



Introduction to Cavitation

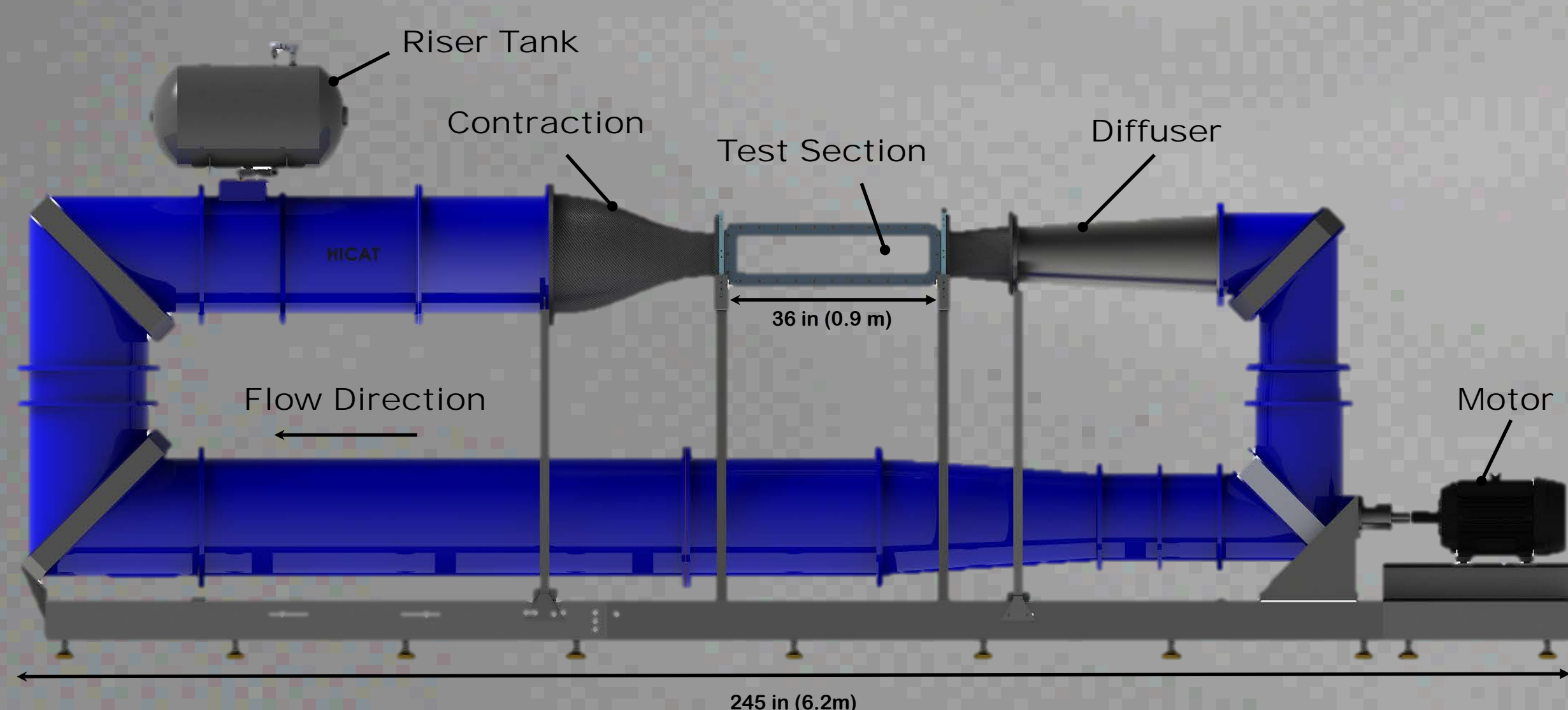


- Formation of vapor in a liquid in regions of low pressure
- Detrimental to the performance of devices
- May cause damage and destruction



2011, Centrifugal Pump Help; Photograph by Erik Ax Dahl, John Anspach Consulting. 2006.

