CALIFORNIA SCIENCE & ENGINEERING FAIR
2019 PROJECT SUMMARY

Name(s)

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Project Number

S0313

Project Title

Wind Tunnel Analysis of Semi-Rigid Airfoil Structures for a Collapsible Hybrid Buoyant Atmospheric Spacecraft

Abstract

Objectives

The goal of the research was to identify potential internal support rib designs for a collapsible, hybrid-bouyant spacecraft wing structure, when covered by a flexible material like Mylar, may more efficiently provide long term-sustained flight in another planet s atmosphere.

Methods

Based on previous research utilizing a scale model of a proposed spacecraft, it was determined that a 10cm wing segment with the average chord length of the full 1-meter wingspan wing would act as a representative model for this study. The 10cm wing segments were built with different numbers of 3D-printed internal ribs to provide different amounts of support to the covering. The NACA 4421 airfoil shape was selected as the cross-sectional design for the test segment ribs. A wind tunnel from California Baptist University was used for generating lift and drag data for the model wing segments. The data from the Mylar covered test wing segments were compared against data from a similarly shaped but fully rigid control wing segment.

Results

It was determined that all the test wing segments had higher lift-to-drag and lift-to-weight ratios than the control wing segment. When scaled to the full 1-meter wingspan, only the wing segment with two widely spaced ribs demonstrated a weight ratio above 1, which indicates the wing could sustain flight. Additionally, a wing segment with five total ribs had a maximum approximate lift-to-drag ratio of 3.5, meaning it was the most efficient at generating lift relative to the amount of induced drag.

Conclusions

The study sheds further light into the design of a collapsible, hybrid-buoyant wing for flight on a high-density atmosphere planet, such as Venus or Jupiter. With the discoveries made with the two-rib wing segment, further experimentation into different airfoil designs and optimizations of wing volume will guide further development efforts to make the wing more efficient for both compacting for launch and expanding for atmospheric flight.

Summary Statement

My research has shown that an internal wing design containing a flexible skin and multiple ribs has the potential for long-term sustained flight for an atmospheric-based spacecraft to collect data on another planet.

Help Received

Dr. Daniel Clark assisted in clarifying aerodynamic concepts and supervised wind tunnel experimentation. Dr. Kevin Krock assisted in 3-D printing and wing assembly.