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Engineering & Computer Science

Faculty of Engineering and Computer Science – ConCAVE Research Centre

A General View

Ion Stiharu

Professor and Director

Quebec Mission to Poland, March 2-6, 2009

Université Concordia University

Ion Stiharu
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Principal Activities

Dr. Ion Stiharu research interests are focused on micro/nano scale integrated microsystems, MEMS and NEMS sensors, DPHM for aircraft systems, with a special interest in advanced sensors for structural integrity monitoring in composite materials and mechanical structures in general.

Interests in Collaboration with Poland

His research focuses on the combination of these technologies to produce new knowledge and innovative solutions for a wide range of applications, including wireless communications systems, health care, and aerospace.

Bio

Dr. Stiharu is a Professor and Director of CONCAVE Research Centre at Concordia University, Montreal, Canada. He is one of the funders of the microsystems technology research in Canada. Dr. Stiharu multidisciplinary expertise in the dynamics of mechanical systems enabled him to develop applications of microsystems in vehicle engineering, aerospace applications, bio-medicine, acoustics and vibrations control, DPHM and development of new sensing materials. His interests are focused on diagnostics, prognostics and health monitoring of composite materials and mechanical systems in general, including aircraft structures. He is an established researcher who has published over 75 journal papers, 3 book chapters, 2 patents pending

Presentation Highlights

- Some information about our university's engineering programs (undergraduate and graduate)
- ConCAVE – academic research unit – activities and potential cooperative projects
- The aerospace related interests of the Mechanical Engineering Department professors (few)
- Some potential cooperative projects with Poland

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Our Programs

- Undergraduate Programs:
  - Building Engineering (unique in Canada)
  - Civil Engineering
  - Computer Engineering
  - Computer Science
  - Electrical Engineering
  - Industrial Engineering
  - Mechanical Engineering
  - Software Engineering

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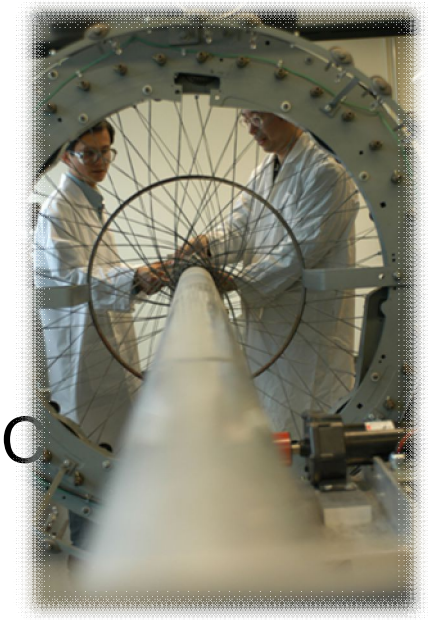
Graduate Studies

All Units



- M.Eng. coursework Masters
- M.A.Sc. thesis-based Masters
- PhD doctoral programs
- Several Graduate Certificate Programs (BC

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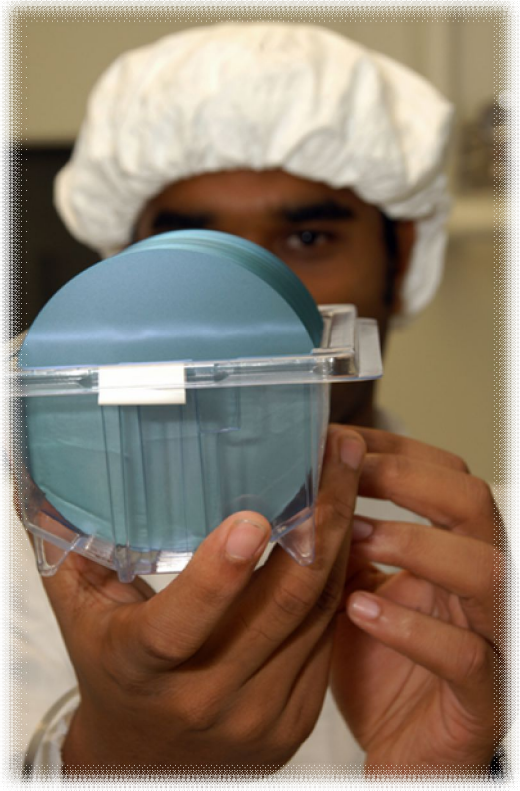
Some Major Research Thrusts

- Some of the research topics in the Graduate Programs
  - Renewable energy
  - Sustainable buildings
  - Environment and water management
  - Sustainable infrastructure & construction management
  - Information Security
  - Aerospace
  - Materials and composites
  - MEMS and nanotechnologies
  - Computer imaging & gaming
  - Wireless communication



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ConCAVE Research Centre

- Facts: created in 1986
- Mission – Research and graduate education in all aspects of transport systems dynamics; in 1996, the mission was extended to Microsystems Technologies and MEMS
- Gathers 10 FT members and 16 PT collaborators from various interest adjacent institutions, few researchers (3 – 10 at a time) and over 50 graduate students.
- The center is in charge with 16 laboratories which also provide services outside, to the research community
- More than 50 projects (industrial support) are running at any time
- Some of the ongoing projects