Experimental Setup



- Devices tested in the High-Speed Cavitation Tunnel (HiCaT) at Jere A. Chase Ocean Engineering building
- LabVIEW used for calibration and controlling experiments
- Wingtip devices were tested for cavitation inception and desinence
- Experimental Bounds:

Parameter	Minimum	Maximum
Test Section Static Pressure (p_r)	25 kPa	180 kPa
Flow Velocity (U_∞)	3 m/s	9 m/s

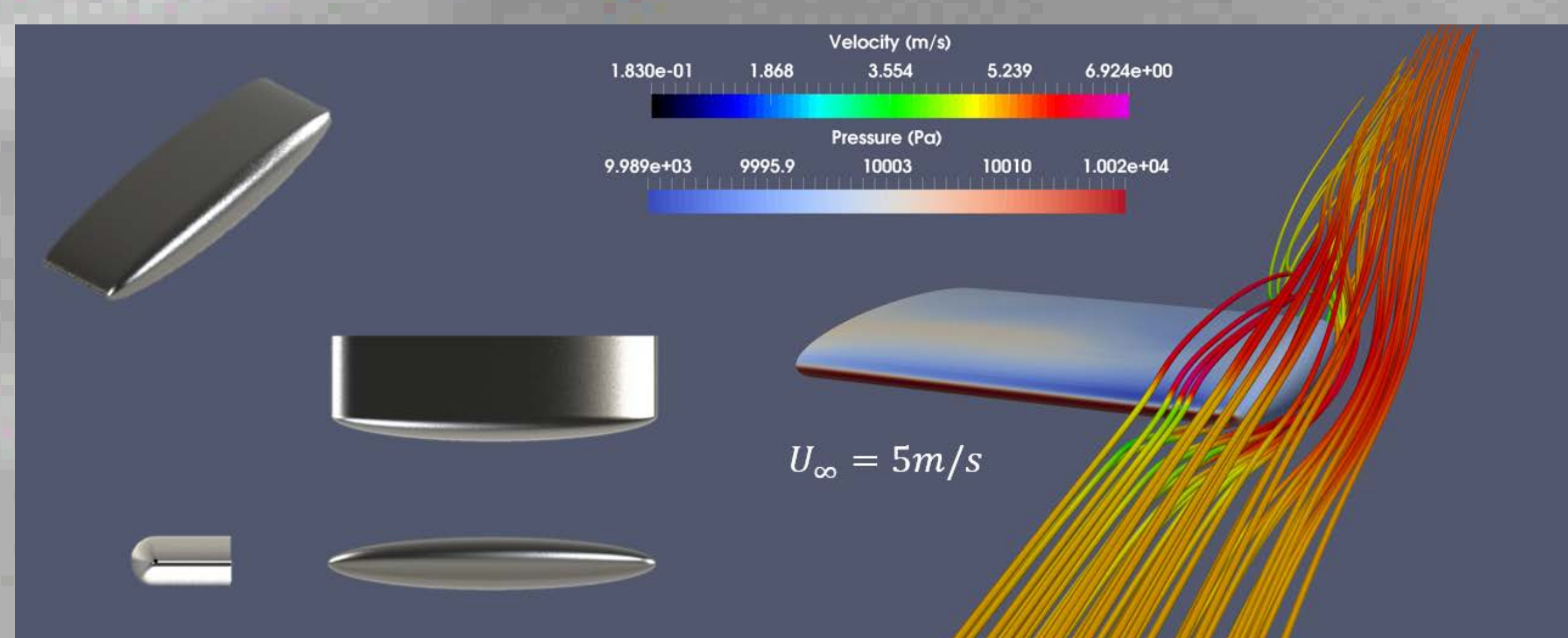
Objectives

- Develop experimental procedure for cavitation investigation
- Standardize data collection and analysis for lift & drag performance analysis
- Identify inception and desinence flow conditions for different wingtips
- Improve theory for wingtip vortex cavitation
- Determine effects of tip geometry on cavitation characteristics

