

Research Interests

Low Reynolds number aerodynamics

Flow control

Vortex-dominated flows

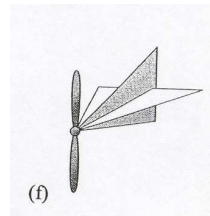
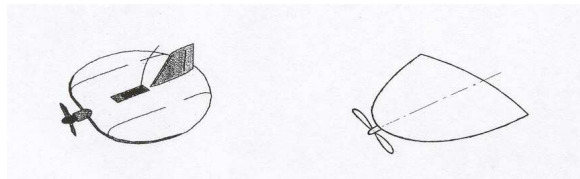
Unsteady aerodynamics

- **Unmanned Combat Air Vehicles (UCAVs)**



flying wings; highly flexible; highly maneuverable

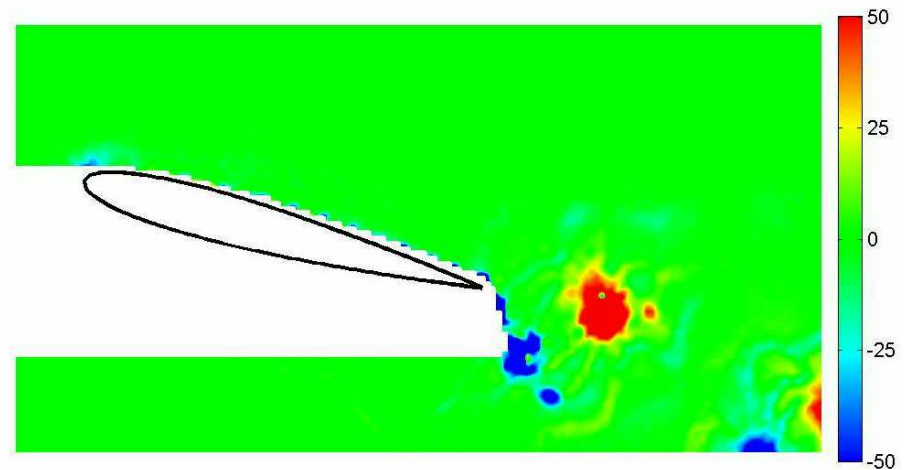
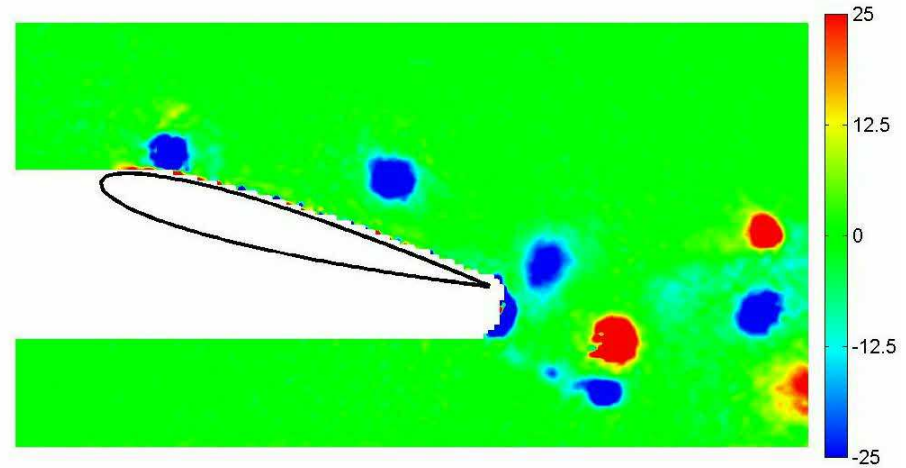
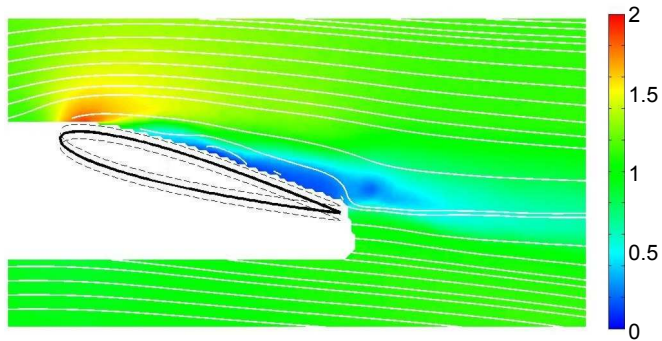
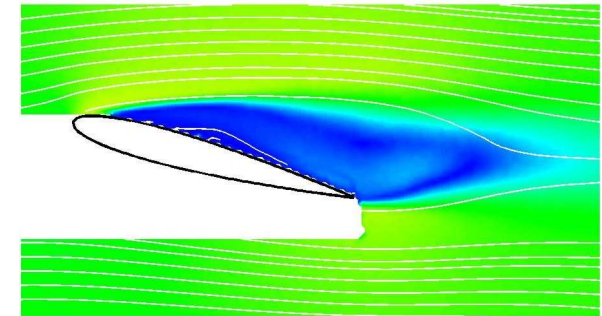
- **Micro Air Vehicles (MAVs)**



