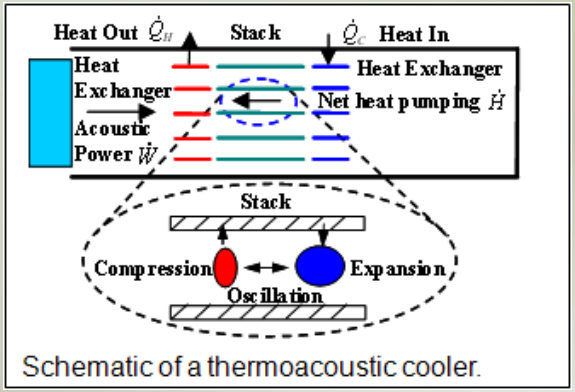


Applied research in acoustics, flow-induced mechanical vibrations, and fluid-structure interactions.



- Fluid-structure interactions within the human larynx during voice production: Mechanics and dynamics of self-oscillations
- Development of voice prosthesis for laryngectomy patients
- Stress and strain measurements in vocal folds tissue using digital image correlation methods and endoscopic high-speed imaging
- Fluid flow through the human larynx: Measurements using laser Doppler velocimetry, particle image velocimetry, and numerical simulations
- Thermoacoustic heat pumping: Model validation and design optimization, prototype development
- Sound from flow-excited cavities and structures, applied to aircraft and road vehicles
- Control noise emissions of hydraulic pumps and hoses
- Jet noise: direct numerical simulations using lattice gas methods





Schematic of a thermoacoustic cooler.

LABORATORY

ENGMD 53 and 155

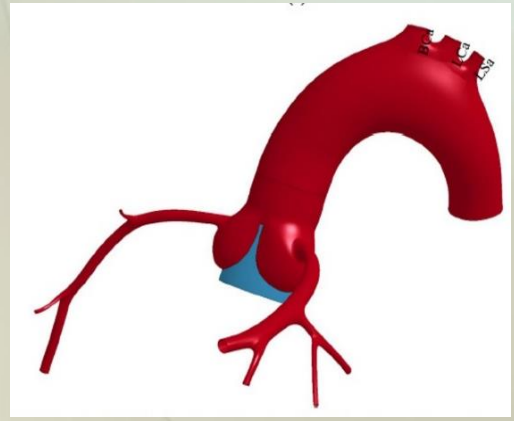
McGill
Department of Mechanical Engineering

Prof. Rosaire Mongrain

CARDIOVASCULAR ENGINEERING LAB

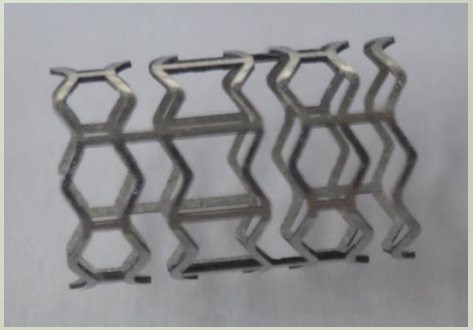
rosaire.mongrain@mcgill.ca
Laboratory: ENGMD 353

- Main objective: Study the biomechanics of cardiovascular tissues and design and optimize cardiovascular devices.
- Main Equipment: - Nano-micro indenter (micromechanics), Rheometer for viscoelasticy, Mechanical tester for soft tissue, Modeling software LS-Dyna, Fluent, Matlab, Ansys.



