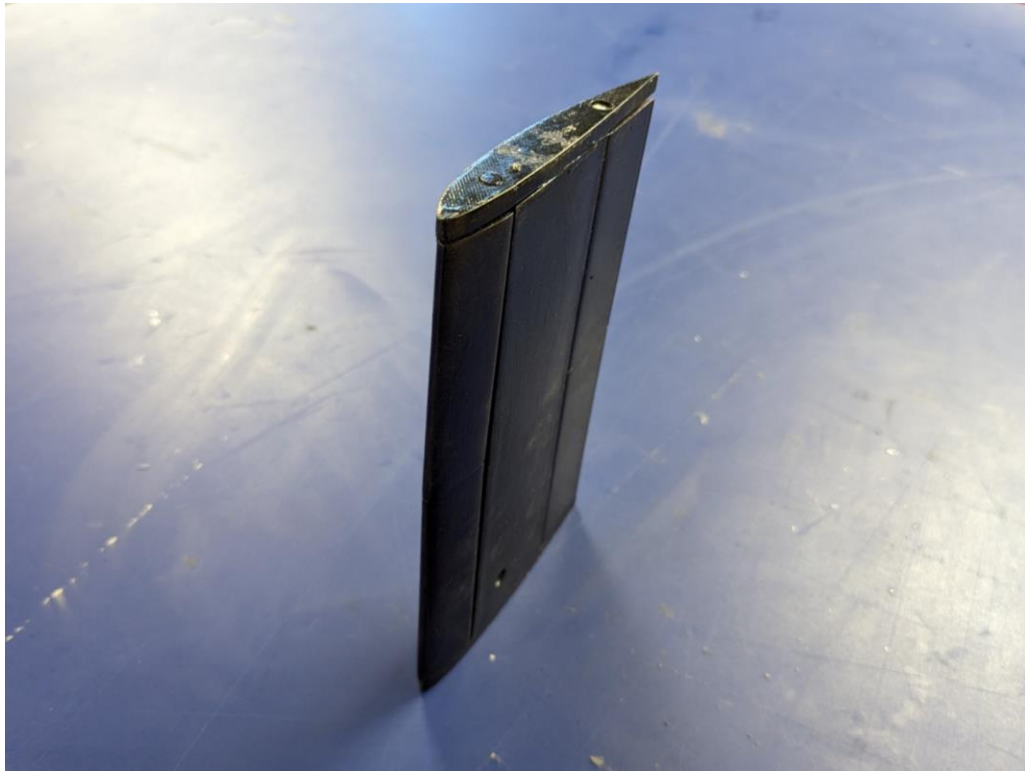
Wind Tunnel Testing

Test Readiness Review

Test Model Overview



⅓ Scale Mechanized Wing

½ Scale Aircraft Model

Wind Tunnel Team Introduction

Jacob McMillin
Program Manager

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Chief Engineer

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Aerodynamics Engineer

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Presentation Objectives

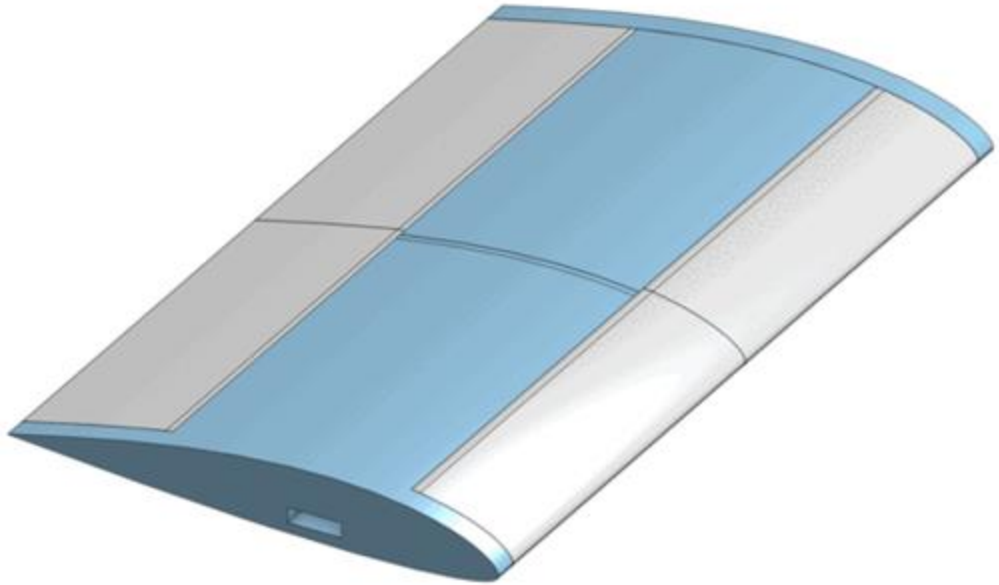
- Demonstrate that the test articles are ready for wind tunnel testing.
- Provide a description of the test articles and the testing procedure.
- Describe the testing plan in detail.
- Discuss impact of results on design.