poor lift; inefficient propulsion, unsteady aerodynamics, gust response

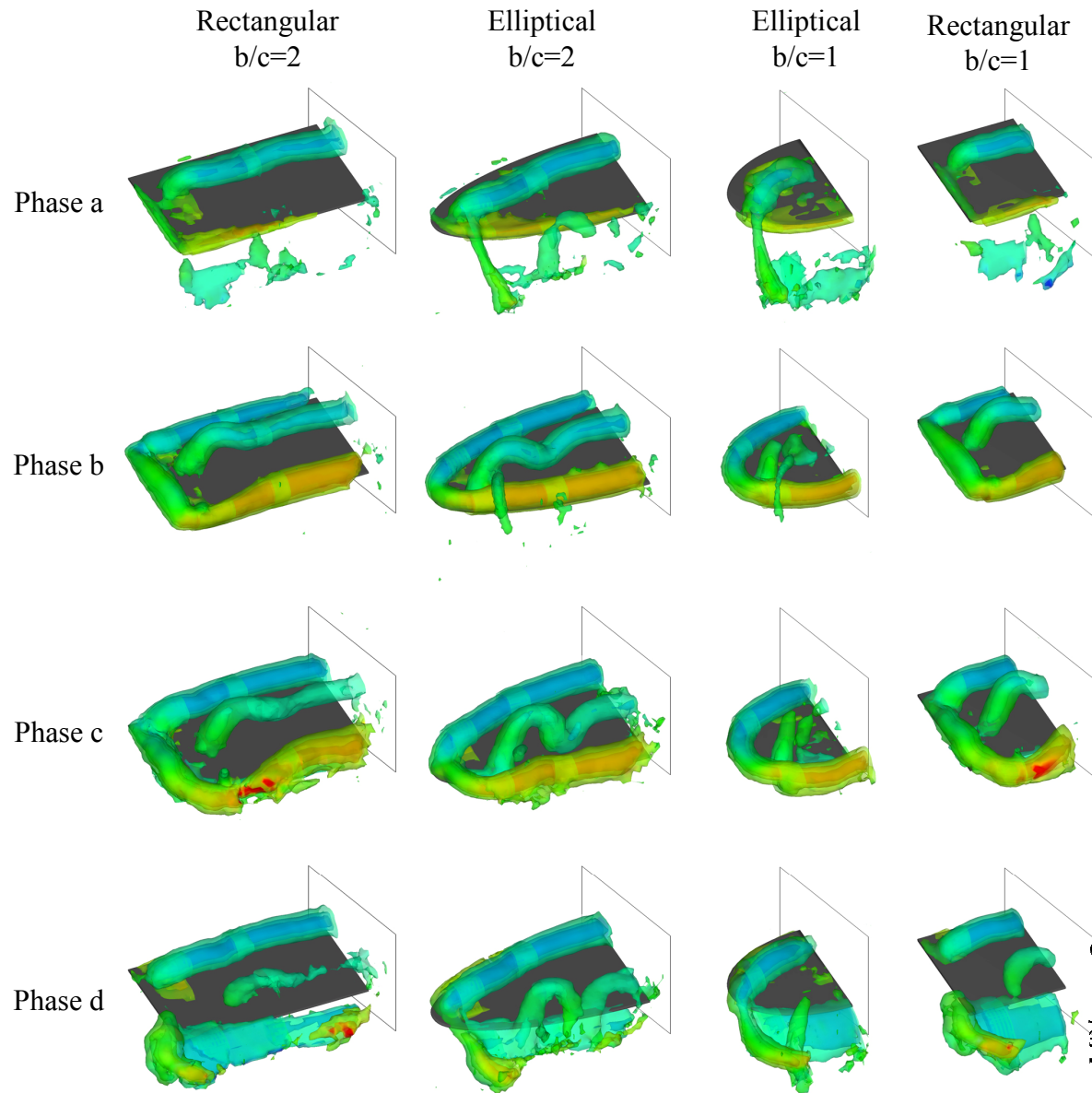
Low Reynolds number flows

Separation control with oscillating airfoils

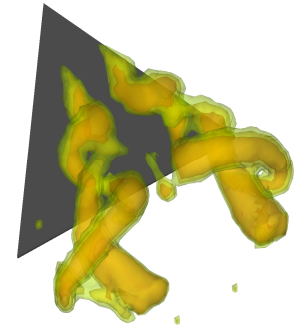


Oscillating 3D Wings

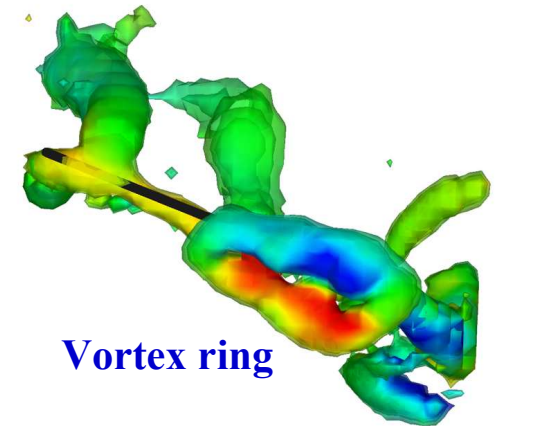
Vorticity magnitude iso-surfaces for $St=0.8$



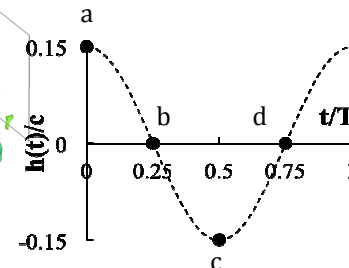
Delta wing and breakdown

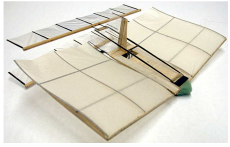


Rectangular wing $sAR=1$ side view



Vortex ring

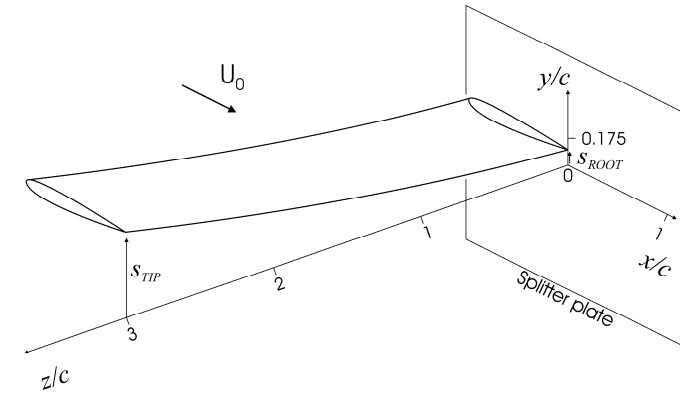
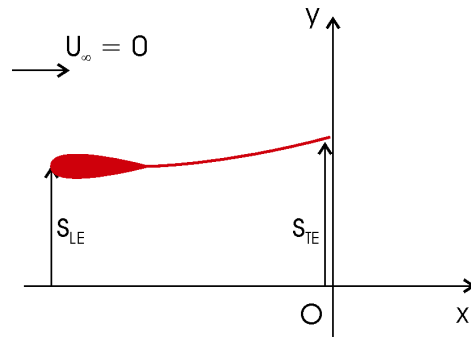




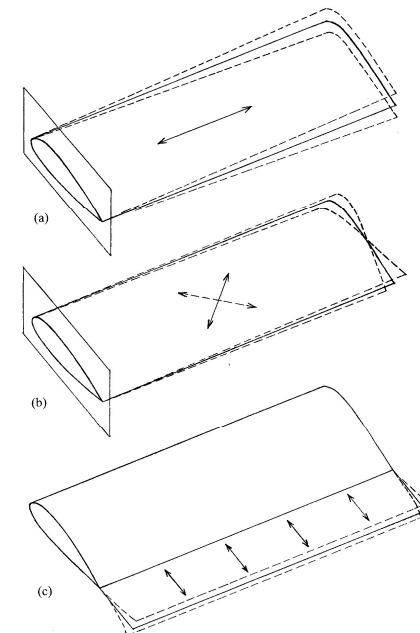
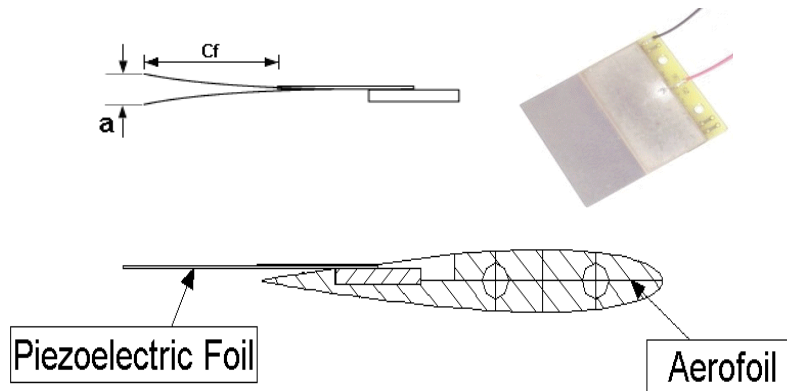
Low Reynolds number flows