FSI of aortic model

Nano-micro indenter

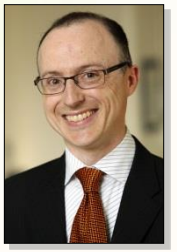


Nano-structured biodegradable stent

McGill
Department of Mechanical Engineering

Prof. Laurent Mydlarski

laurent.mydlarski@mcgill.ca



RESEARCH INTERESTS

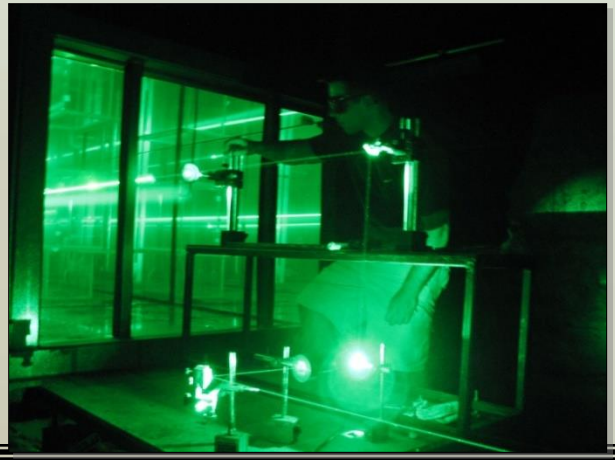
- Theoretical and experimental work in the challenging area of turbulence
- Mixing of scalars (e.g., temperature, chemical species concentration, etc.) in turbulent flows

PROJECTS

- Effect of background turbulence on the mixing within environmental and industrial flows
- Quantification of biogenic turbulence
- Lagrangian analysis of turbulent flows by particle tracking velocimetry
- Investigation of Schmidt number effects on multi-scalar mixing
- Industrial projects with Intel Corp., Hydro-Québec