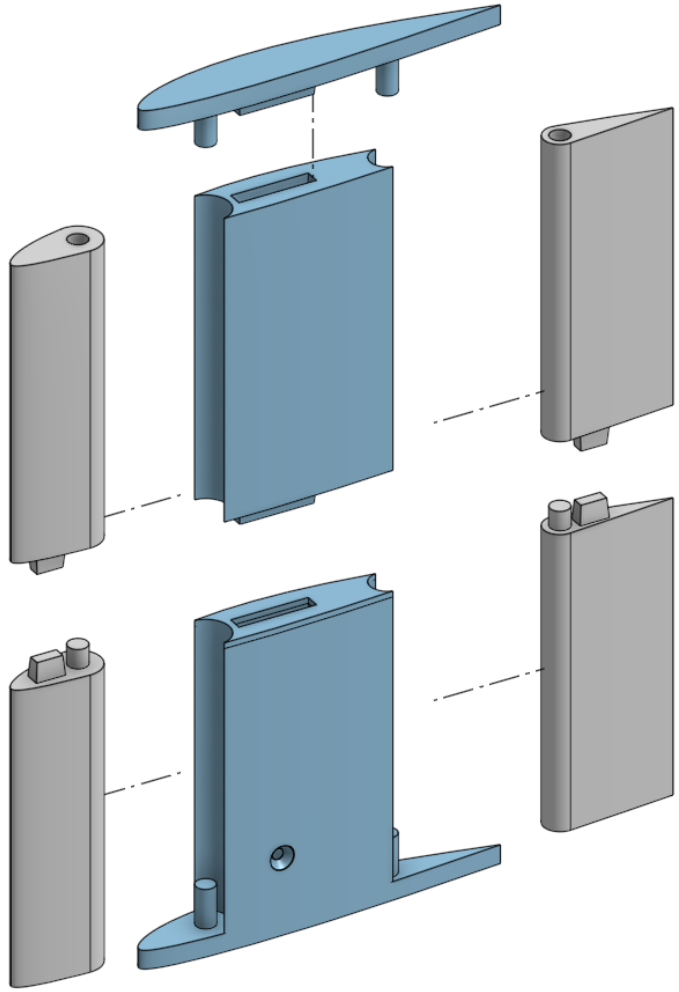
Wind Tunnel Models

Mechanized Wing Model

- Constructed from ABS (blue) and PLA (grey)
- Flaps articulate by 10% (LE) and 30% (TE)

Parameter	Value
Scaling Factor	33%
Wingspan	8 in
Chord	4.67 in
Leading Edge Flap Chord	0.93 in
Trailing Edge Flap Chord	1.40 in