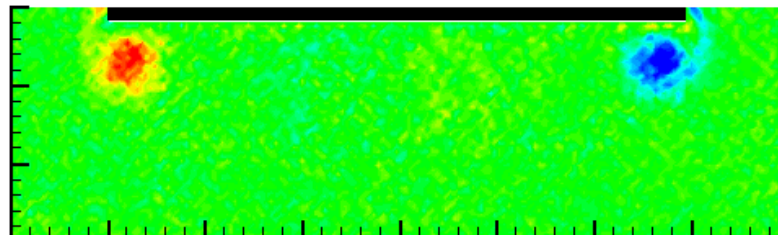
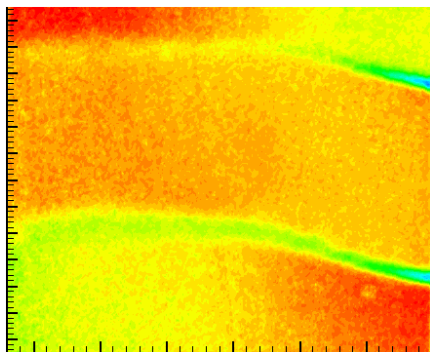
- Flexible flapping airfoil



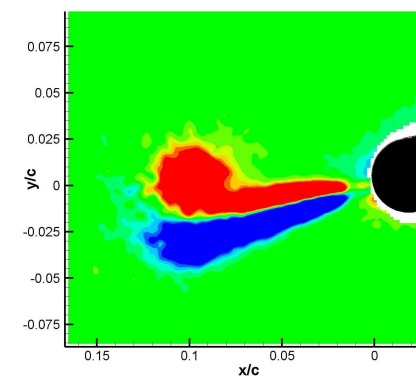
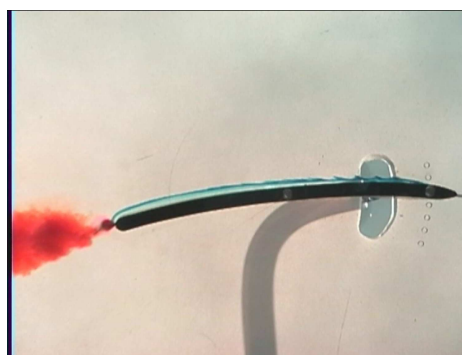
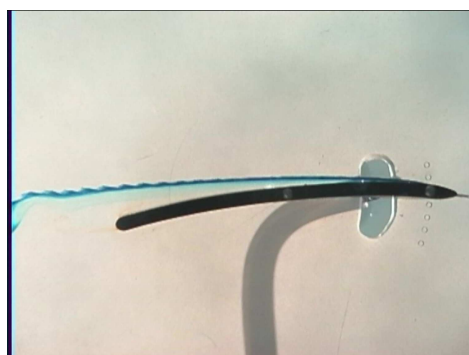
- Smart Flapping Wing



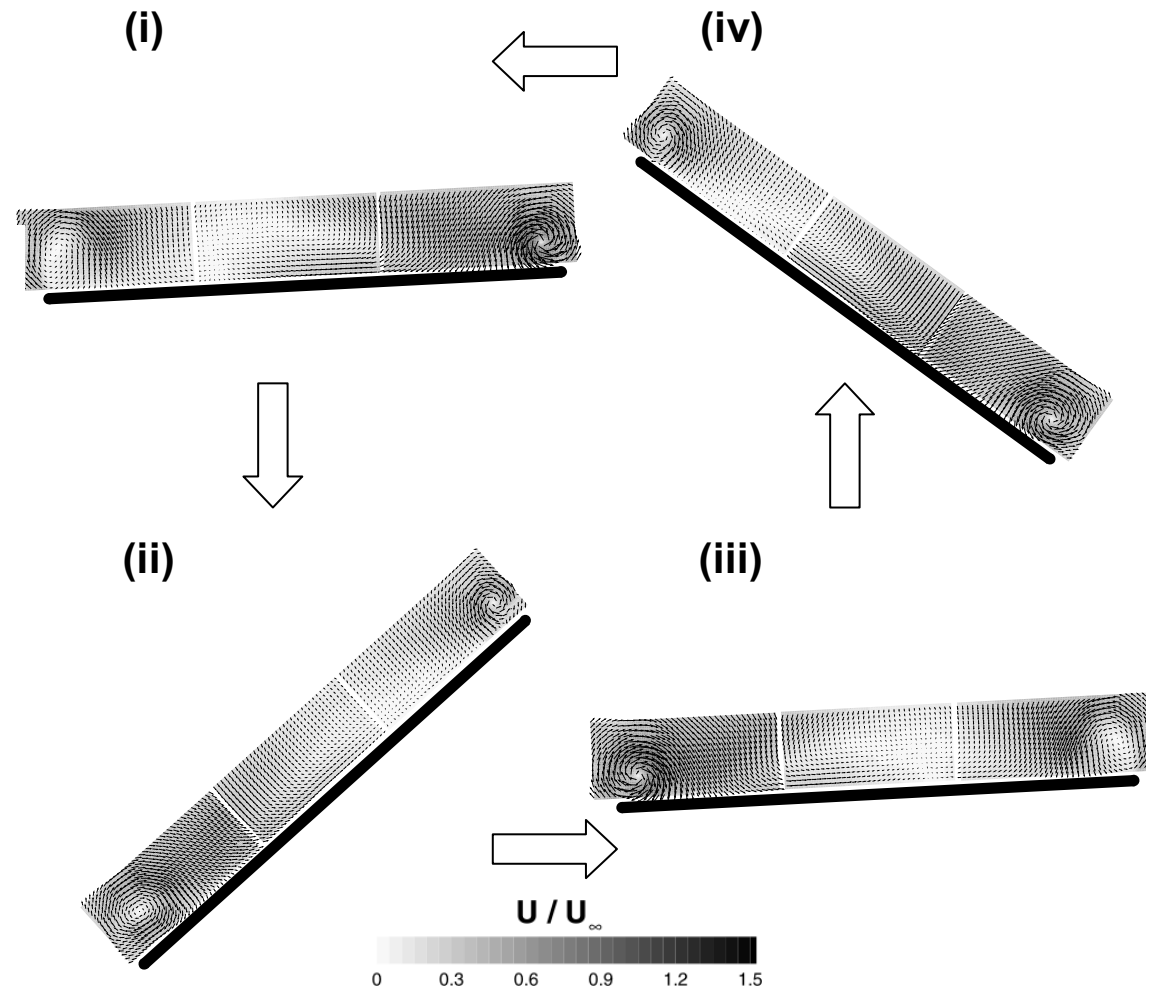
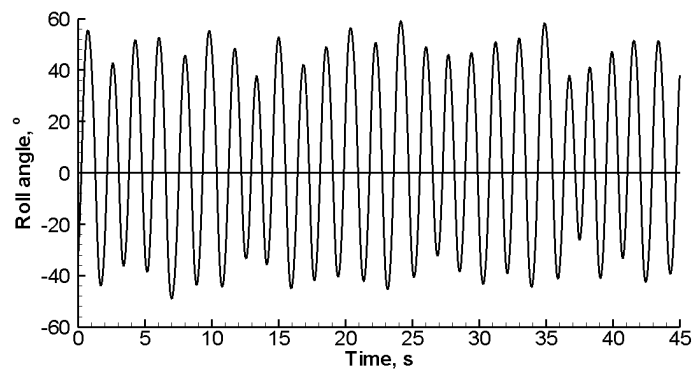
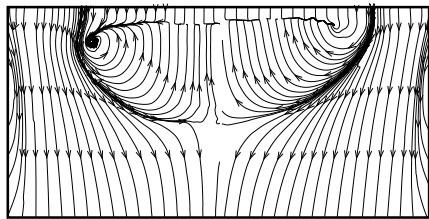
- Gust response of micro air vehicles