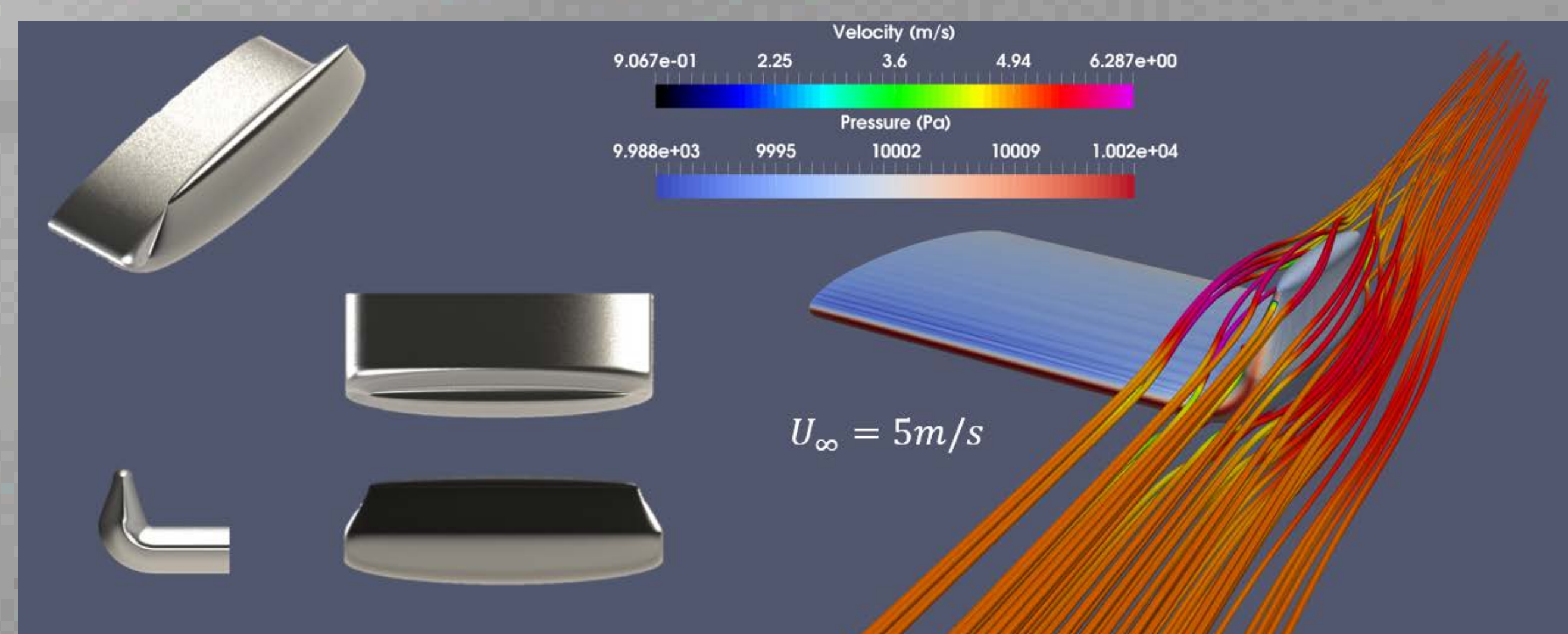
Numerical Analysis

- Comparison of various wingtip devices via open source software for computational fluid dynamics, OpenFOAM

The End Cap



The General Tip



- General Tip decreases vorticity around the foil and pressure drop across the tip; therefore decreasing the probability of cavitation

Theoretical Analysis

$$\sigma = \frac{p_r - p_v}{\frac{1}{2}\rho U^2} \quad Re_c = \frac{\rho U c}{\mu} \quad C_L = \frac{F_L}{\frac{1}{2}\rho A U^2} \quad C_D = \frac{F_D}{\frac{1}{2}\rho A U^2}$$

