

Active Flow Control Technology for Aeronautical Applications

Catalin Nae

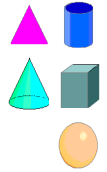
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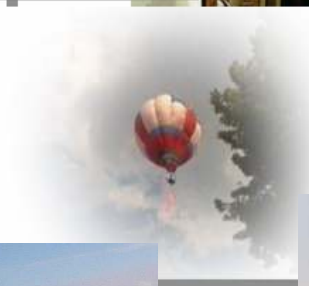
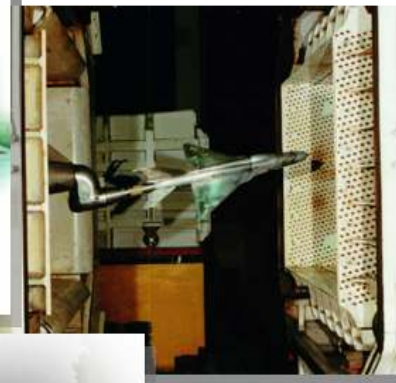


Profile :

- State owned company
- Founded in 1950
- 150 employees
- Leading research establishment for aerospace research in Romania

Major activities :

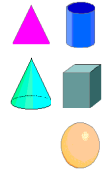
- ✓ Main design authority and system integrator
 - ✓ Aerodynamic design
 - ✓ Structural design and analysis
 - ✓ Experimental wind tunnel validation
 - ✓ Global performance analysis
-
- ❖ Research and development in aeronautics



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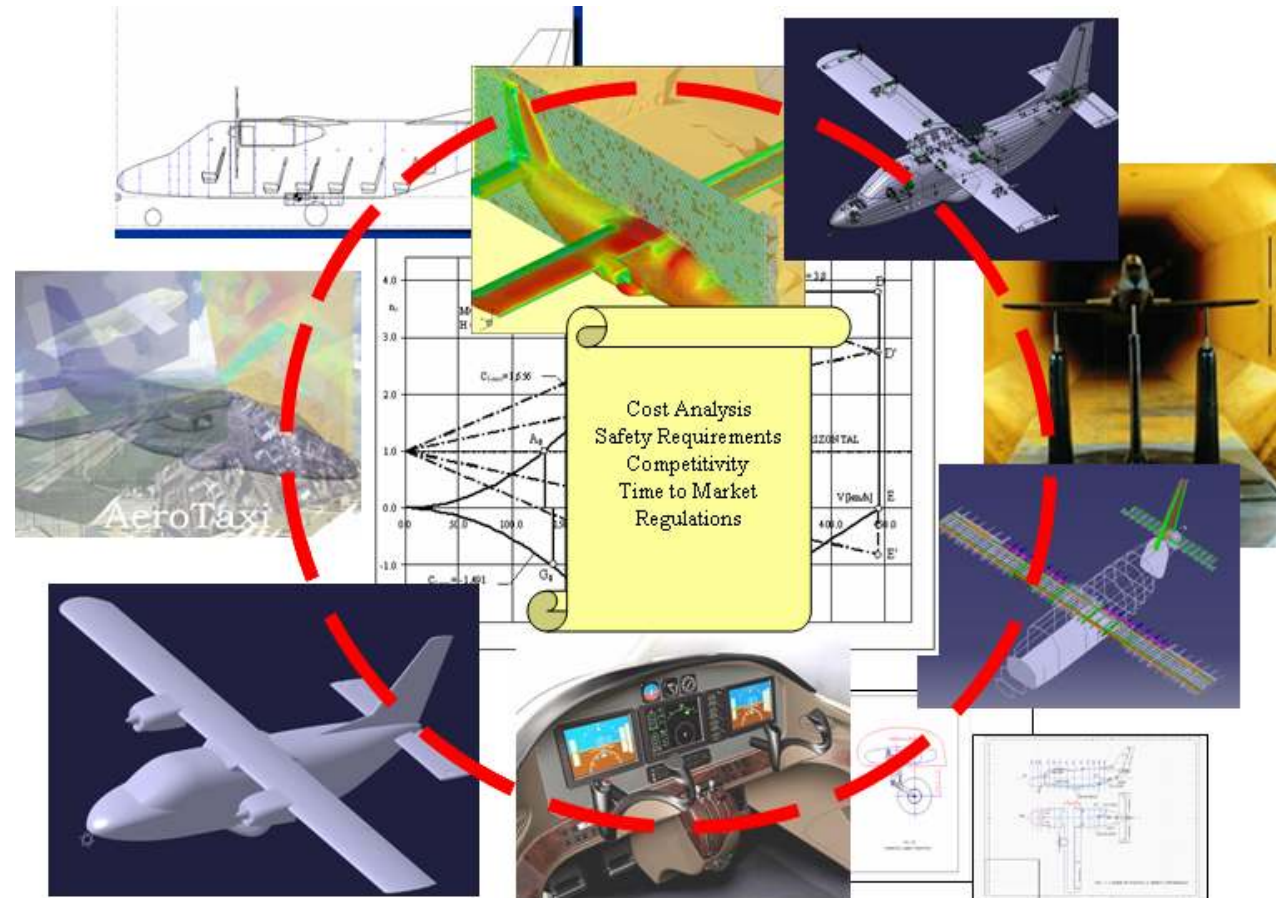


Development strategy :

- Reorganization as public research company
- Maintaining capabilities in key sectors for product development
- Development of existing research infrastructure
- New capabilities and expertise

Major capabilities :

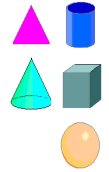
- ✓ Aerodynamic design
- ✓ Wind tunnel testing
- ✓ Global performance analysis
- ❖ System design and integration for civil and military aeronautical products



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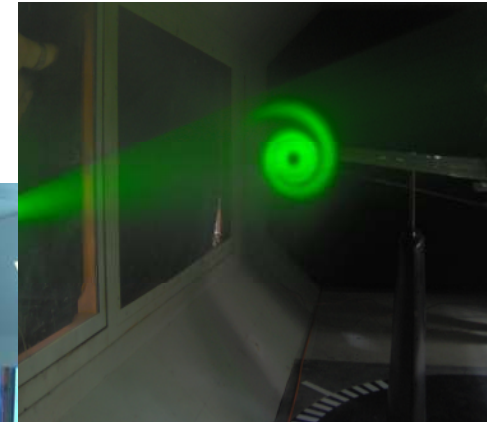


Subsonic Wind Tunnel

- Atmospheric pressure continuous type facility
- Maximum speed of 110 m/s
- Usual Reynolds number up to 1.5 million.

Equipment:

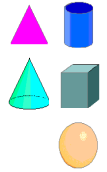
- Traditional type facility
- 6 component pyramidal type balance
- Standard pressure acquisition systems.
- New data acquisition technologies
- Laser visualization systems
- CTS system
- Aeroacoustics and airframe noise evaluation



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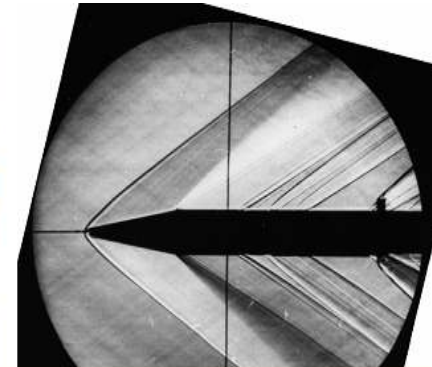
Supersonic Wind Tunnel

- blowdown type 1.2m x 1.2m test section
- Mach number capability : 0.1 ... 3.5
- Reynolds number up to 100 millions

- Interchangeable porous transonic test section
- Variable porosity from 0.01% up to 9%
- Interchangeable complex 2D 0.8m x 1.2m test section

Equipment:

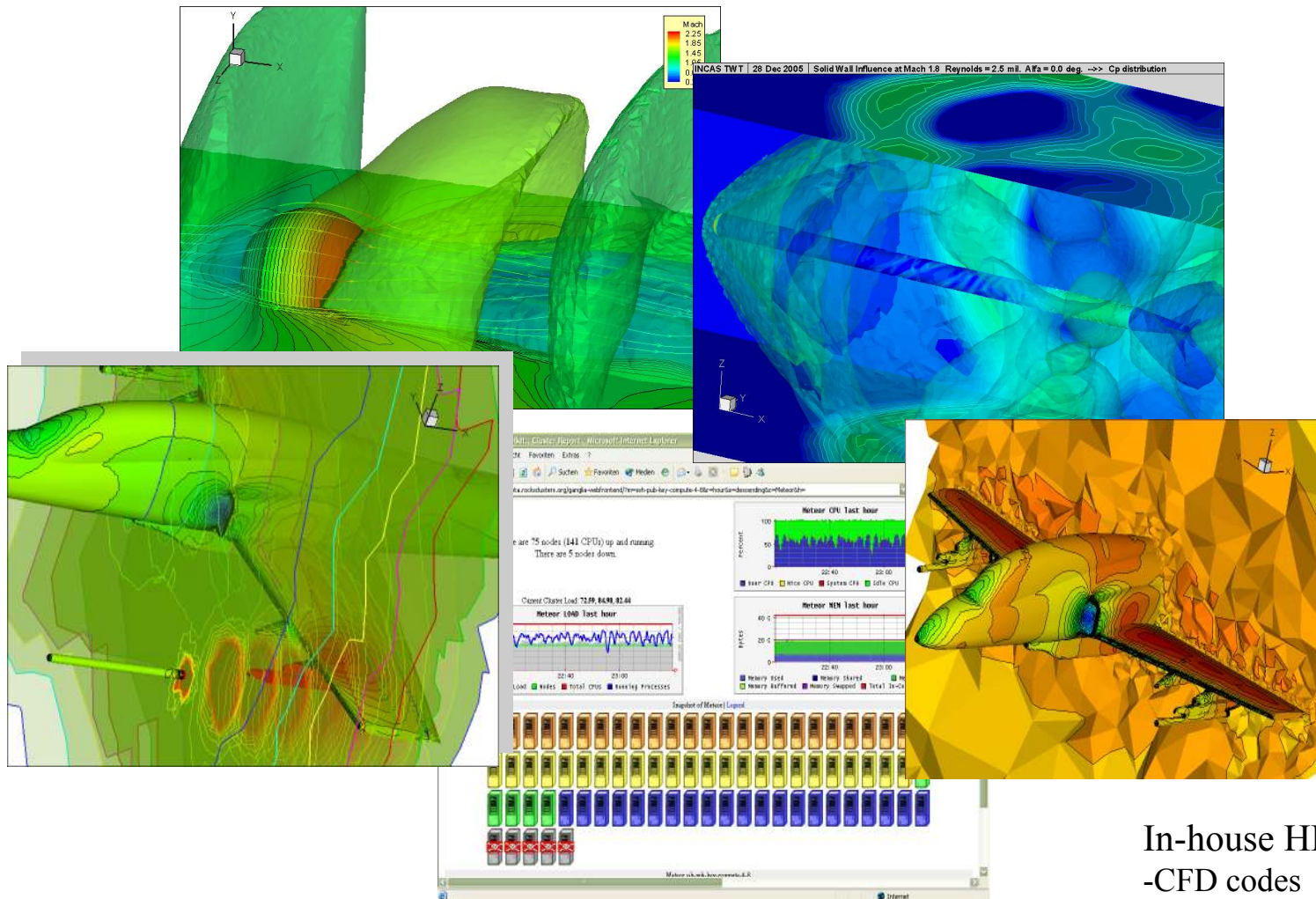
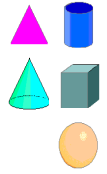
- Sting mounted, internal balance
- Side-wall, half model balance
- 800 mm schlieren system
- CTS system
- PIV under development.



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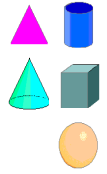
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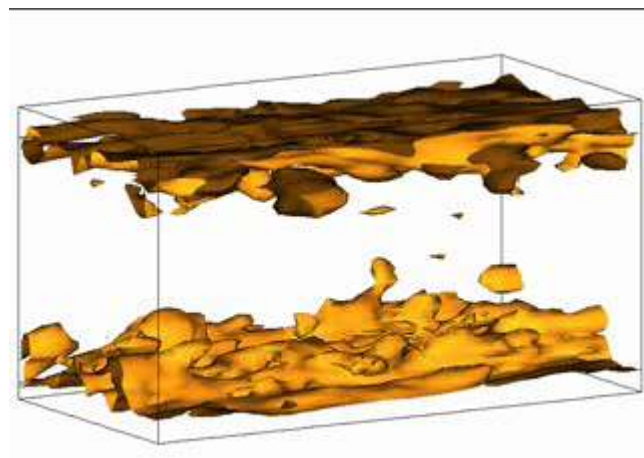
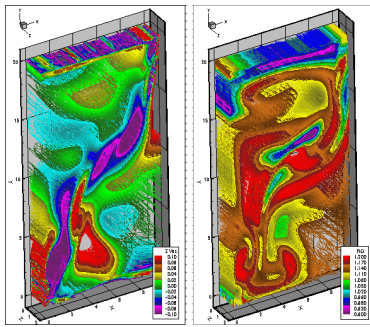
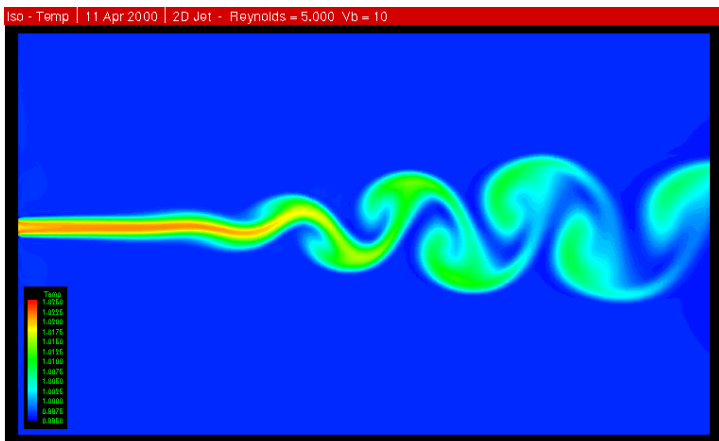
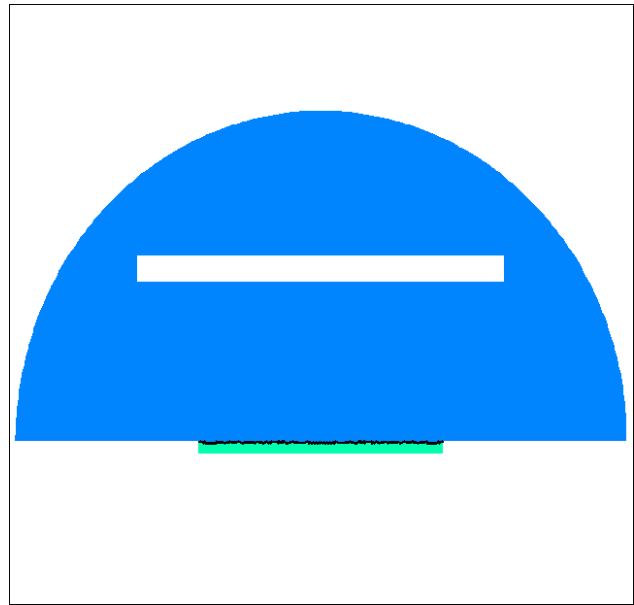
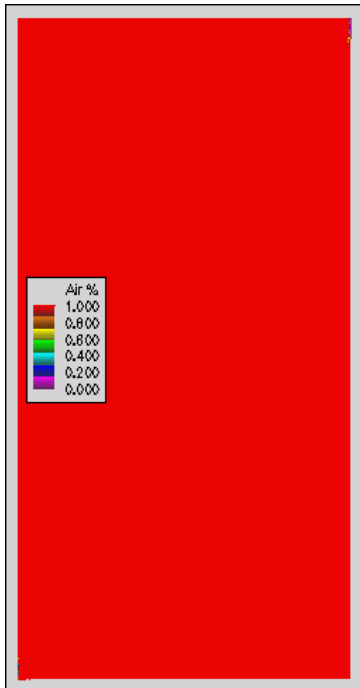
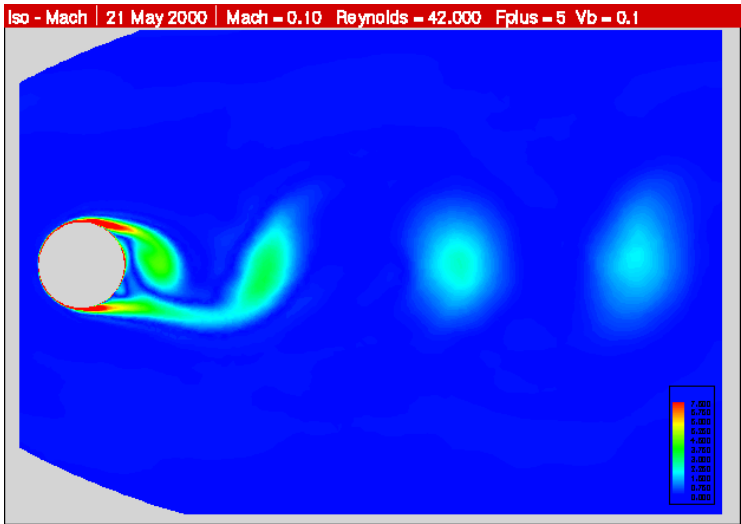


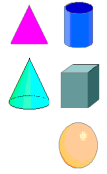
In-house HPC capabilities
-CFD codes
-Cluster computing (Grid)