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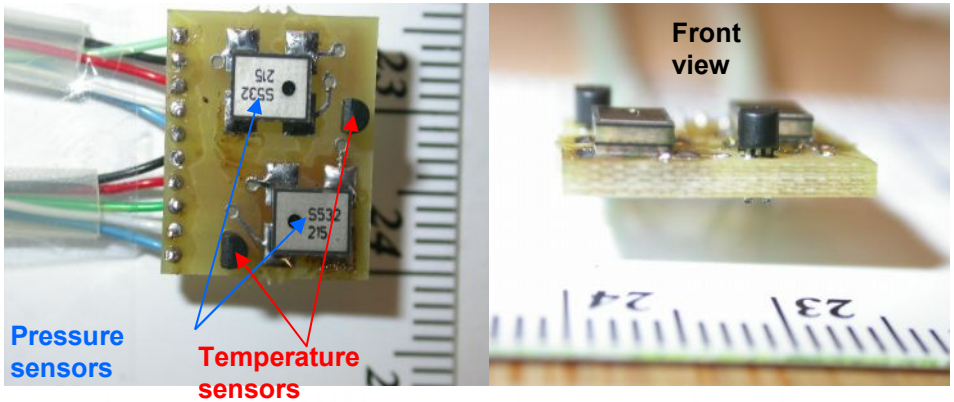
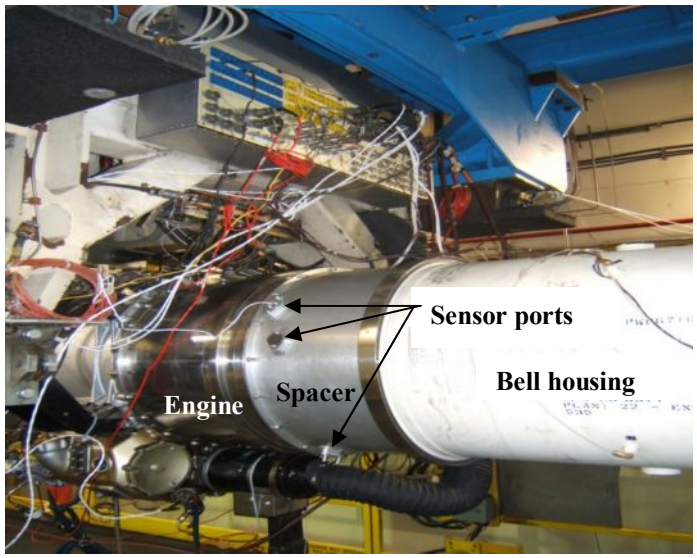
CRIAQ project - MEMS for GTEs





DEMONSTRATOR

Development of micro-sensors to operate inside of the compressor and turbine

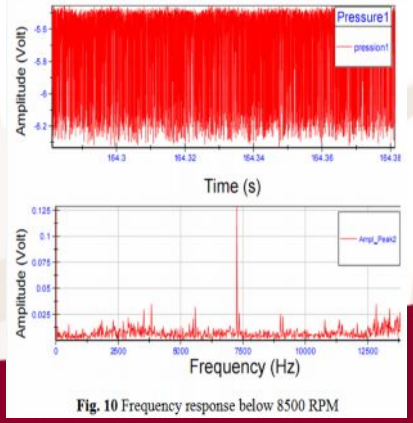
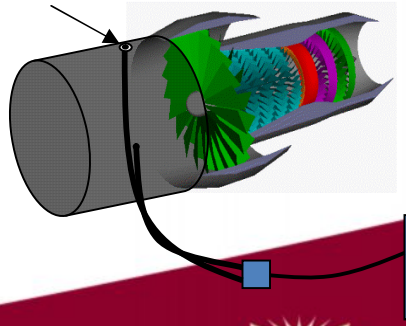


Fig. 10 Frequency response below 8500 RPM



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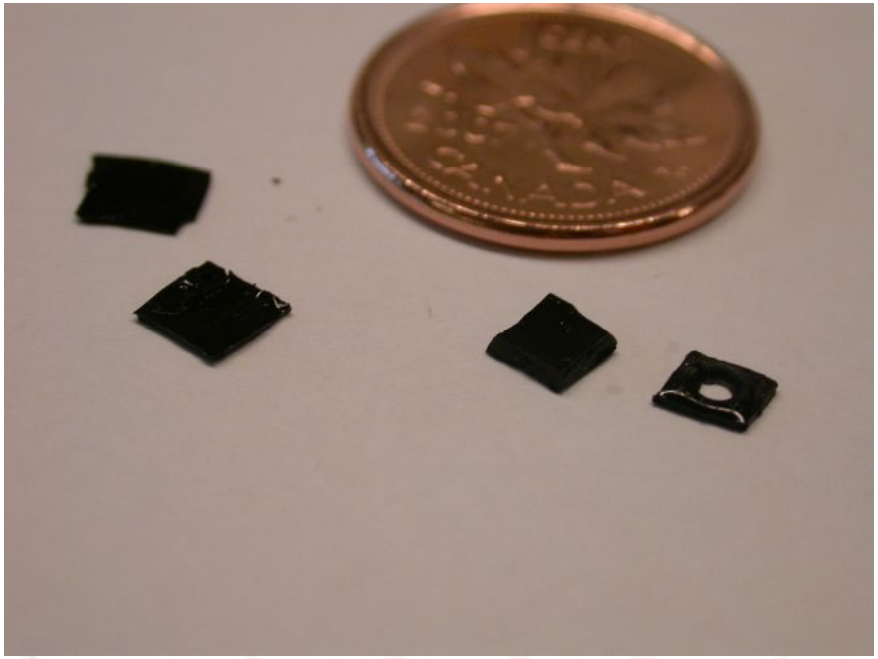
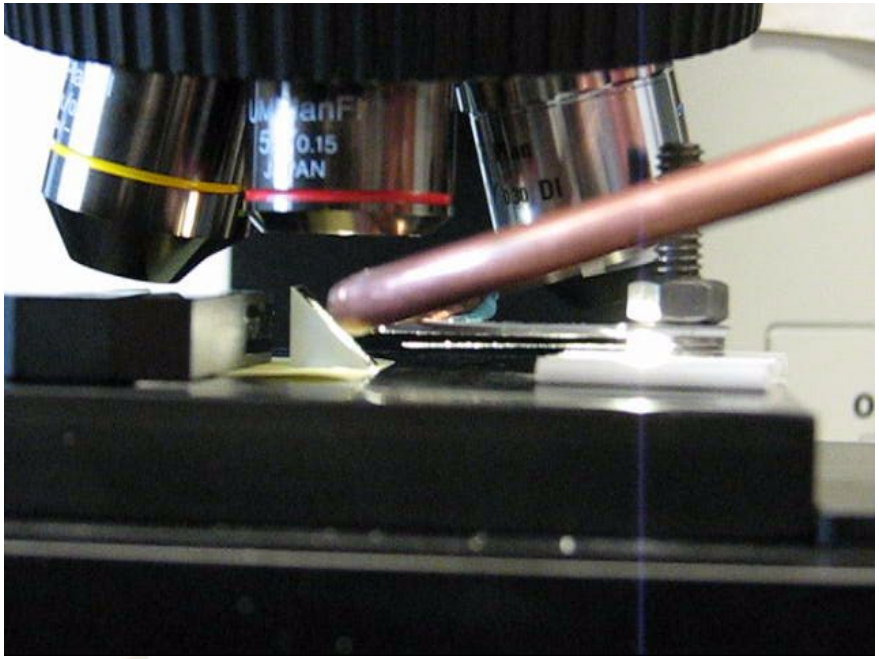
SiCN Pressure Sensors for Very High Temperature