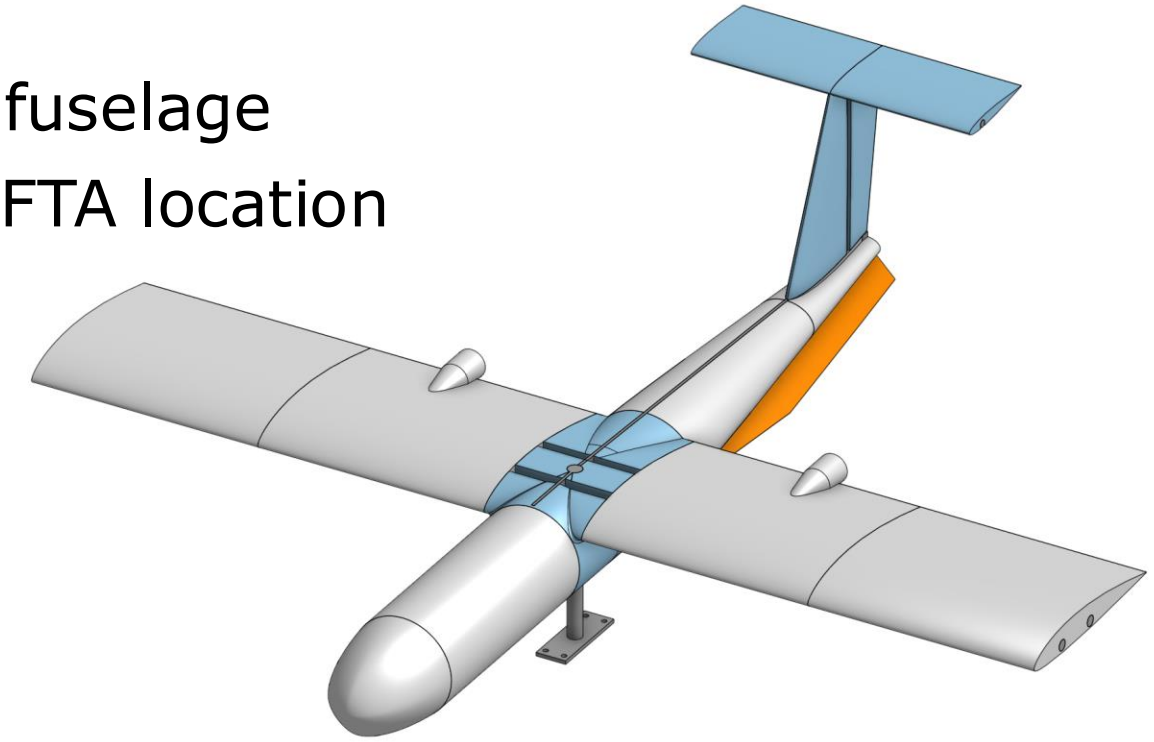




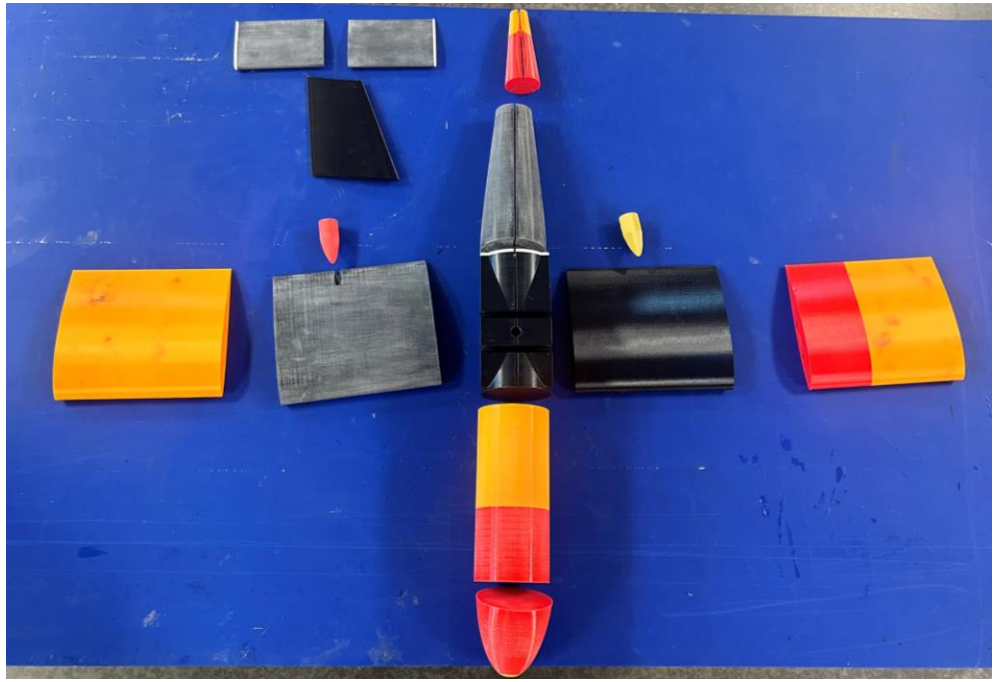
Whole Aircraft Model

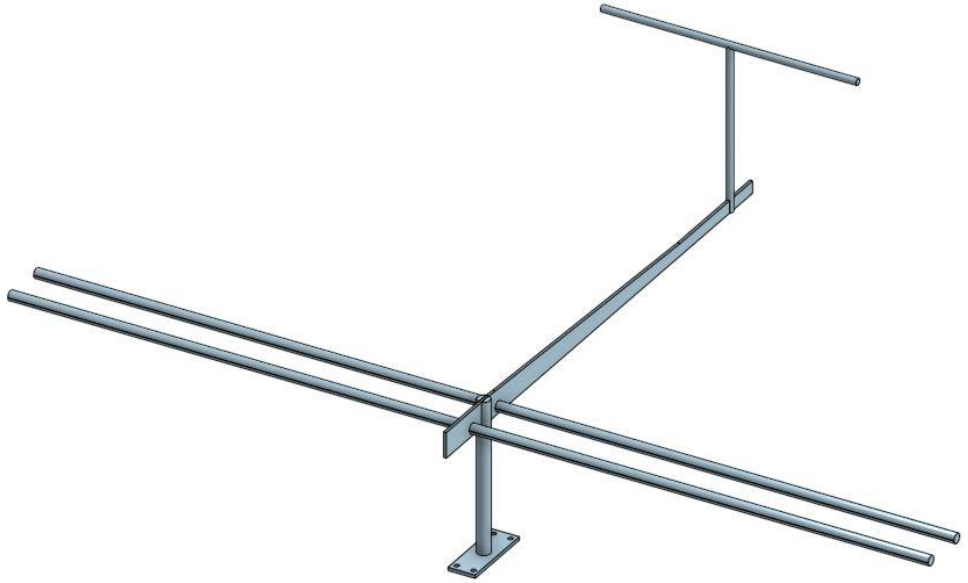
- Constructed from ABS (blue), PLA (grey), and a steel frame (dark grey)
- Strakes are bonded into slots on fuselage
- CG location within 25% chord of FTA location

Parameter	Value
Scaling Factor	50%
Wingspan	36 in
Chord	7 in
Strake Vertical Area	104 in^2
CG Location (Aft of Leading Edge)	1.75 in

