NC STATE UNIVERSITY

Mechanical and Aerospace Engineering

MAE 480/481 : Aerospace Engineering Capstone Senior Design 2021 - 2022

Instructor: Dr. Felix Ewere
Teacher Assistant: Auston Gray

THE OVERSEERS PRESENT THE... F.A.L.C.O.N. UAV PROJECT

Forestry
Aerial
Liason for the
Care and
Observation of
Nature

Customer:
The North Carolina State Forest
Represented by Stakeholders:
Kevin Gitushi and Michael Taylor

OUR TEAM

Jordan	William	Joshua Fry	Jonathan Hatfield	Carson Davis
Project Manager Materials Lead	*Systems Engineer Structures Lead CAD / Simulations*	*Communications Financial Lead Stability / Control*	*Test / Safety Lead Propulsion Lead*	*Manufacturing Lead*

Overview of Missions

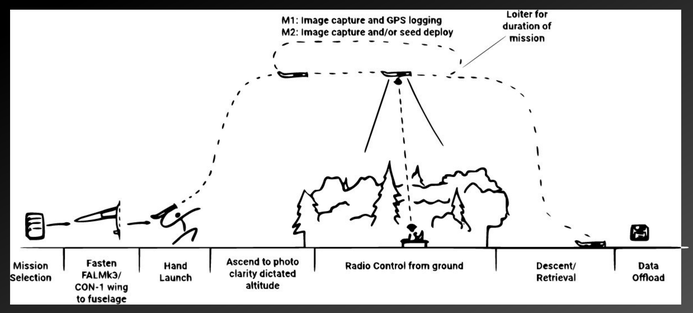
Mission 1: Forestry Management

The primary purpose of the forestry management mission is to use the UAS to monitor the general condition of forestry areas, and for forest mapping. Additional goals include: gathering data on reforestation; forest health; identification of timber harvest boundaries, road locations; and to assess damage from natural disasters and weather events. To accomplish these tasks, the F.A.L.C.O.N. UAS can use Stereoscopic or planimetric mapping, or general photographic imaging to generate maps of forest regions pre- and post- large weather events. These maps and images can also be used to track forest inventory and health, by imaging stand size, growth, species, and other similar metrics for forest regions. These images, maps, and data can serve as a basis for management plans and location of research areas of interest.

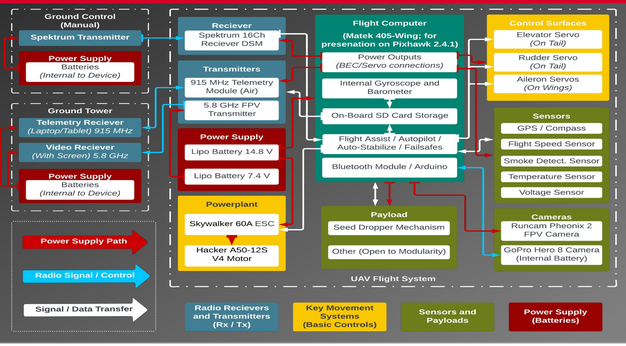
Mission 2: Fire Prevention

The UAS can be used to assist the USFS in meeting their fire prevention goals by increasing efficiency of tasks such as mapping and reseeding. The F.A.L.C.O.N. aircraft can be used to mark dry regions prone to fire, help reseed large areas of burned forest or other clearings, and can be used to map road/access points to fire prone areas for use by first responders. In order to complete these missions, the F.A.L.C.O.N. configuration for mission 2 will include a camera for imaging and mapping, along with a seed dropping payload bay. This payload bay will have a mechanism for dumping seeds evenly over a large area.