SiCN fabrication form liquid precursor
Drag effect pressure/flow sensors

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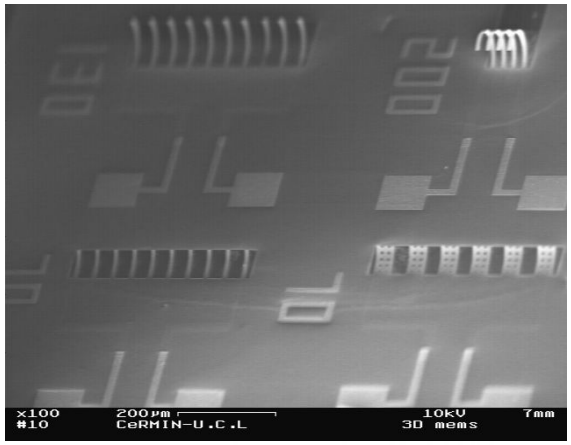
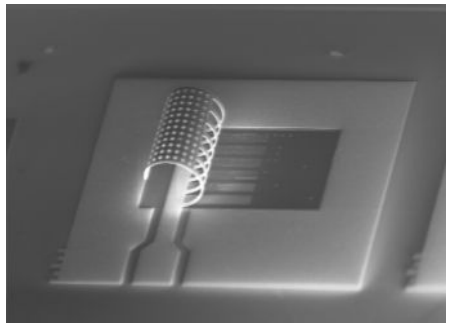
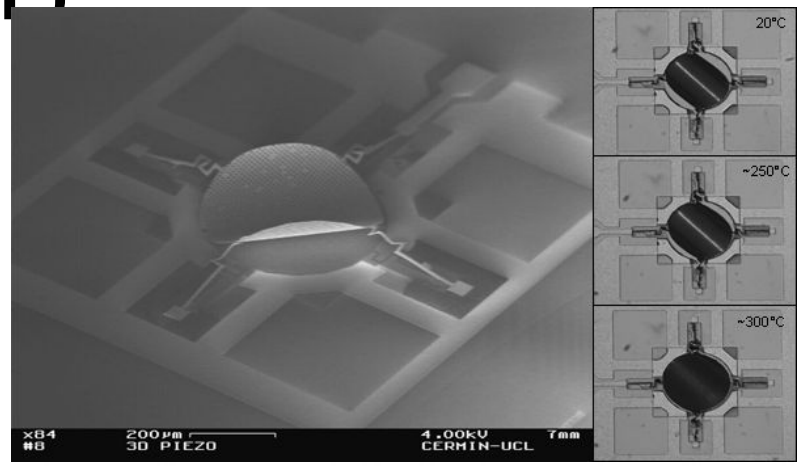
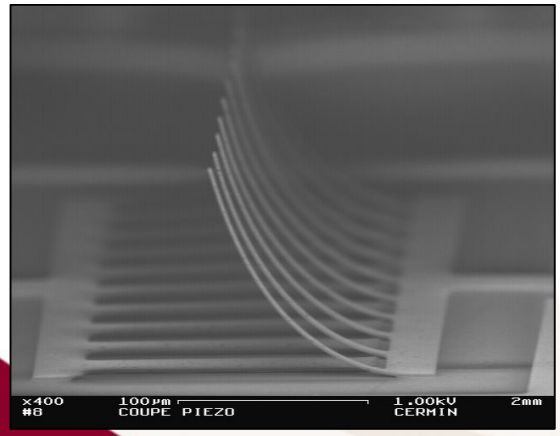
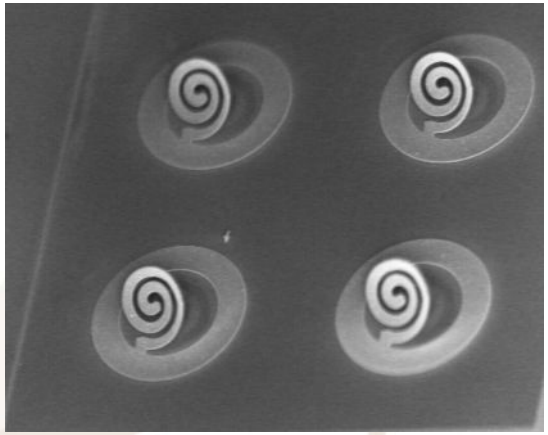
MEMS for Sensing Applications (collaboration with UCL)

