

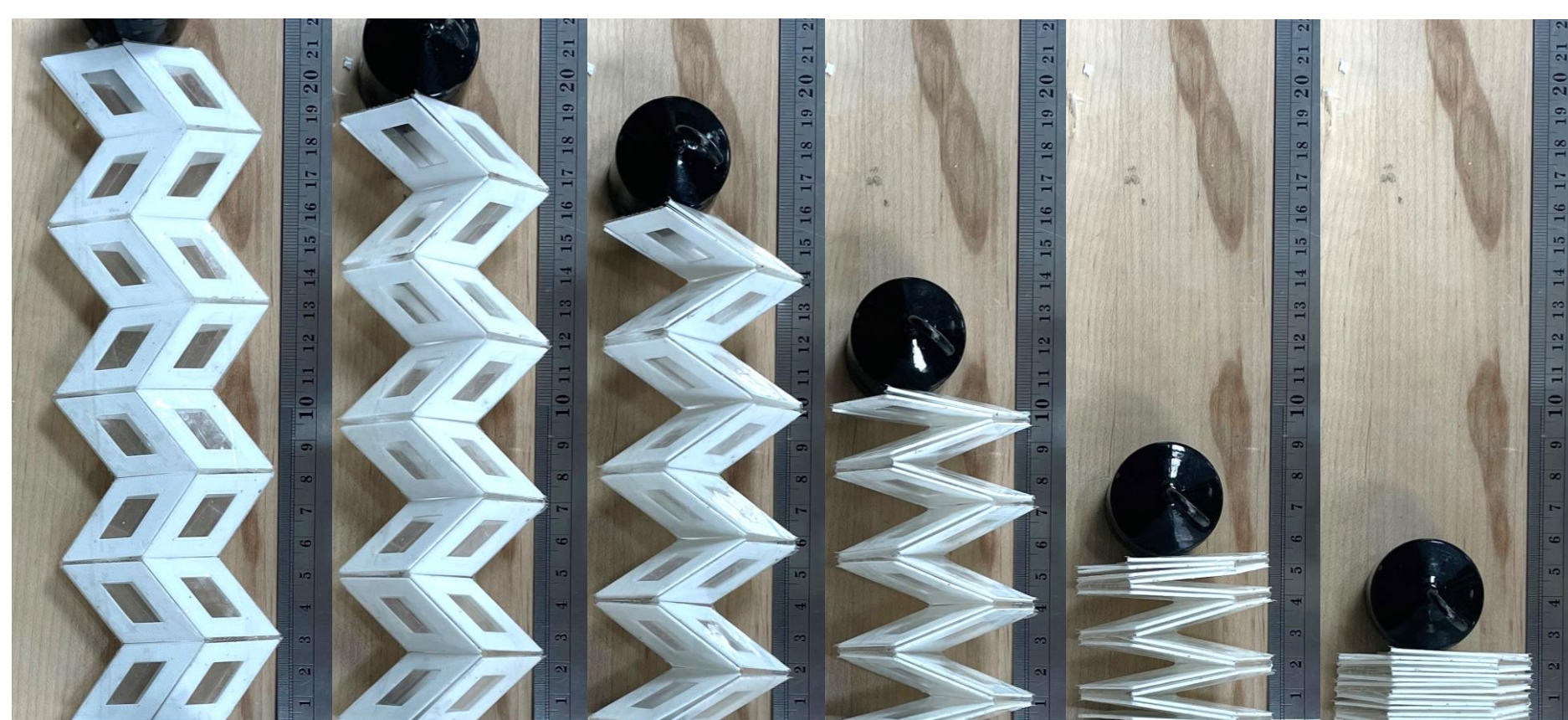
Introduction

- Hybrid aerial vehicle (HAV) uses a central bistable mechanism to switch between modes¹
 - Fixed wing: energy efficiency for longer distances
 - Quadrotor: maneuverability and hovering
- Folding wings reduce drag in quadrotor mode