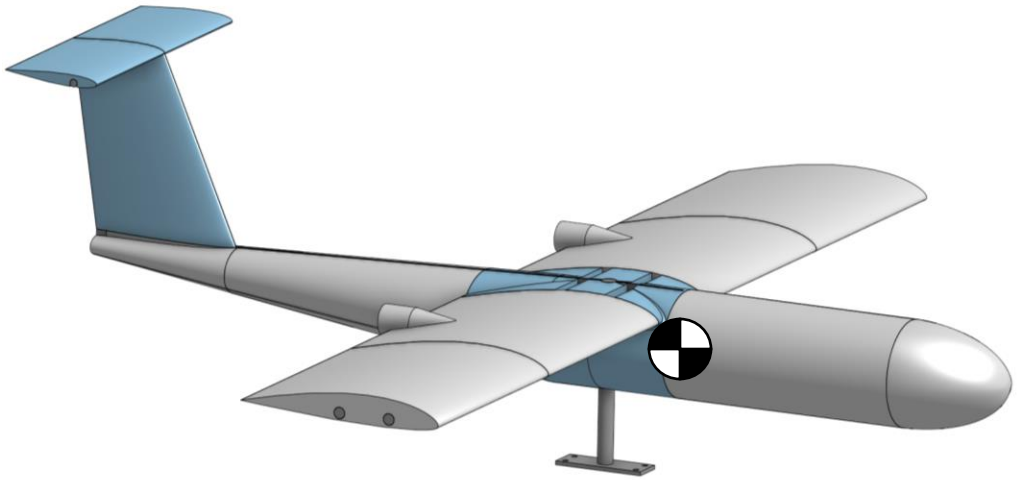


Steel Frame Reinforces Aircraft Structure and Locates Printed Components



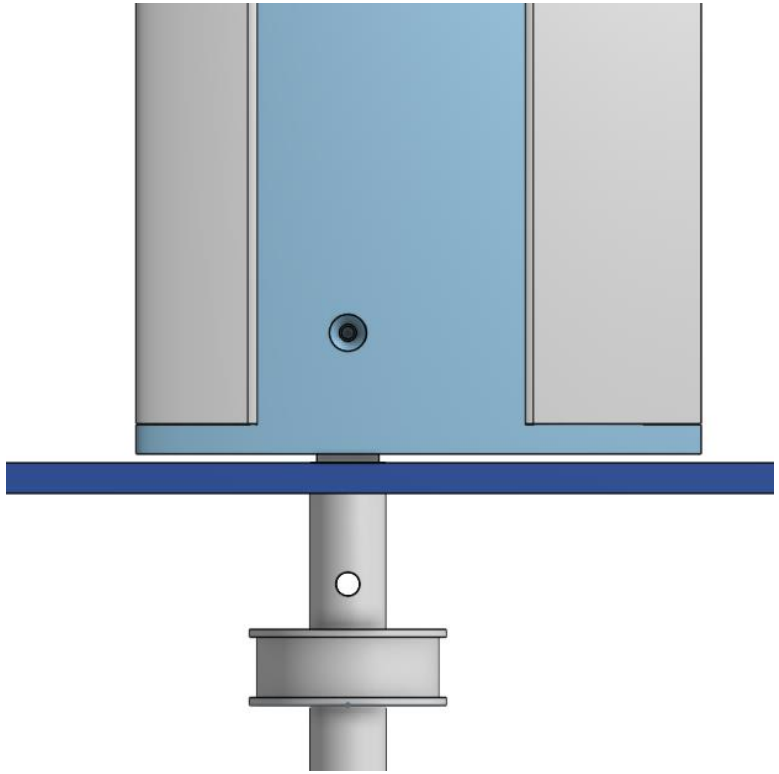


CG Locations are Within Range for Useful Results

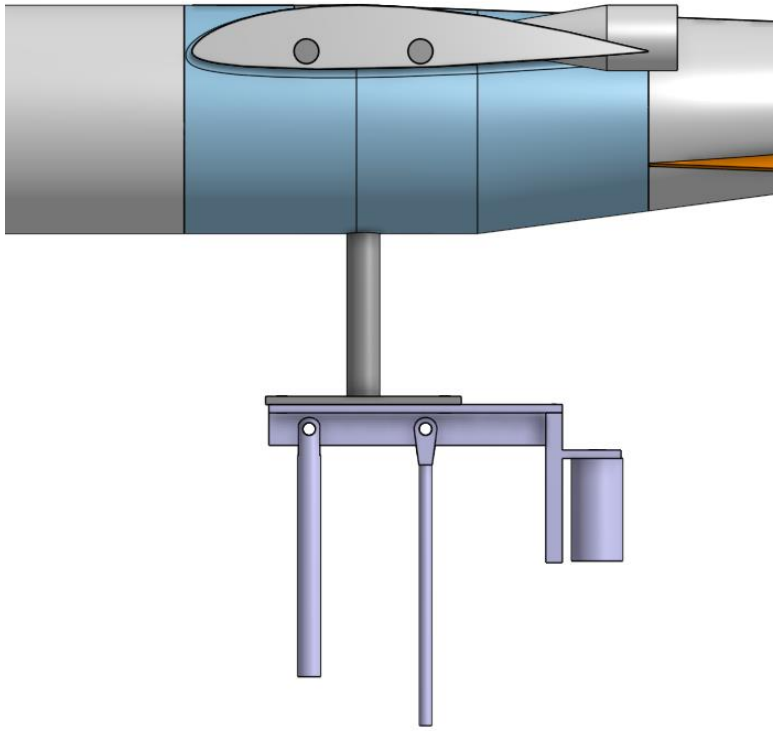


Test Articles Use Existing Mounts

- Wing model uses blade mount for the 12” by 12” tunnel
- Center span has slot for blade



- Aircraft model uses 4-bolt mount for the 48” by 32” tunnel
- Matching plate will be welded to frame



Model Structure Satisfies Strength Requirement

Testing Procedure

Wind Tunnel Testing Outcomes

- Verify Calypso aircraft **meets** all performance criteria
- Discover areas of **high drag** requiring design changes
- Determine aerodynamic response to **high-alpha and sideslip**
- Establish benefits of experimental components
  - Mechanized wing, with leading & trailing-edge flaps
  - Aft-body strakes, mounted near the T-Tail

Test Conditions Simulate Mission Parameters

- Open-circuit 12” x 12” wind tunnel used to test wing section with leading & trailing-edge flaps
- Closed-circuit 32" x 48" wind tunnel used to test plane model.

