07 – Flutter Phenomenon

PART 2 – SECTION 1:

INTRODUCTION TO THE FORMULATION OF THE UNSTEADY AERODYNAMIC FORCES

Vibraciones y Aeroelasticidad
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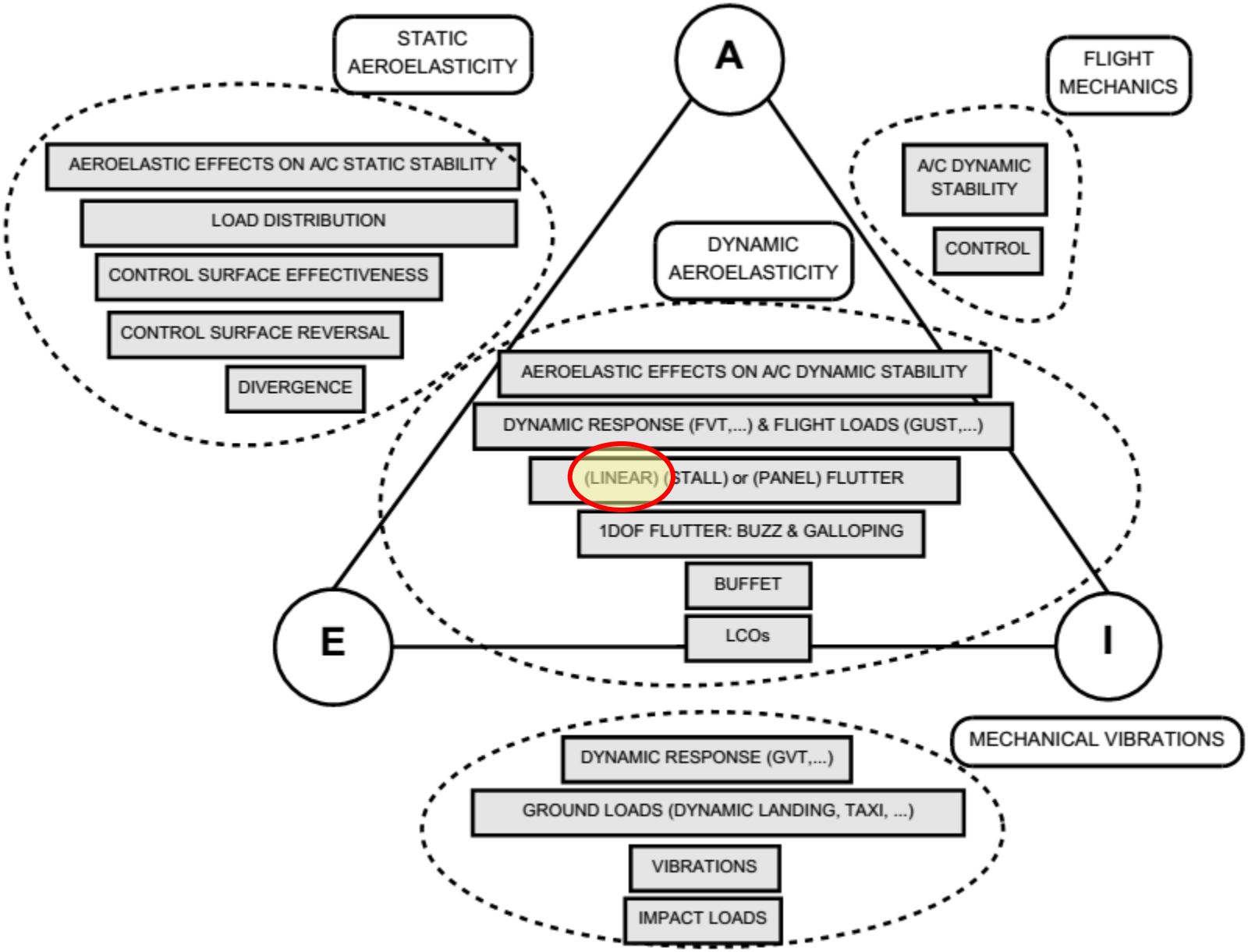
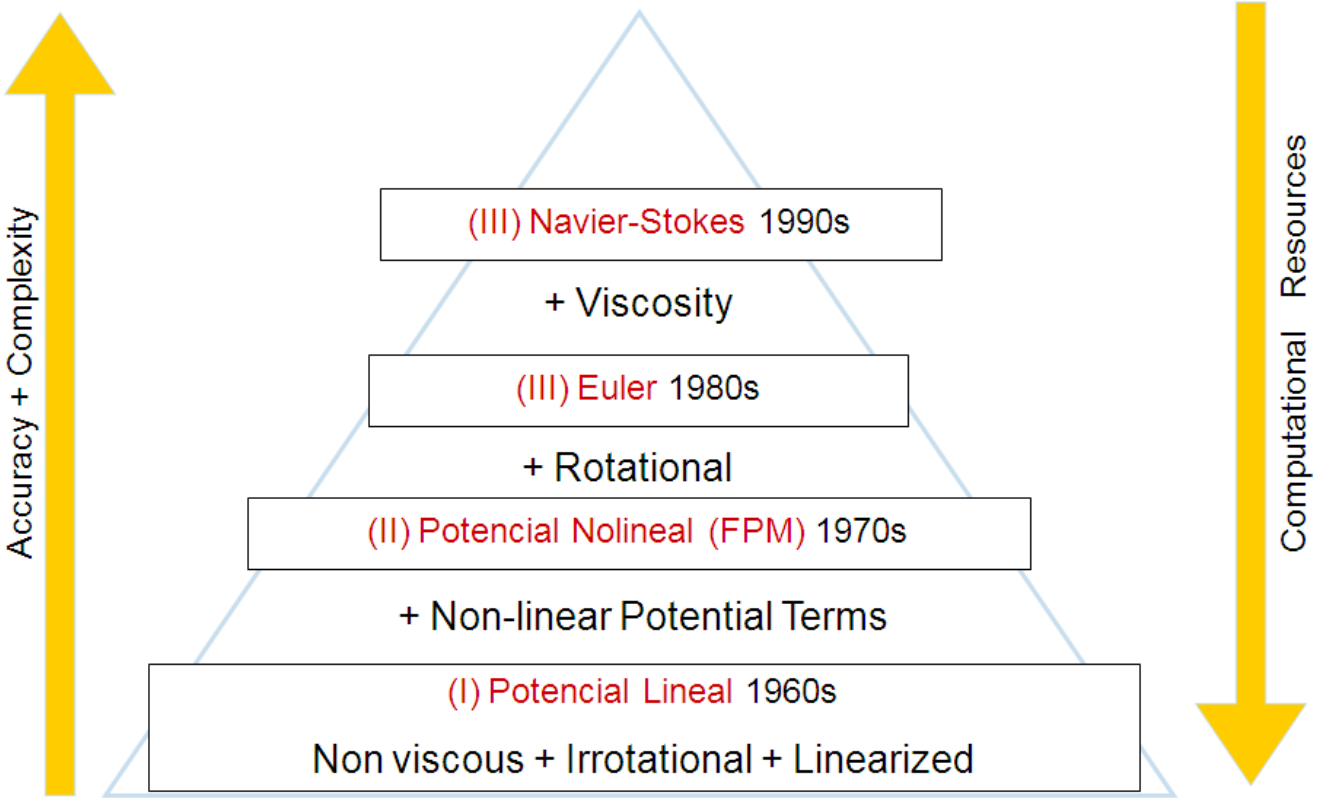
UNIVERSIDAD POLITÉCNICA DE MADRID