- Synthetic jet propulsion



Self-Induced Roll Oscillations of Low Aspect Ratio Wings



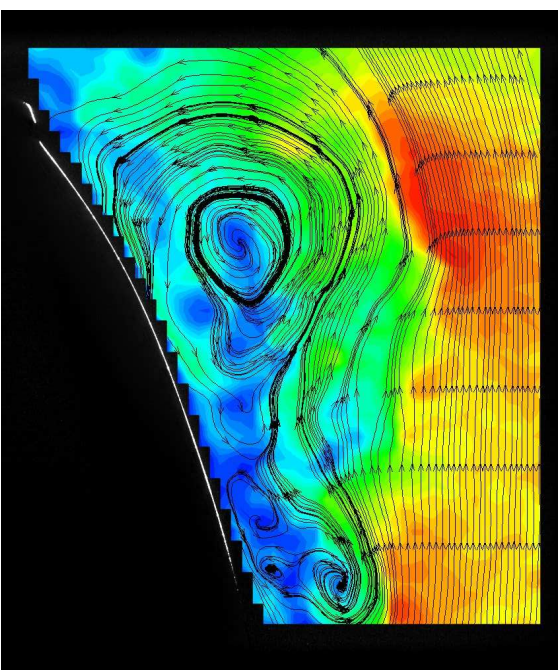
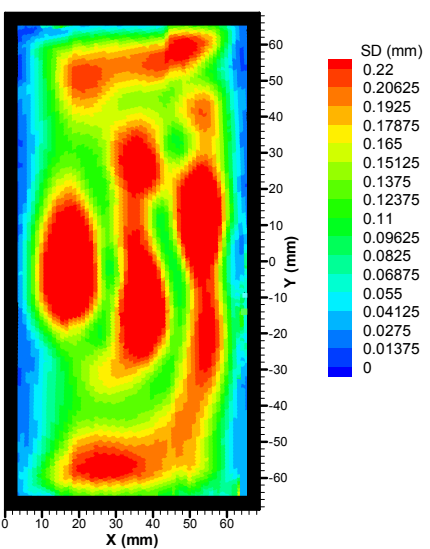
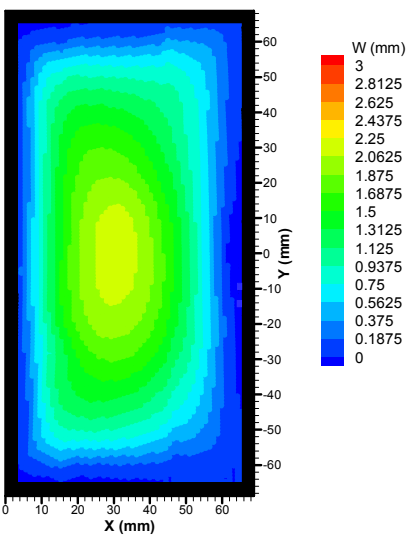
Membrane Airfoils and Wings



Rigid membrane



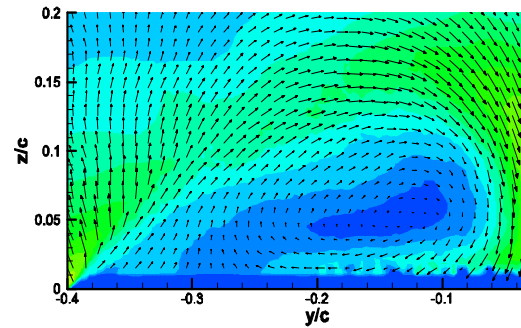
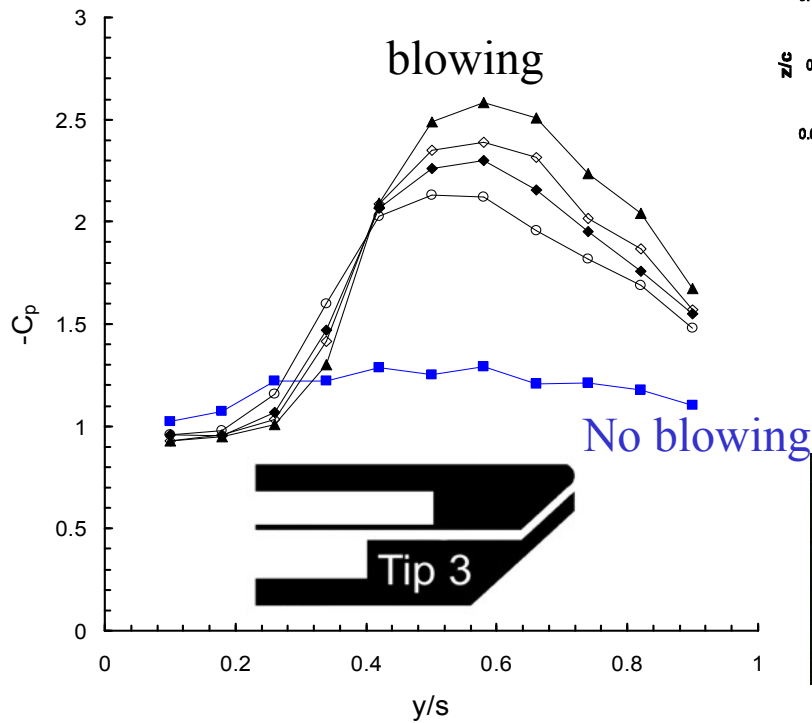
Flexible membrane