OFFICE & LABORATORY

- Office: MD 374
- Laboratory: MD 152



McGill

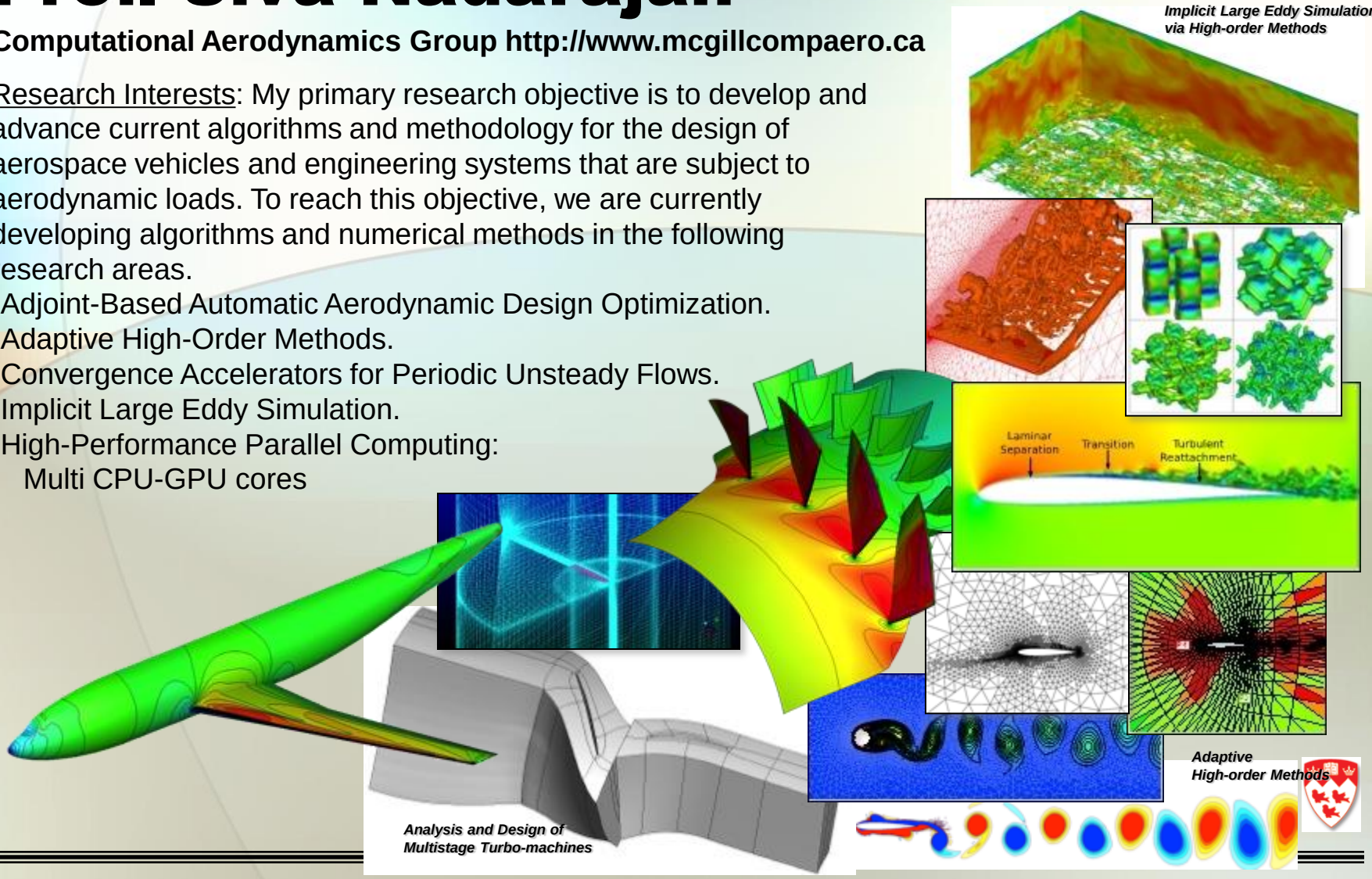
Department of Mechanical Engineering

Prof. Siva Nadarajah

Computational Aerodynamics Group http://www.mcgillcompaero.ca

Research Interests: My primary research objective is to develop and advance current algorithms and methodology for the design of aerospace vehicles and engineering systems that are subject to aerodynamic loads. To reach this objective, we are currently developing algorithms and numerical methods in the following research areas.

-Adjoint-Based Automatic Aerodynamic Design Optimization.
-Adaptive High-Order Methods.
-Convergence Accelerators for Periodic Unsteady Flows.
-Implicit Large Eddy Simulation.
-High-Performance Parallel Computing:
Multi CPU-GPU cores

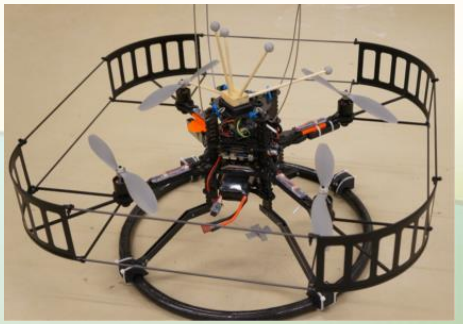


McGill
Department of Mechanical Engineering

Prof. Meyer Nahon (meyer.nahon@mcgill.ca)

Overview

Dynamics and control of vehicles and mechanical systems---simulation, testing, analysis and design. Unmanned Aerial Vehicles (UAVs)



Projects

- Dynamics and control of supermaneuverable fixed-wing UAVs
- Dynamics and control of rotorcraft UAVs
  - Landing, wind-tolerant control
- Dynamics/control of cable actuation
  - systems actuated using cables, such as robots, cranes, elevators, etc.
- Dynamics and control of underwater vehicles

Laboratory

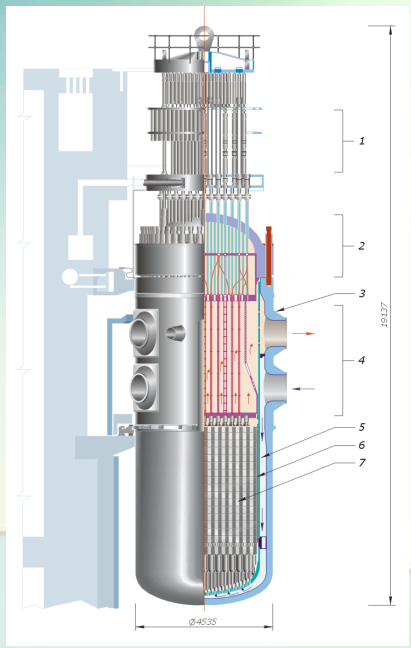
ENGMD 149

Agile UAV performing aerobatics

McGill
Department of Mechanical Engineering

Prof. Michael Paidoussis

(michael.paidoussis@mcgill.ca)



