# 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
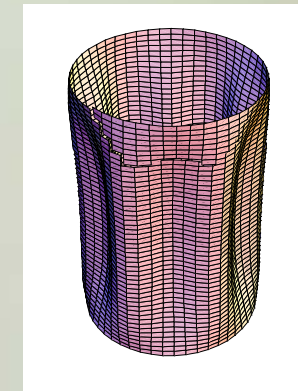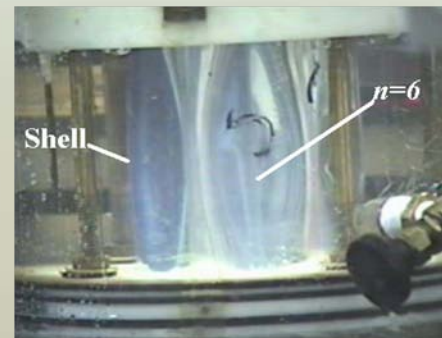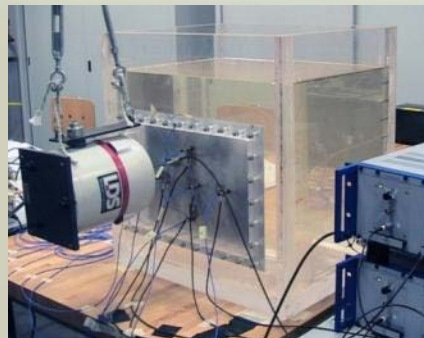
PROJECTS

- 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
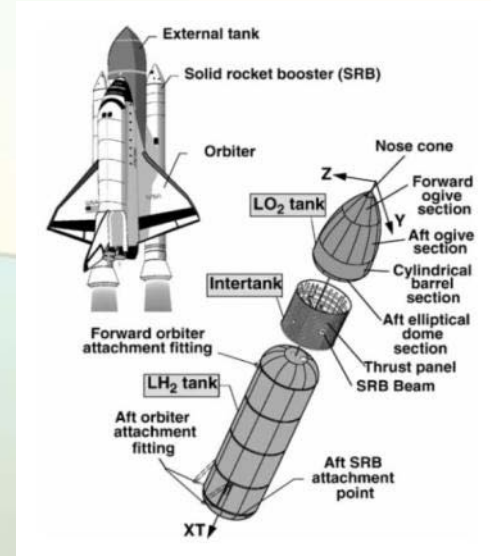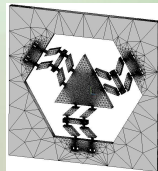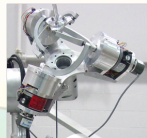
LABORATORY

ENGMD 052
ENGMD 259

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

OVERVIEW

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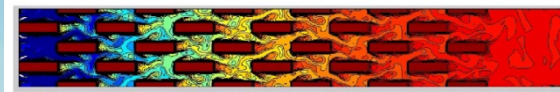
PROJECTS

- Design theory: Complexity measures for conceptual design
- PLATO: Simplicial architectures for multi-axis accelerometers and algorithms for twist & pose estimation from acceleration measurements
- Development of innovative clutch mechanisms for hybrid vehicles
- Gearless speed reducers: Speed-o-Cam; Slide-o-Cam; epicyclic trains
- SMG: Schönflies-motion generators for fast pick and place operations

LABORATORY

- Robotic Mechanical Systems Lab, McConnell 418

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

OVERVIEW

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

PROJECTS

- Loop heat pipes
- Compact and ultracompact heat exchangers
- Heat transfer in slurries of microencapsulated phase-change materials
- Heat transfer enhancement using porous metal foams
- Thermal design of oil-cooled power and distribution transformers
- Computational optimization of thermal performance
- Thermal energy storage in rock beds and phase-change systems
- Cooling systems for computers and electronics
- Control-volume finite element methods for fluid flow and heat transfer

LABORATORY
ENGMC 012

McGill
Department of Mechanical Engineering
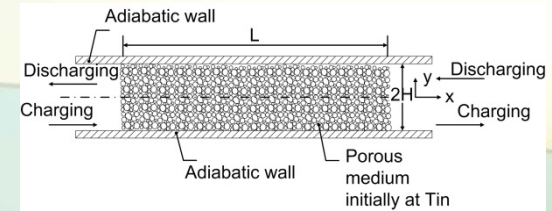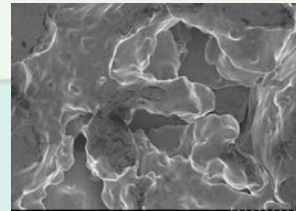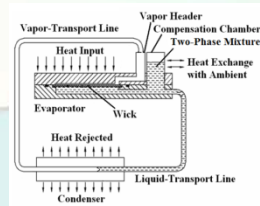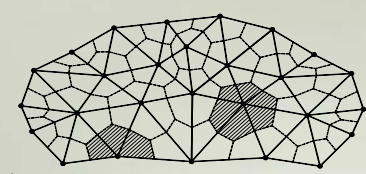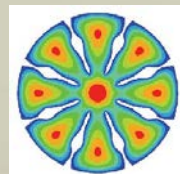
Prof. Francois Barthelat
(francois.barthelat@mcgill.ca)

Biomimetic Materials Laboratory

OVERVIEW
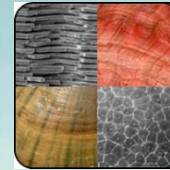- Structure and mechanics of biological materials (deformation, fracture)
- Design, fabrication and testing of bio-inspired materials (biomimetics)

PROJECTS
- Super ceramics at the seashore: mollusc shells
- A tough, ultra-light flexible armor: scaled fish skin
- Stiffness, hardness and toughness: tooth enamel
- Effect of age and disease on bone damage
- Novel bio-inspired composites
- Morphing and multifunctional materials

Novel bio-inspired materials

20 μm
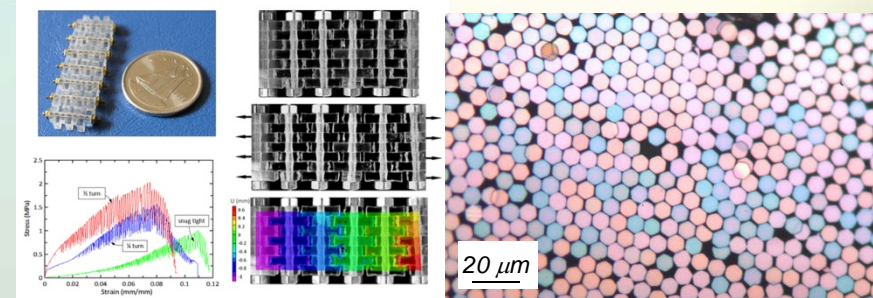
Structure and performance of fish scales
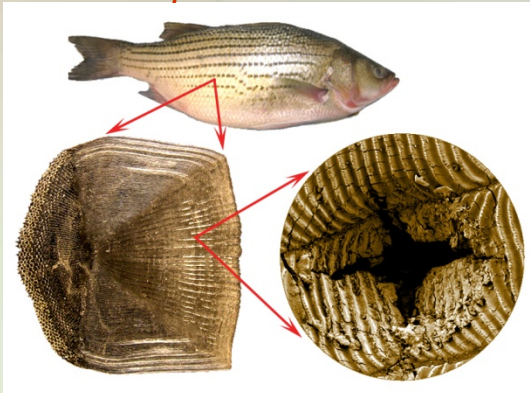
Unusual fracture mechanisms in an ultra-tough material: mother-of-pearl