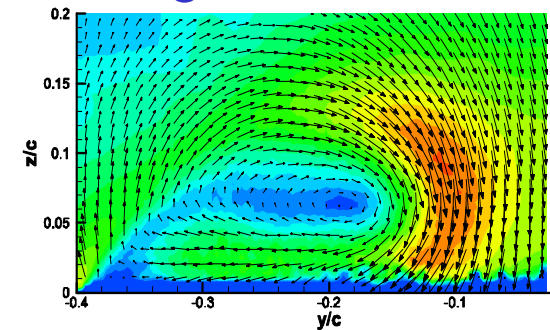
Flow Control

Active control on nonslender delta wing

Pulsed blowing



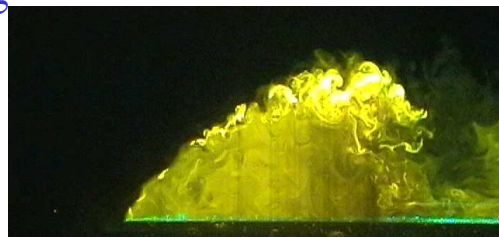
Stalled flow



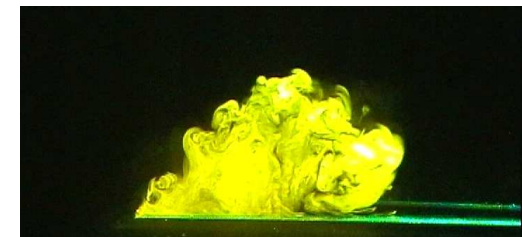
With excitation

Leading-edge oscillations

Gursul et al

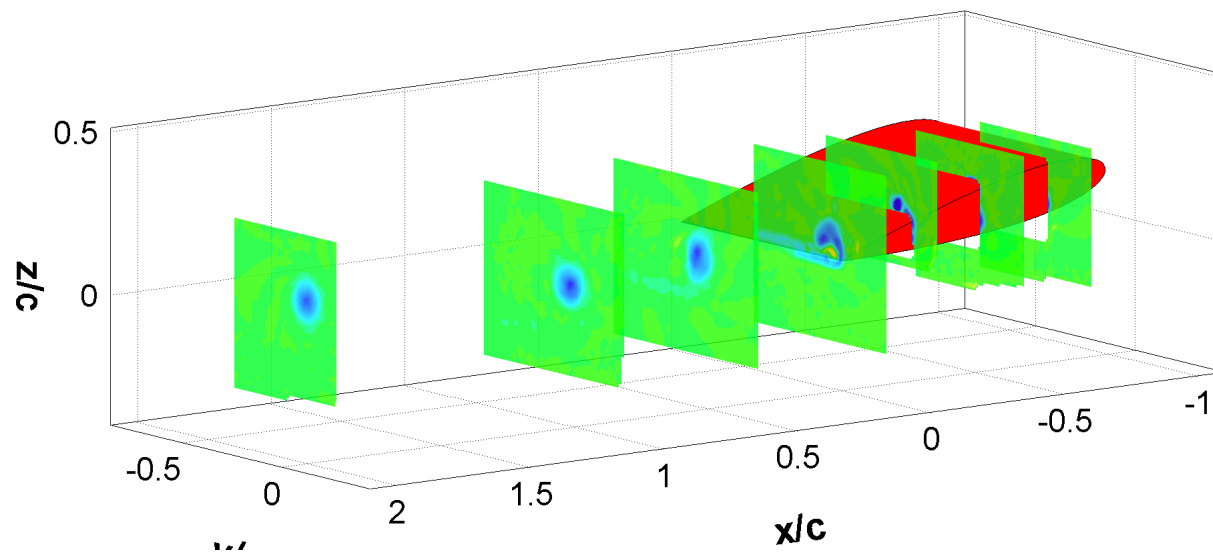


Stalled flow

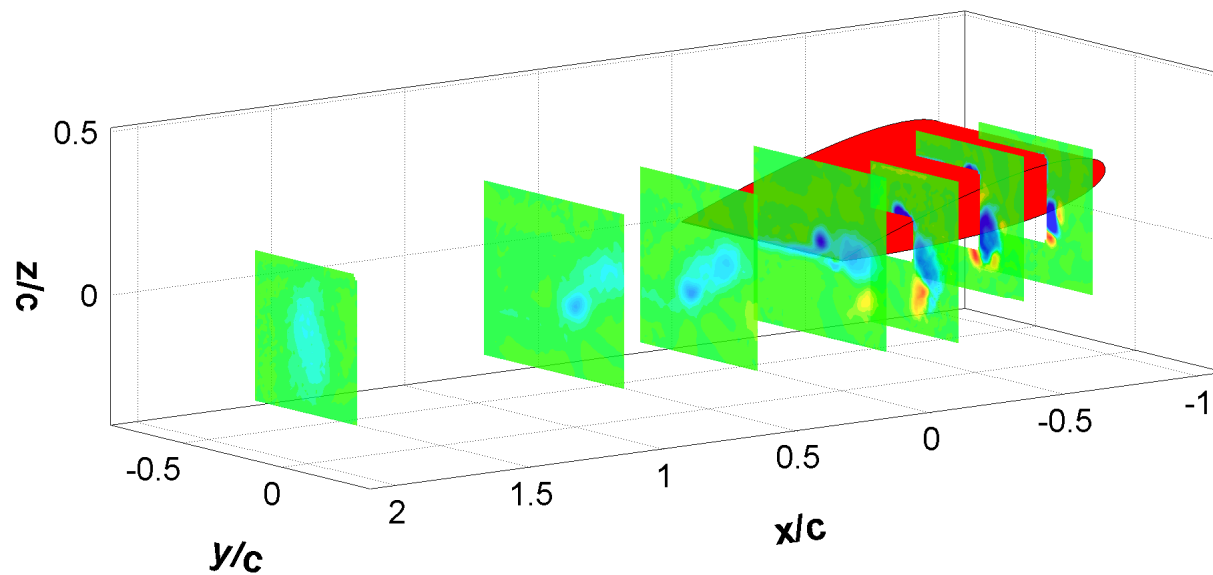


With excitation

- Active control of tip vortices



reference
case

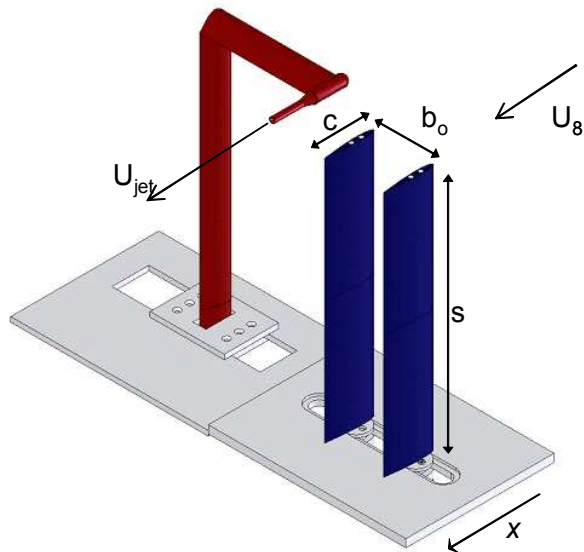
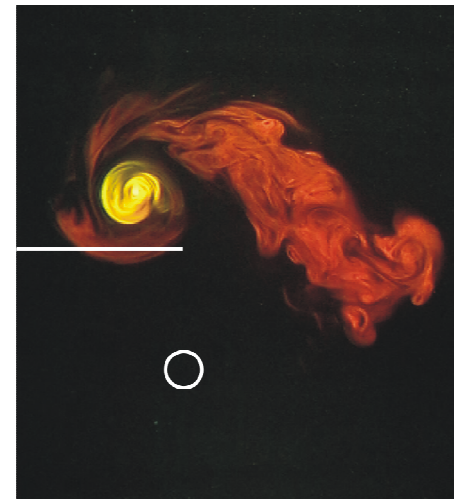
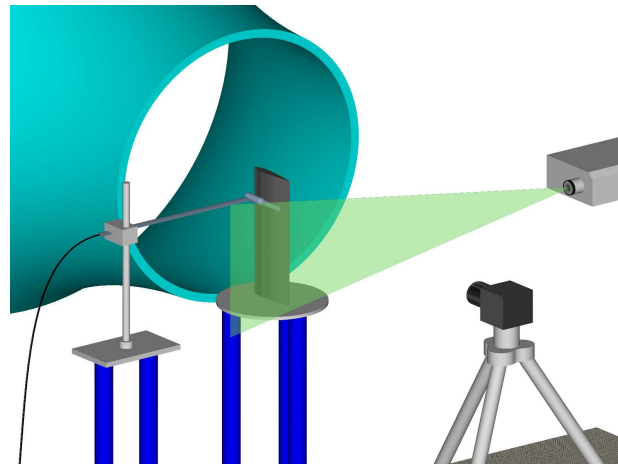