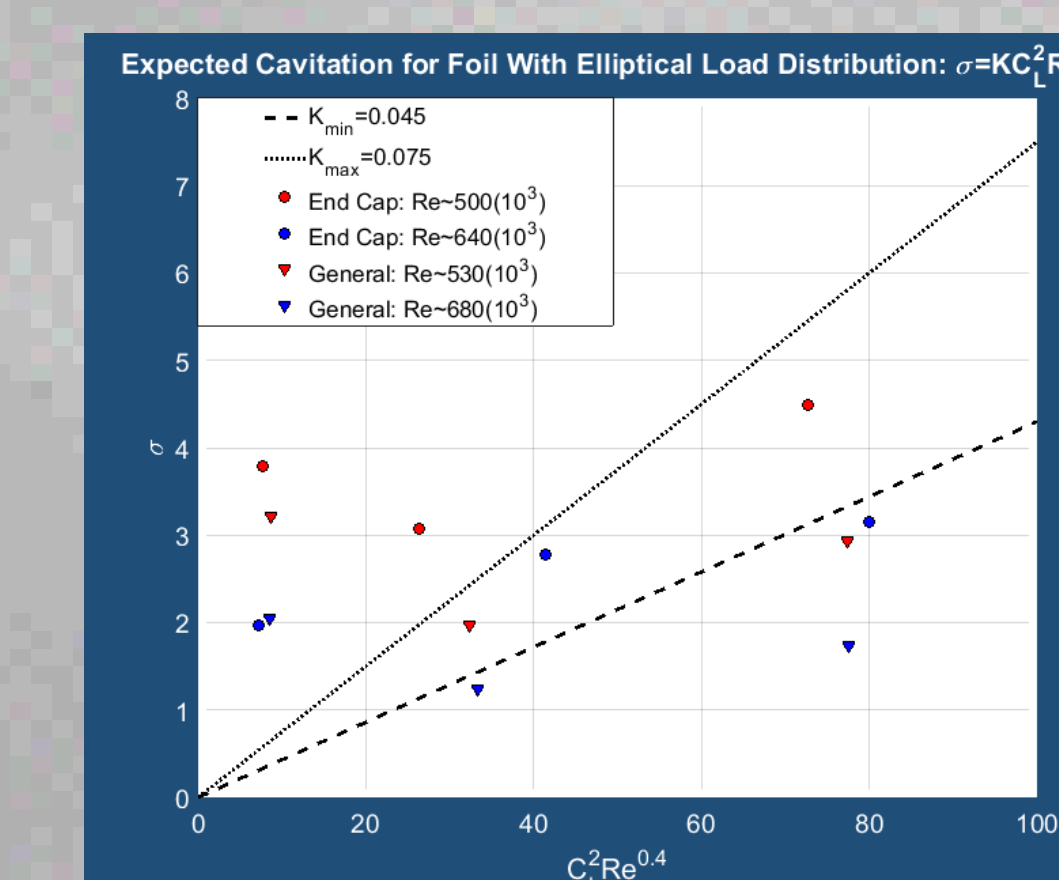
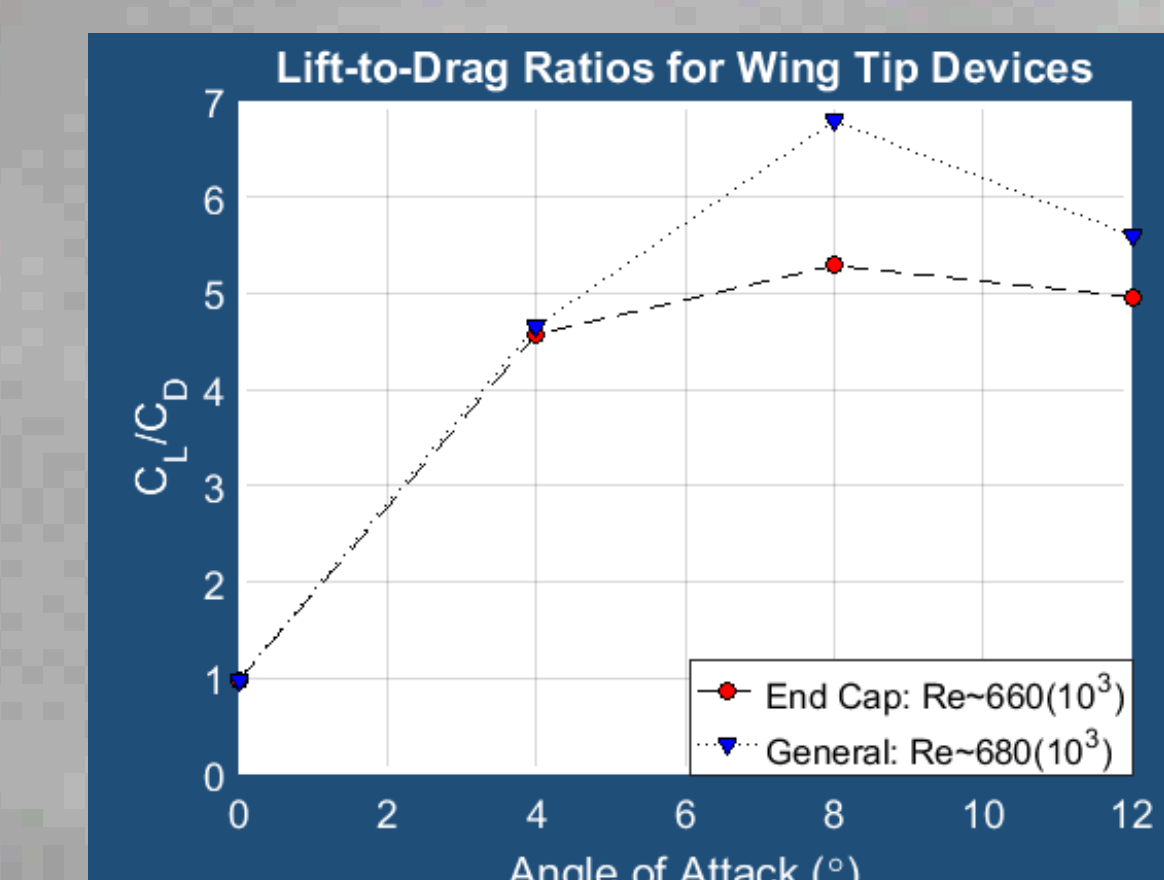
σ – Cavitation number is a pressure ratio describing when a fluid flow will cavitate