In-situ imaging of micro-mechanisms (scanning probe microscope)

Numerical modeling

Crack

200 μm

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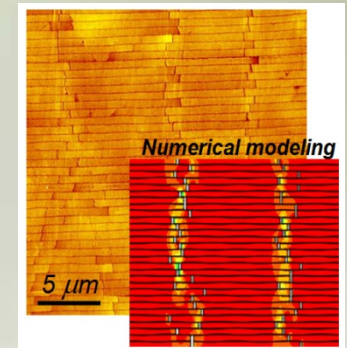
Prof. Jeff Bergthorson (jeff.bergthorson@mcgill.ca)

OVERVIEW

- Combustion of alternative biofuels for automotive and aircraft engines

Combustion in small channels
for fuel reformation

Flame studies using
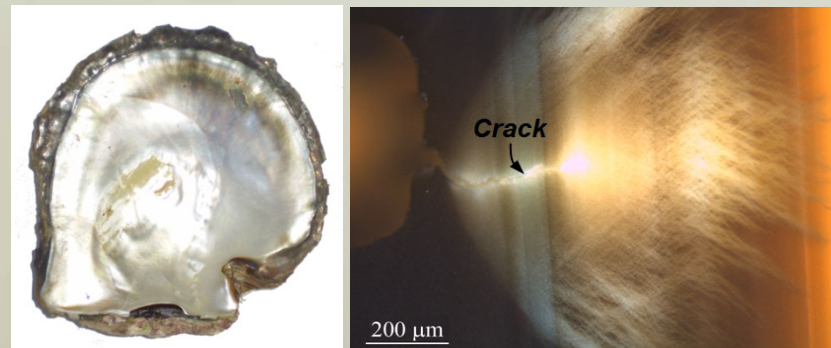laser diagnostics

Shock tube ignition experiments

Ignition kernel

Optical fibre

Reflected shock wave
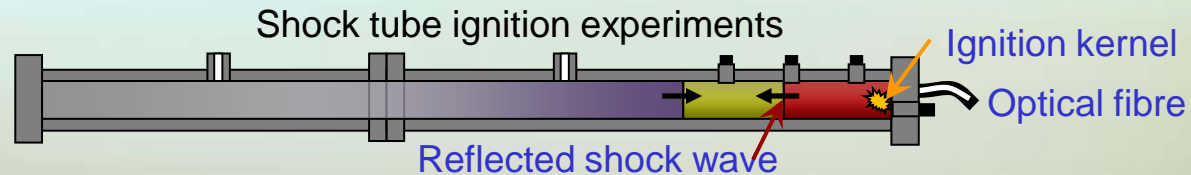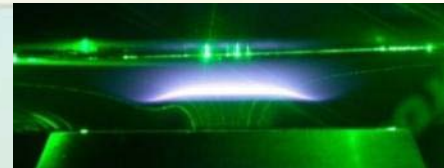
PROJECTS

- Non-catalytic reformation of fuels to hydrogen for fuel cell vehicles
- Combustion properties of biofuels, including biodiesel and biojet fuels
- Shock tube ignition experiments and flame studies using laser diagnostics

LABORATORY

- Macdonald Engineering 257, 051

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
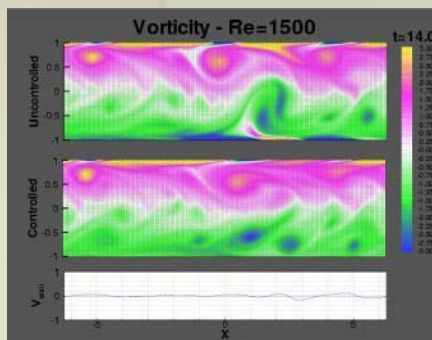
Mixing Optimization

Transverse Jet Manipulation

Prof. James Forbes (james.richard.forbes@mcgill.ca)
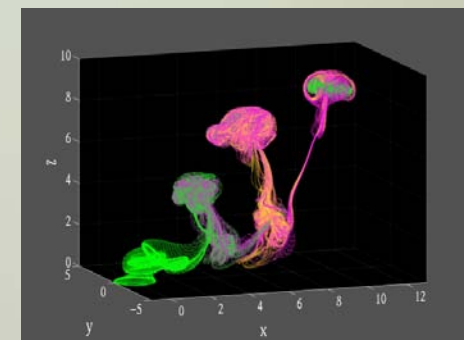
OVERVIEW

- Control and estimation techniques for mechanical, aerospace, and robotic systems.

PROJECTS

- Spacecraft attitude control and estimation using the rotation matrix
- Magnetic attitude control - using the Earth's magnetic field for actuation
- Nonlinear control of flexible space structures and space manipulators (e.g., Canadarm)
- The dynamics and control of Martian "tumbleweed" rovers

Prof. Eliot Fried

(eliot.fried@mcgill.ca)

Focus

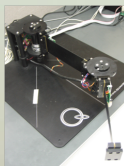Novel Material Systems such as nanocrystalline alloys, biomembranes gels, block copolymers, granular aggregates, and liquid crystals. Turbulence modeling.

Common Challenge

Developing tractable macroscopic models which account correctly for evolving defects and microstructure

Theoretical Tools

Statistical mechanics, continuum mechanics, and thermodynamics

Analytical Tools

Bifurcation theory, differential geometry, perturbation methods, and numerical simulation

McGill
Department of Mechanical Engineering

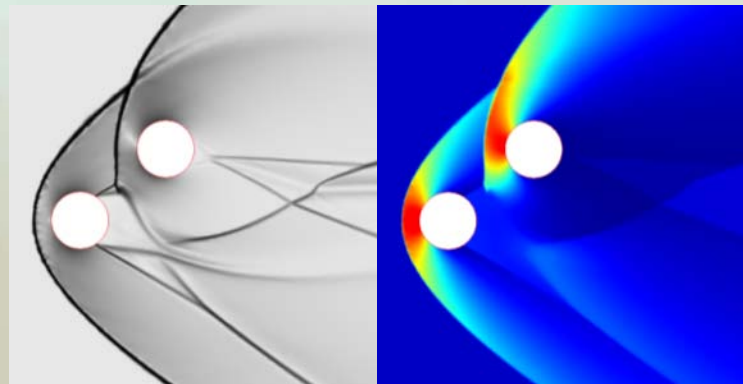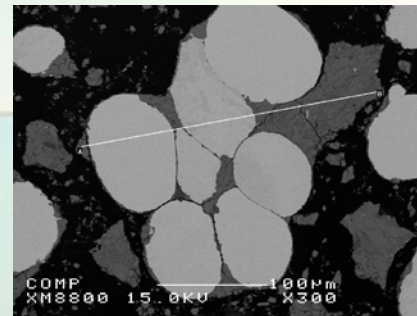# Prof. David Frost   (david.frost@mcgill.ca)