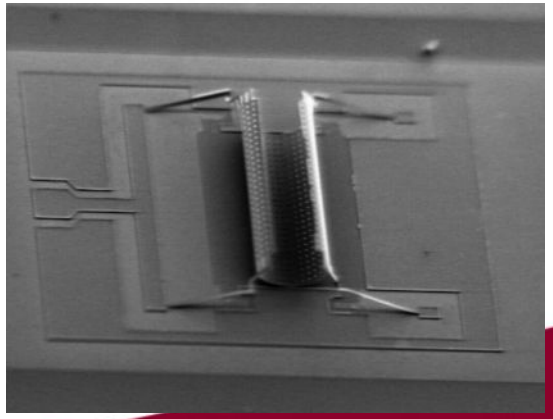












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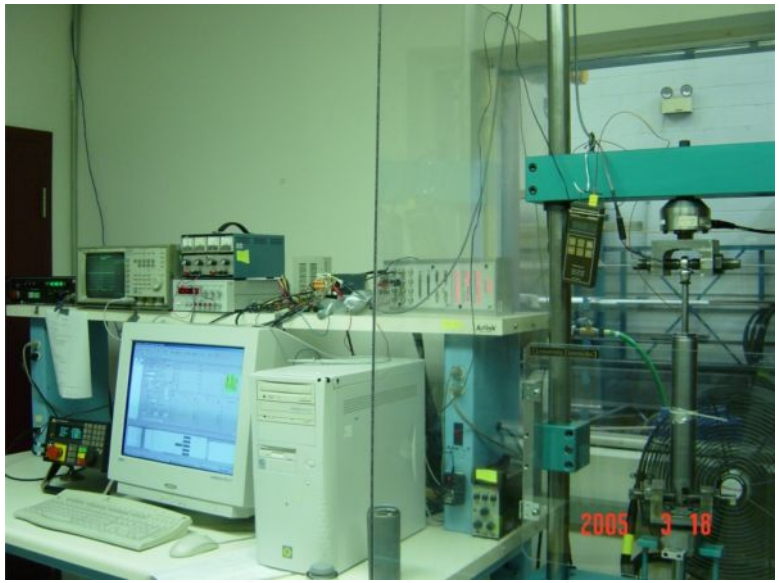
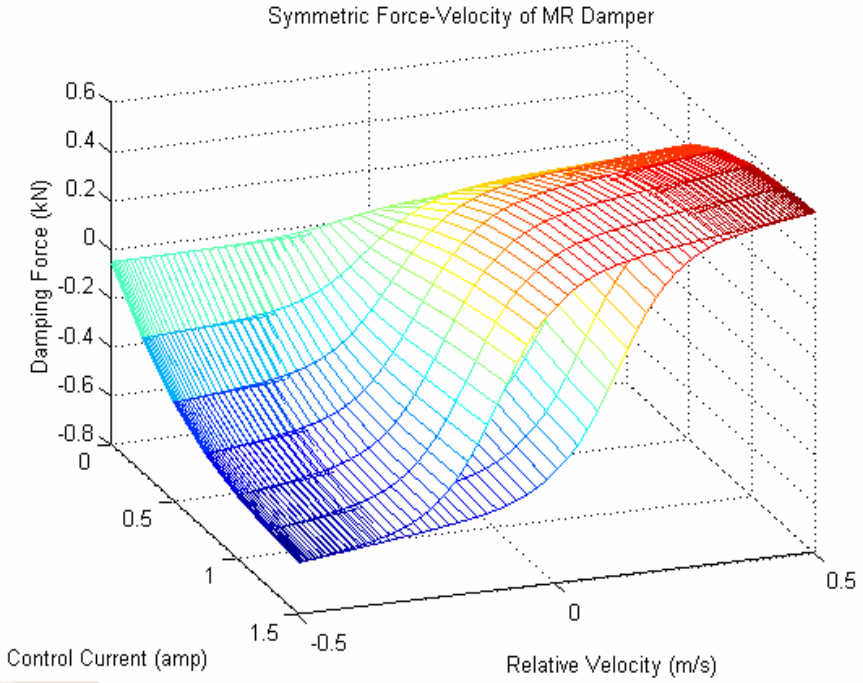
Modeling and Analysis of Vehicle Subsystems

Hydro-pneumatic Semi-active Suspension





Magneto-Rheological Fluid Suspensions

- MR dampers for landing gears

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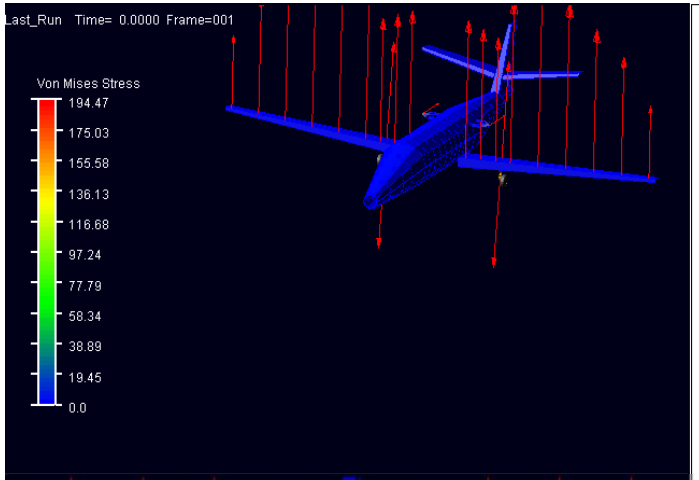
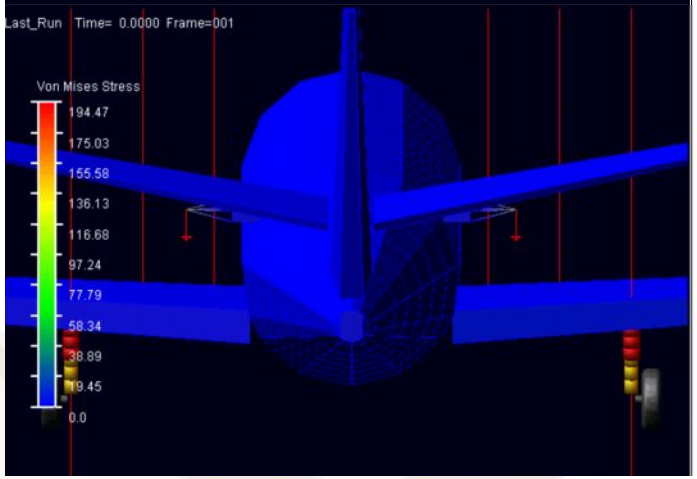
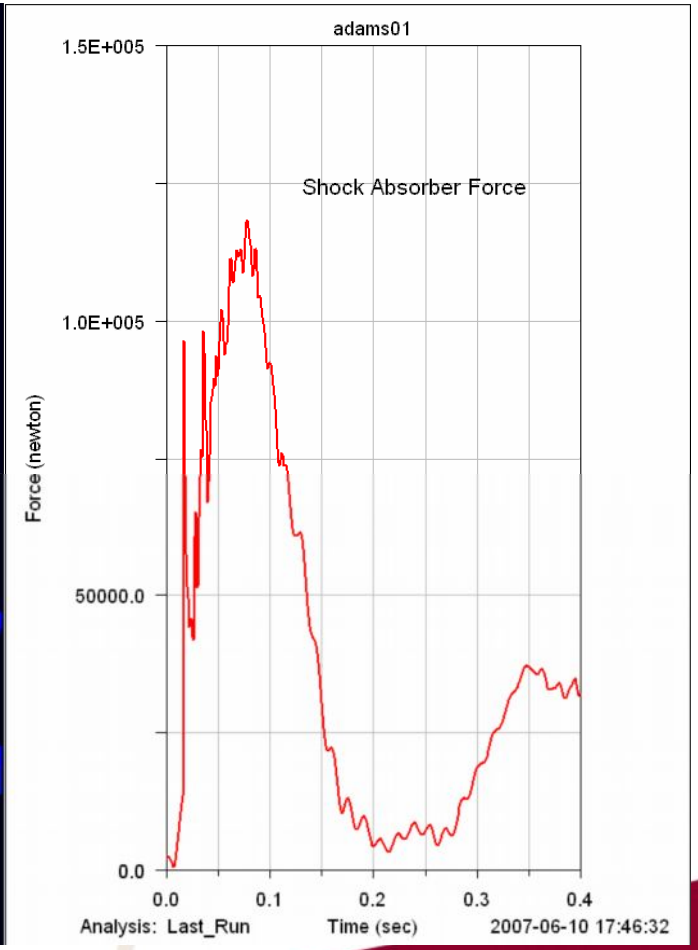
DPHM of Aircraft Structure