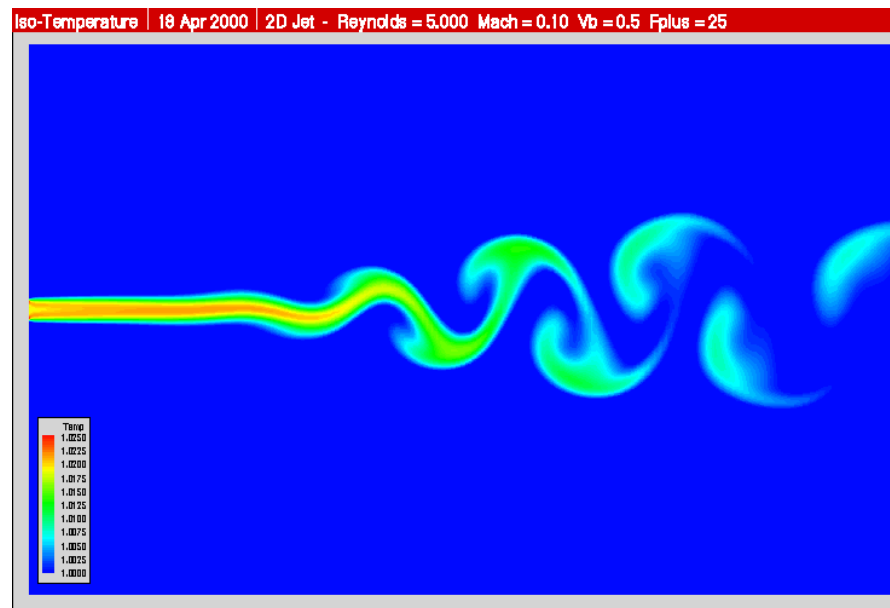
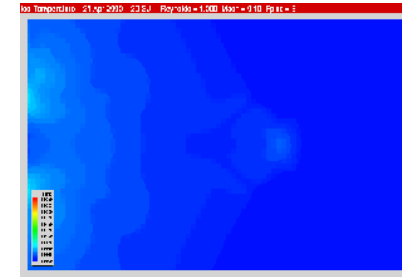
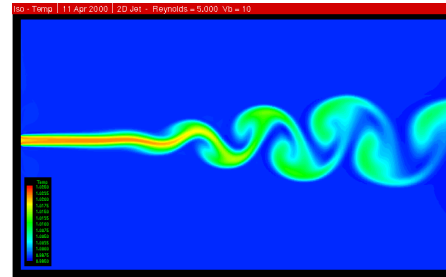
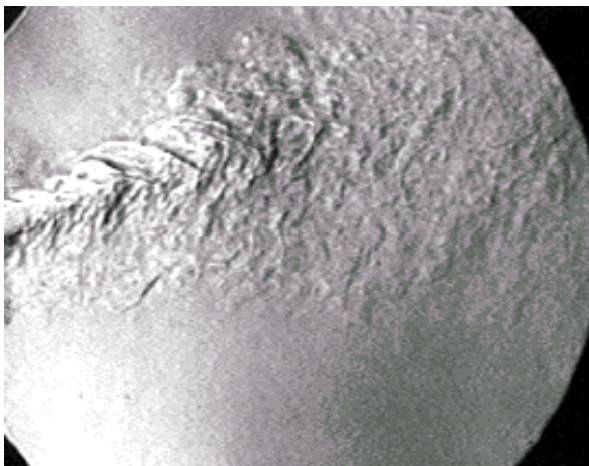


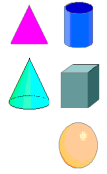
Some examples





Fluidic interaction – jet vectoring



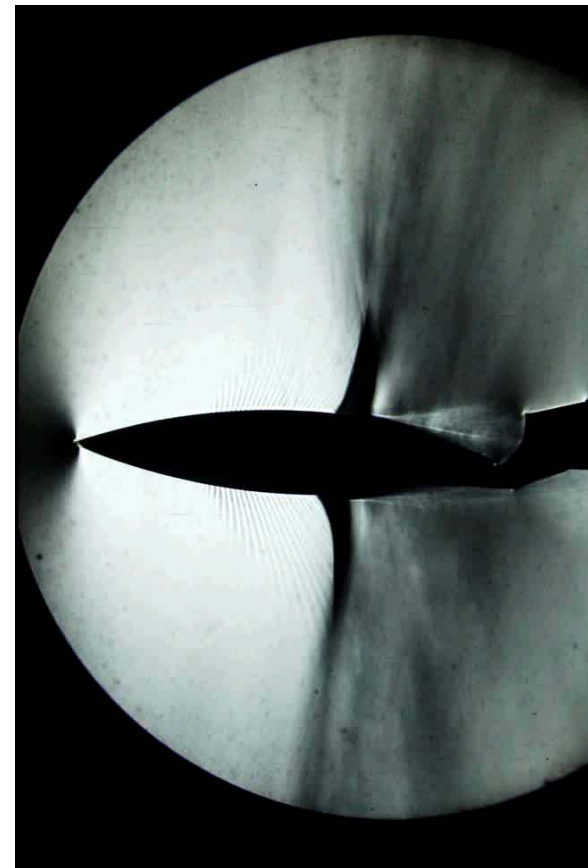


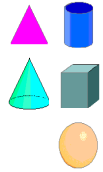
A buffeting experiment

Mach 0.748, Reynolds 8 mil.

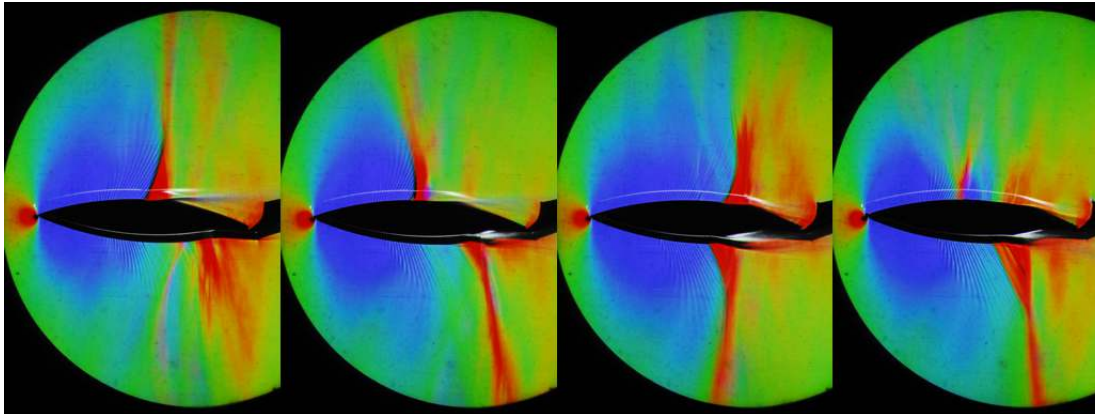


Mach 0.755, Reynolds 8 mil.

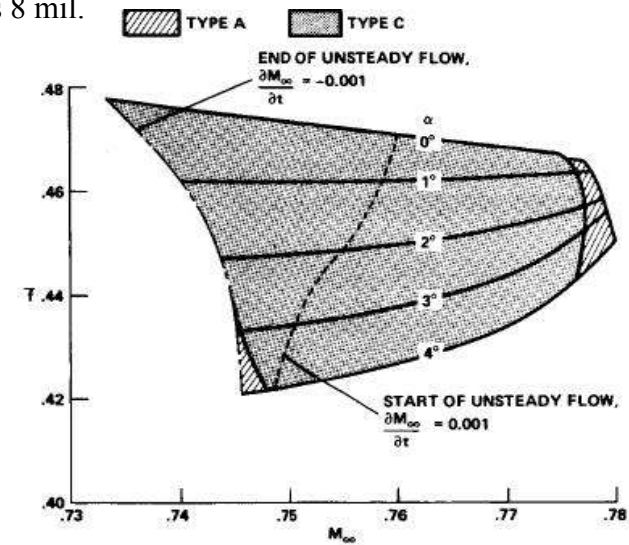
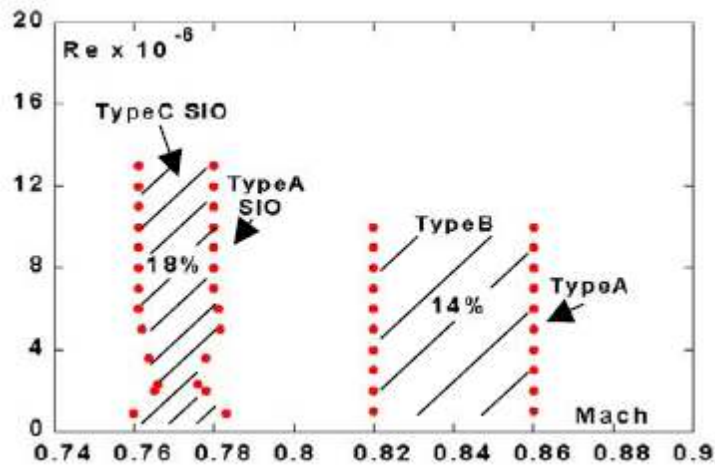


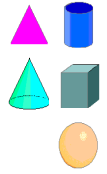


When do we get buffeting ? – exp.



