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Approved for Public Release

Construction/Testing of the Suction Wing for the Generation of High Lift Forces

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Warfighter Innovation in Science & Engineering Challenge 2025

Introduction & Motivation

- Rising Fuel Costs
- IMO Initiatives to reduce GHG emissions
- EPA & similar environmental agency concerns

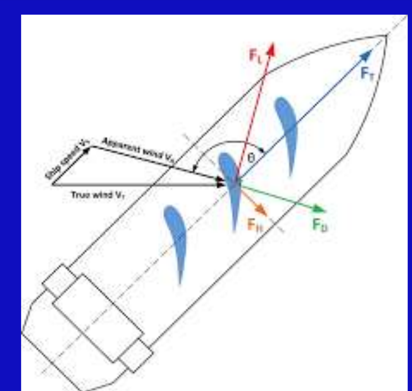
Suction Wing technology is a unique way to generate high lift forces for maritime vessels.

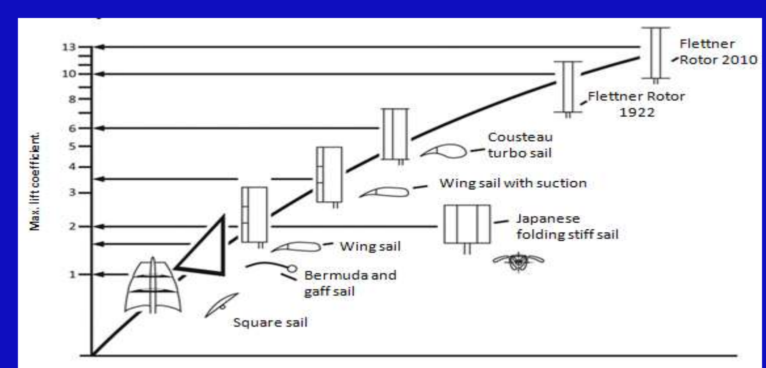
The wide scale use would reduce oceangoing vessel fuel consumption (15 - 35%) and air emissions

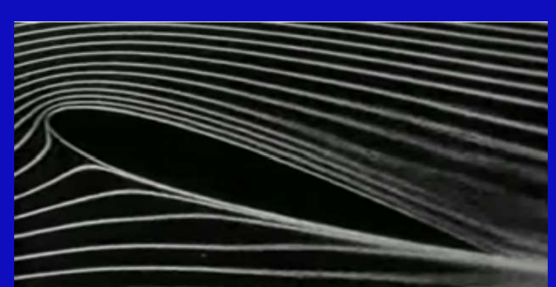
Our model suction wing's preliminary results showed a marked increase in aerodynamic lift force, as compared to without suction.

History & Background

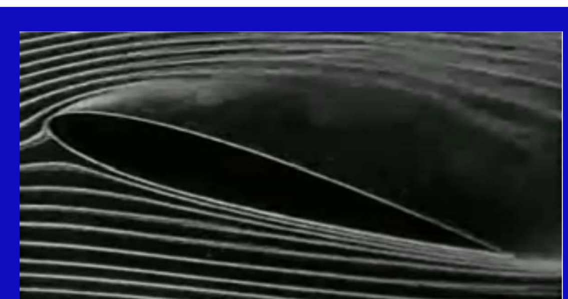
- Based on 1900's concept of **Boundary Layer Suction**
- Jacques - Yves Cousteau
- Suction allows use of thicker airfoils at high angles of attack for larger lift coefficients
- Size of masts and sails can be reduced
- Reduces fuel consumption and air emissions







Suction Used



No Suction

Notable System Features

Model Wing (12.25 in x 4.375 in) with three open suction slits

5 HP Shop Vacuum drawing a volumetric flow rate (Q) = 0.006765 m³/s

Large 2 m diameter electric fan

Model Construction & Testing

3D printed, large, hollow model of an airfoil with open slits on the upper camber, towards the airfoil trailing edge.

Adhesive to the airfoil onto a rotating disk with marked 10° intervals to vary the angle of attack.