System and element approach







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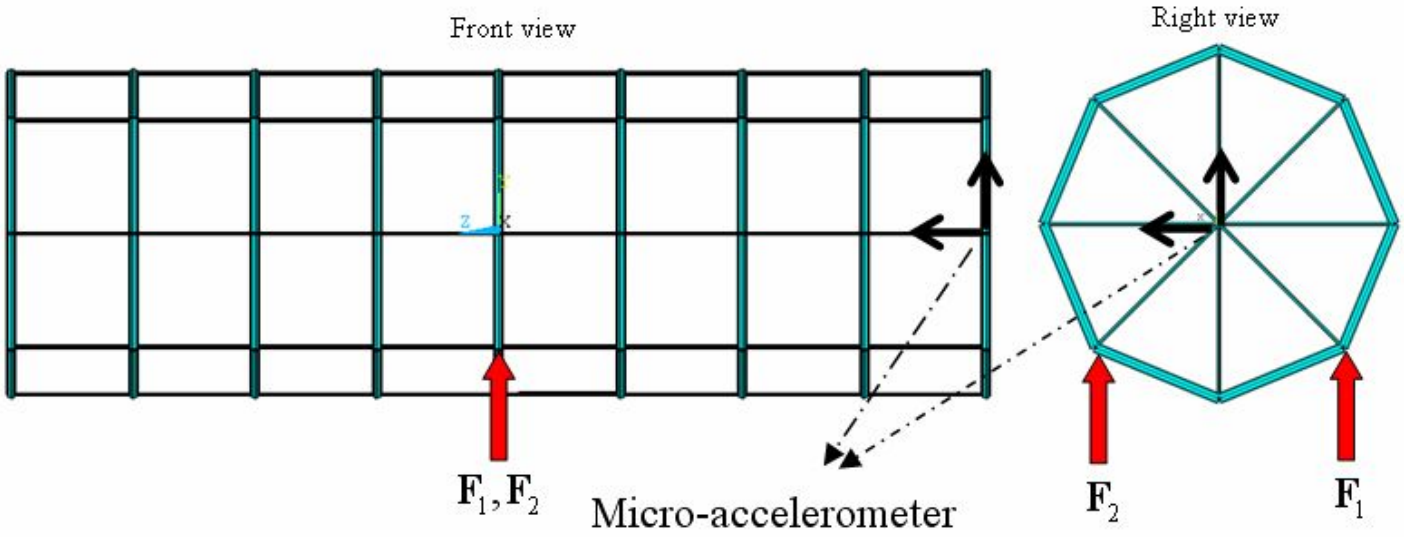
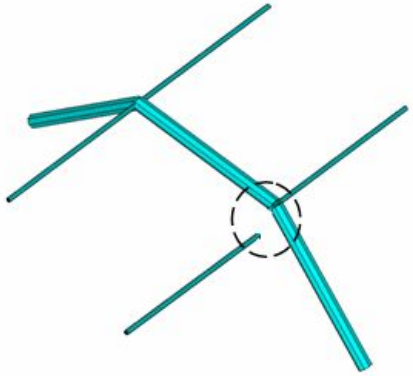
Damage Identification and Localization



$$\mathbf{M}.\ddot{u} + \mathbf{C}\dot{u} + \mathbf{K}.u = F$$

$$\mathbf{C} = \frac{\eta^*}{\rho A}\mathbf{M} \qquad \eta^* = 0.005$$

$$\mathbf{M}.\ddot{u} + \mathbf{C}\dot{u} + (\mathbf{K} - \Delta\mathbf{K}).u = F$$



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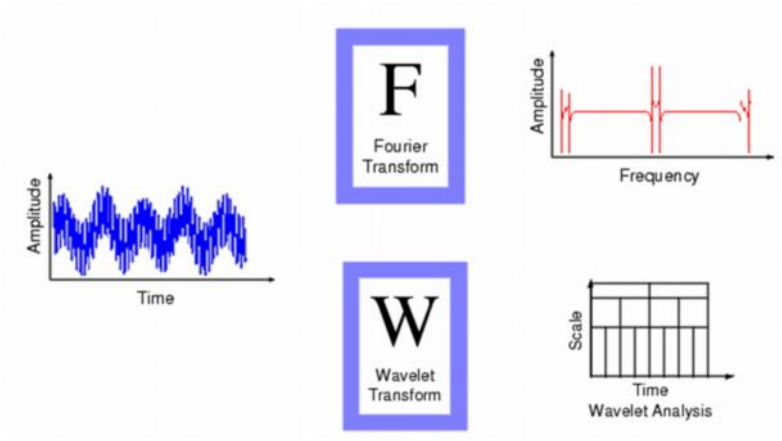
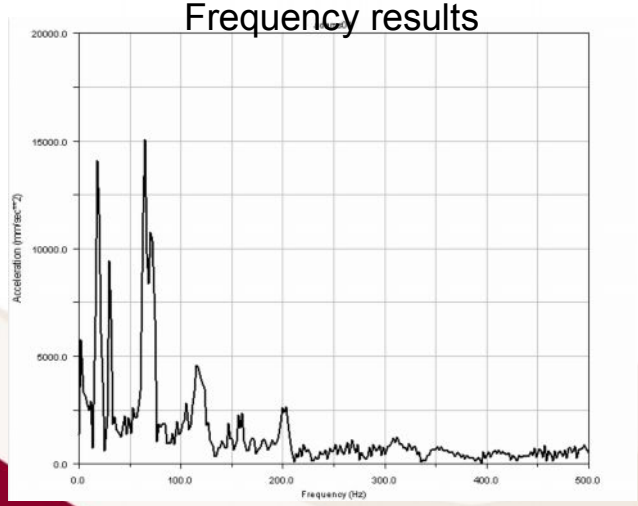