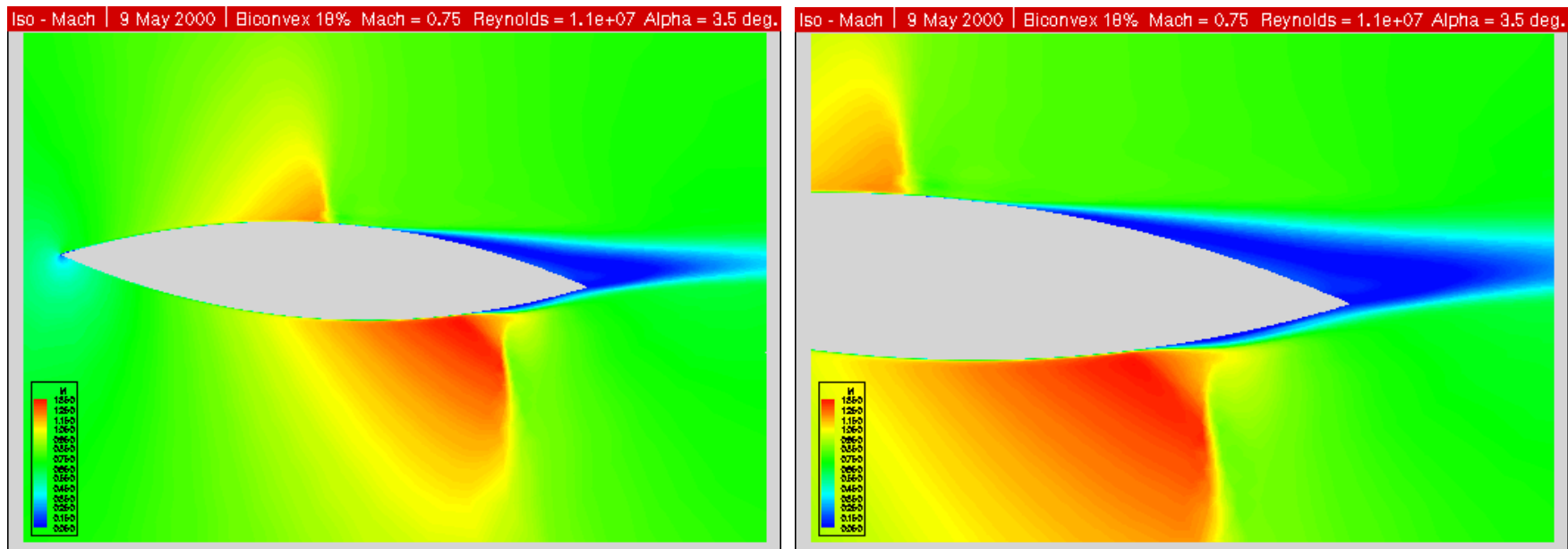
Schlieren pictures for 18% biconvex, 1 deg., Mach 0.762, Reynolds 8 mil.

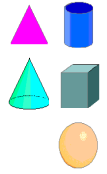




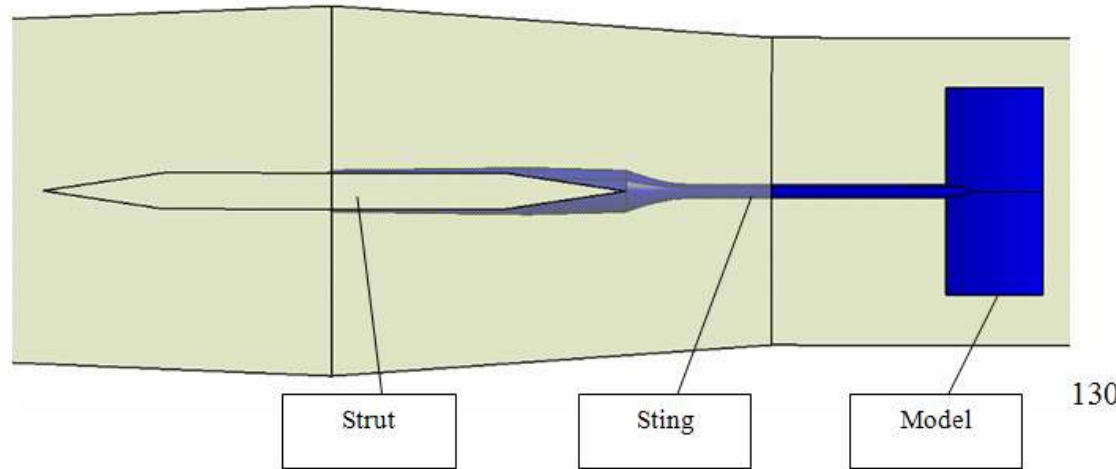
When do we get buffeting ? – num.

Mach 0.75, Reynolds 11 mil., 3.5 deg





Design of buffeting experiment



$$c = 2 \cdot R \cdot \cos(\theta_0) = 400\text{mm}$$

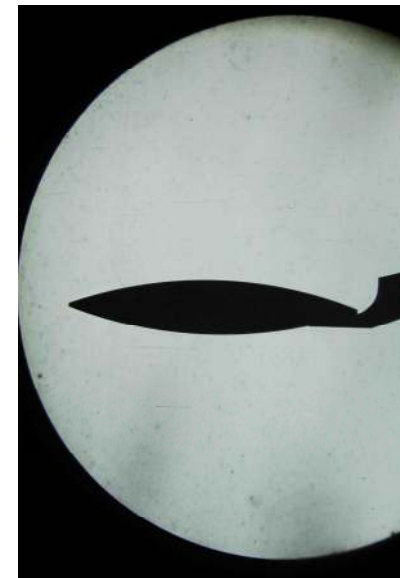
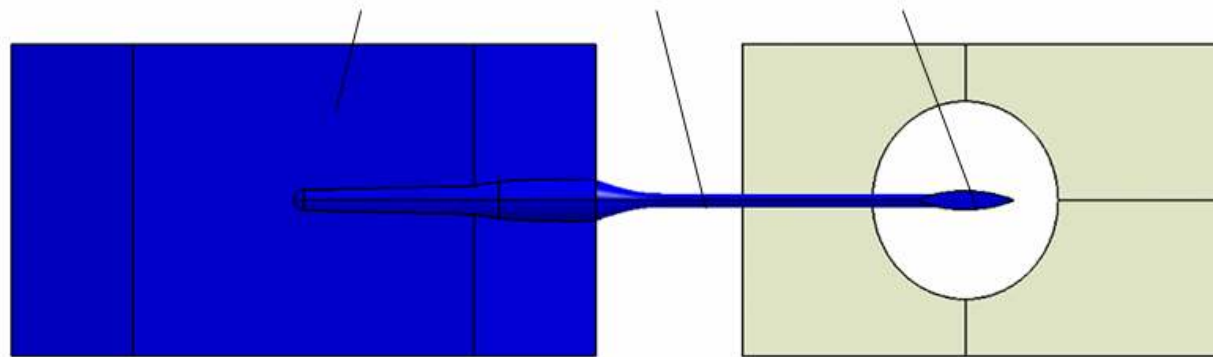
$$b = \frac{h}{c} = 0.18$$

