Effect of Changing Sweep Angles on the Stability of Small Aircraft

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Introduction

While it might seem like the design of small scale flying vehicles would be simple, it is actually quite complicated. This is because, at slower speeds, small scale aircraft are more affected by wind. For stable flight, small aircraft have to have higher static margins than larger aircraft do. One of the ways proposed to improve the design of small aircraft is to have wings that bend in flight like birds. With these morphing wings, stability characteristics can change in flight. For a morphing wing design to be used, these stability changes have to be investigated.

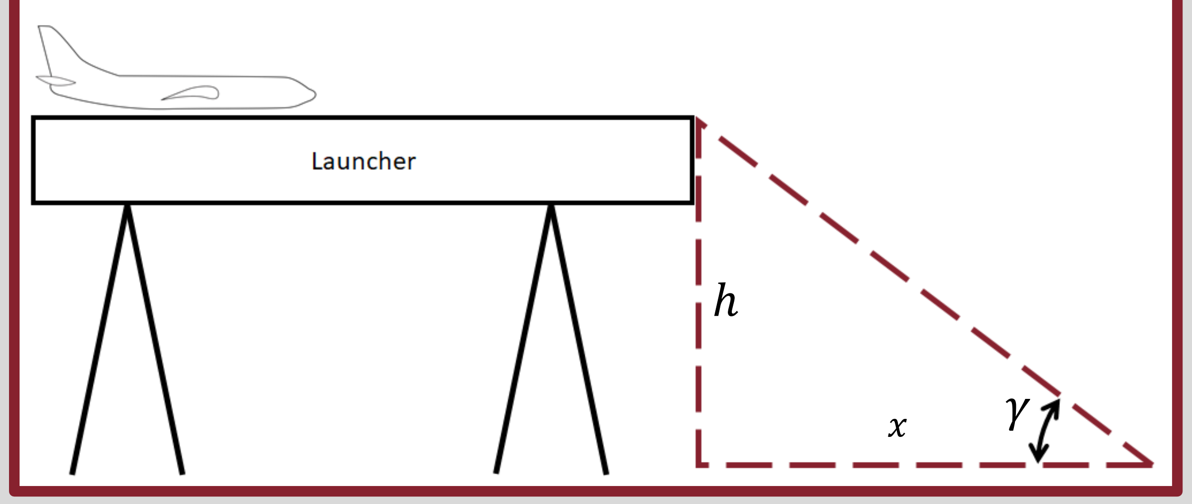
Objective & Impact

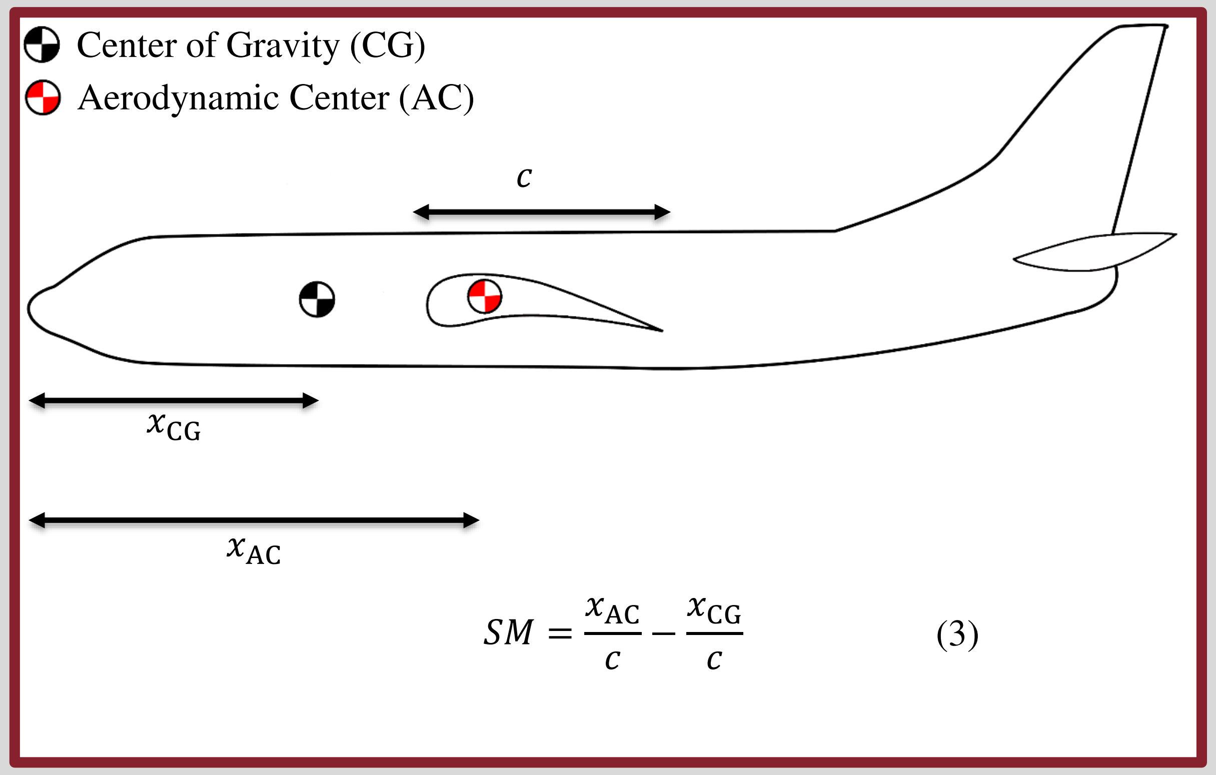
- Design of small scale aircraft can be improved with morphing wings.
- It is important to understand how morphing would affect stability
- The objective is to gain a greater understanding of how inboard and outboard sweep angles affect stability and performance of small aircraft.