$$C(a,b) = \int_R s(t)\frac{1}{\sqrt{a}}\psi\left(\frac{t-b}{a}\right)dt$$

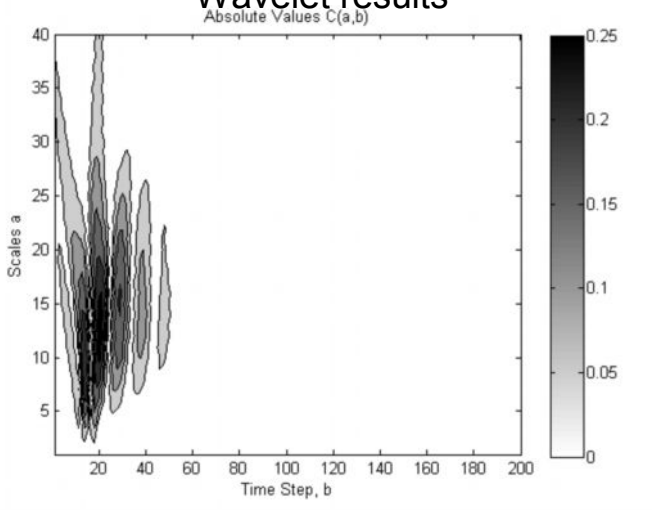
$$a \in R^{+}-\{0\}, b \in R$$

Frequency results



Wavelet Transform

Wavelet results



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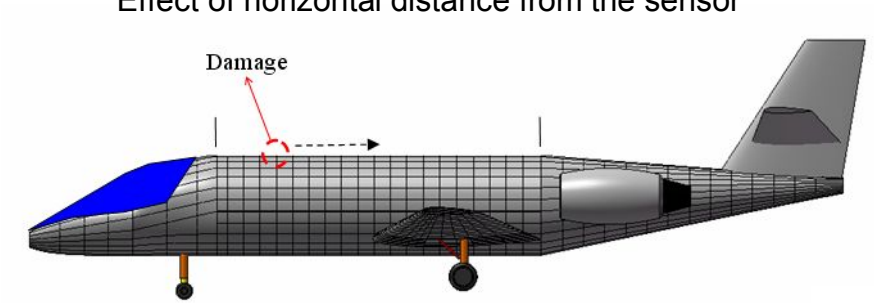
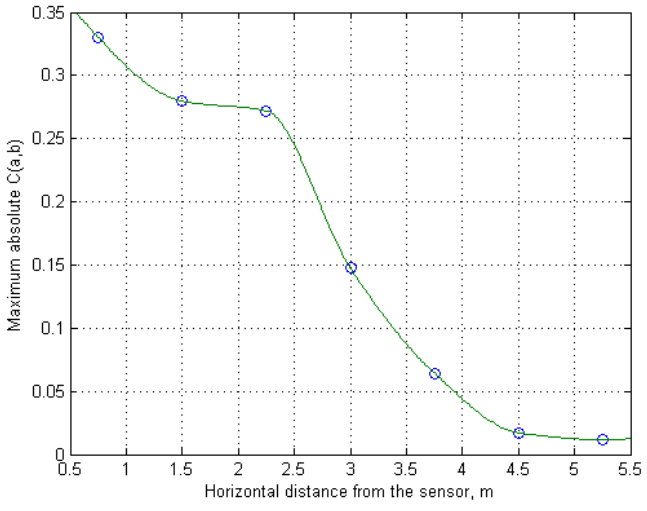
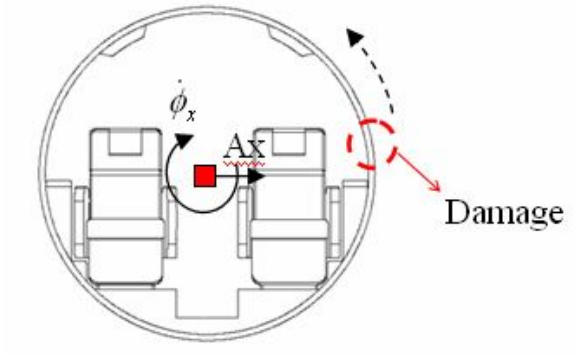
Damage Localization

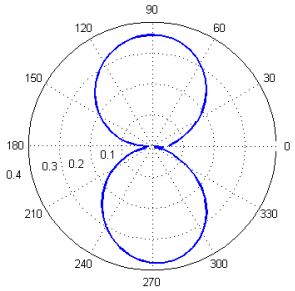
Effect of horizontal distance from the sensor