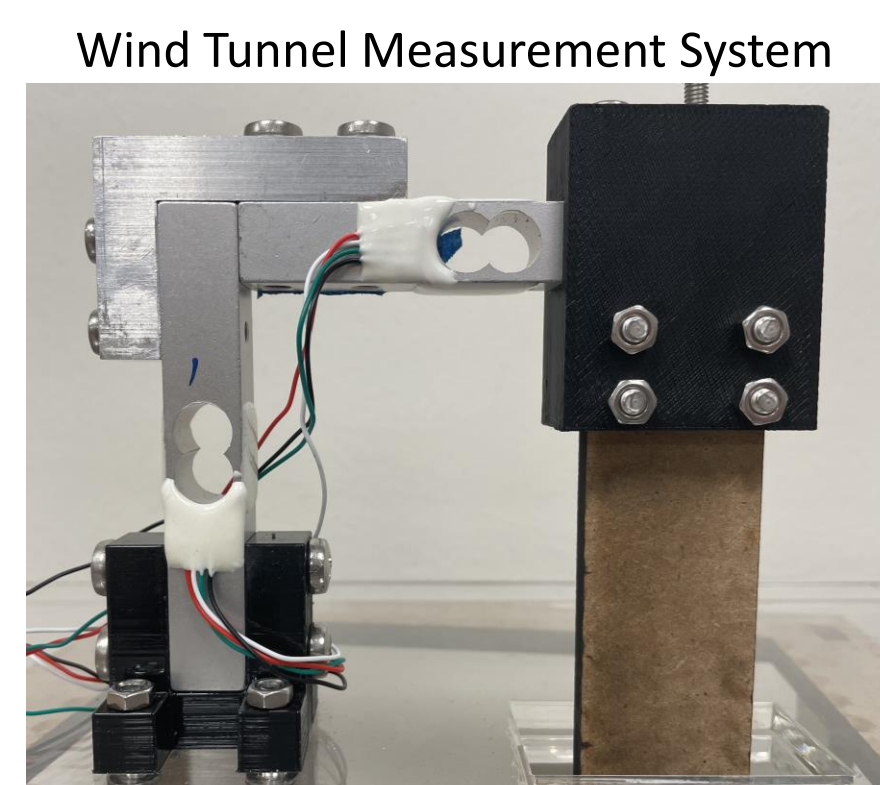
Actuation Method

- Wing Design: Miura origami tube² with an airfoil frame covered in a tight skin, actuated by string through pulleys
- Miura Origami Tube Fabrication: 3D print thin faces that are laminated together
- Characteristics: < 0.1N to contract, passive extension, resistant to deformation in non-spanwise directions, contracts to 8.8% of full length