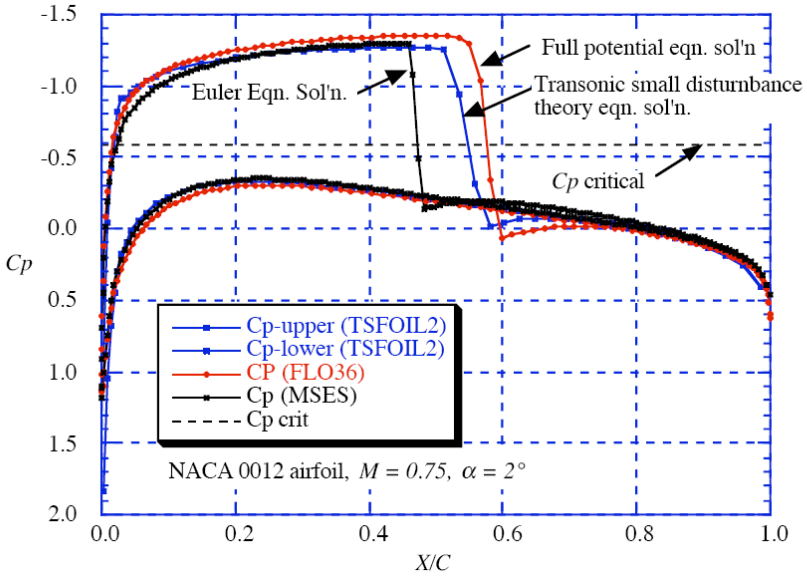
2013-2014

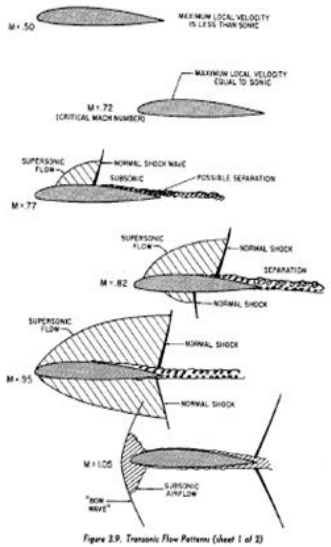
CLASSICAL LINEAR FLUTTER
WHERE WE ARE IN THE COLLAR'S DIAGRAM ?