Test Case	Air Density	Air Viscosity	Flow Velocity	Aero. Chord	Re
Wing Model–Takeoff	$1.05\ \frac{kg}{m^3}$	$1.76 * 10^{-5}\ \frac{kg}{m * s}$	22 m/s	0.118 m (4.67 in)	150k
Aircraft Model–Takeoff			15 m/s	0.178 m (7 in)	150k
Aircraft Model–Cruise			48 m/s	0.178 m (7 in)	500k

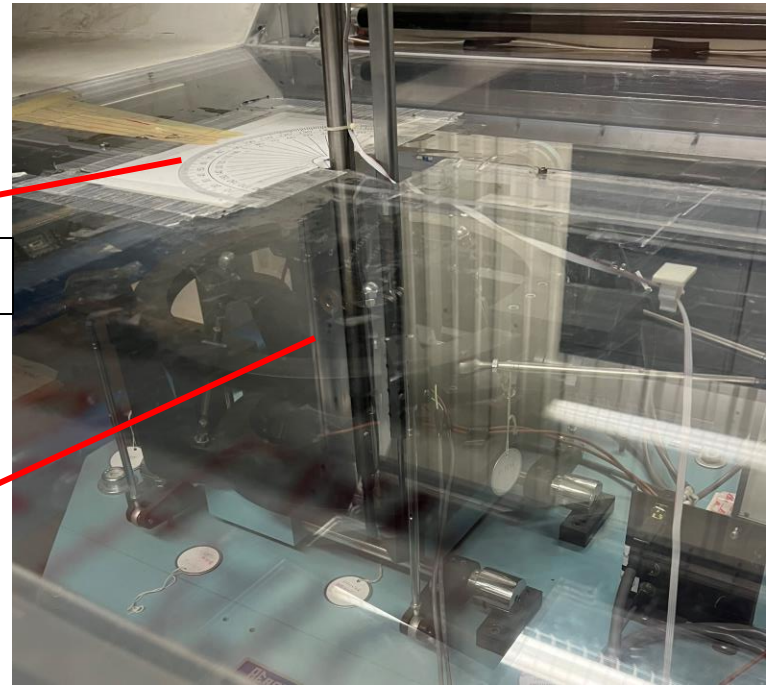
Data Acquisition

Hardware

- Pyramidal force balance/strain gauge balance to measure forces and moments in 6 directions
- Manual controlled sideslip
- Servo controlled angle of attack

Software

- AC-DC converter connects to LabView
- Results are stored as CSV file
- All tests are time independent



Test Plan (⅓-Scale Wing)

Objective: Validate XFLR5 Data for MRC-16 Airfoil

Test Configurations:

- Combinations of leading- and trailing-edge flaps

Test Conditions:

- Reynolds Number of 150,000 (takeoff)
- Range of AoA from -4° to 20°

Test Plan (½-Scale Aircraft)

Objective: Determine overall aerodynamic performance

- Lift, drag, and stability
- Examine stall behavior

Test Configurations:

- With and without strakes
- With flow visualization tufts

Test Conditions:

- Reynolds Number of 150,000 (takeoff) or 500,000 (cruise)
- Range of AoA from -4° to 20°
- Range of sideslip from -10° to 10°

Test Case Details and Order

Test Designation	Velocity, (m/s)	AoA, °	Sideslip, °	LE Flap Angle, °	TE Flap Angle, °	Re
MW-1	22	-4:2:20	0	0	0	150K
MW-2	22	-4:2:20	0	10	0	150K
MW-3	22	-4:2:20	0	0	30	150K
MW-4	22	-4:2:20	0	10	30	150K

⅓ Scale Wing

MW – Mechanized Wing
TO – Takeoff
CR – Cruise
FV – Flow Visualization

Test Designation	Velocity, (m/s)	AoA, °	Sideslip, °	Strakes	Tufts	Re
TO-1	15	-4:2:20	0	N	N	150K
TO-2	15	α_{C_L}Max	-10:2:10	N	N	150K
CR-1	48	-4:2:20	0	N	N	500K
CR-2	48	$\alpha_{L/D}$Max	-10:2:10	N	N	500K
TO-3	15	-4:2:20	0	Y	N	150K
TO-4	15	α_{C_L} Max	-10:2:10	Y	N	150K
CR-3	48	-4:2:20	0	Y	N	500K
CR-4	48	$\alpha_{L/D}$Max	-10:2:10	Y	N	500K
FV-1	15	-4:2:20	0	Y	Y	150K
FV-2	48	-4:2:20	0	Y	Y	500K

½ Scale Model

Conclusions and Significance of Results

Testing Accurately Represents Aircraft Design

3D printed parts allow for **dimensional accuracy**

Models **support structural loads** at planned velocities

Test cases match **planned flight regimes**

Test Outputs Determine Design Compliance

Establish compliance with aerodynamic requirements through preliminary calculations

- Maximum continuous cruise speed (100 kts)
- Take-off & landing speeds (27 kts)
- Stability & control response (Positive stability in all conditions)

Selection of experimental components for finalized design

Questions?