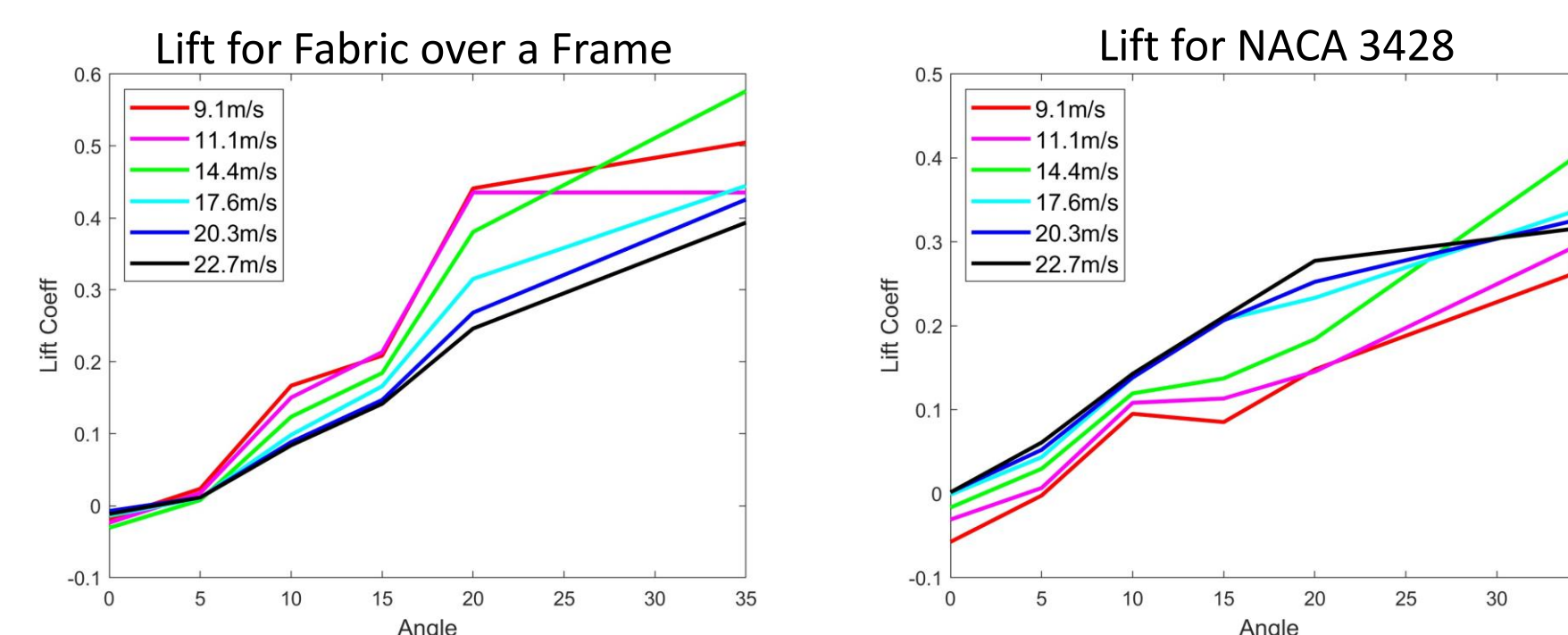
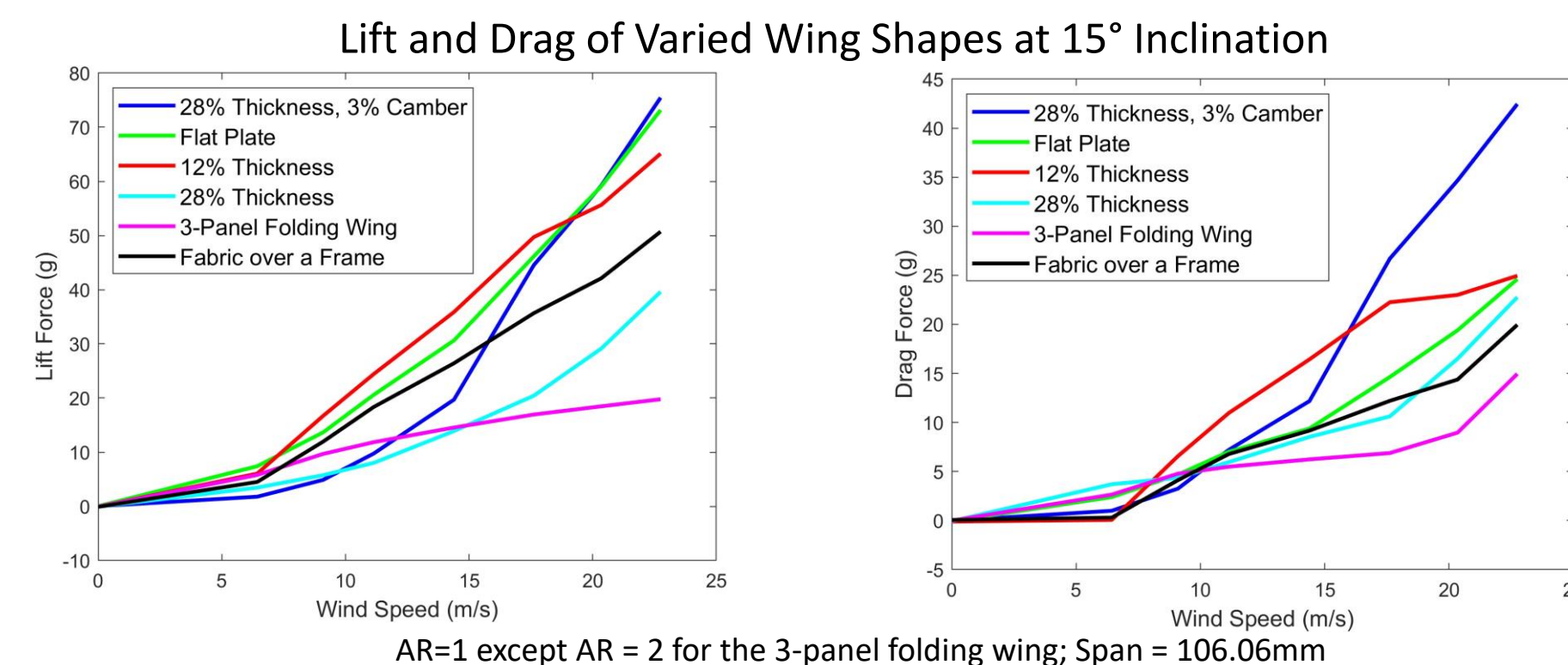
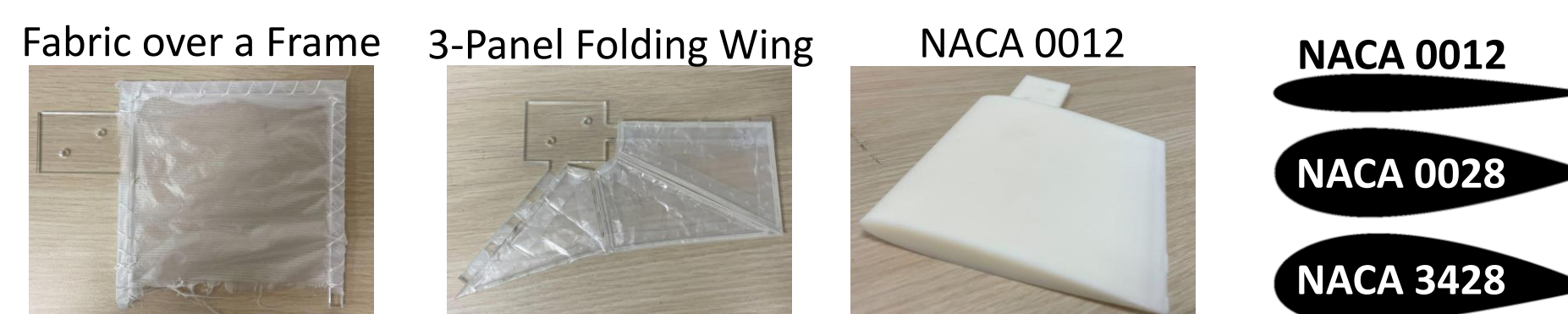
Wind Tunnel Setup