Methods

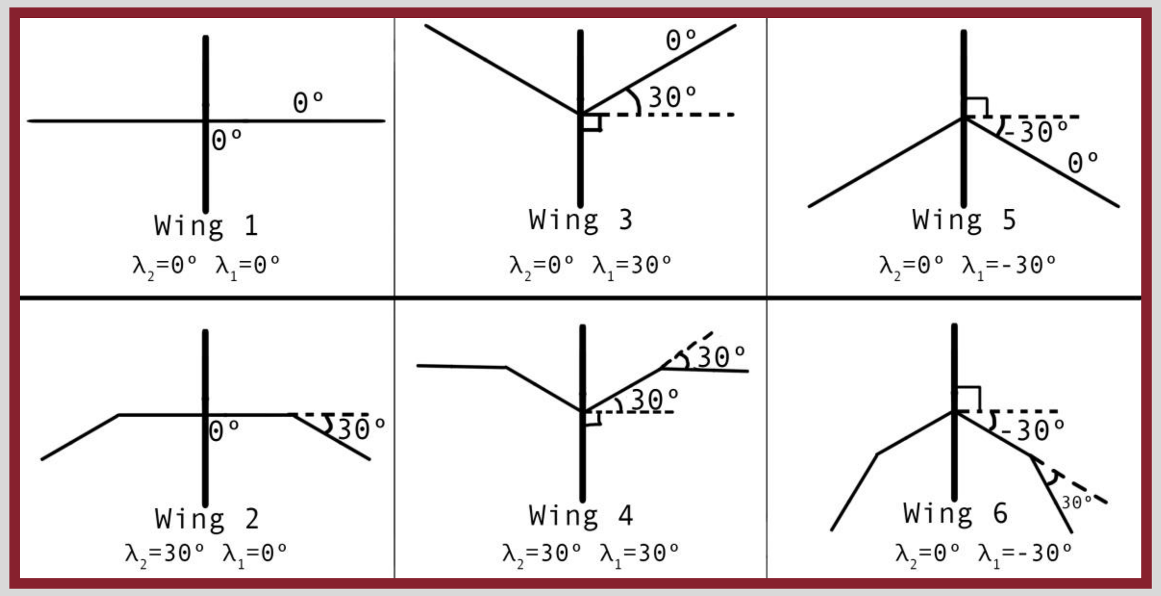
$$\gamma = \tan\frac{h}{x} \qquad (1)$$

$$\cot\gamma = \frac{L}{D} \qquad (2)$$



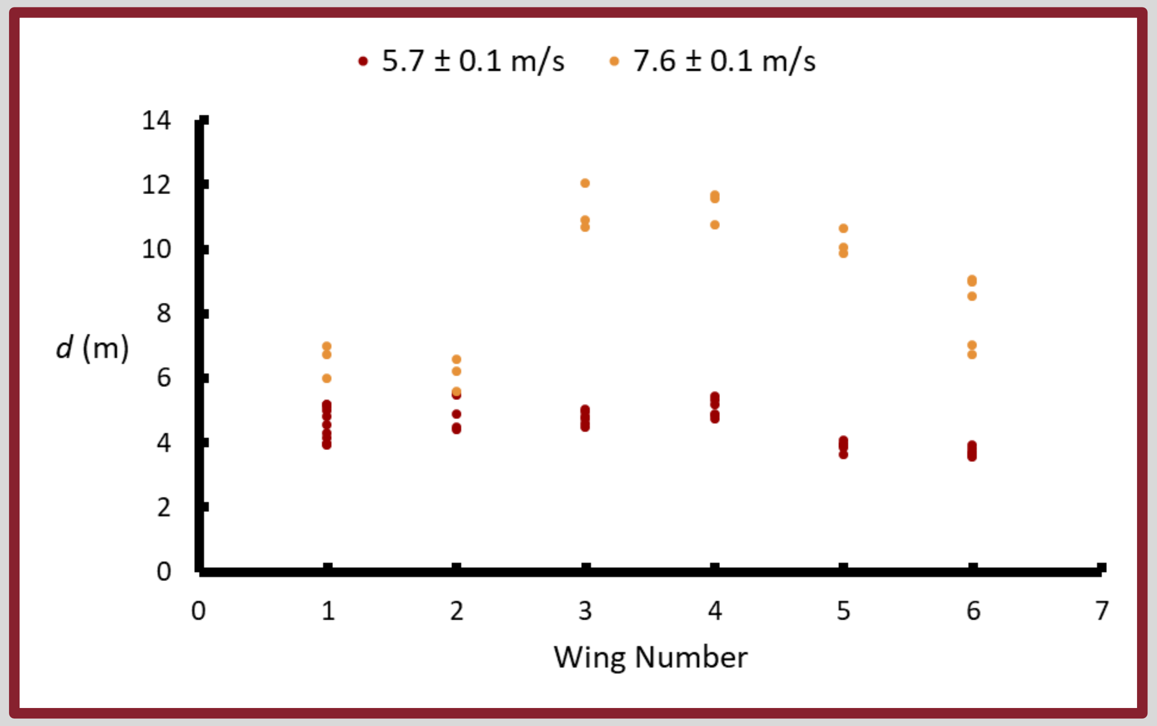


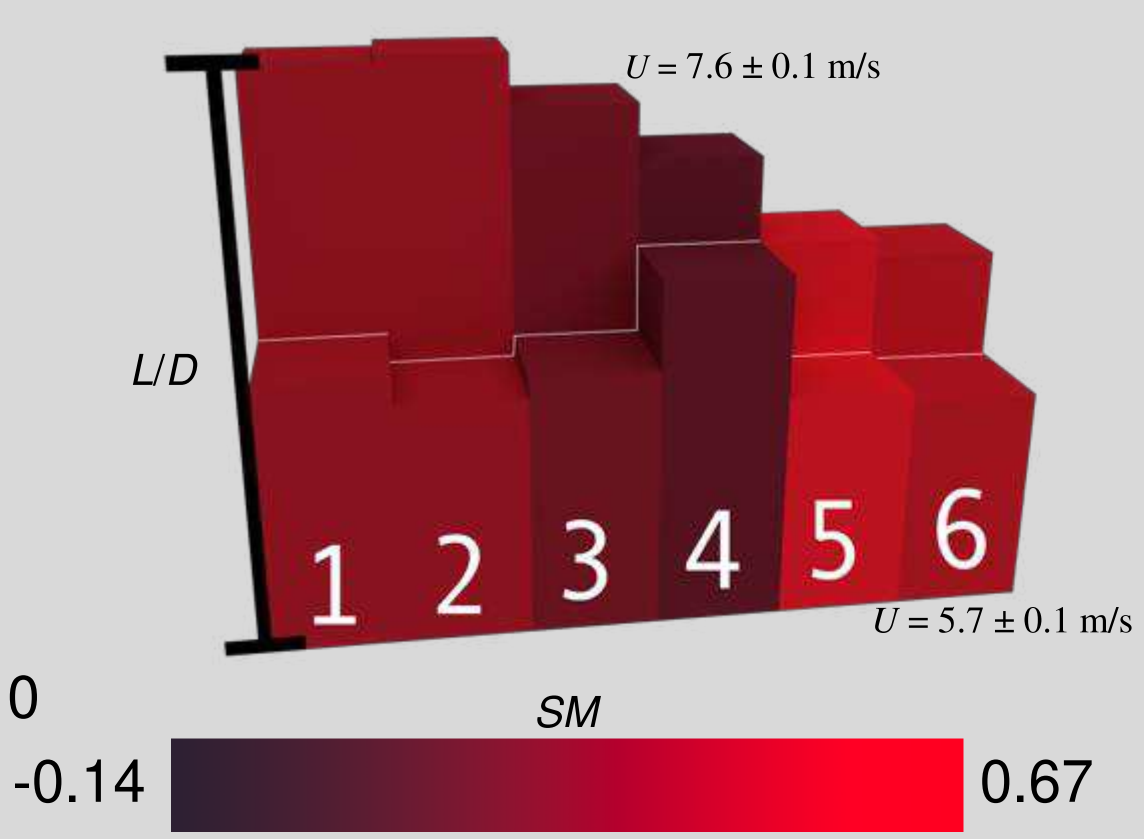
Wing Configurations



- We created six different wing configurations for foam gliders with varying sweep angles.
- Subsequently, we balanced the glider with a straight wing, and measured center of gravity
- We estimated the center of pressure, then calculated static margin for all wing configurations.
- Then, we launched a foam glider with six different wing configurations at two different speed presets(5.7 ± 0.1 m/s and 7.6 ± 0.1 m/s).
- After each launch, we measured the distance of the glider from the launcher using two tape measures and the Pythagorean theorem.
