Breeze UAS

NC STATE UNIVERSITY

Department of Mechanical and Aerospace Engineering

Aerospace Engineering Capstone Senior Design 2020 - 2021

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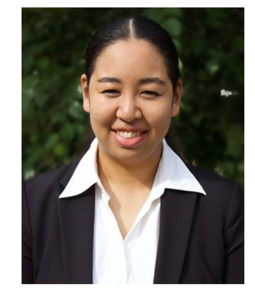
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Financial Lead
Aerodynamics and Propulsion Co-Lead


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Systems Engineer
Aerodynamics Lead


Jan Fernandez
Communications Lead
Propulsion Lead


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Test/Safety Lead
Stability and Control Lead

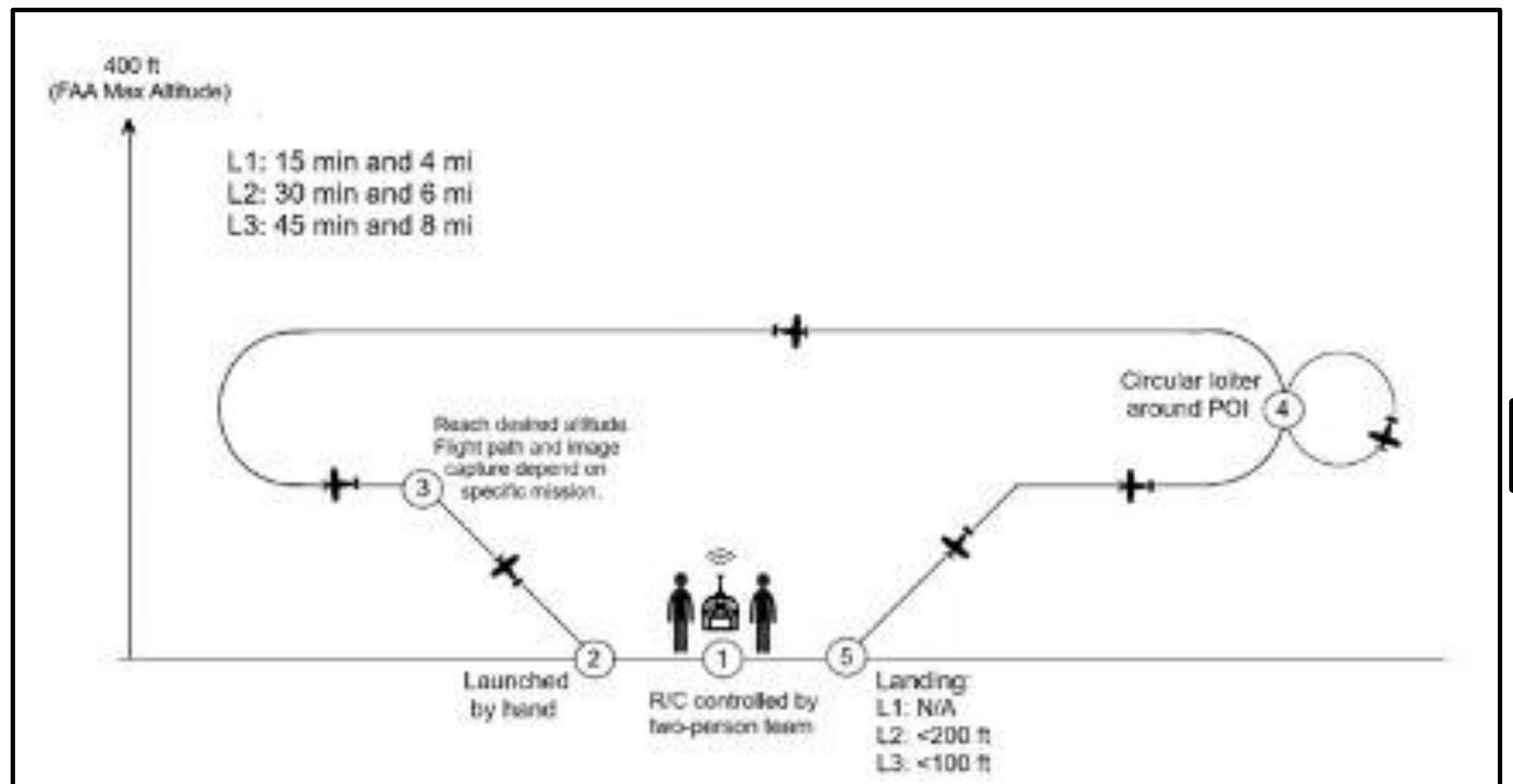
Customer:
US Forest Service

Represented by Stakeholders:

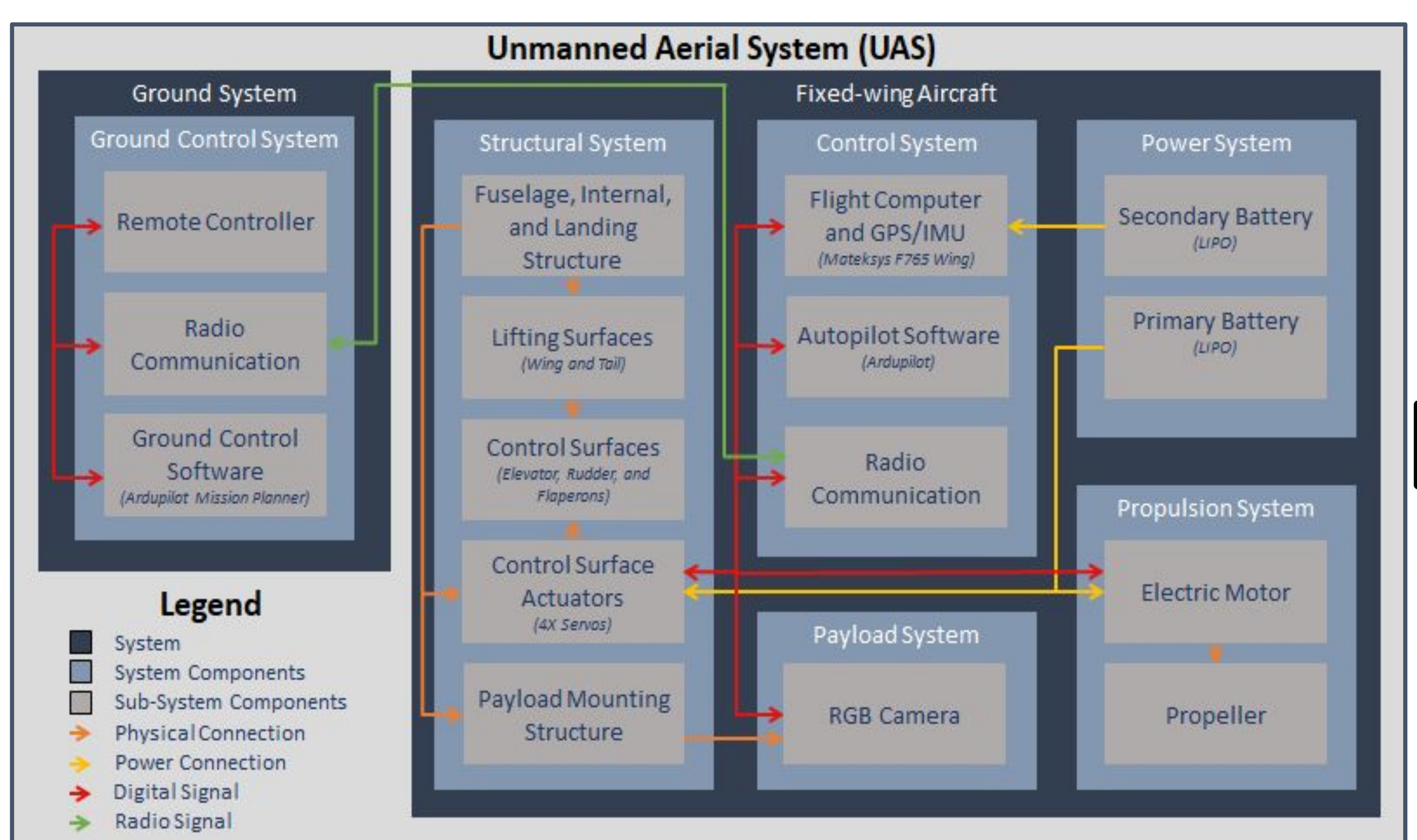
Josh Glazer and Kevin Gitushi

Project Overview:

The US Forest Service is responsible for the mapping and monitoring of the general condition of the National Forests and Grasslands in the public trust. This includes determining the effectiveness of vegetation treatments and reforestation efforts; as well as monitoring timber harvest unit boundaries, the identification of road locations, and the assessment of damage following severe weather events.



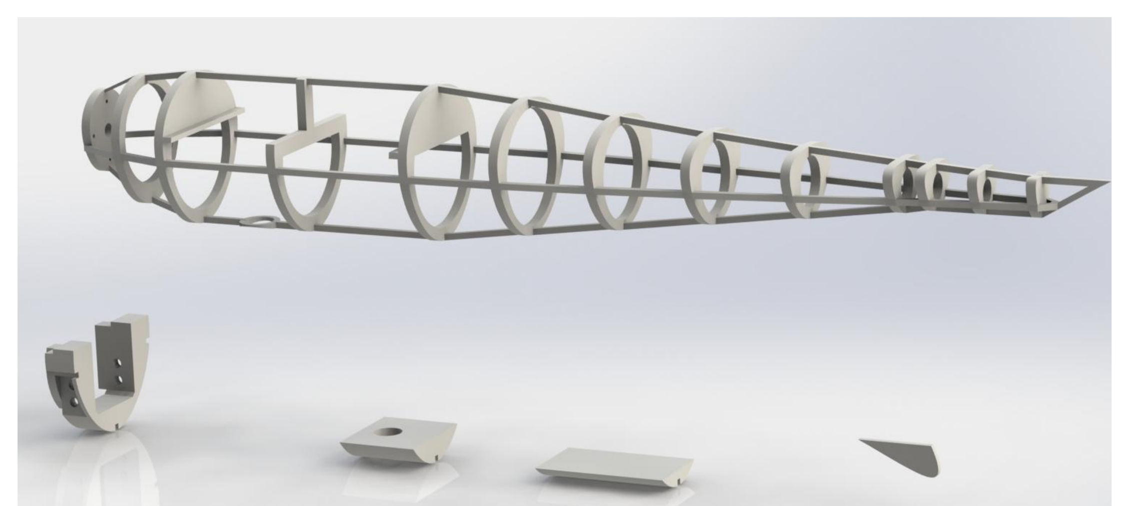
The goal of this project is to design and manufacture an Unmanned Aerial System (UAS) that is capable of collecting the data required for the Forest Service to manage the forests. The UAS at hand follows the CONOPS diagram shown above where a two person team assembles, hand launches, and operates the UAS within a 400 ft altitude (as per FAA regulations for flying by line-of-sight).