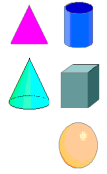
$$\theta_0 = 2 \cdot \text{arctg}\left(\frac{1-b}{1+b}\right) = 69.592^\circ$$

$$x = R \cdot \cos(\theta)$$

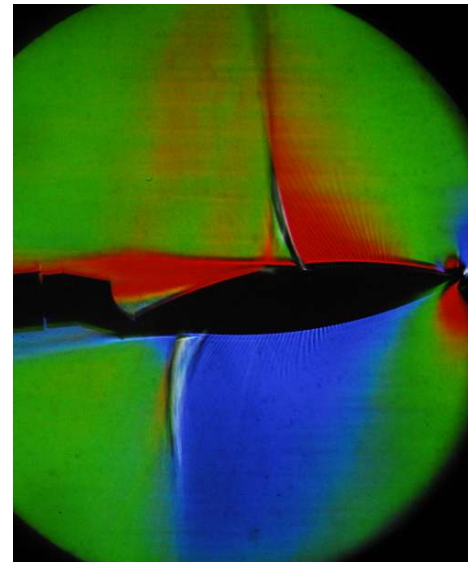
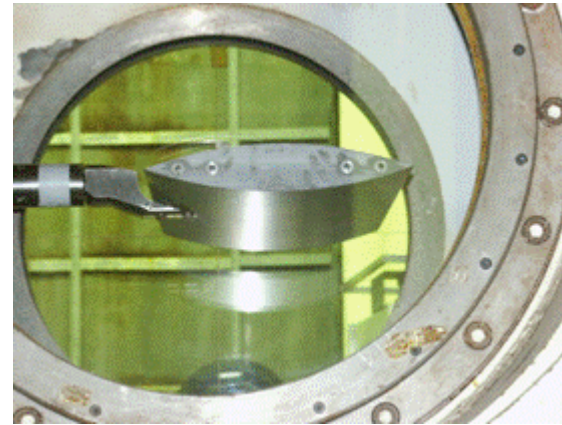
$$z = R \cdot (\sin(\theta) \pm \sin(\theta_0))$$

$$\theta \in [\theta_0, \pi - \theta_0]$$

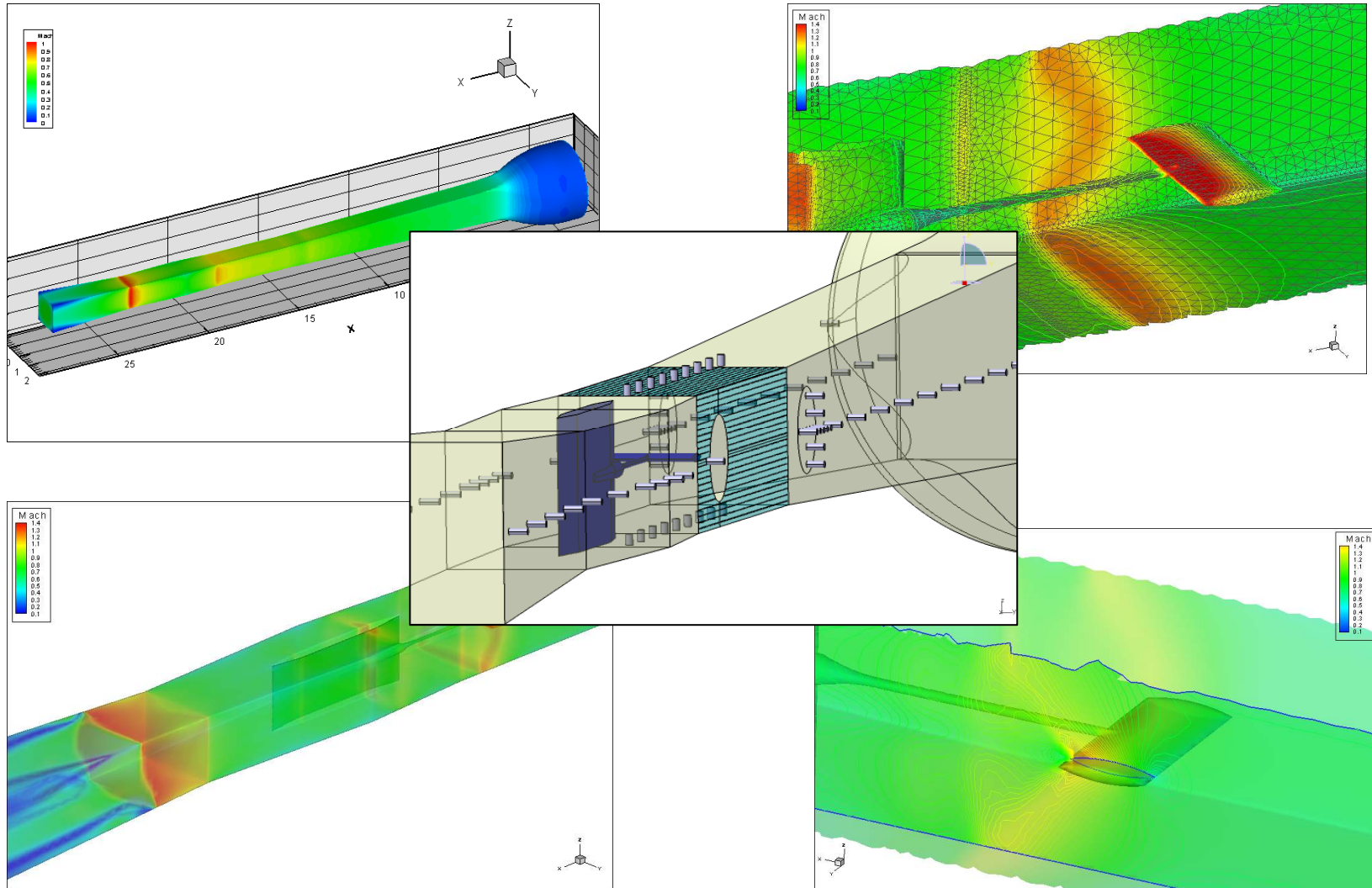
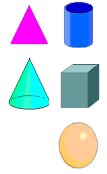


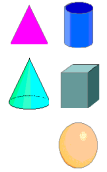


The Buffeting Experiment

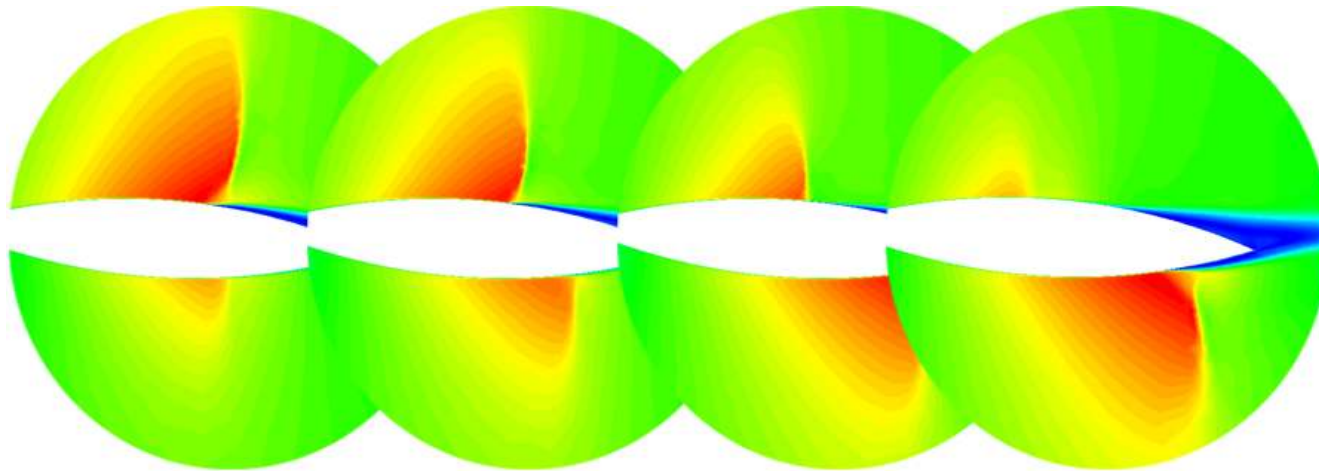


CFD Analysis – Global Flow Analysis



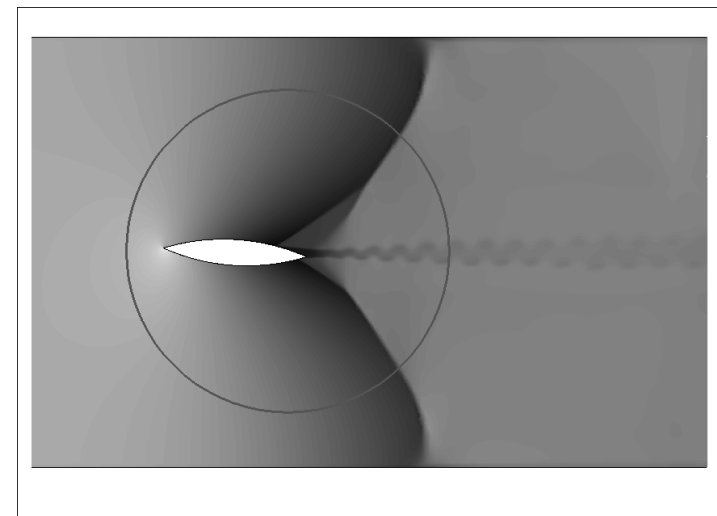


CFD Analysis ...