Re_c – Reynolds Number is a force ratio describing when a fluid flow will become turbulent

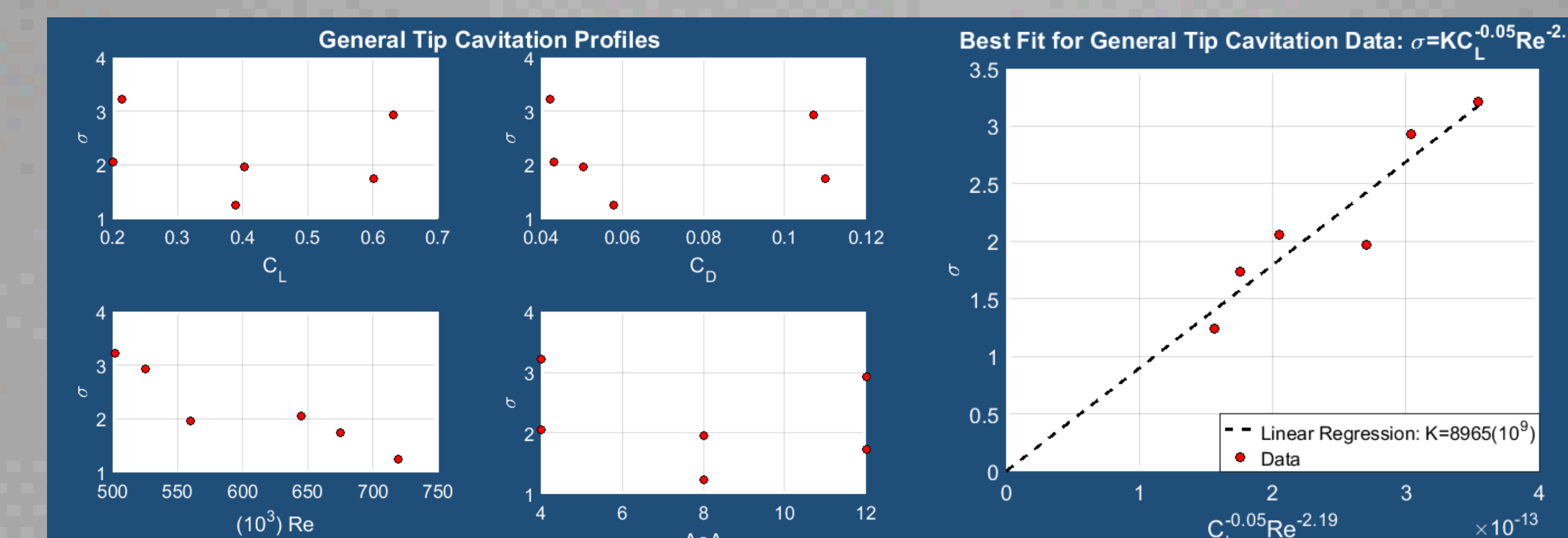
C_L – Coefficient of Lift is a re-scaled nondimensional force describing the lift force versus dynamic pressure on lifting area

C_D – Coefficient of Drag is a re-scaled nondimensional force describing the drag force versus dynamic pressure on lifting area

Results



- Displayed data is 7 m/s and 9 m/s flows, as higher Re_c flows experience more consistent cavitation
- General Tip increases wing performance compared to End Cap
- For most cases tested, the General Tip's wingspan cavitated before its wingtip, i.e. attached cavitation
- Future studies should define cavitation less subjectively



Contributors:

Timothy Barrett,
Aleksandra Wojtowicz,
Gavin Hess, Michael Cook

Advisors:

Martin Wosnik
Ivaylo Nedyalkov

Funding:

New Hampshire Sea Grant
Mechanical Engineering Dept.