OVERVIEW

Multiphase Combustion Processes, Explosions, and Shock Wave Physics

PROJECTS

- Metal particle combustion
- Shock-induced reactions in powder mixtures
- Ballistic impact of shear-thickening fluids
- Particle motion in supersonic flows

LABORATORIES

- Macdonald-Harrington B30/32

Prof. Wagdi Habashi

(wagdi.habashi@mcgill.ca)
Director CFD Lab, Chairholder NSERC-Bombardier-Bell Helicopter-CAE IRC

OVERVIEW
Development of advanced CFD simulation
for aircraft, rotorcraft, UAVs, jet engines.
Computational wind engineering around buildings.

PROJECTS
- Aero-icing: in-flight icing simulation (ICE)
- Aero-elasticity: fluid-structure interaction
- Aero-numerics: automatic mesh adaptation (AMA)
- Aero-heat transfer: fluid-solid heat transfer (CHT)
- Multistage turbomachinery (TURBO)
- Computational wind engineering (CWE)
- High-performance computing (HPC)
- CFD data: flight simulators (SIM)

CWE

TURBO

CFD   AMA

HPC   SIM   CHT   ICE
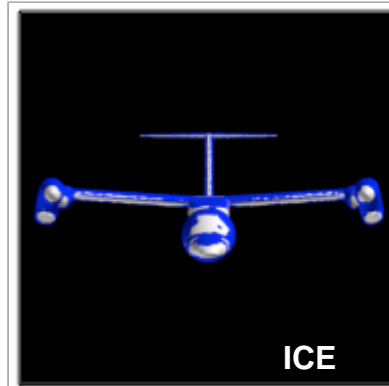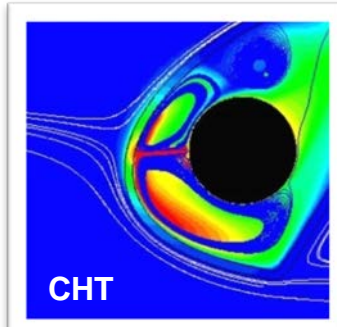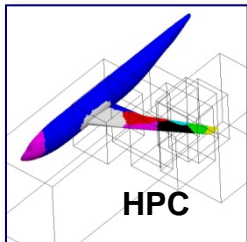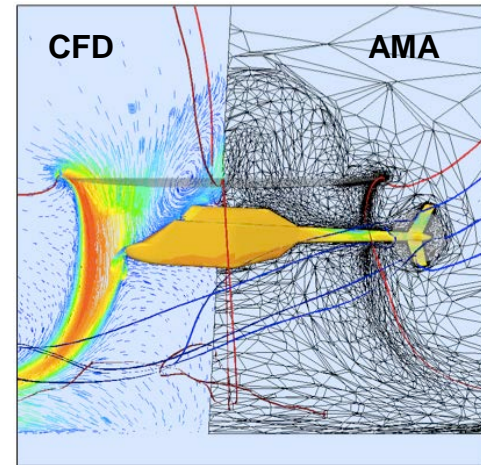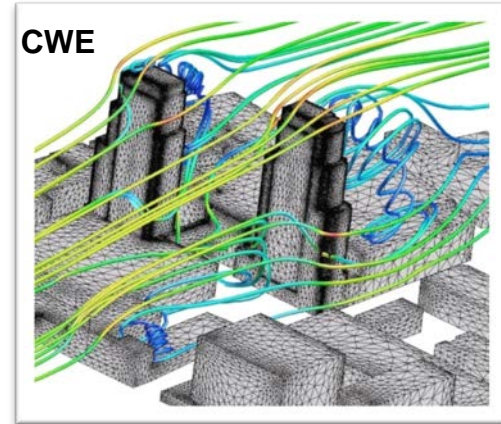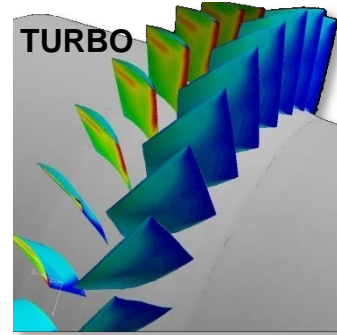
Prof. Andrew Higgins   (andrew.higgins@mcgill.ca)

OVERVIEW

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

PROJECTS

- Combustion of Bulk Metals in Supersonic Flow

Zr
Al
Mg

- Existence and Stability of Oblique Detonation

Fuel Injection
Detonation Wave
Air Flow
Inlet
Combustion Zone
Expansion Nozzle

1 m
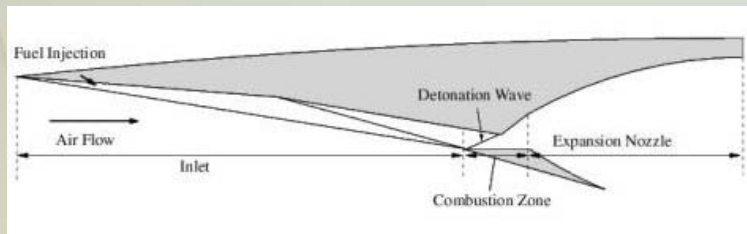
LABORATORY

- Macdonald-Harrington B30/32

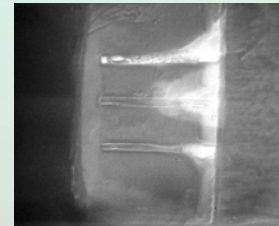# Prof. Pascal Hubert   (pascal.hubert@mcgill.ca)

OVERVIEW
- Development, processing, testing and modeling of advanced composite and nanocomposite materials.

PROJECTS
- Carbon Nanotube Composites: Microscopic and Macroscopic Applications
- Development of Out of Autoclave Processes
- Welding of Thermoplastic Composites
- Wind Turbine Blades Optimization
- Automated Fabrication of Thermoplastic Composites

LABORATORY
FDA 015
FDA 012
FDA 012B
ENGMD 155

5nm

Prof. Jozsef Kövecses (jozsef.kovecses@mcgill.ca)
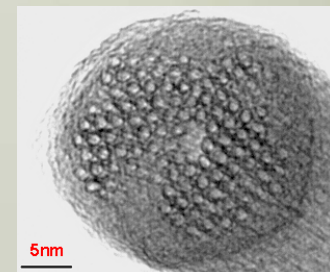
OVERVIEW

- Dynamics and Control of Mechanical Systems.