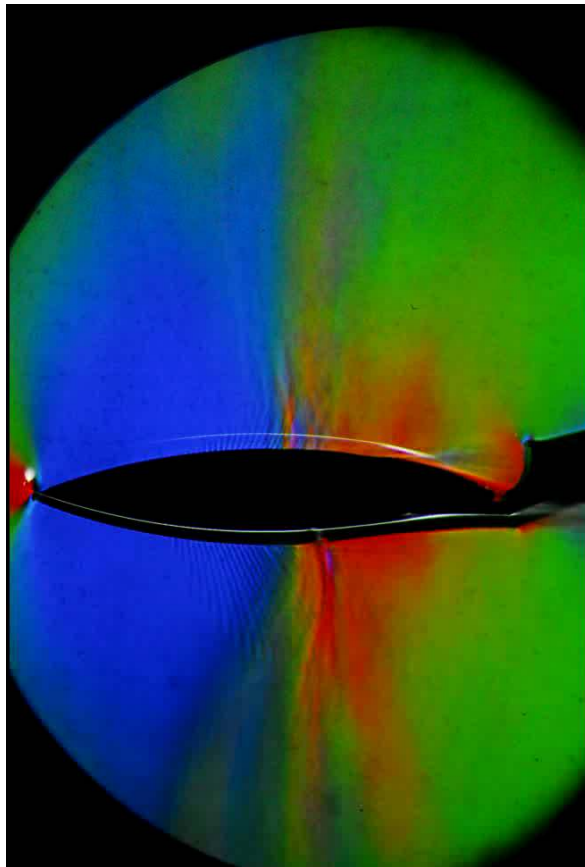
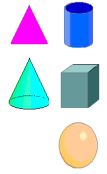


Mach = 0.76 Reynolds = 11 mil., 1 deg. (3D, 40%, URANS)

Mach = 0.79 Reynolds = 11 mil., 3.5 deg. (2D, URANS)



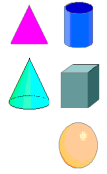
Experimental Activities - Overview



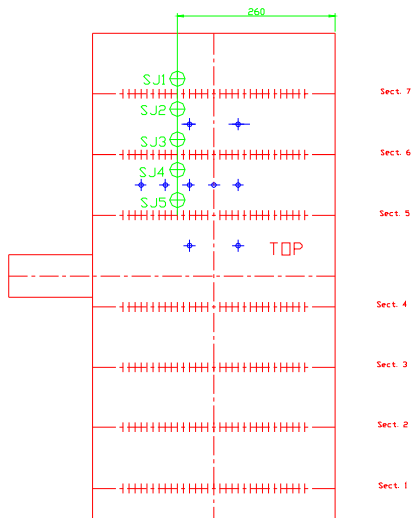
Mach 0.75 – step tests



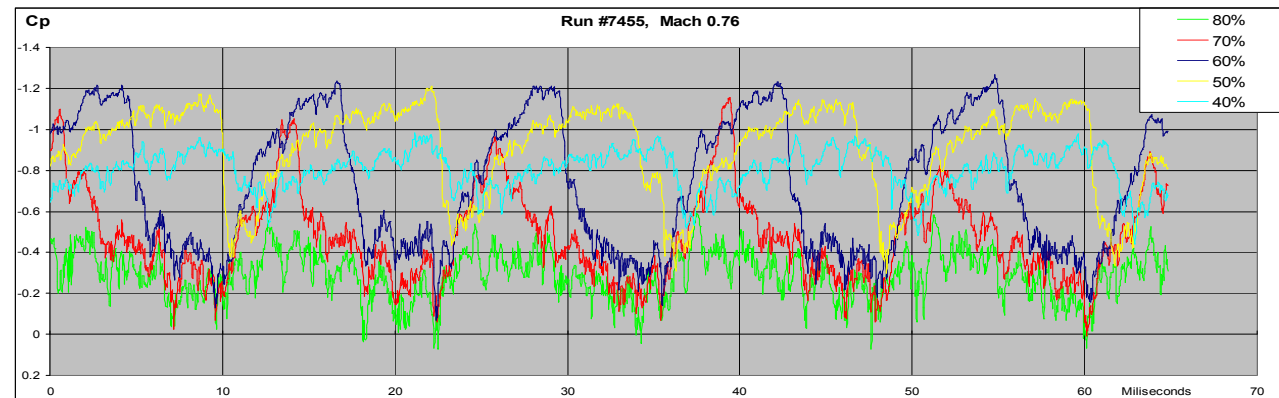
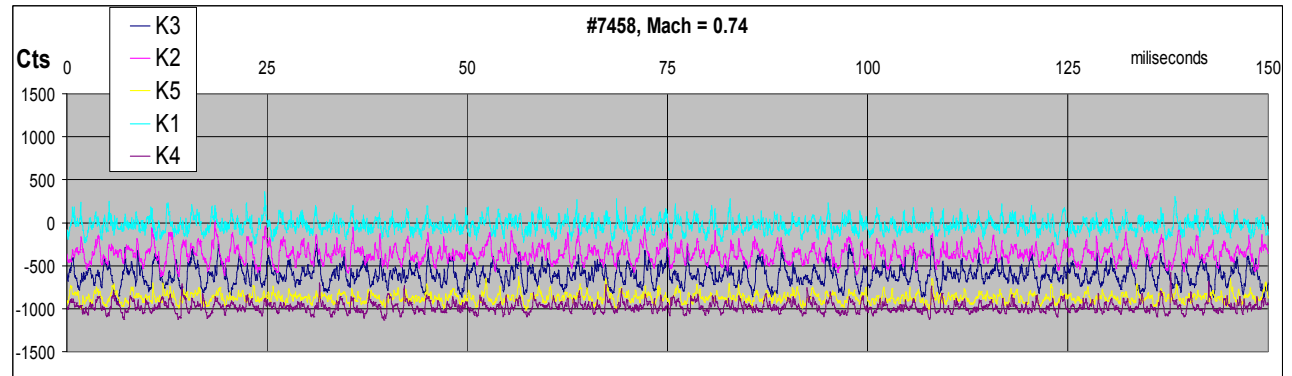
Mach 0.76, $\alpha = 2$ deg.



Buffeting experiment w/o SJ control

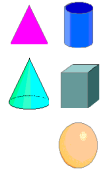


Model instrumentation

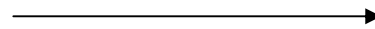
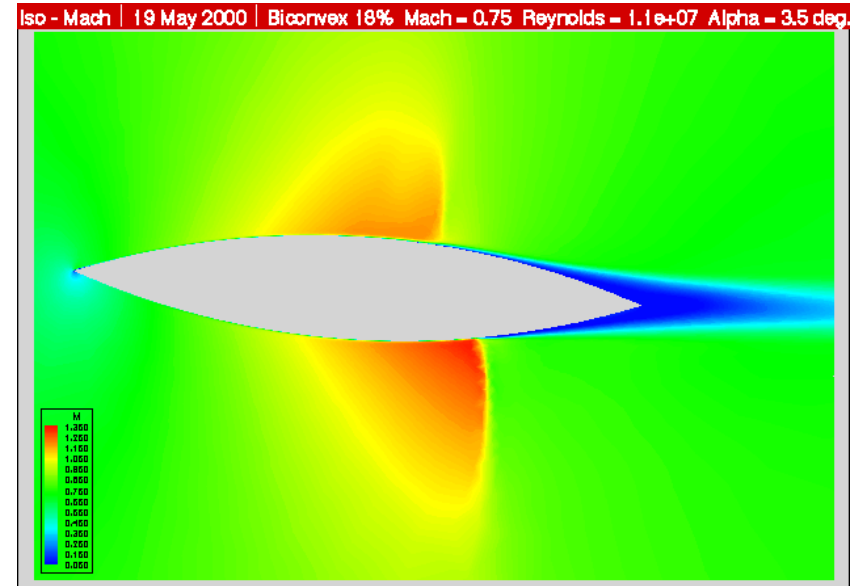
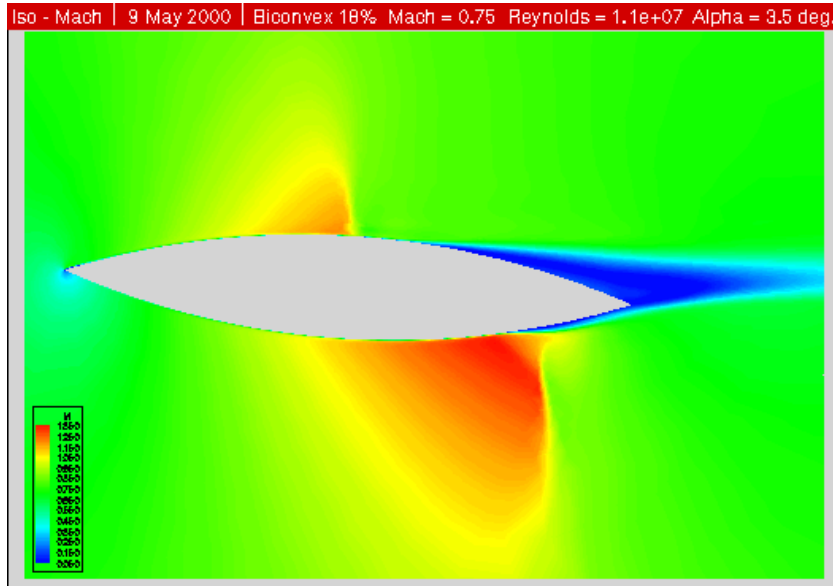