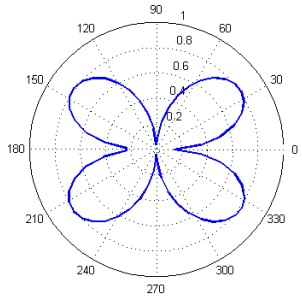


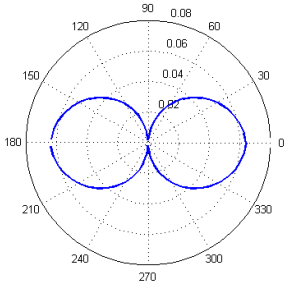


Localization of Damage on the Circumference





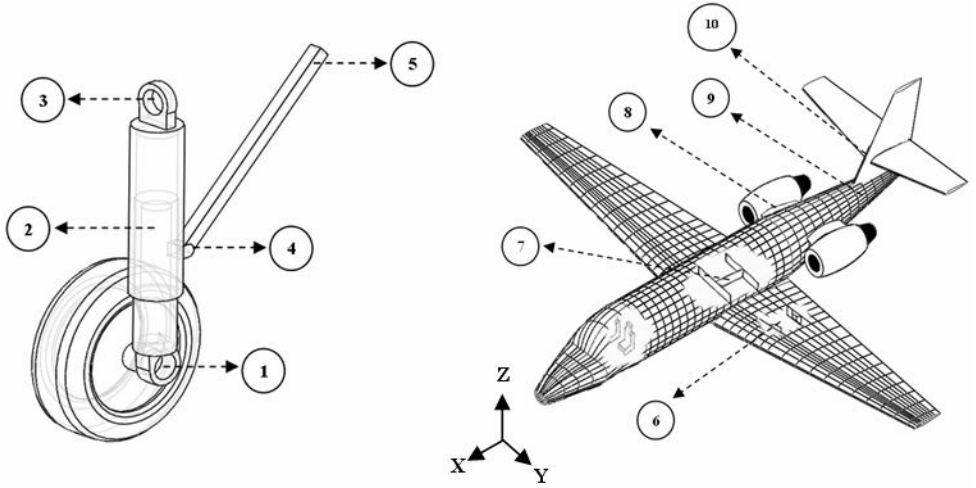


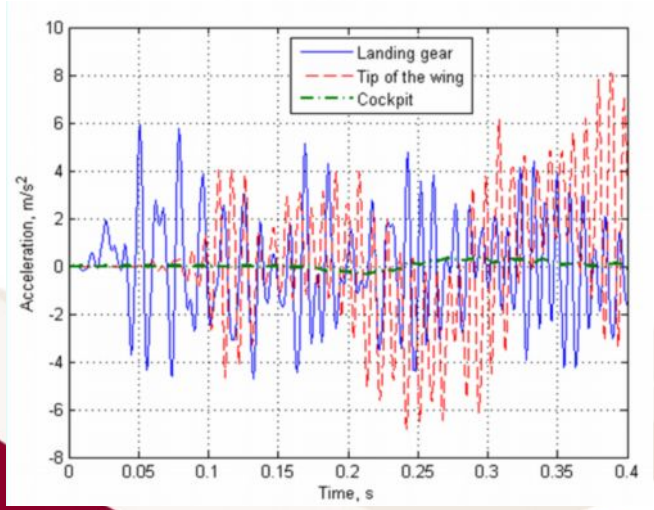


Hard Landing and Structural DPHM

- A number of points are selected on the airframe
- Acceleration and stress analysis are carried out
- Three Landing Parameters are studies:

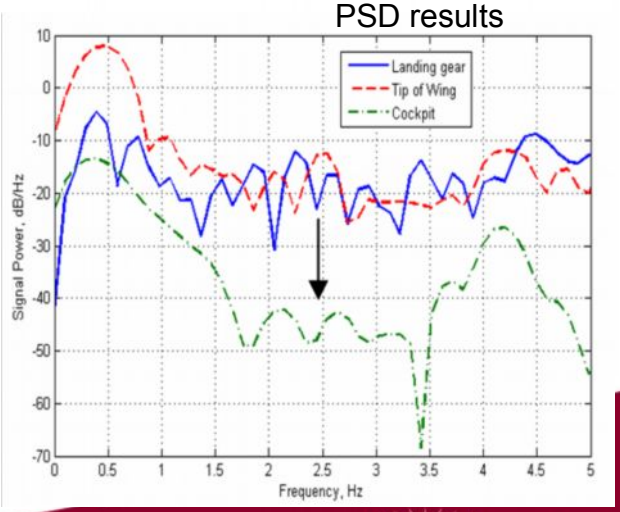
1. Descend speed (sink speed)
2. Roll angle
3. Vertical acceleration





$$\mathbf{P}_{dB} = 10 \log_{10}(|\mathbf{P}_{xx}(f)|)$$

PSD results



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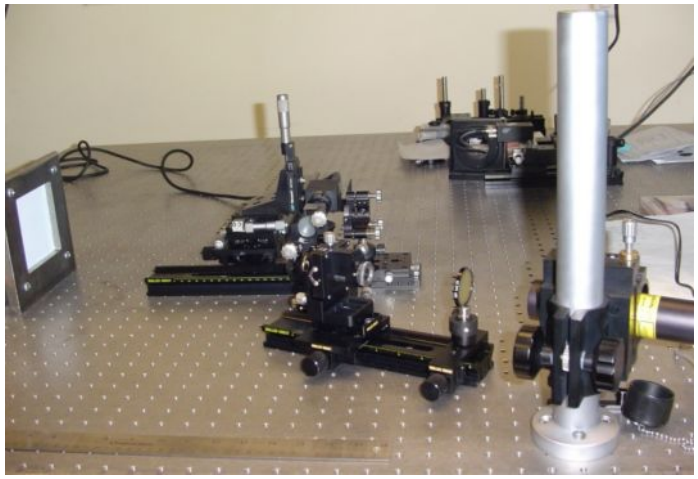
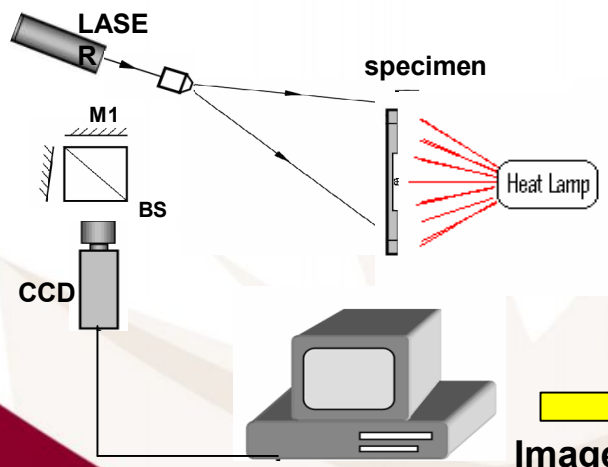
Sub-surface Defect and Crack Detection

- Identifies strain-concentrated areas as anomalies in the fringe
- Comparison of deformations under load and no-load conditions
- Detection of sub-surface defects and cracks