PROJECTS

- Contact Dynamics: Modelling, Analysis and Design
- Computational Techniques for Dynamics Simulation of Multibody Systems
- Modelling and Analysis of Mobile Robots and Space Systems
- Dynamics of Kinesthetic Haptic Systems
- Applications of Dynamics in Biomechanical and Manufacturing Systems

LABORATORY

- ENGMC 418

McGill
Department of Mechanical Engineering

PROF. JOHN H.S. LEE   (john.lee@mcgill.ca)

SHOCK WAVE PHYSICS GROUP

Radulescu et al.

Schlieren photography and numerical simulation of the turbulent structure of a detonation wave

An experimental smoked foil to illustrate the unstable pattern of a detonation front propagation

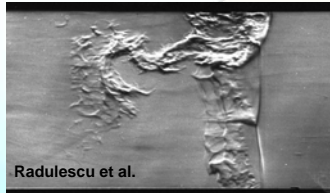**Numerical simulation of flame acceleration in a obstructed tube**

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.
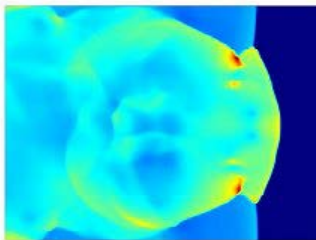
PROJECTS

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.
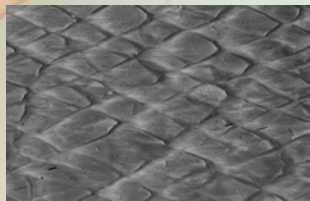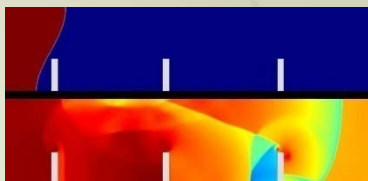
LABORATORY

MD 271

Detonation tube facility
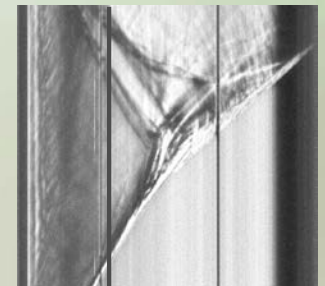
Streak-Schlieren photography showing the x-t diagram for the onset of detonation from turbulent deflagration

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. Mathias Legrand
(mathias.legrand@mcgill.ca)

Structural Dynamics and Vibration Laboratory
http://structdynviblab.mcgill.ca
122 McConnell

Aerospace applications

- Analysis of bladed disks featuring mistuning
- Shape optimization of multi-stage bladed rotors
- Aerodynamic analysis of flutter phenomena
- Centrifugal pendulum vibration absorbers
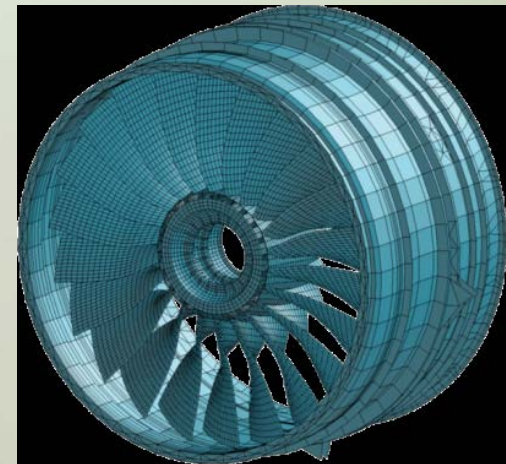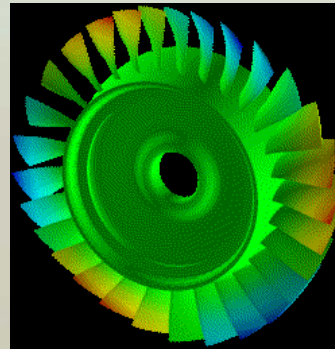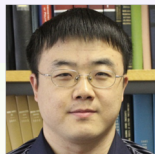
Nonlinear dynamics of complex systems

- Reduced order models of non-smooth systems
- Nonlinear modal analysis
- Wear of abradable coatings

Partners

- NSERC
- Pratt & Whitney Canada
- Snecma, SAFRAN Group
- Bombardier Aerospace

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

OVERVIEW

- Dynamics and control of microrobotic systems and MEMS (micro-electro-mechanical systems) devices.

PROJECTS

- Kinematic and dynamic modelling of microrobotic systems for biomanipulation
- Visual servo control of microrobotic systems
- Nanonewton force sensing and control during microrobotic manipulation
- Assimilation of multimodal feedback (e.g., position, vision, and force)
- Nonlinear modelling and control of MEMS actuators

LABORATORY

- Room 357, Macdonald Engineering Building

# Prof. Dan Mateescu　　(dan.mateescu@mcgill.ca)

OVERVIEW
- Aerodynamics: Steady and unsteady flows past geometrical configurations with fixed or oscillating walls in subsonic, transonic and supersonic regimes.

APPROACH
- Theoretical solutions and computational methods based on finite difference, finite volume, and hybrid-spectral formulations

PROJECTS
- Effect of ground proximity on the unsteady flows past oscillating airfoils and wings (related to a CRIAQ – CAE research contract)
- Analysis of oscillating wing structures with piezoelectric sensor and actuator strips (related to a CRIAQ – Bombardier research contract)
- Aerodynamics of lifting surfaces at very low Reynolds numbers for micro-aircraft and UAV (unmanned air vehicles) applications
- Study of aerodynamic problems of unspecified geometry (adaptive, flexible and jet-flapped wings and aerodynamic shape design)
- Effect of variable inflow velocity on the unsteady flows in confined configurations with oscillating walls (for various engineering applications)
- Optimization of aerodynamic flows using synthetic jets
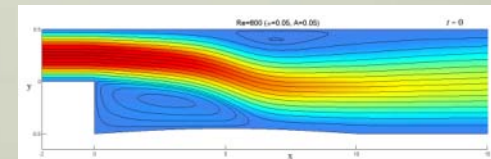
OFFICE and WEBSITE
Macdonald Engineering Bldg., Room 359　　**www.mcgill.ca/mecheng/staff/academic**

Prof. Arun Misra (arun.misra@mcgill.ca)

OVERVIEW

- Study of the dynamics and control of satellites, space structures and space robots.