Wind applied from suction side of large fan through a short model wind tunnel

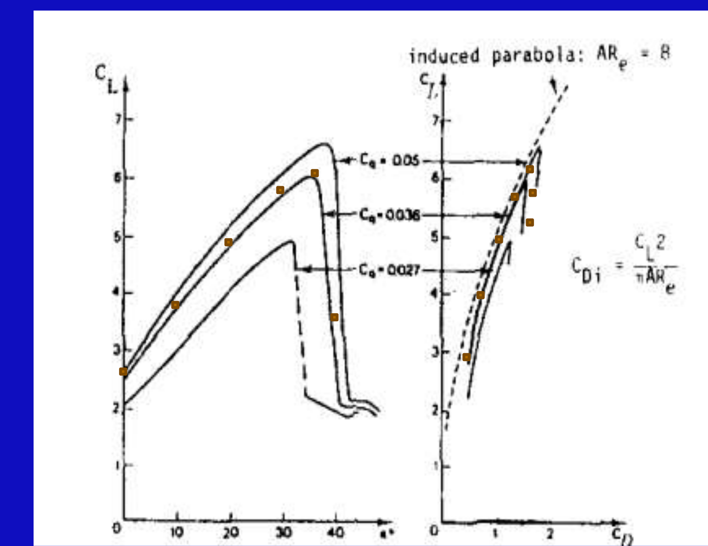
Cart orientation altered through tests to measure lift/drag from 0 – 40 degrees via force gauge (+/- 0.01 N) as wind speed monitored via hot-wire anemometer