Basic experiment - Kulite readings



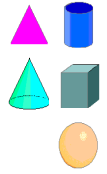


Active Flow Control using SJ

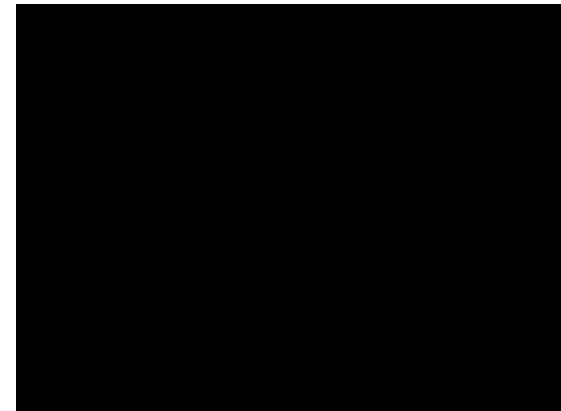
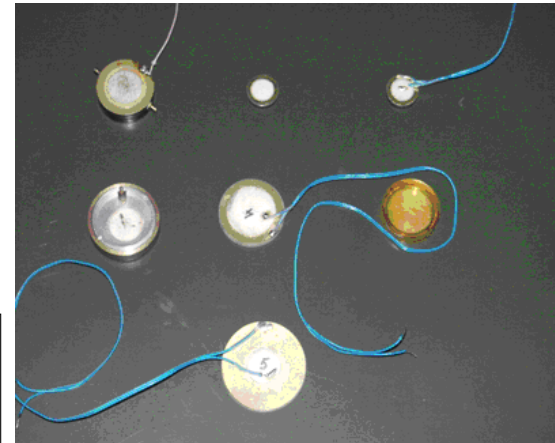
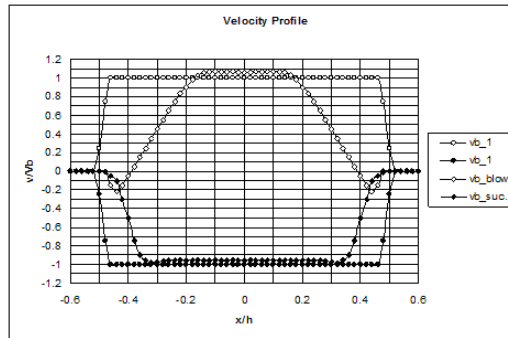
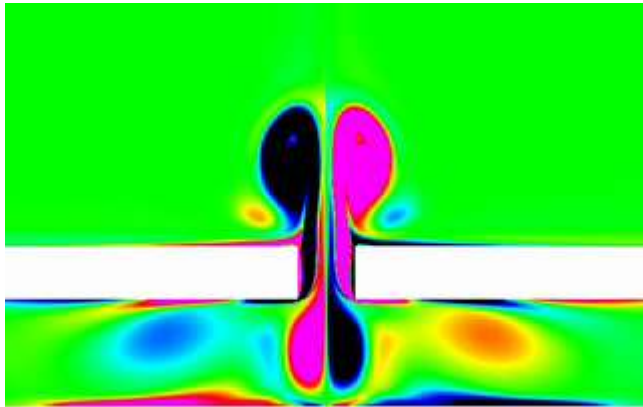
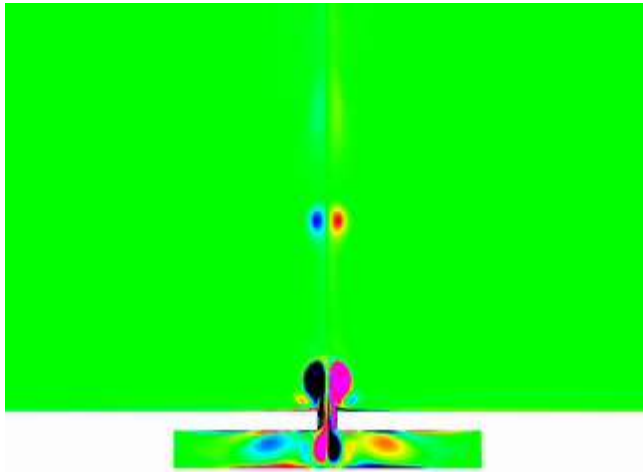


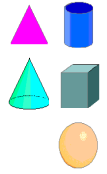
UFAST



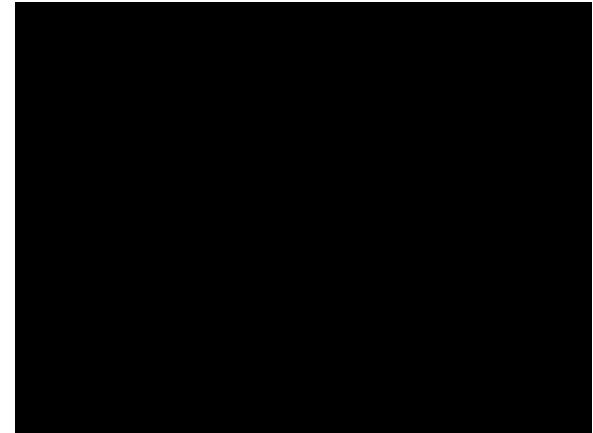
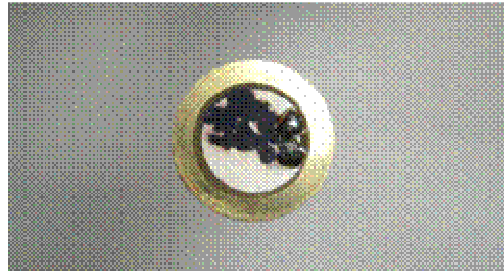
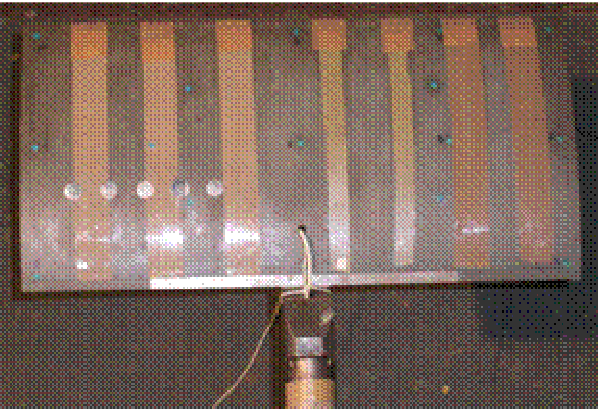
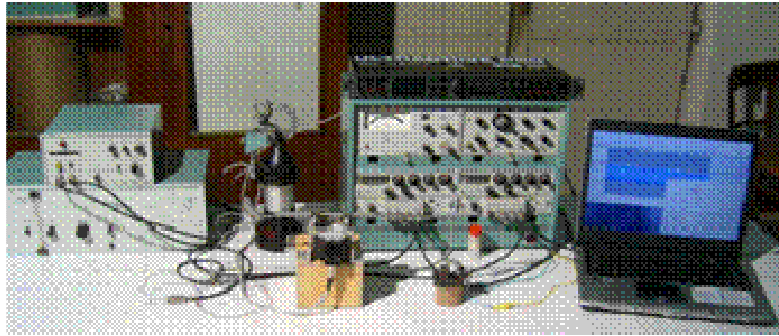
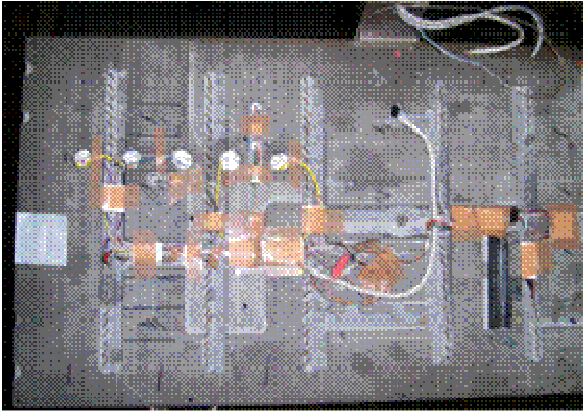