PROJECTS

- Dynamics of Sun-Earth and Earth-Moon Lagrangian point satellites
- Dynamics of control of tethered satellites
- Dynamics of the space elevator
- Formation flight of satellites
- Space manipulator assisted capture of satellites
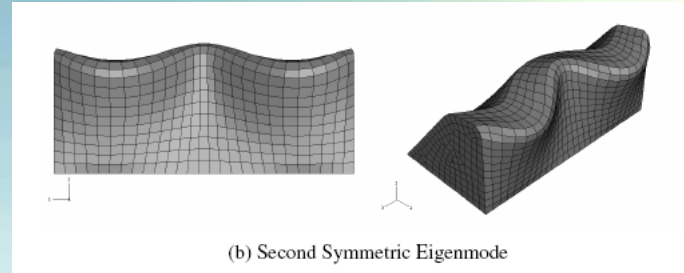- Attitude dynamics of satellites orbiting asteroids

Department of Mechanical Engineering

Prof. Luc Mongeau

(luc.mongeau@mcgill.ca)

(b) Second Symmetric Eigenmode

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
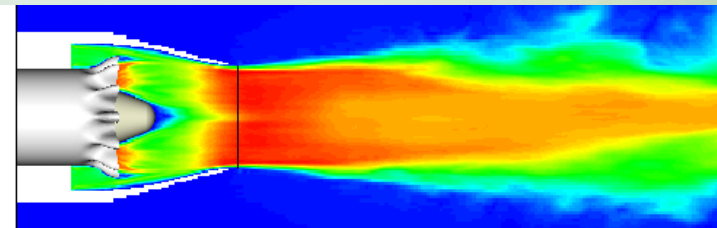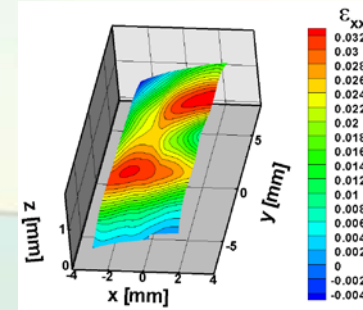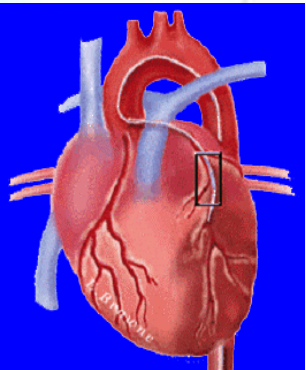
LABORATORY
ENGMD 53 and 155
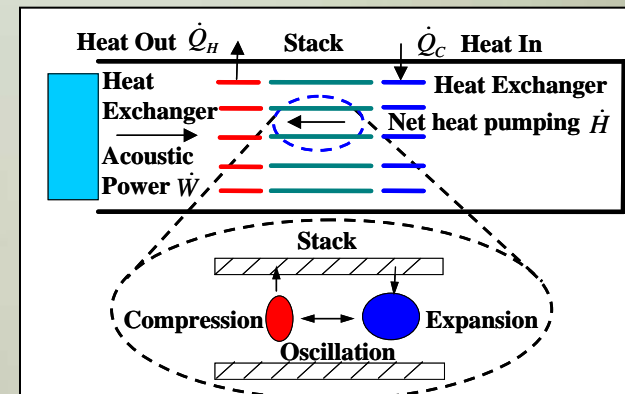
Schematic of a thermoacoustic cooler.

Prof. Rosaire Mongrain
## CARDIOVASCULAR ENGINEERING LAB

- Main objective: Study the biomechanics of cardiovascular tissues and design and optimize cardiovascular devices.

- Main Equipment: - PIV system for flow visualization, Rheometer for viscoelasticy, Mechanical tester for soft tissue, Modeling software CFX, Matlab, Ansys, Pro-E, Femlab
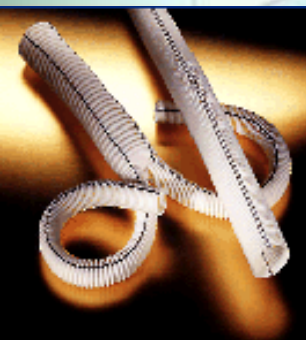
www.cvel.org
rosaire.mongrain@mcgill.ca
Laboratory: ENGMD 53
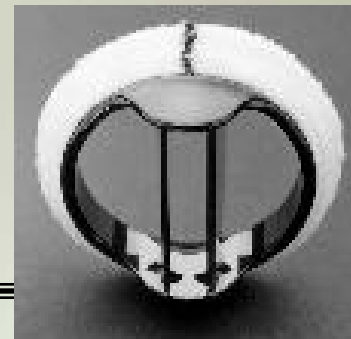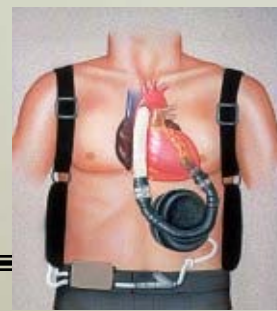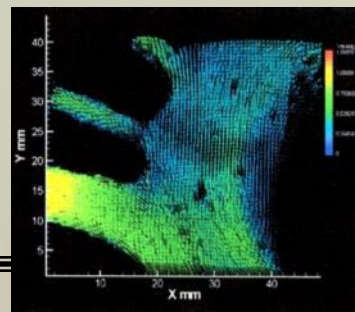
Prof. Laurent Mydlarski

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

- Studies of differential diffusion (i.e. effects of molecular diffusivities) in turbulent flows

- Algorithm development for the detection of scalar (chemical, biological, radioactive, etc.) releases within a turbulent flow

- Lagrangian analysis of turbulent flows by particle tracking velocimetry

- Industrial projects with Intel Corp., Hydro-Québec

OFFICE & LABORATORY

- Office: MD 162

- Laboratory: MD 152

![McGill] **Department of Mechanical Engineering**

Prof. Siva Nadarajah

**(siva.nadarajah@mcgill.ca)**
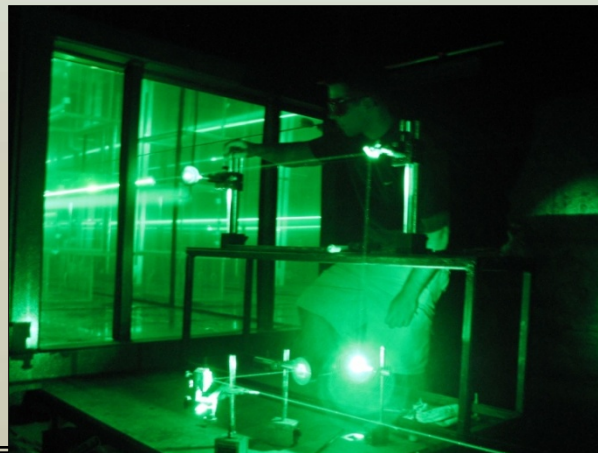
OVERVIEW

- Develop and advance current algorithms and methodology for the design of aerospace vehicles and engineering systems that are subject to aerodynamic loads.