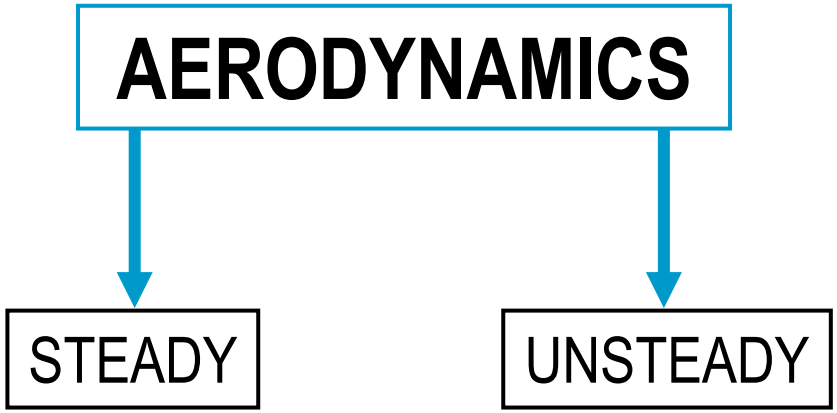
COMPUTATIONAL AERODYNAMICS







STEADY vs. UNSTEADY AERODYNAMICS

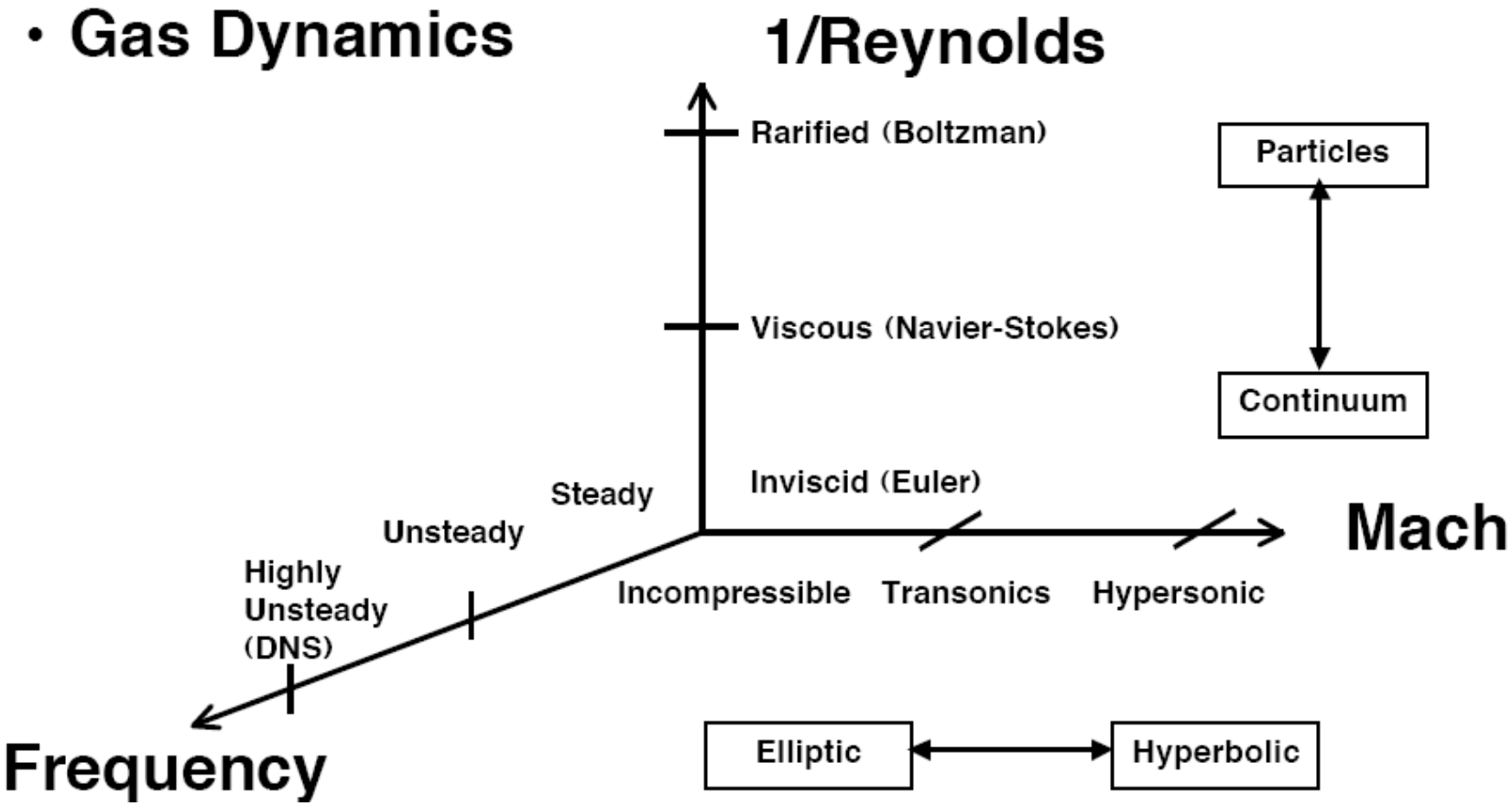


- Analysis of steady flight condition (trim)
- Coupling structure-fluid : flexibility factors, divergence, control surface reversal, ...

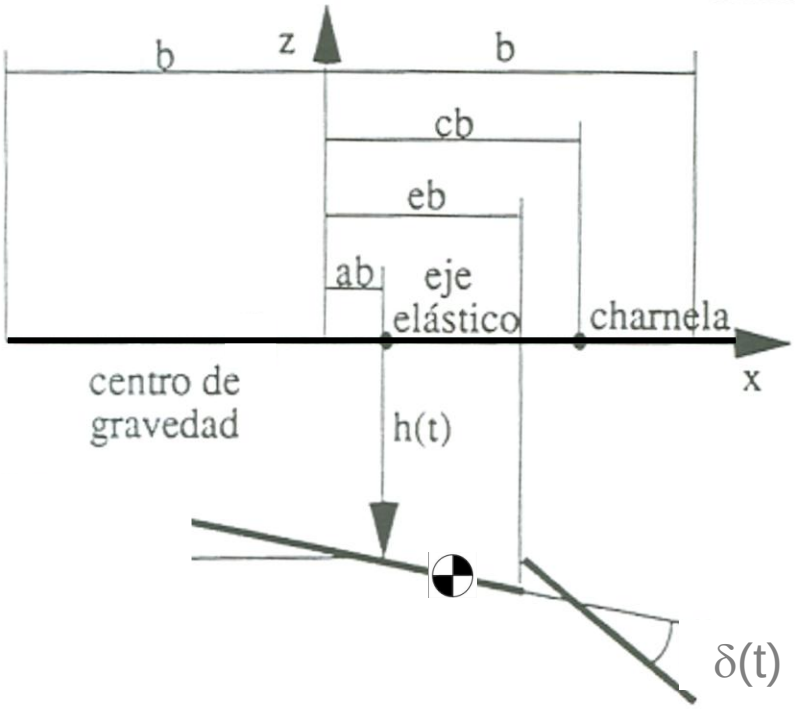
- Small disturbances with respect to the nominal condition
- Unsteady coupling fluid-structure: Flutter, LCOs, ...