Fringes

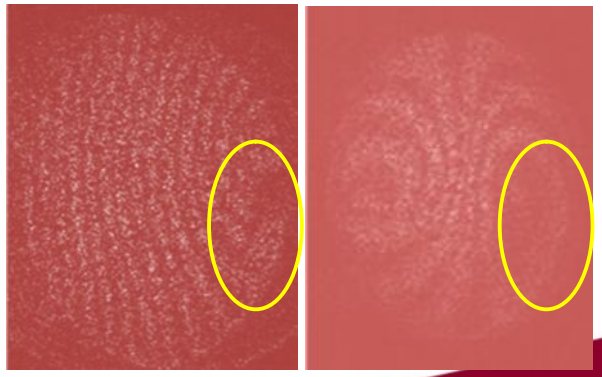


Image processing

Output

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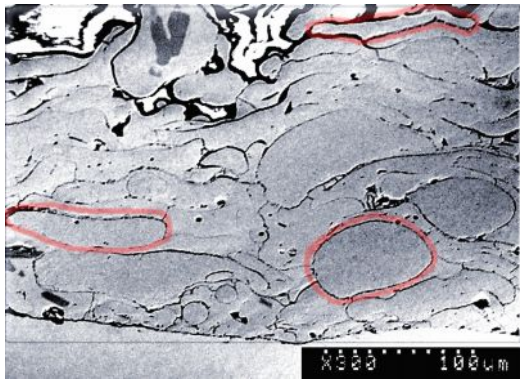
Thermal Spray Coating

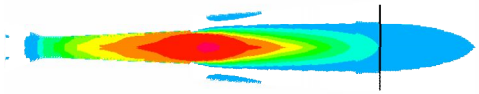


Development of methodologies to

- Improve deposition efficiency
- Reduce particle in-flight oxidation
- Facilitate ceramic coatings with HVOF

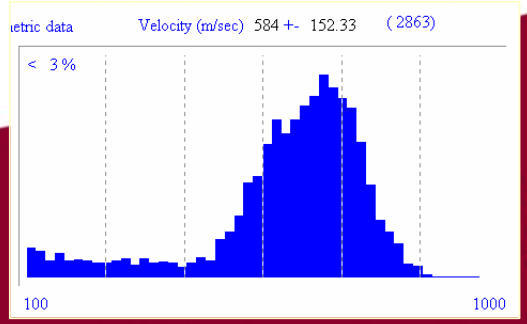
Numerical modelling of Gas-particle flow

- Lagrangian
- Eulerian



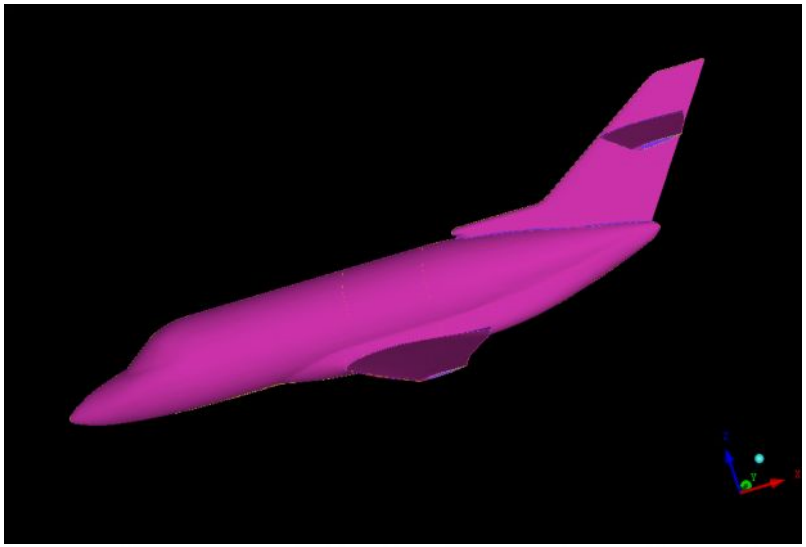
Experimental techniques

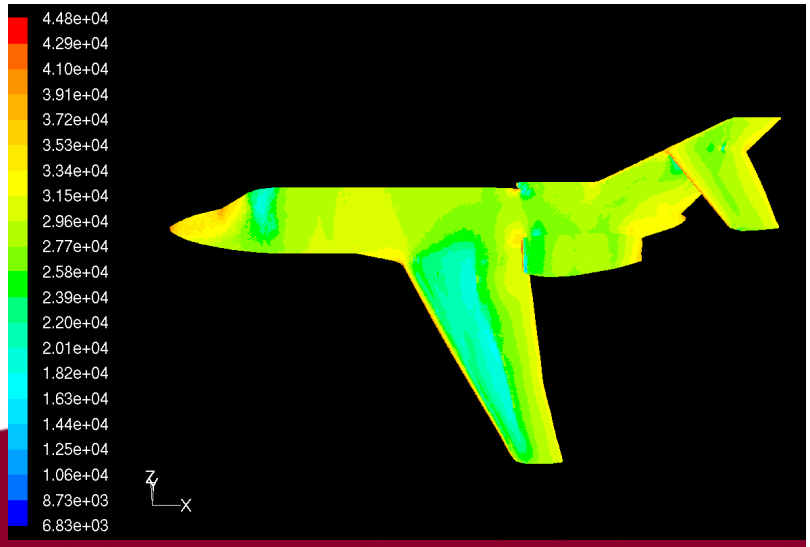
- Particle diagnostic system
- Nozzle prototyping



Flow Simulation around Airplanes

- **Euler flow simulation around the airplane with FLUENT and in house finite volume code**
- **Modification of fluxes and GMRES solver for a faster matrix-free format**
- **Application of LU-SGS preconditioner to speed up computations**
- **Beowulf parallel implementation**





Potential Collaborative Projects

- Pressure sensors to operate at very high temperatures (over 1000°C)
- Material development for sensors working at very high temperatures and machining (laser)
- Semi-active landing gears
- Integration of DPHM of the aircraft structure
- Sensing embedding in composite materials structure for condition monitoring
- Non-destructive detection of internal cracks
- Thermal spray coating
- Multi-physics simulation

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