PROJECTS

- Adjoint-Based Aerodynamic Shape Optimization of Steady and Unsteady Flows.
- Adaptive High-Order Methods.
- Non-Linear Frequency Domain Methods for Periodic Flows.
- Adaptive Gradient-Enhanced Kriging Response Surfaces.
- Detached Eddy Simulation.
- High-Performance Computing.
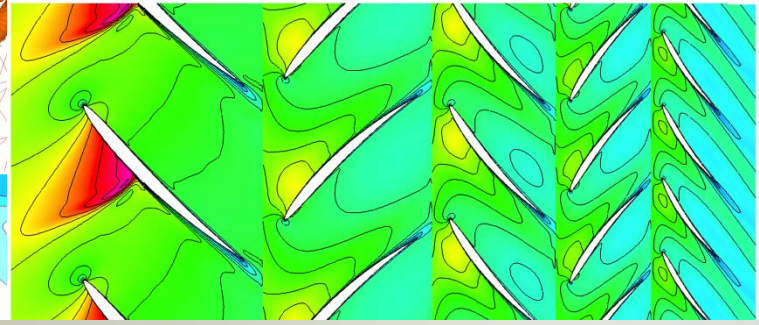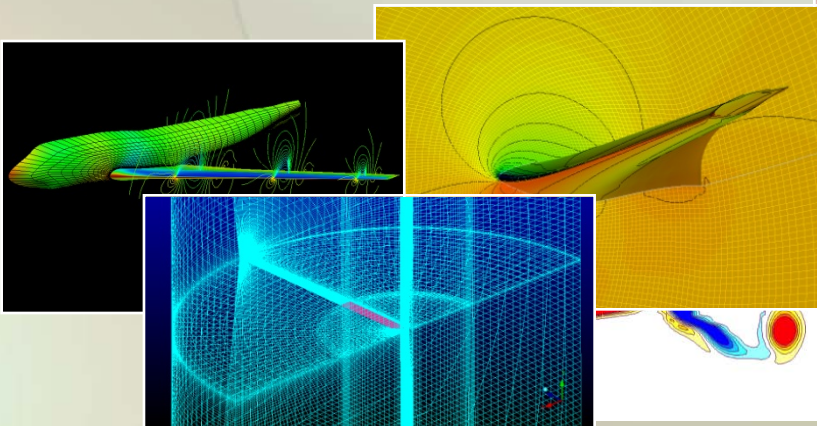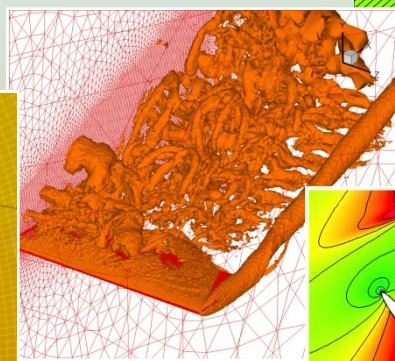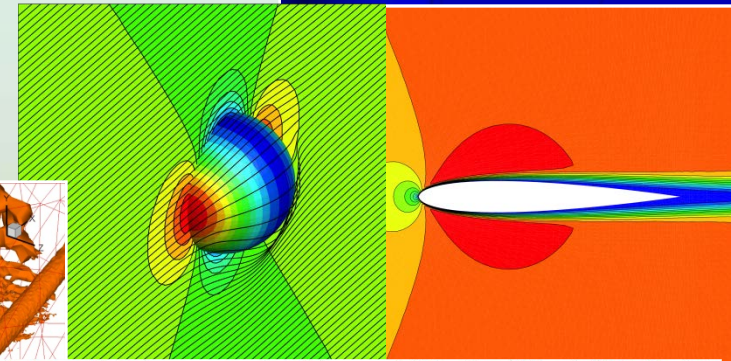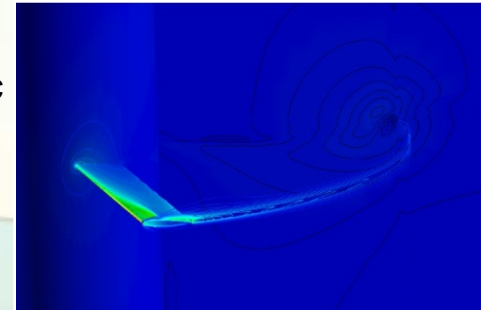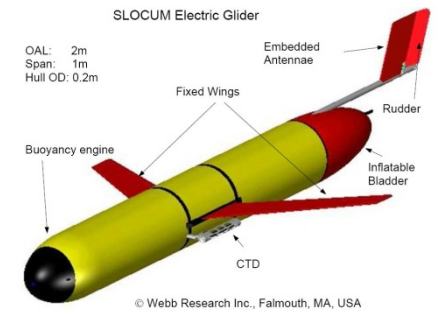
Prof. Meyer Nahon (meyer.nahon@mcgill.ca)

| **Overview** |
| Dynamics and control of vehicles and mechanical systems---simulation, testing, analysis and design |
| **Projects**

• Dynamics/control of cable actuation (systems actuated using cables, such as robots, cranes, elevators, etc.)

• Dynamics and control of unmanned aerial vehicles (UAVs)

• Dynamics and control of underwater glider, robotic eel

• Dynamics modeling of bicycles |
| **Laboratories**: ENGMD 263
ENGMC 411 |

SLOCUM Electric Glider

OAL: 2m
Span: 1m
Hull OD: 0.2m

Embedded Antennae

Fixed Wings

Rudder

Buoyancy engine

Inflatable Bladder

CTD

© Webb Research Inc., Falmouth, MA, USA

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

OVERVIEW

- Dynamics and control of vehicles and mechanical systems—simulation, testing, analysis and design.

PROJECTS

- Dynamics/control of cable actuation (applies to systems actuated using cables, such as robots, cranes, etc.)
- Dynamics and control of high-performance airships
- Dynamics and control of underwater gliders
- Dynamics and control of unmanned aerial vehicles (UAVs)

LABORATORIES

- ENGMD 263; ENGMC 411
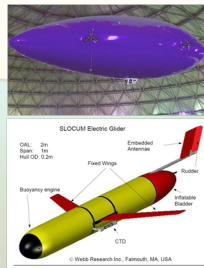
Prof. Michael Paidoussis
(michael.paidoussis@mcgill.ca)
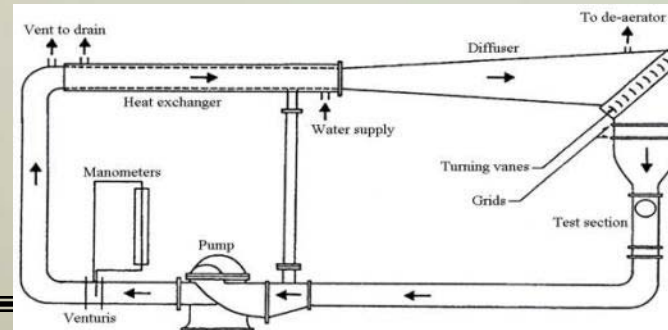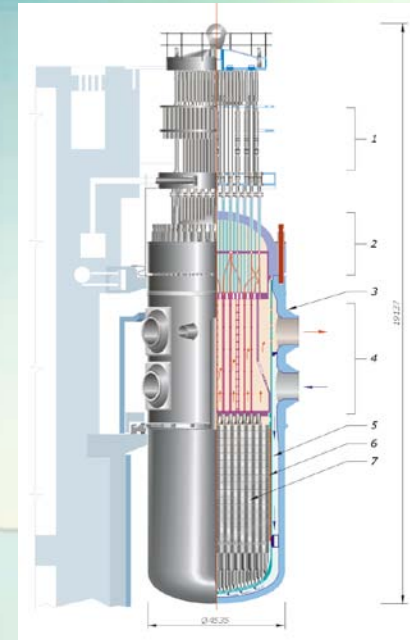