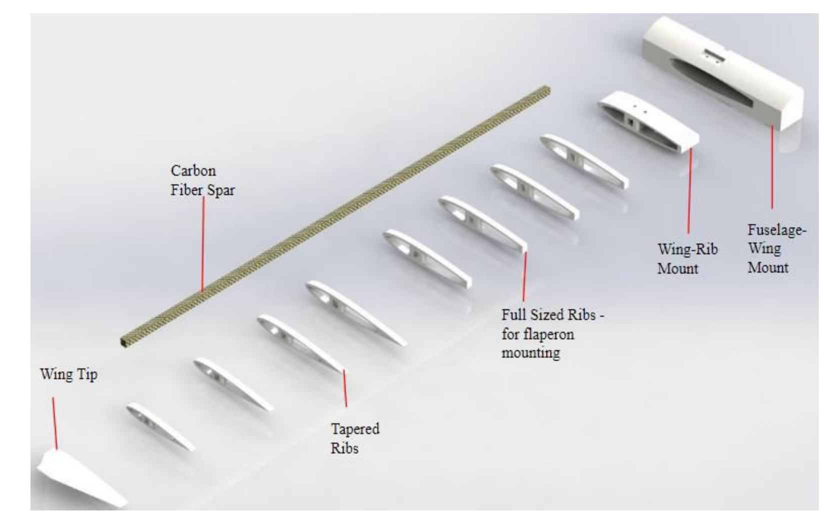


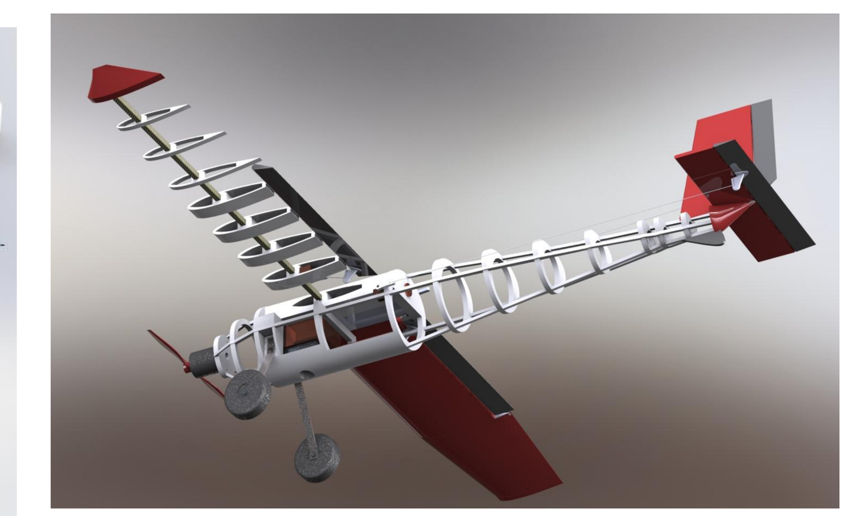
The systems architecture of the UAS is presented in the functional block diagram shown below. The diagram breaks the UAS into systems, system components, sub-system components, and the connections/signals between them.

The UAS is designed with a monocoque fuselage that supports a high, detachable, cantilevered wing. The fuselage also allows for a conventional tail and tail dragger landing configuration with a skid on the rear end. The propulsion system consists of a 470 kV Brushless Outrunner electric motor and a two blade 13 x 8.5 inch propeller. All structural components and mounting surfaces are 3D printed using PLA filament. Finally, to finish the design, a polyester covering film is stretched and adhered over the entire structure.

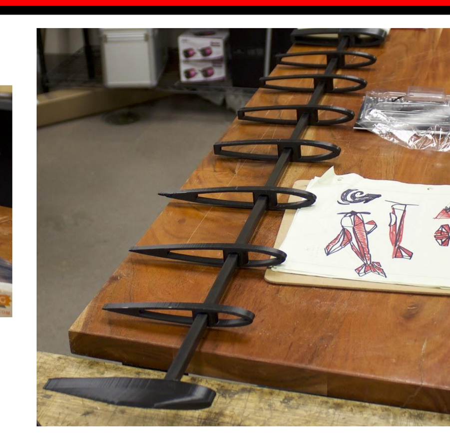
CAD Design:

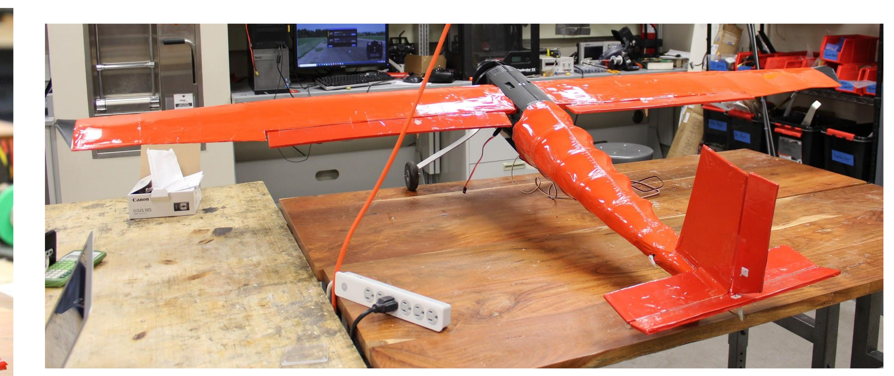


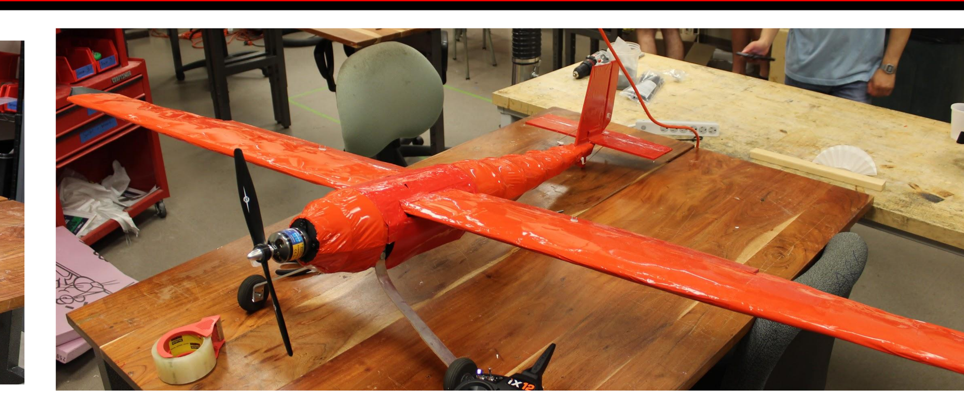




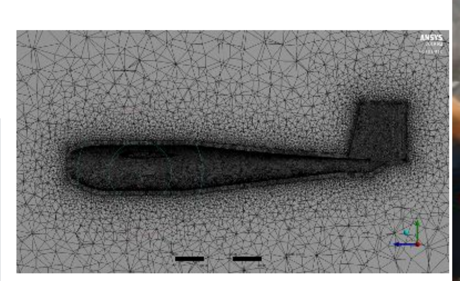
Manufacturing:

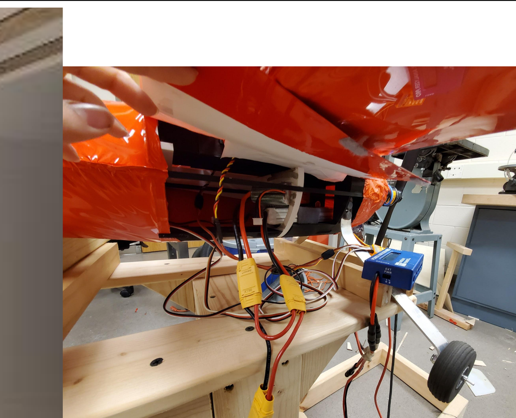






Testing:





The UAS was put through a variety of computer aided and physical testing. A few of the most prominent tests conducted were (from left to right in the images above) Ansys Fluent flow simulation, wing loading test, static thrust test, center-of-gravity determination, sub-scale wind tunnel test, and battery endurance test.

Final Prototype:

Aerodynamic Properties:

Flight Conditions: V_{cruise} = 20 m/s, Level-Flight (α = 0°), Mass = 3.4 kg

Static Margin	24%
T/W Ratio	1.28:1
Endurance	13 minutes
Range	15 km
Max thrust	42 N
$C_{L,\alpha}$	3.8

Project Outcome:

The maiden flight of the Breeze UAS was a success, although there were a couple of issues that affected it. The first issue came up during the preflight test, when the propulsion system was advanced to full throttle and tore off the nose, but it was fixed and the UAS was able to fly. The flight ended after 56 seconds due to the extremely windy conditions, with gusts reaching up to 30 mph. A strong gust of wind proved to be too much for the carbon fiber spar, tearing off the wing on the port side and causing the UAS to crash land and break into pieces. Despite the inflight disintegration, the Breeze UAS met its goals, and would have flown successfully in calm conditions.