blowing

Vortex-dominated flows

Jet / vortex interaction

EC project: FAR-Wake
16 partners and Airbus-D



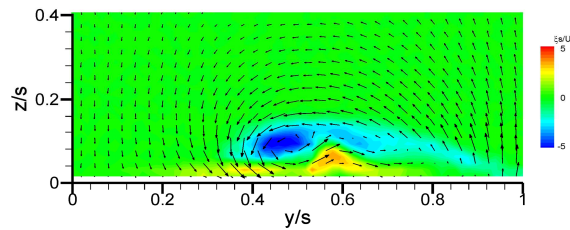
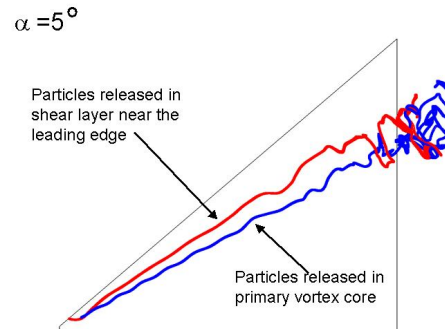
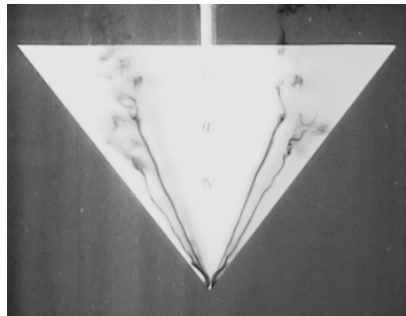


Vortex-dominated flows



Non slender vortices

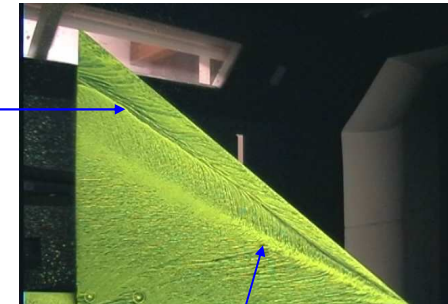
Dual vortex structure



Vortices at very low incidences

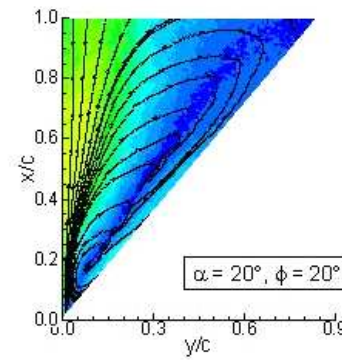
Secondary separation

$\alpha = 2.5^\circ$

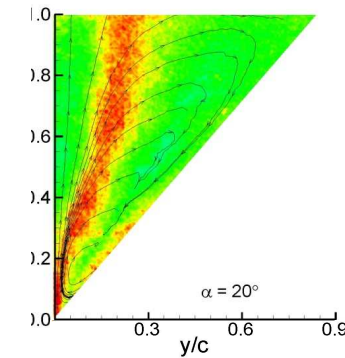


reattachment

Buffeting

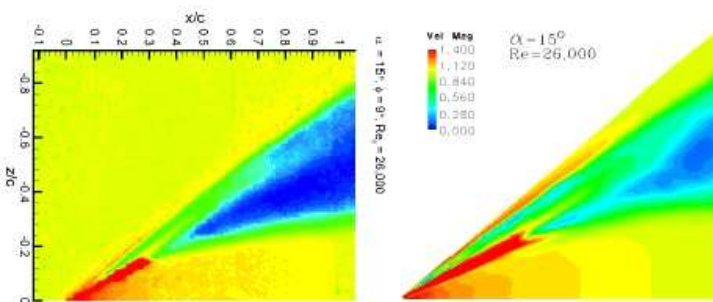


Mean velocity near surface



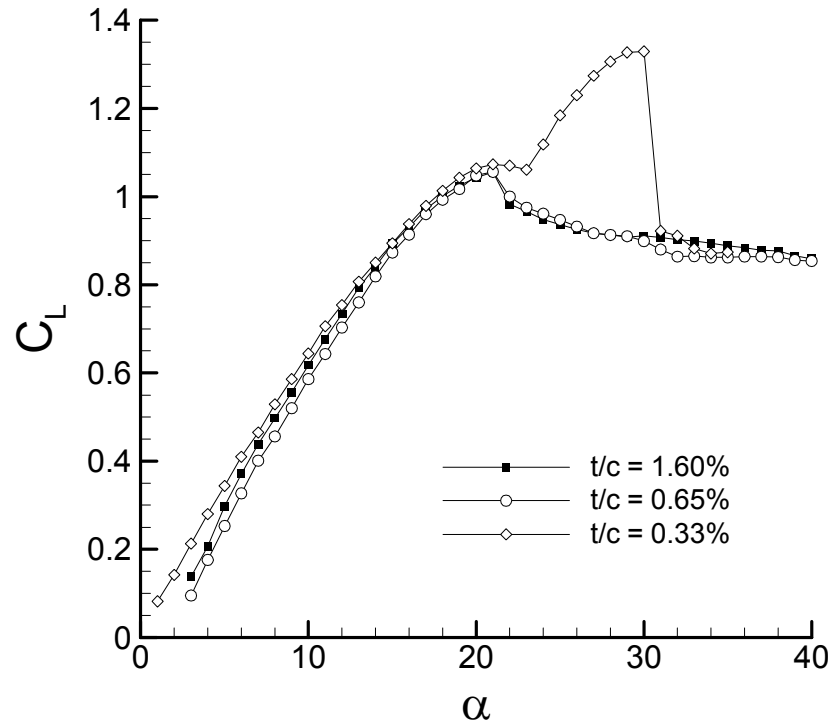
RMS velocity near surface

Vortex breakdown

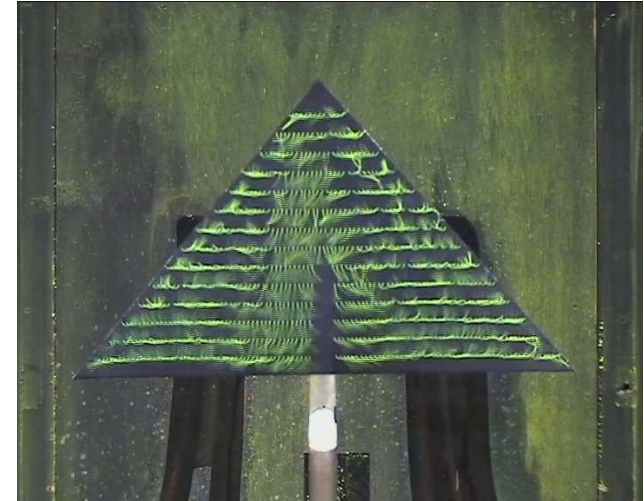


Flexible Delta Wings

Lift enhancement!