OVERVIEW

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

Prof. Damiano Pasini   damiano.pasini@mcgill.ca

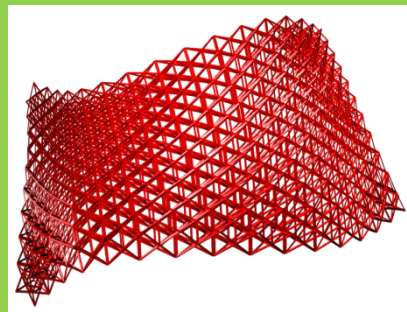Biomechanics, Solids Mechanics, Design Optimization, Multiscale Mechanics

RESEARCH ON HYBRID MATERIALS

- Microarchitectured materials, e.g. cellular materials
- Plant-inspired hierarchical materials and devices
- Composite structures

Biological cellular material
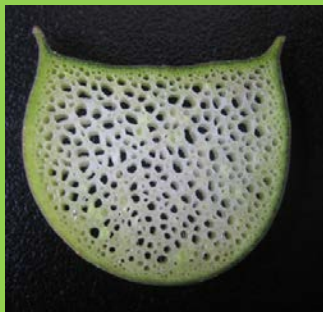
Artificial cellular material

Plant tissue

Three-dimensional lattice

APPLIED TO BIOENGINEERING AND AEROSPACE

- Reconstructive orthopaedics: hip implants
- Intravascular devices
- Automated Fiber Placement Technology for laminate composites
- Ultralighweight sandwich panels

Orthopaedics

Intravascular devices

Cellular hip implant

Novel lattice for stent-like devices
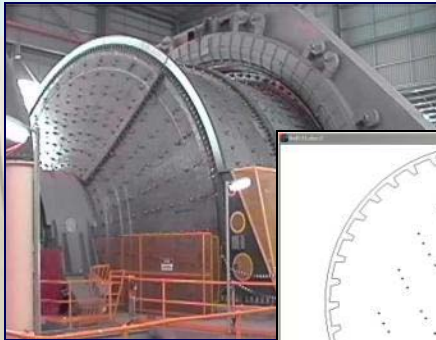
Prof. Peter Radziszewski peter.radziszewski@mcgill.ca

Comminution Processes *(or Rock n' Roll)*

Comminution Dynamics Lab (http://comminutiondynamicslab.mcgill.ca/)

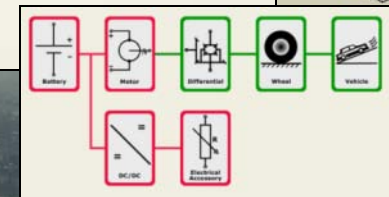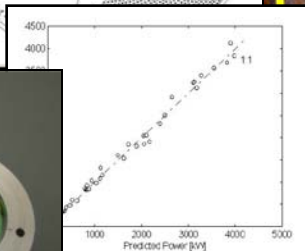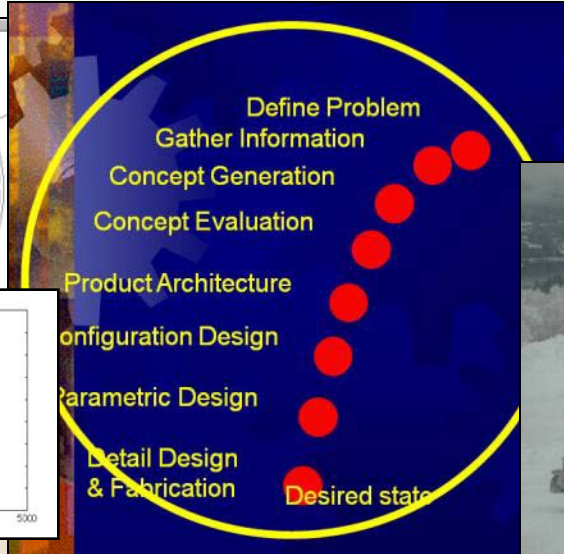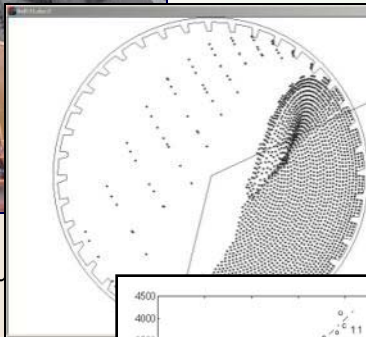Rock n' Roll describes a system that can be defined by interactive or interdependent elements working together to accomplish some desired task. In the case of comminution processes, this task is rock breakage where the rocks and balls are elements and the rolls are interactions & interdependencies between those elements. This is the original focus of the CDLab.

However, Rock n' Roll is also an inspiration to describe the highly iterative process that is engineering design. Engineering design is also the subject that I have the pleasure of teaching and which has led to the development of research activities in recreational scale electric/hybrid vehicles as well as lunar mobility.

After all, a wheel is just an inside out tumbling mill!

40' diameter SAG mill
Orange NSW, Au

Define Problem
Gather Information
Concept Generation
Concept Evaluation
Product Architecture
Configuration Design
Parametric Design
Detail Design & Fabrication
Desired state

Laboratory: Comminution Dynamics Lab MD019

Prof. Inna Sharf (inna.sharf@mcgill.ca)
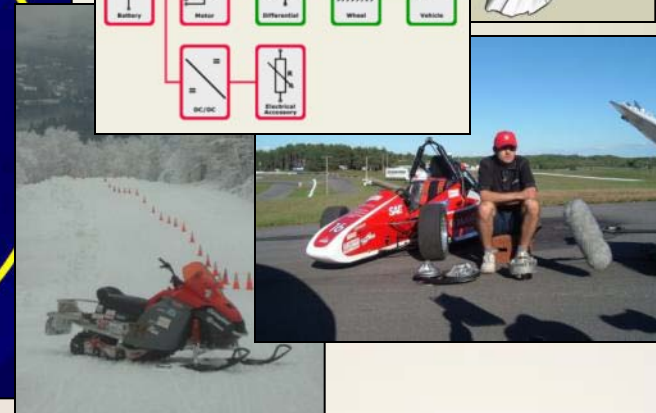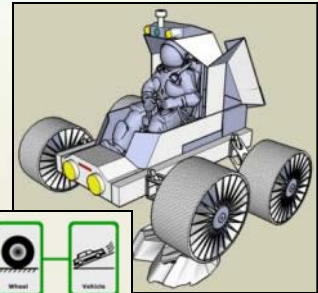

OVERVIEW

- Dynamics, Control, Motion Planning and Navigation for Unmanned Aerial Vehicles (UAVs), Legged Robotic Systems and Robotic Manipulators for On-orbit Servicing.