Initial Comparisons

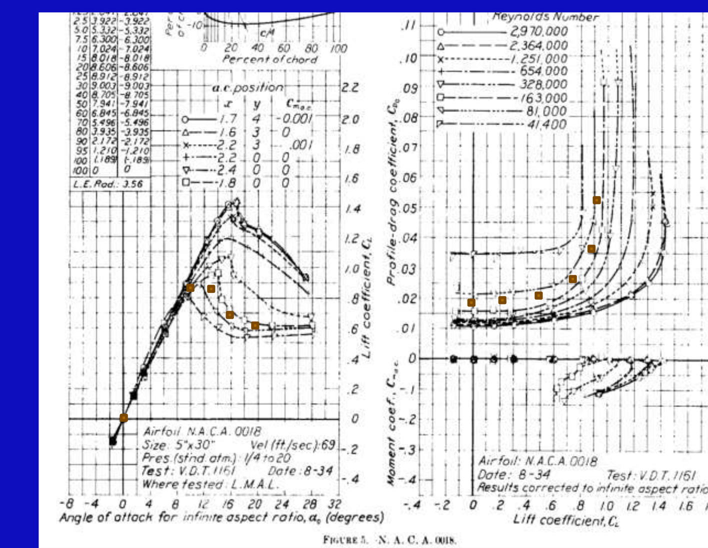
Model Reynold's Number (Re) = 121,987.8

Model Coefficient of Output (C_Q) = 0.0391

Model Effective Aspect Ratio (AR_E) = 5.6

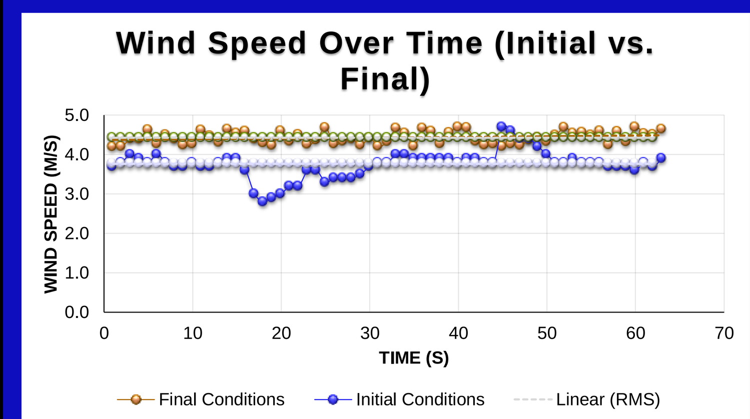


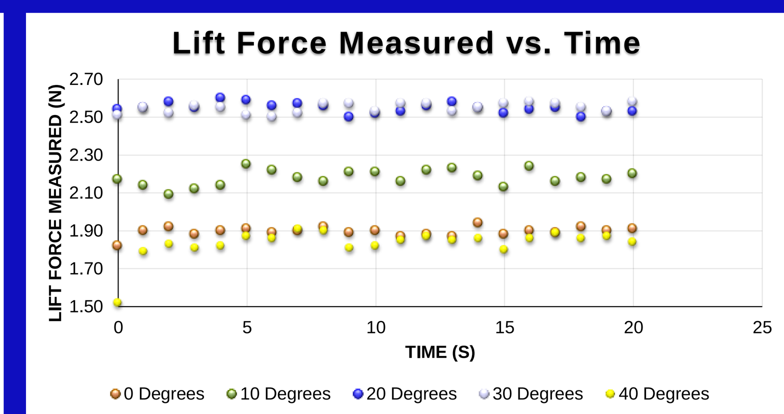
Cousteau Report (AR_E = 4.0)

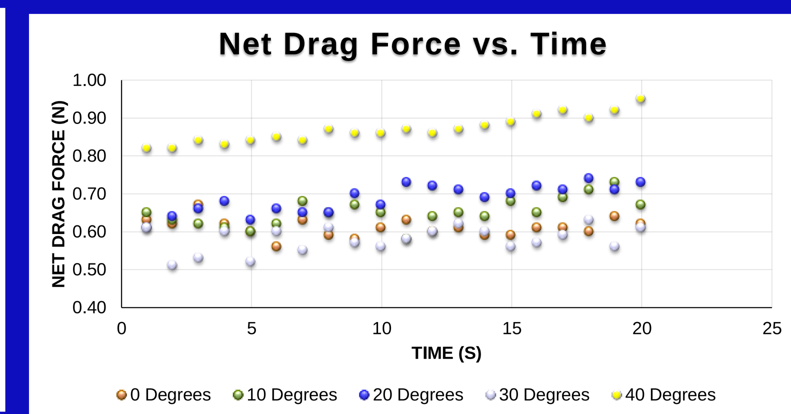


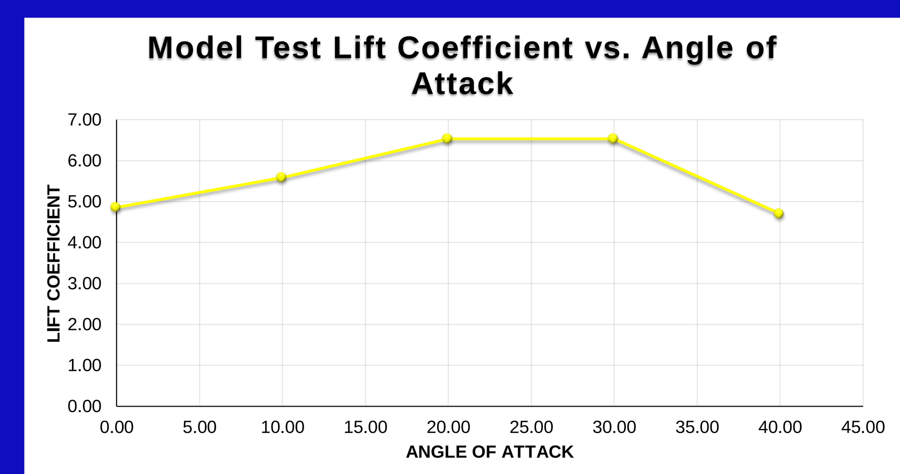
NACA0018 Airfoil (AR_E = Inf.)

