DBF Senior Design Proposal

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UNIVERSITY OF NOTRE DAME | COLLEGE OF ENGINEERING

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Introduction

- Collaborating with Notre Dame's DBF Club to develop an autonomous glider for the 2025 AIAA Design Build Fly Competition

- Focused on designing the electronics system, including an ESP32 microcontroller to process sensor data and control flight surfaces

- The goal is to achieve a lightweight, autonomous glider capable of precise navigation and scoring highly in the competition

Problem Description

- The glider must adhere to the constraints outlined by the AIAA Design Build Fly Competition

- Objective is to ensure the glider meets all competition requirements, maximizes bonus points, and demonstrates reliable flight performance

AIAA Competition Constraints

Launch altitude: 200-400 feet.

Weight limit: 0.55 lbs (250 grams)

Prohibited Equipment: Radio Receivers

Flight Control Method: Determined by team

Storage and Launch:

- Glider must fit between the airplane's two external fuel tanks
- Must remained secured to the airplane during all flight stages except the mission launch
- Minimum gap of 0.25 inches between the airplane fuselage and glider wings

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AIAA Scoring Criteria

- Number of laps completed by the main aircraft
- Weight of the glider
- Proximity of the glider to the landing zone

$$Score = 2 + \#\, of\ laps\ flown + \frac{Bonus\ Box\ Score}{Glider\ Weight}$$

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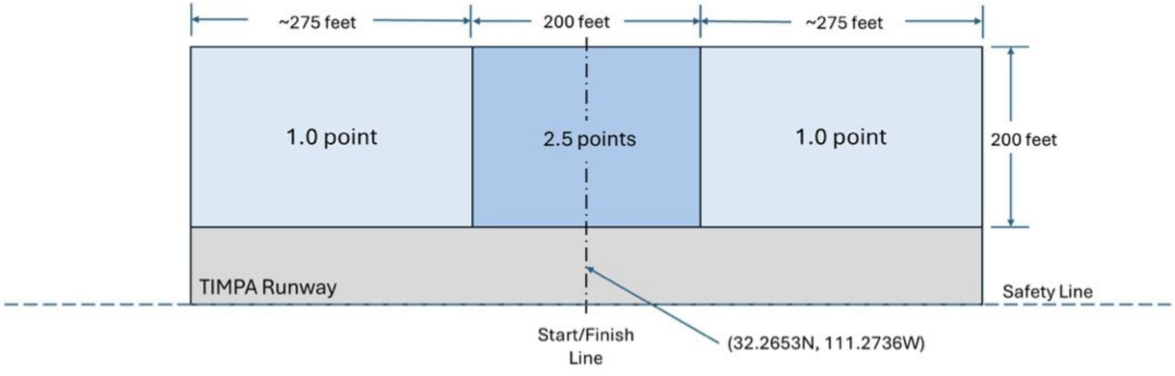
Opportunities for Bonus Points

- Execute 180 degree turn post launch
- Strobe lights turn on **only** after glider release
- Follow a control descent or landing pattern to land in highest-scoring zones
    - No bonus points awarded if landing is outside the bonus boxes



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Proposed Solution

- Develop an electronic system centered around an ESP32 microcontroller to process data and control flight surfaces
- Integrate sensors, including an IMU, GPS module, and pitot tube, to allow precise navigation and autonomous flight
- Implement a PID control algorithm for real-time adjustments to ailerons and elevator
- Utilize strobe lights triggered by launch conditions
- Use a proximity sensor to detect when the Glider has been launched from the Main Aircraft

Demonstrated Features

Launch Mechanism

- Launch mechanism ensures reliable deployment of the glider
- Enable transition to autonomous flight without failed launches

Flight Control Surface Actuation

- The glider will demonstrate actuation of the flight control surfaces
- Proper flight control surface actuation is critical for scoring

Strobe Lights

- The strobe lights activate after the glider is launched from the airplane
- Must identify launch conditions and trigger lights at the right time

Demonstrated Features

Video of Landing Precision

- Video of glider demonstrating its ability to land in the designated scoring zone, specifically the 2.5 points
- This achievement will be essential to a competitive performance in the competition

Optimized Weight and Power Systems

- Glider will demonstrate its lightweight construction to meet the maximum weight limit of 0.55 pounds
- It will show versatility in power sourcing, being able to operate on either USB or LiPo battery power