- We then calculated γ from Eq. 1
- Finally, we were able to calculate the lift to drag ratio, *L*/*D*, using Eq. 2

Results





Conclusion

- Wing configurations that swept forward gave the glider a negative static margin and a lower L/D at the higher speed than wings that had a 0º inboard sweep angle.
- Configurations 3 and 4 likely performed worse at higher speeds because their instability caused them to pitch up and stall.
- Wings 5 and 6 exhibited similar stall behavior at both flight speeds.
- Further research is needed to investigate additional configurations and flight speeds in order to develop a model to be used in future flight control.

Skills Learned

- Physics
  - Finding the resultant force
  - Moments
- Basic Aerodynamics
  - Lift and drag coefficients
  - dynamic pressure
  - Ideal gas law
  - *L*/*D* ratio
  - Static margin
  - Took into account static margin to build stable gliders
  - Found *L*/*D* for gliders tested
- MATLAB
  - Learned basics of programming, plotting, and exporting data in MATLAB
  - Created program to generate shape of four-digit NACA airfoils
- SolidWorks
  - Learned how to use interface to create parts and assemblies
  - Created potential parts to act as an interface between glider and launch rail

Acknowledgements

Thank you to Dr. Geoffrey Spedding, Yohanna Hanna, Jessica Lee, Dr. Katie Mills, and all of SHINE staff for all your work this summer.