- Lift and drag load cells with 5g of error
- Measurements adjusted with an empirical linear model
- Assume approximate superposition for removing setup influence



Wind Tunnel Results

- Evaluating different wing shapes and designs



Summary

- Identified a new application for Miura origami tubes
 - Origami design allows for low-friction folding, crash resistance, low weight, and high rigidity
- Characterized lift and drag of various wing shapes
- Developed a combination of structure and shape that should meet or exceed goals
 - Can be actuated with <4N by the bistable core of the HAV
 - Resulting wing is estimated to provide enough lift to support the robot
 - Miura tubes allow wing span to change by an order of magnitude

Future Work

- Construct airfoil frame around origami tube
- Investigate adding springs to support airfoil in extended state
- Combine bistable mechanism, pulley system, and folding wing

Acknowledgements

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Citations

- Xuan Li, Jessica McWilliams, Minchen Li, Cynthia Sung, and Chenfanfu Jiang. Soft hybrid aerial vehicle via bistable mechanism. arXiv:2011.00426, 2020.
- Filipov, E. T., Tachi, T., Paulino, G. H. & Weitz, D. A. Origami tubes assembled into stiff, yet reconfigurable structures and metamaterials. *Proc. Natl. Acad. Sci. USA* **112**, 12321–12326 (2015).