SJ actuator – design and CFD analysis





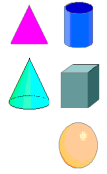
Model design & manufacturing – Phase 2



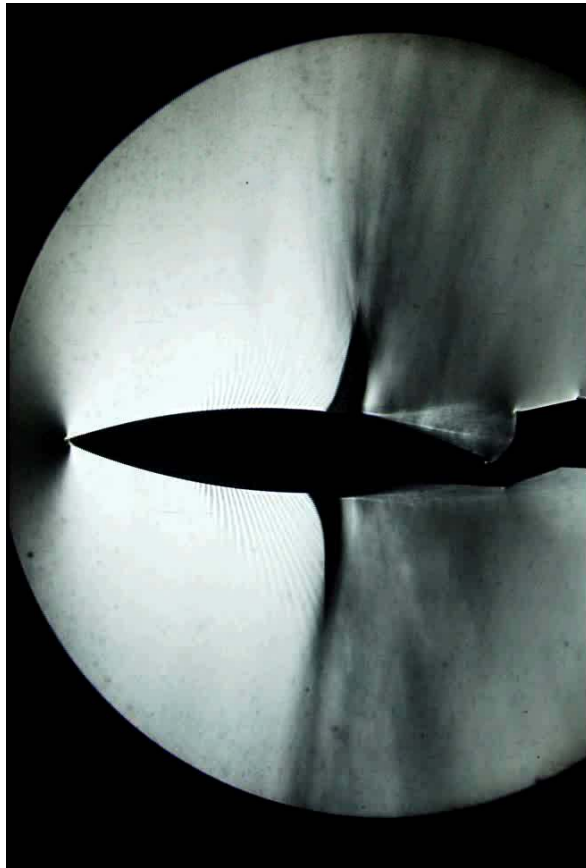
Model with SJ controls

Damaged SJ diaphragm

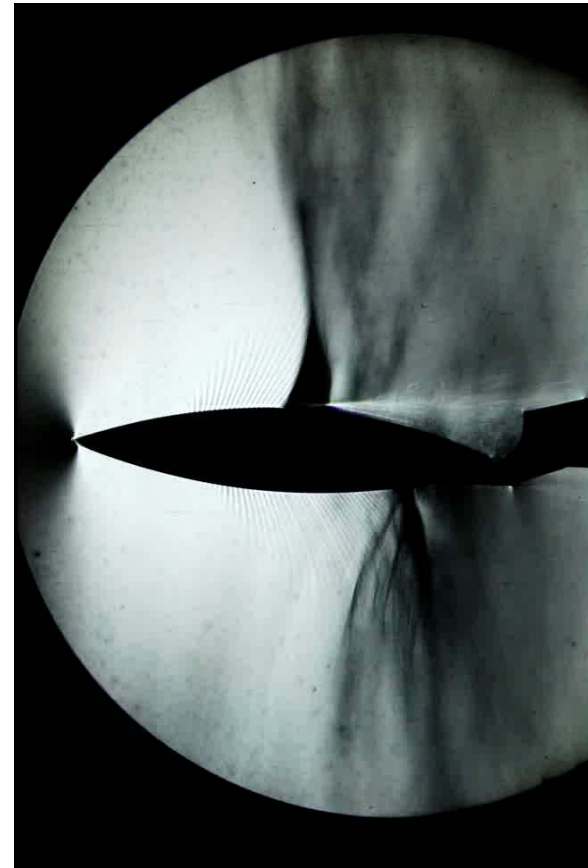
Testing the actuators – no flow



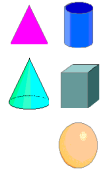
Buffeting alleviation using SJ



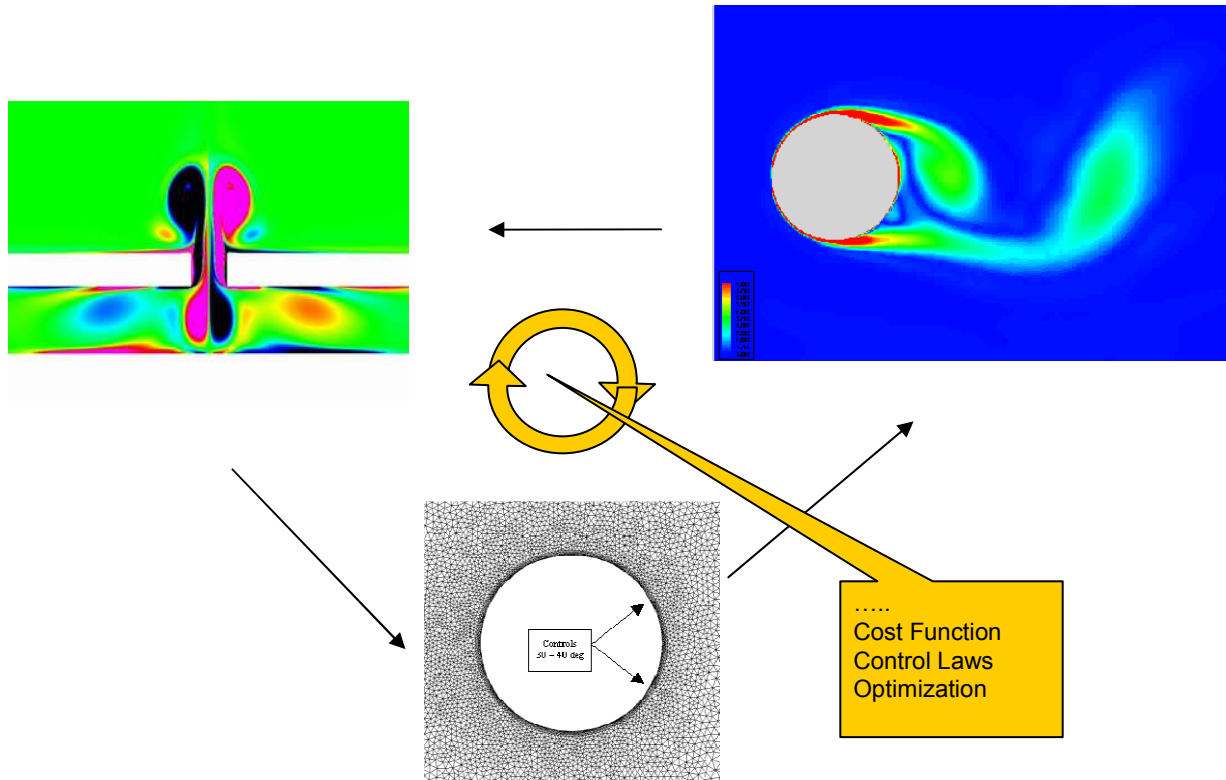
Basic motion, Mach 0.75



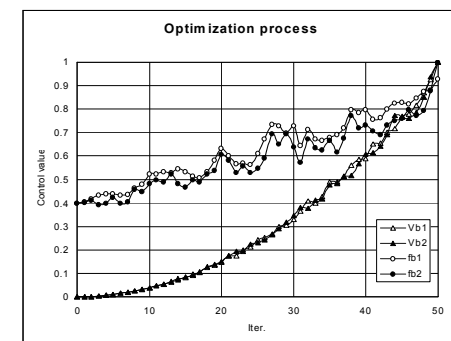
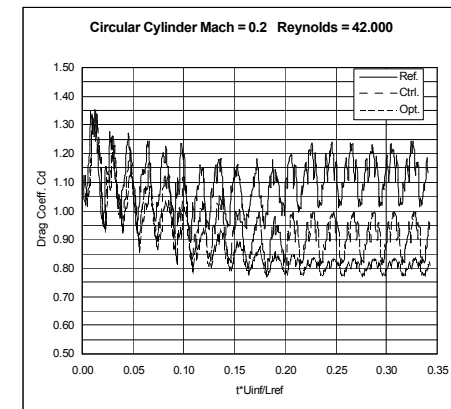
SJ control, Mach 0.75, $F^+ = 8.5$

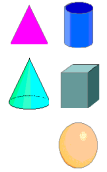


Active Flow Control using SJ



$$C(\varphi, \zeta) = \min_{\varphi, \zeta} J(\varphi, \zeta) = \min_{\varphi, \zeta} \left(\frac{1}{n_T} \int_0^{n_T \cdot T} Cd(\varphi(t), \zeta(t)) \cdot dt \right)$$





Invitation to AEROSPATIAL 2008

AEROSPATIAL 2008 CONFERENCE
1 - 2 OCTOBER 2008
INCAS - BUCHAREST, ROMANIA

www.incas.ro/AEROSPATIAL_2008

Celebrating the 40th anniversary of
INCAS - National Institute for Aerospace Research "Elie Carafoli"
Bucharest - ROMANIA

The AEROSPATIAL 2008 Conference will take place at
INCAS, B-dul Iuliu Maniu no. 220, sector 6, Bucharest,
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The Conference Program includes:

- Special session dedicated to the celebration of 40th anniversary of INCAS as National Institute for Aerospace Research;
- Dedicated scientific session for major topics in aeronautics;
- Exhibition with latest achievements in aeronautical R&D.

Conference Topics

1. Basic Theoretical and Experimental Research in
 - Aerodynamics, Flow Physics, Combustion
 - Flight Dynamics, Flight Tests, Space Dynamics
 - Complex Systems
 - Structural Analysis, Aerelasticity
2. Concept and Analysis of Aeronautical Systems
 - New concepts and designs
 - Aerostructures
 - Propulsion Systems
 - Systems and Avionics
 - Space Technology
3. New Materials and Technologies in Aeronautics
4. Management Systems for Aeronautical Industry
 - Extended Enterprise and Virtual Enterprise in Aeronautics
 - Air Traffic Management