Available Technologies

Central Microcontroller

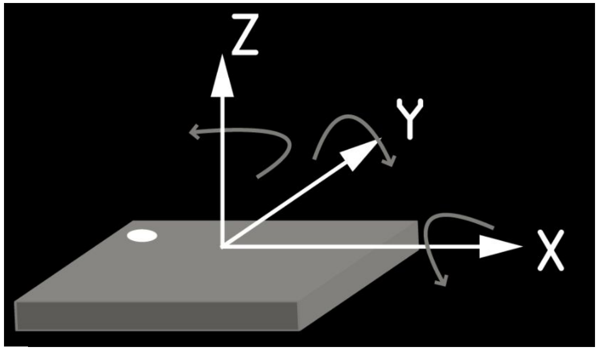
- ESP32-PICO-V3-02

GPS Module

- NEO-M9N

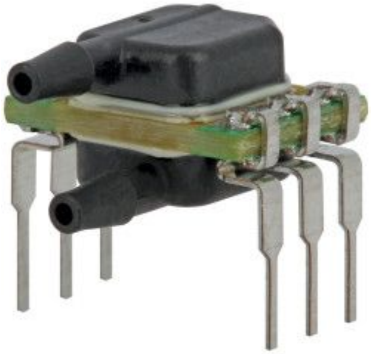
Inertial Measurement Unit

- BNO085



Pitot Tube (Differential Pressure Sensor)

- ABP2DRRT001PD2A3XX



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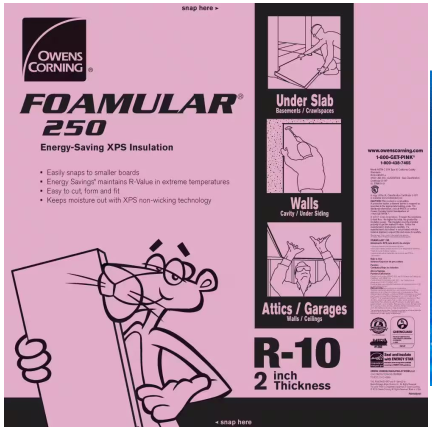
Available Technologies

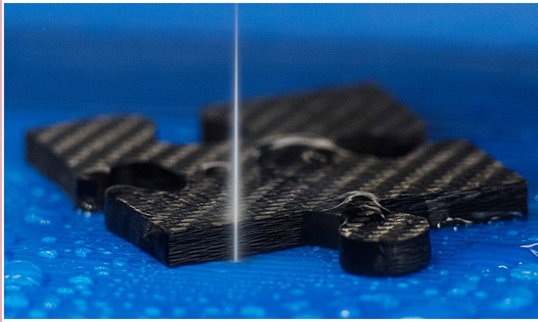
Motors

- MKS Servos

Construction Materials

- XPS Foam and Carbon Fiber



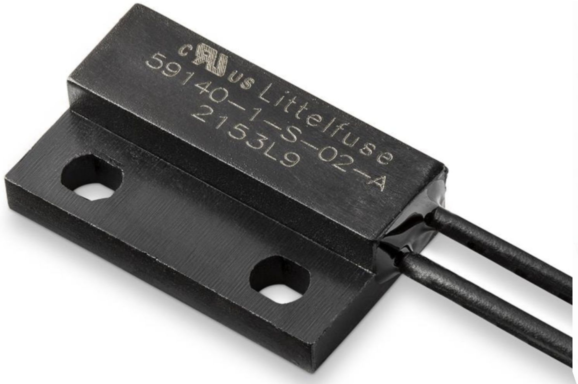


Battery

- 2s 300mAh LiPo

Proximity Sensors

- Hamlin 59140-010
- Hamlin 57140-000



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Engineering Content

Schematic Design

- Develop a comprehensive circuit schematic incorporating the ESP32, sensors, servos, and power systems to ensure proper functionality and integration.

PCB Design and Layout

- Optimize the circuit board for minimal size and weight while ensuring manufacturability.

Overall CAD Design of Glider

- Coordinate with Aerodynamics and Structures team to ensure compatibility and proper integration with the Glider

Engineering Content

Programming and Control Logic

- Implement FreeRTOS for task scheduling, sensor data processing, and PID-based control of flight surfaces for precise navigation

Testing and Validation

- Conduct flight tests to verify system functionality, refine algorithms, and ensure competition readiness

Conclusions

- Our project designs the electronics for an autonomous glider to meet AIAA Design Build Fly competition goals
- The glider will demonstrate precise flight control, reliable navigation, and lightweight construction for optimal performance
- Successful implementation involves integrating sensors, motors, and a real-time operating system into a compact design
- The project blends principles of electrical, aeronautical, and mechanical engineering and is an exploration into the feasibility of autonomous flight

Current Progress