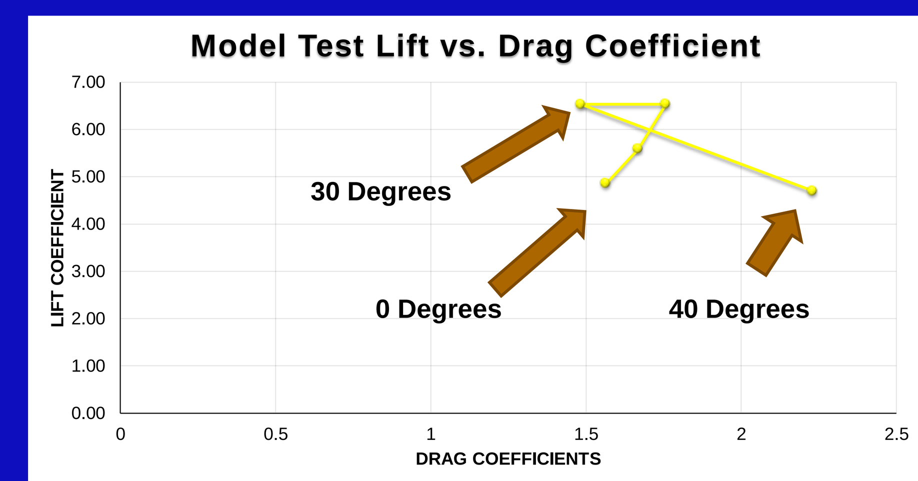
Model Test Data & Results



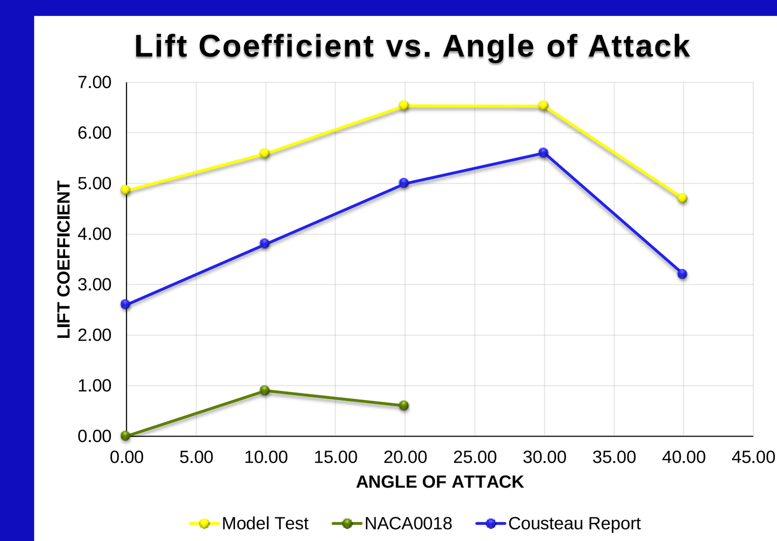


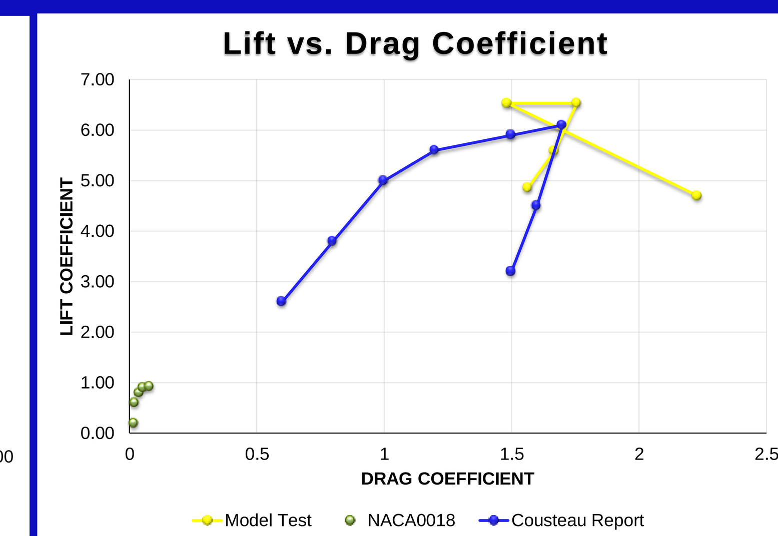






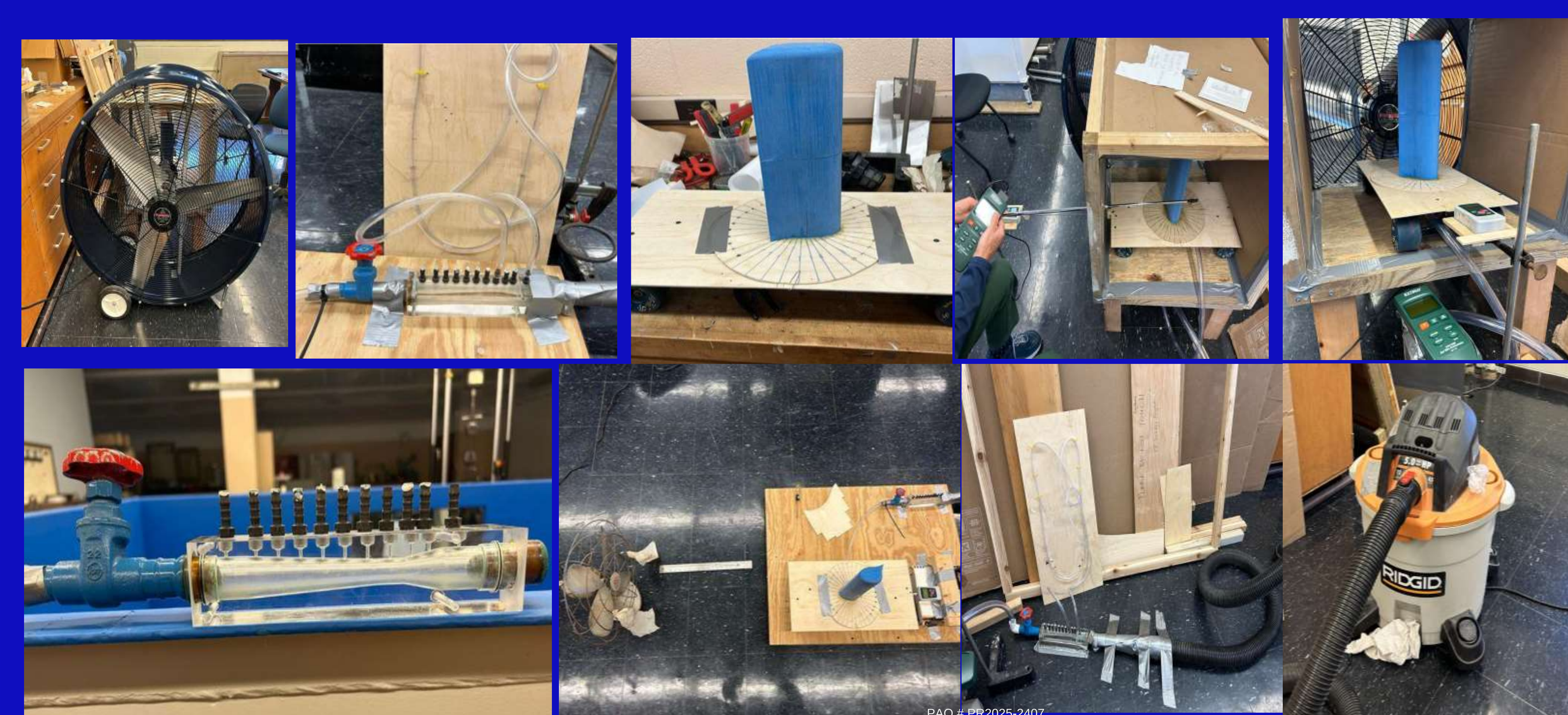
Result Analysis





A real-scale suction sail is predicted to have an Re = 16,469,444 (22 x 4.5 m @ 11 m/s).

Using NACA Airfoil trends, we can expect lift coefficients to increase by **1.6x (up to 10.5)** at this Re.



Limitations & Final Remarks

The pump head required to achieve this suction is approx. 234.12 m, which is equivalent to **19.03 W** at our volumetric flow rate of suction (frictionless pump).

Cousteau Report suggests that 0.53 W may be a more realistic approximation may be the power required for the suction aspiration alone.

Saving fuel can be decisive in maritime and naval competition for resources and outlasting the enemy

Preloading the device created a measurement device inaccuracy

Brittleness, limited fixing points (flutter), & small wing size caused vibrations, causing wing to shed vortices & force fluctuations under high wind speeds

Few other formal reports and research papers are available online for the device. Lack of resources available to idealize conditions of the tests to be performed

Further research is needed, though, as a model of the device can only provide preliminary results. Scaled results can only be estimated. Current research suggests that it is feasible to implement this device under the right conditions (i.e. fan within suction chamber)

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