OVERVIEW

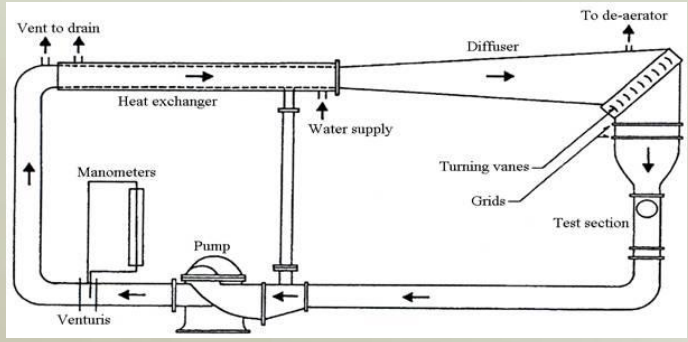
Modeling and problem-solving in fluid-structure interaction systems and systems subject to flow-induced vibration

PROJECTS

- Towed systems for gas and oil exploration
- Piping systems for ocean mining and production of liquid nitrogen at sea
- Vibrations in heat exchangers and nuclear reactor internals
- Flutter of plates and electricity generation
- Low-damping devices for MEMS/nano applications
- Modeling of pressure pulsations and wall vibrations in hydraulic lines

LABORATORY

ENGMD 259; ENGMD 052

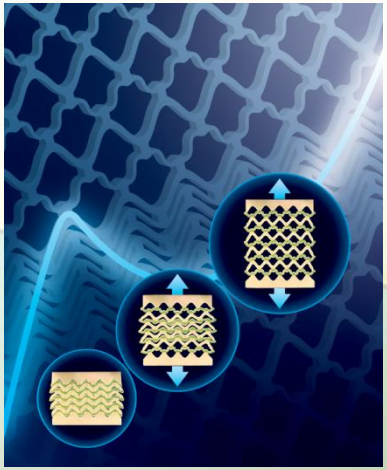


McGill
Department of Mechanical Engineering

Prof. Damiano Pasini (damiano.pasini@mcgill.ca)

KEYWORDS

- Mechanical Metamaterials, Cellular solids, Functional Graded Materials, Multifunctional Lattices for Aerospace, Multiscale Plant Biomimetics, Orthopaedics Implants



CURRENT PROJECTS

- Flexible Mechanical Metamaterials with Cellular Architecture
- Lattice Materials with Low Thermal Expansion
- Auxetic Porous Structures for Optimal Thermal Stress and Cooling
- Topology Optimization of Lattice Materials for Orthopaedic Implants
- Plant-Inspired Devices
- Optimal tailoring of Fiber-steered Laminates

LABORATORY: MD53

McGill
Department of Mechanical Engineering

Prof. Inna Sharf

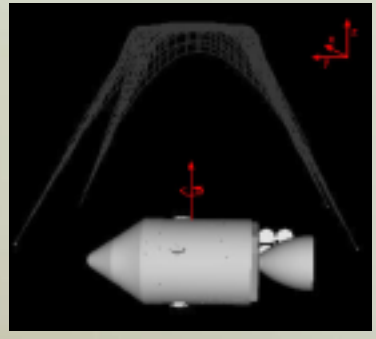
(inna.sharf@mcgill.ca)

OVERVIEW

- Dynamics, Control, State Estimation, Motion Planning, Contact Dynamics
  - Unmanned Aerial Vehicles (UAVs)
  - Space Debris Removal and On-orbit Servicing

PROJECTS

- Design, Navigation, and Control of Quadrotors
- Collision Recovery for Small UAVs
- Sense and Avoid Algorithms for Small UAVs
- Attitude Propagation of Space Debris
- Active Debris Removal
- Reactionless Path Planning and Control of Space Robotic Systems



LABORATORY

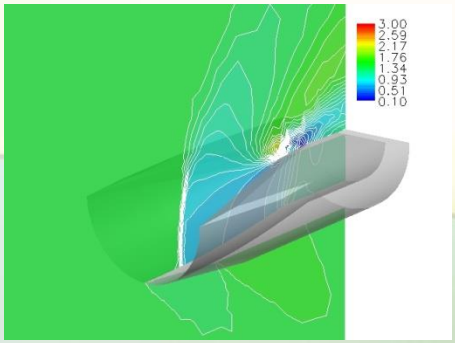
Aerospace Mechatronics Lab,
ENGMD 149

McGill
Department of Mechanical Engineering

Prof. Evgeny Timofeev (evgeny.timofeev@mcgill.ca)

