NC STATE UNIVERSITY Mechanical and Aerospace Engineering

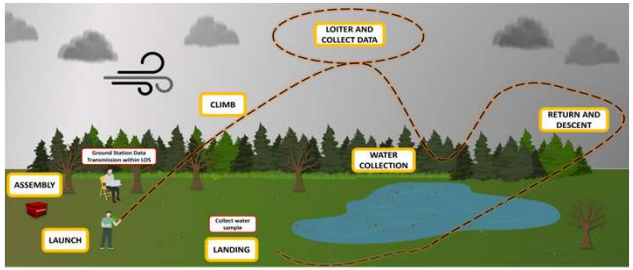
Skimmer by Team S.O.A.R.

Course Instructor: Dr. Ewere
Teaching Assistant: Joseph Deneke

Aerospace Engineering Capstone Senior Design 2023-2024
Team Members: Ruben Pelayo Quezada, Hailey Bruce, Emilie Hughes, Pranav Murukesh, Taimur Chaudhry, Victor Ibarra-Mendoza
Project Customers: Tom Freeman, Kevin Gitushi, Michael Hughes, Auston Gray

Project Overview

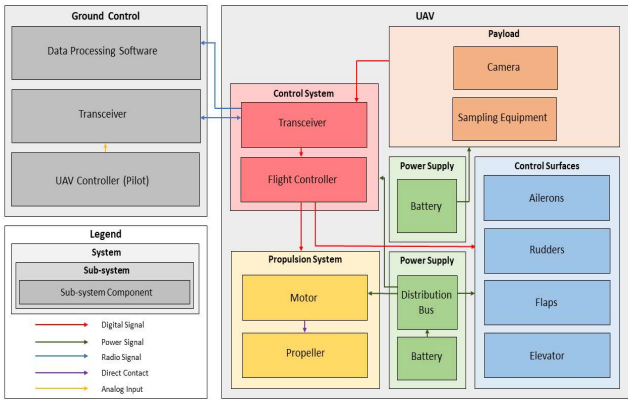
Skimmer was designed to serve as a mobile land and water surveying platform in the preparation and recovery phases of hurricanes. The payload systems allow for collection of water samples and weather data while conducting ground imaging surveys along a predicted hurricane path. This will assist natural disaster response and research teams in identifying critically hit areas and understanding the impact of the hurricane on water quality and carbon flux for use in climate models and future prediction software.



Key Objectives: The UAV shall be remote controlled, less than 20 pounds, hand-launchable, fit in a 2ft x 3ft x 5ft space, remain in line-of-sight of the pilot during flight, and land successfully without detrimental damage.

Goals: Run on clean energy sources, collect water samples, collect high quality images and video footage, and support recovery and response phases of hurricanes.

Functional Block Diagram



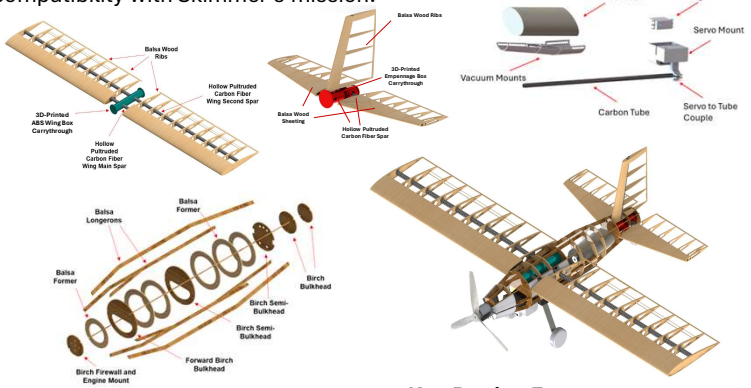
Final Prototype

Specifications

Total Weight	13 lb
T/W	1.16:1
Cruise Speed	20 m/s
Max (L/D)	12.4
Center of Gravity Location	3.5 in aft of wing LE
Static Margin	7%
Endurance	15 min
Range	1 mile
Aerodynamic Chord	0.88 ft (10.6 in)
Taper Ratio	1.0
Water Collection Rate	0.3 fl oz/s

Design Solution

Trade studies were conducted to facilitate design decisions with key considerations for manufacturability, cost, weight, repairability, and overall compatibility with Skimmer's mission.



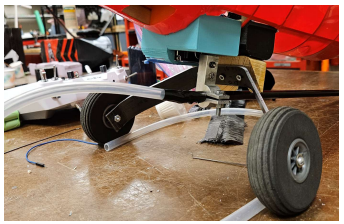
A vacuum system was chosen to serve as the UAV's water collection mechanism. As Skimmer skims the water surface, a fuselage-mounted tube is unfolded and submerged, and the vacuum within the fuselage and connected to the tube is activated.

Key Design Features:

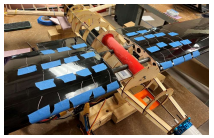
- Rectangular, NACA 2412 wing
- Conventional empennage
- Semi-monocoque fuselage
- Tractor propeller configuration
- Mounted GoPro camera
- Vacuum water collection mechanism

Manufacturing

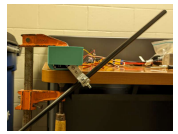
A laser cutter was used to cut balsa ribs and birch bulkheads, formers, and longerons for the UAV's structure. A 3D printer was also used to create several ABS and PLA parts, including the wing and empennage boxes as well as the landing gear, camera, and vacuum system mounts. Pultruded carbon fiber tubes were used for wing and empennage spars, and the vacuum system piping which would receive high loads at water contact. Aluminum sheets were installed onto the upper fuselage surface to serve as removable panels for avionics/battery access and supply torsional rigidity.



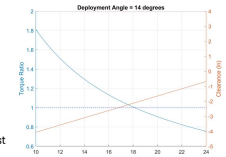
Testing



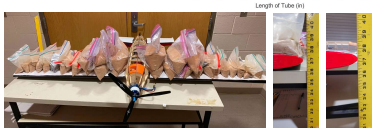
(a) Flow Visualization Test



(b) Deployment Servo Impact Test



(c) Water Sample Collection Test



(d) Static Wing Loading Test with 3.8 G loading and without loading

Tests were performed for Skimmer's structural integrity, propulsive effectiveness, aerodynamic quality, stability and control, and payload capabilities.

- The flow visualization experiment (a) validated flow attachment across the wing under different airspeeds and angles of attack.
- The deployment servo impact test (b) simulated the hydrodynamic forces on the 55 kg-cm rated servo for the vacuum tube.
- The sample collection test (c) gave insight into how quickly and effectively Skimmer would collect 0.5 cups or 118 grams of water.
- The static wing loading test (d) showed that each of Skimmer's wings could safely withstand a weight of 30 lbs (equivalent to 3.8 G's) with a maximum deflection of 0.3 inches.