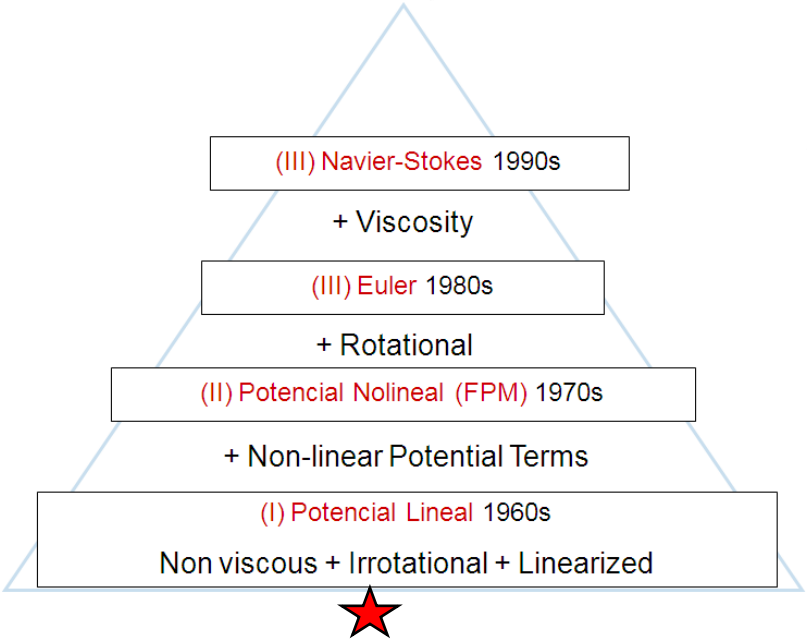
THREE MAIN VARIABLES : **REYNOLDS** + **MACH** + **FREQUENCY**

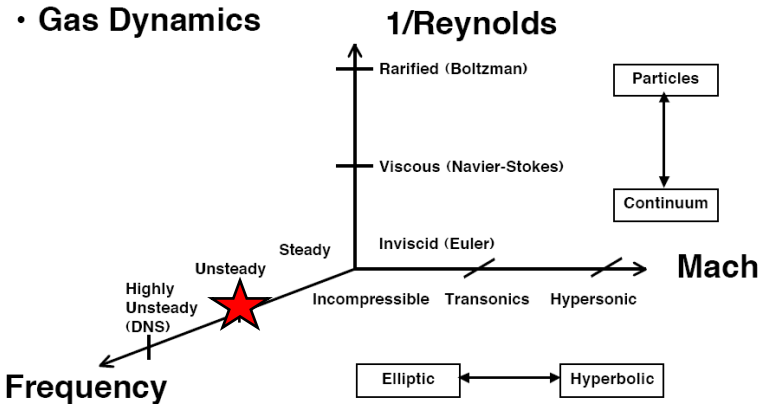
- **Gas Dynamics**



3DOFs "TYPICAL SECTION"
THEODORSEN'S SOLUTION FOR 2D INCOMPRESSIBLE UNSTEADY FLOW



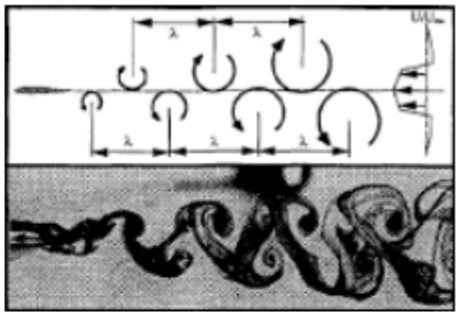


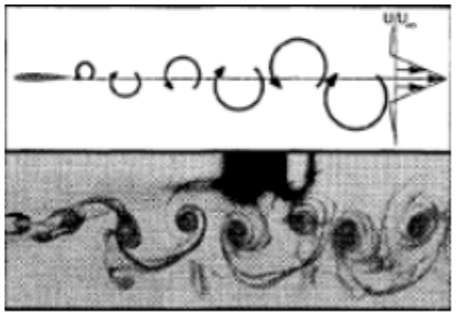


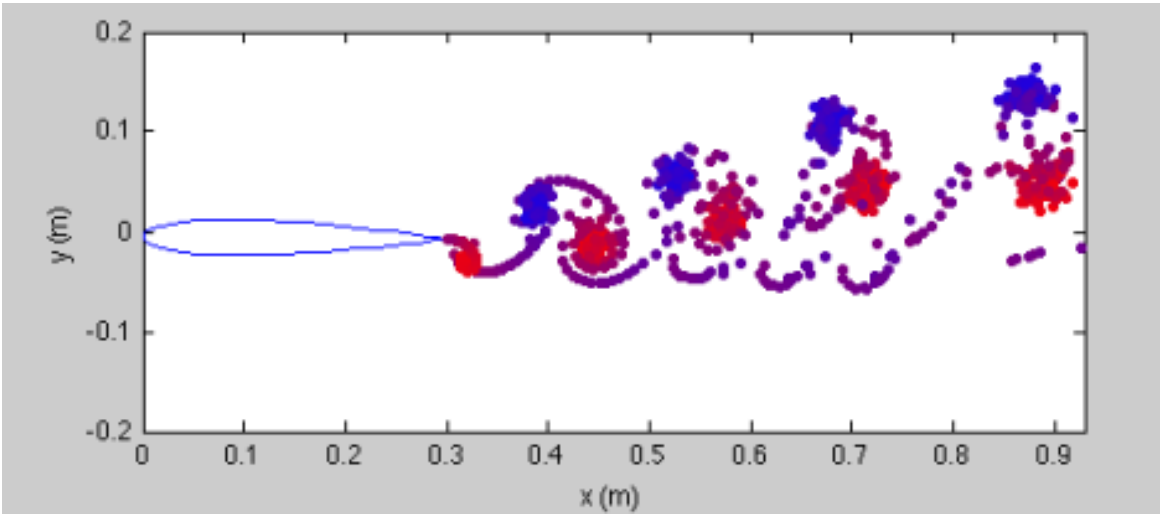
Oscillating airfoils leave behind them a strong vortex street. The vorticity in the wake affects the flow over the airfoil:

The instantaneous aerodynamic forces depend not only on the instantaneous position of the airfoil but also on the position and strength of the wake vortices.

This means that instantaneous aerodynamic forces depend not only on the current motion of the airfoil but on all its motion history from the beginning of the motion.

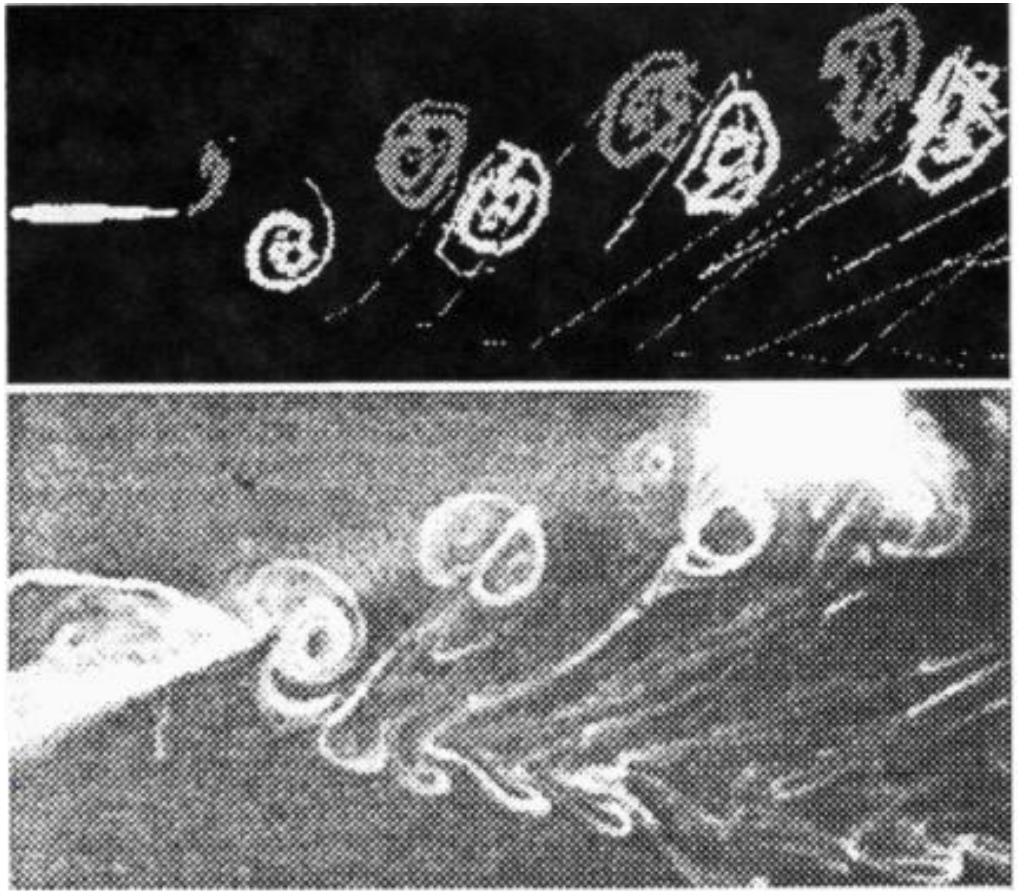






EXPERIMENTAL RESULTS

Wake vorticity is a real-world phenomenon. Here is a comparison between numerical simulation results (top) and flow visualization in a water tunnel (bottom) by Jones and Platzer.



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