Rigid wing



Flexible wing

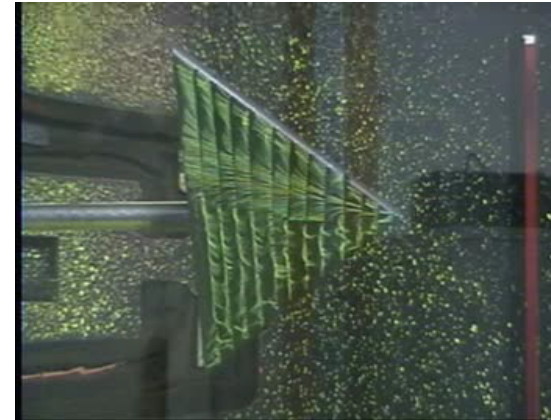
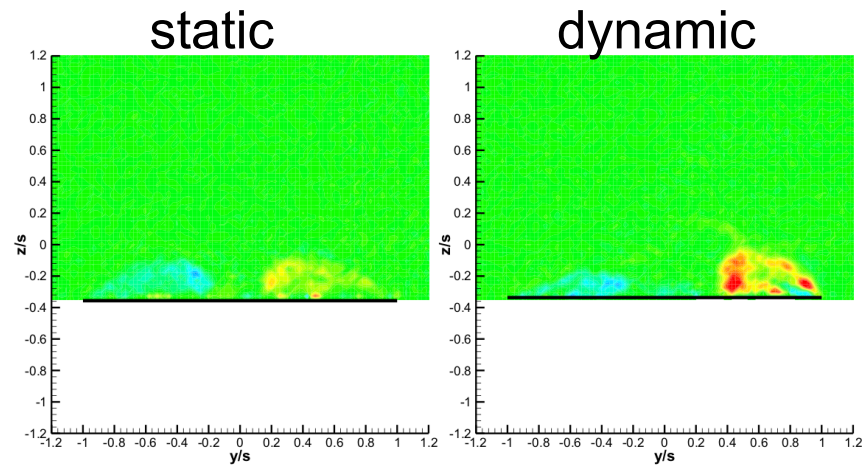




Vortex-dominated flows

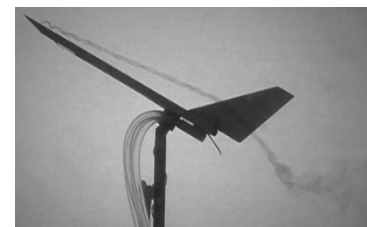
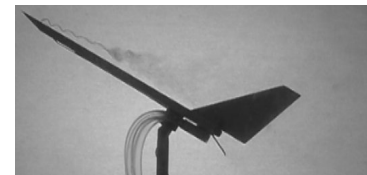
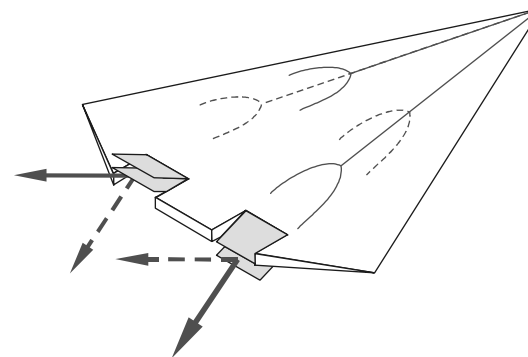
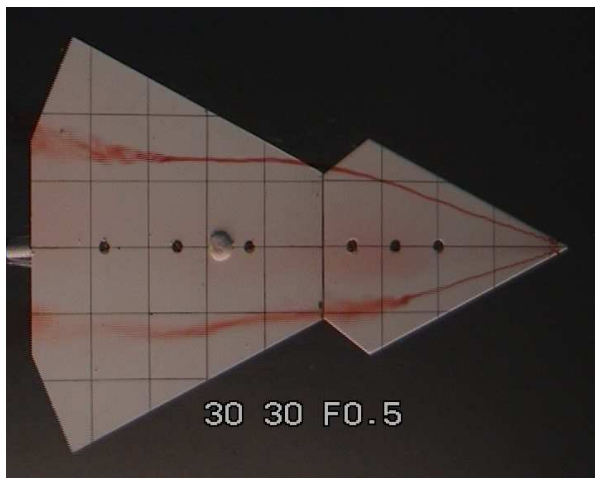
- Rolling delta wing

- Free-to-roll nonslender wings



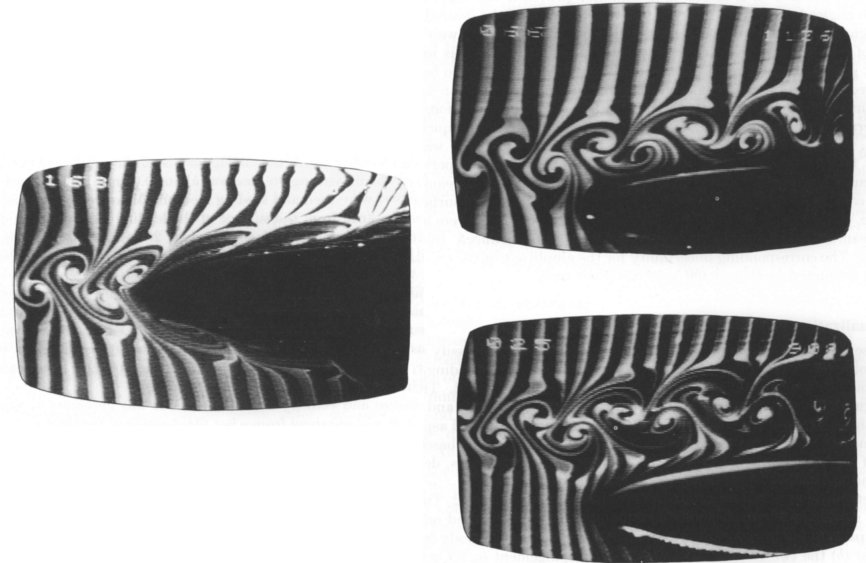
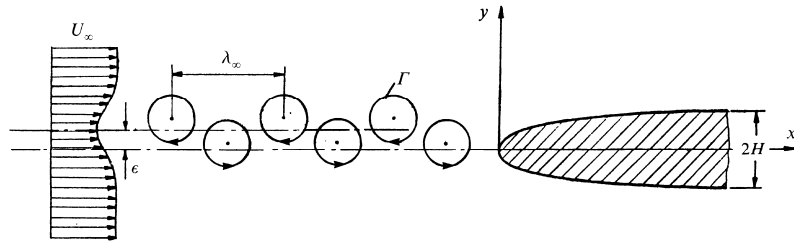
- Rolling UAV

