The Variable Mean Camber Line Airfoil

Team #16 - MEM
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Abstract

Shape morphing technology enables an aircraft to actively morph its wings in place of deploying flaps. Traditional hinged flaps on UAVs create drag and aerodynamic losses, which limits efficiency and thus range. **Our project's goal is to develop a Variable Mean Camber Line ("VMCL") airfoil that enable real-time morphing capability. The VMCL's goal is to improve the performance of UAVs by extending range and increasing maneuverability.** Our design process has since included the design & simulations of morphed vs flapped airfoils using SolidWorks & CFD. 3D printing of these models for wind tunnel testing is planned. Lastly, a functional prototype will be built to demonstrate real-time camber-line adjustment & airflow visualization. Validating this technology can pave the way for more efficient & capable UAVs across private, commercial, & military sectors

Problem Statement
The aerodynamic performance of current fixed-wing aircraft is limited due to flow separation during hinge-flap use.

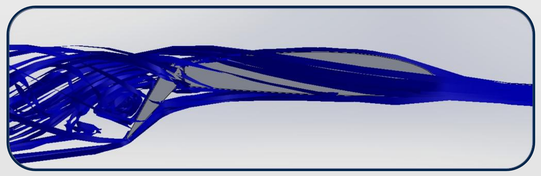

Figure 1 – *NACA_2412 - 50°_Flapped Flow Bends*

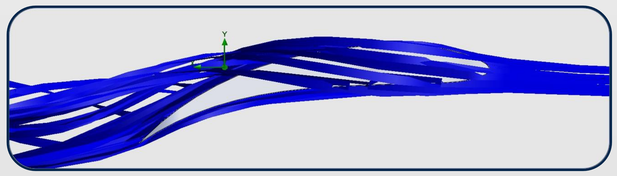

Figure 2 – *NACA_2412 - 50°_VMCL Flow Bends*

NO** formal definition of the word **'Morphing'
***SO** how does the aerospace industry define morphing?*

- **Planform**
  - Sweep
  - Span
  - Chord
- **Out-of-Plane**
  - Twist
  - Dihedral/Gull
- **Airfoil**
  - Thickness
  - Camber

Camber-morphing wing technology is the active, reversible change of an airfoil's camber (curvature of its mean line) in flight, without altering planform or thickness, to tailor lift and drag for different flight conditions.

Stakeholders

DEFENSE

UAV
- Anduril Industries
- U.S. Air Force

MISSLES
- Raytheon Technologies
- Lockheed Martin

COMMERCIAL

DRONES
- Wing
- Volatus Aerospace

AIRCRAFT
- Airbus
- Clean Aviation

INSTITUTIONAL

RESEARCH
- NASA
- FlexSys

UNIVERSITY
- MIT
- University of Michigan

Current Progress

Work Package 1 - Wind Tunnel Access and Experimentation Criteria

Objective: Confirm access to, use, and operational training of the new AEROLAB EWT

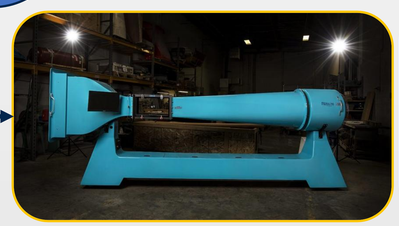

Figure 3 – *Educational Wind Tunnel ("EWT")*

Figure 4 – *Testing Chamber*

Figure 5 – *Clark Y-14 on 3-Force Probe*

Work Package 2 & 3 - Design, Simulate, 3D Print Flapped & Morphed Airfoil(s)

Objective: Design and fabricate static VMCL airfoils and compare them to flapped airfoils at equal deflection angle to show similar lift (C_l) with reduced drag.

Table 1 – *VMCL vs Flapped Deflection Angle*

Deflection Angles				
Flapped Angle (°)	Flapped Angle (rad)	Matching Vertical Distance (inch)	VMCL Angle (rad)	VMCL Angle (°)
20	0.349	0.291	0.104	5.937
30	0.524	0.462	0.163	9.367
40	0.698	0.671	0.235	13.482
50	0.873	0.953	0.328	18.804

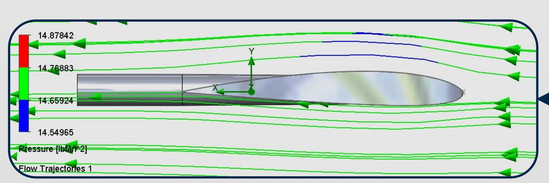

Figure 6 *- NACA_2412-control (Side View)*

Pressure flow trajectories at peak morphed deflection angle displaying no trailing-edge separation.

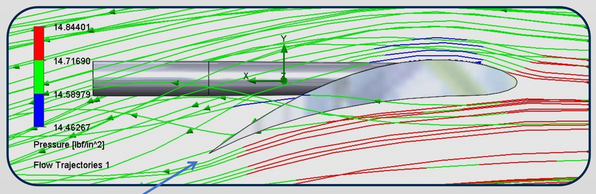

Figure 7 *- NACA_2412-50°_VMCL Pressure Flow Trajectories (Side View)*

VS

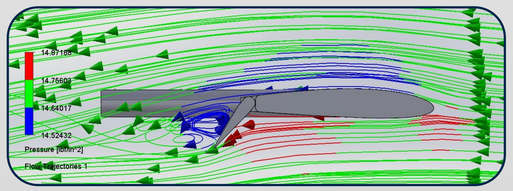

Figure 8 *- NACA_2412-50°_Flapped Pressure Flow Trajectories (Side View)*

Work Package 4 - Design & Prototype Mechanical Actuation VMCL Airfoil

Objective: Design an internal mechanical actuation mechanism capable of achieving airfoil profile of WPs 2 & 3

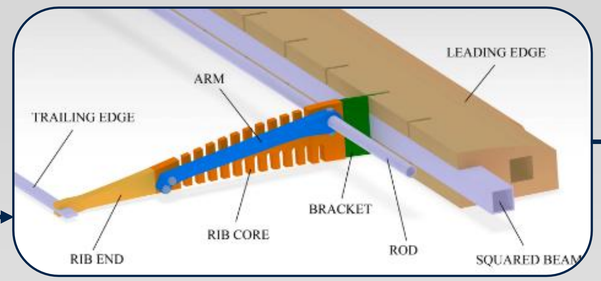

Figure 9 *- Mechanical actuation mechanism (Scoppelliti et al., 2017)*

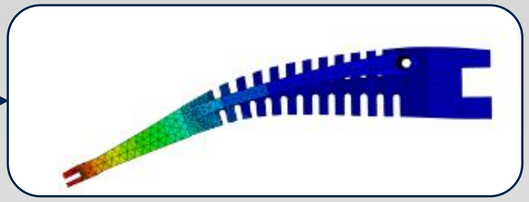

Figure 10 *– Rib Core FEA (Scoppelliti et al., 2017)*

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