PROJECTS

- Control of Fully-Actuated In-door Airship
- Autonomous Capture of Uncooperative Targets for On-orbit Servicing
- Autonomous Landing of Small Rotary UAVs
- Locomotion of Legged and Wheel/legged Robots

LABORATORIES

- ENGMD 149; ENGMC 411
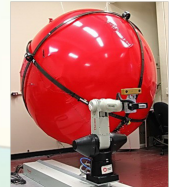
Prof. Vincent Thomson
(vince.thomson@mcgill.ca)

PROJECTS

Process Management (improve execution of knowledge processes)
- Concurrent engineering
- Product life cycle management (Aerospace)
- Interface control documents
- Coordination mechanisms
- Change management

Production in Aerospace
- Tool wear (NRC AMTC, Pratt & Whitney)
- Laser-assisted machining (NRC AMTC)
- Design models for prediction of part performance (Pratt & Whitney)
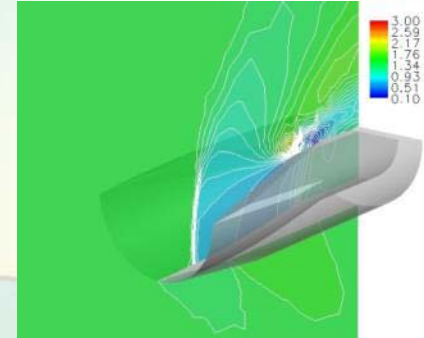
Model-Based Control
- Metal Powder Grinding (Domfer)
- Steel production (ArcelorMittal)

McGill

Department of Mechanical Engineering
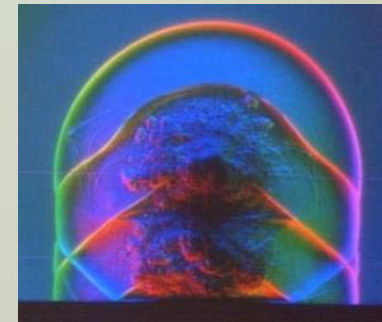
Prof. Evgeny Timofeev (evgeny.timofeev@mcgill.ca)

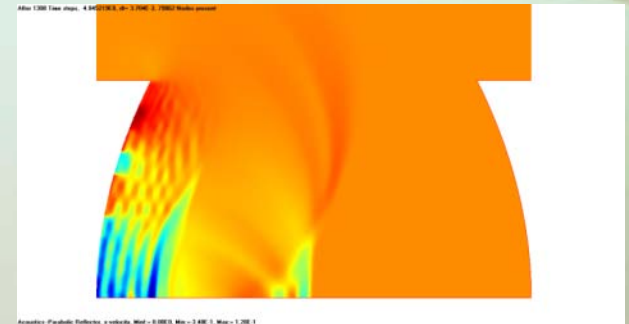## OVERVIEW

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


RESEARCH DIRECTIONS

- Fundamental studies of unsteady shock reflections

- Air inlets for next-generation hypersonic air-breathing engines

- Unsteady mixture flows induced by detonation of explosives with applications to channel effect, hypervelocity implosion launcher, ram accelerator etc.

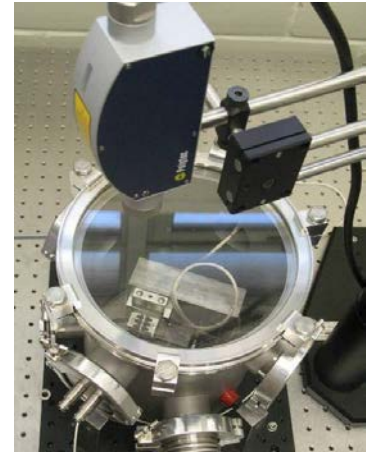- Nonlinear acoustics in heterogeneous media with applications to medicine, non-destructive testing
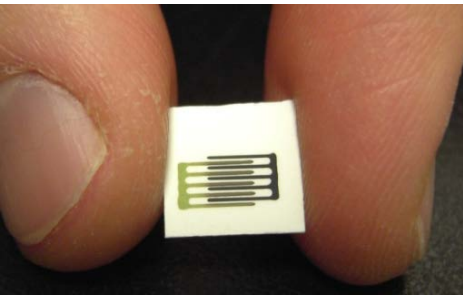
Prof. Srikar Vengallatore
srikar.vengallatore@mcgill.ca

Research Program
Advanced materials, structures and devices for microsystems and nanosystems (MEMS/NEMS)

Research Projects
- Fundamental studies of energy dissipation in micro/nanoresonators using theory, experiments, and atomistic simulations.
- Energy harvesting using MEMS for portable power generation.
- Integration of nanomaterials with microsystems.

Research Facilities
- NanoTools Microfabrication Facility
- Laboratory for Micro/Nanosystems (MEMS/NEMS)
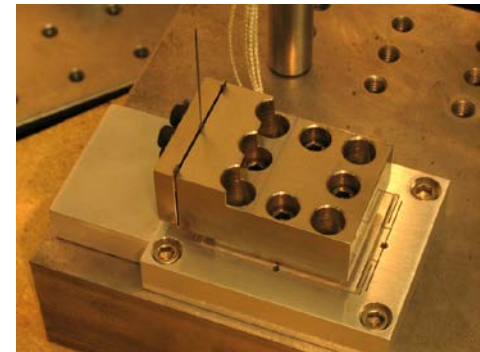
Prof. Paul Zsombor-Murray
## (paul@cim.mcgill.ca)

OVERVIEW
• Geometric methods for design, automation and inspection

PROJECTS
• Simplification of mechanism analysis and synthesis with kinematic mapping

• Measurement of quadric surfaces using minimum data points

• Shortest path on the torus; sewers, structures and stents

• Mini-accelerometers with Platonic symmetry; masses on the corners, circuits and elasto-extensors on the edges

LABORATORY & WEBSITE
• Lab: ENGMC 418
• Website: www.cim.mcgill.ca/~paul
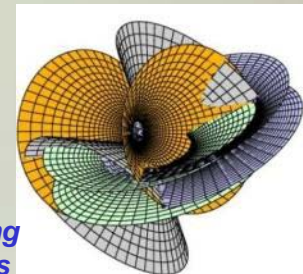
4 quadrics of revolution being placed on seven given points