- Thrust vectoring



Vortex-dominated flows

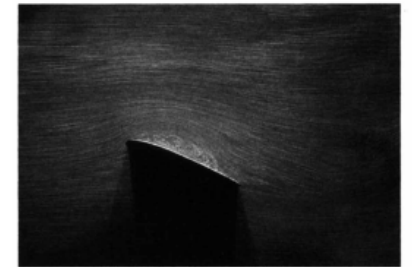
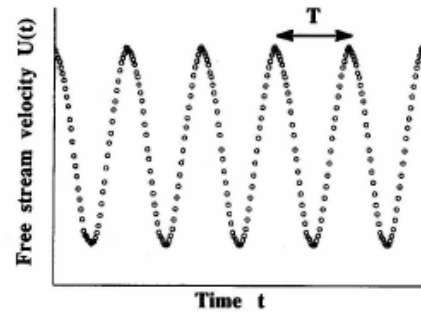
- Vortex/body interactions



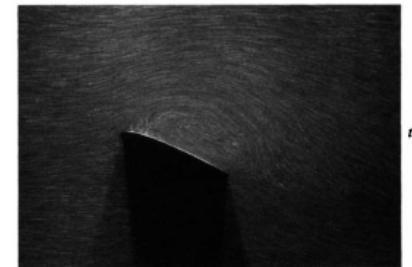
- Aerodynamics of wings in unsteady free stream



STEADY FREE STREAM

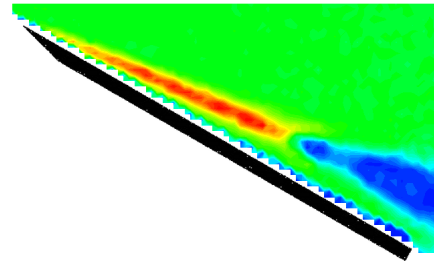
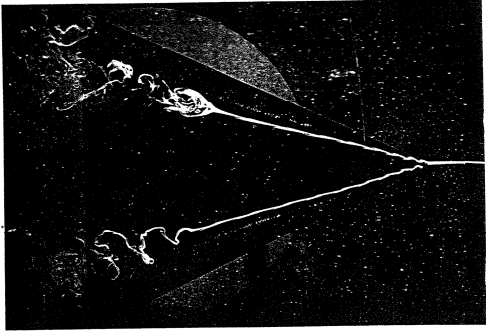


$t/T = 0$



$t/T = 0.25$

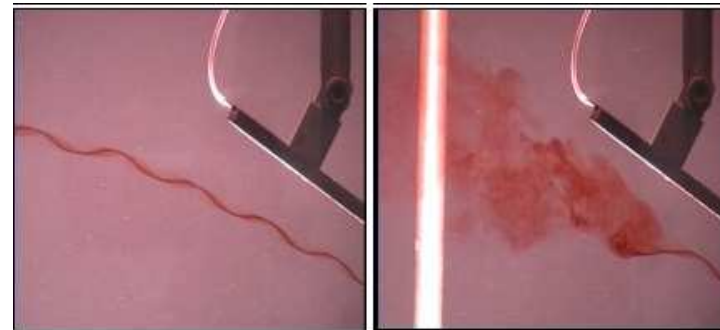
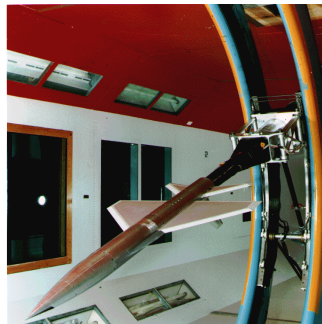
- Vortex Breakdown over Unsteady Delta Wings and its Control
leading-edge devices and suction



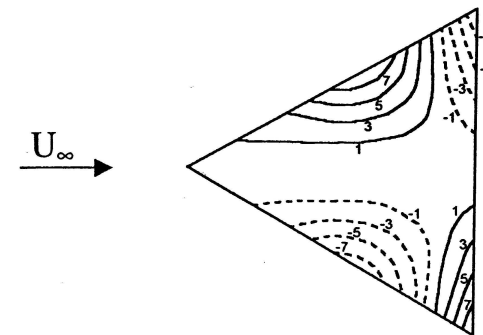
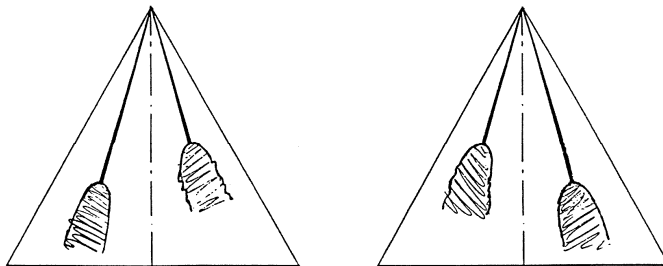
- Fin Buffeting and its Control



- Investigation of Support Interference in Oscillatory Dynamic Testing



- Investigation of Unsteady Vortex Interactions



Current and recent sponsors

- Drag Reduction with Flexible Trailing-Edge Devices in Unsteady Motion ([ONR](#))
- Control of Low Reynolds Number Flows with Fluid-Structure Interactions ([AFOSR](#))
- Fluid-Structure Interaction of Oscillating Low Aspect Ratio wings at Low Reynolds Numbers ([EOARD](#))
- Equipment for Multiple Projects: Testing and Visualization for Aerospace Research ([EPSRC](#))
- Unsteady aerodynamics of membrane wings ([AFOSR](#))
- Self Excited Roll Oscillations of Nonslender Wings ([AFOSR](#))
- Measurements of Unsteady Vortical Flows with High Speed Particle Image Velocimetry ([EPSRC](#))
- Fundamental Research on Aircraft Wake Phenomena ([EC 6th Framework](#))
- Academic Fellowship in Unmanned Air Vehicles ([EPSRC](#))
- Vortex/propulsion interaction ([EPSRC/MoD](#))
- Fin buffeting ([US Air Force Office of Scientific Research](#))
- Flexible delta wings ([US AFOSR](#))
- Unsteady vortex interactions ([EPSRC](#))
- Highly maneuverable aircraft ([QinetiQ](#))
- Support interference ([QinetiQ](#))
- Synthetic jet based MAVs ([EPSRC/MoD](#))
- Low Reynolds number aerodynamics of MAVs ([BAE](#), [EPSRC](#))
- Flapping wing propulsion ([EPSRC](#))