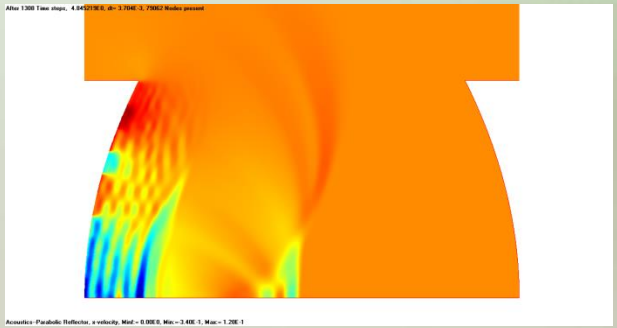
OVERVIEW

- Development of state-of-the-art numerical methods and computer codes for unsteady compressible flows and their application to basic and industrial problems.



RESEARCH DIRECTIONS

- Fundamental studies of unsteady shock reflections
- Air intakes for next-generation hypersonic air-breathing engines
- Flows with gas/liquid/solid interfaces (detonation in channels, magnetized target fusion, jetting phenomena)
- Nonlinear acoustics in heterogeneous media with applications to flow metrology, medicine, non-destructive testing



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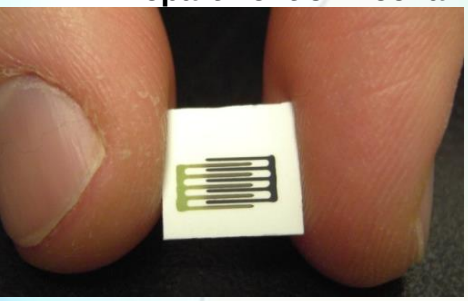
Department of Mechanical Engineering



Prof. Srikar Vengallatore

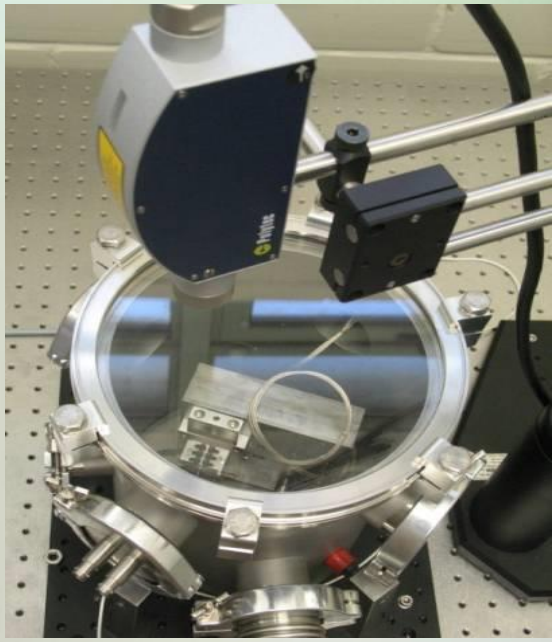
(srikar.vengallatore@mcgill.ca)

Research Program

Advanced materials and structures for micro/nanosystems (MEMS/NEMS) used for sensing, communications, and energy harvesting.

Research Projects

- Energy dissipation and damping in micro/nanoresonators
- Internal friction in thin films and nanomaterials
- Micro engines and micro fuel cells for energy harvesting



Research Facilities

- NanoTools Microfabrication Facility
- Laboratory for Microsystems and Nanosystems

McGill
Department of Mechanical Engineering

Prof. Yaoyao Fiona Zhao

(yaoyao.zhao@mcgill.ca)

OVERVIEW

- Developing novel design methods to achieve multi-functionalities, better performance, and improved sustainability.
- Developing process models, simulation and analysis methods for additive manufacturing processes and additively manufactured products.
- Studying bio-compatible and non-conventional materials that can be used for binder-jetting additive manufacturing processes.

PROJECTS

- Multi-scale multi-functionality design method for additive manufacturing
- Conceptual design flow and method to achieve part consolidation
- Sustainability analysis of additive manufacturing processes and products
- Repair and re-manufacturing of aerospace components via additive manufacturing processes

LABORATORY

MD53