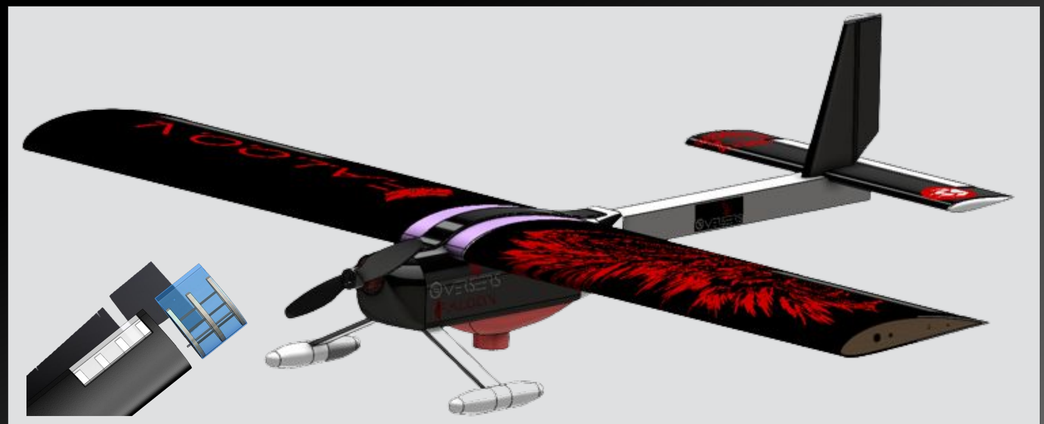
Concept of Operations



Functional Block Diagram



Design Solution



Design Description

The F.A.L.C.O.N. aircraft accomplishes these missions by utilizing a modular wing design to enable increased functionality, as well as a modular payload bay for seed dropping and photography missions. The aircraft is an ***10.2lb*** reinforced ***monocoque*** constructed aircraft, and will consist of a balsa frame and coated polystyrene foam shell. The aircraft will utilize an ***480kV electric outrunner motor*** with a ***18x10in*** propeller in a tractor prop design configuration for propulsion, which will use a ***4S, 8000mAh*** battery to generate thrust. To ensure the motor doesn't burn up, the aircraft will use ***60A ESC.***

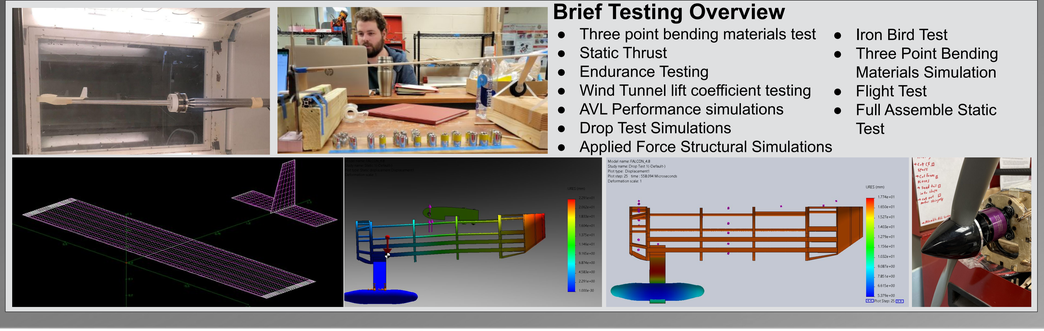
The aircraft will be controlled via communication from a radio controller ground station to an onboard ***Matek F405-Wing*** flight computer through the ***FrSky SBUS 16CH receiver***. The flight controller will use internal sensors as well as connect to a ***BN-880 GPS/compass*** module and Matek ***ASPD 4525 flight speed*** sensor.

For control surfaces, the aircraft has a standard horizontal and vertical tail, as well as aileron control. The aircraft wings have internal spars that slide onto fuselage frame spar mounts, and the wings bolt together. This ensures rigidity and strength of design. For modular aspect ratio, the wing tips have extensions that clip onto the ends of the wing.

The fuselage includes a space for required powerplant and flight controller, as well as ***2 1/2U payload bays***. These bays hold a ***Hero 8 GoPro*** camera for imaging, as well as a removable ***seed dropper module*** for reseeding forestry missions, and allow interchangeability for users to put whatever other lightweight payload they would like to substitute.

The design can be easily transported as the wings, tail, and landing gear are easily removable so that the whole package can fit in a small car trunk with room the spare. At its smallest, it ***packs within a 5 x 2 x 3 box***, when assembled, its ***wingspan is over 7'*** in the smaller configuration and nearly ***9' in the larger*** configuration. The aircraft is ***55" long*** when assembled but splits where the fuselage meets the tail boom into two small halves.

Verification and Testing



Brief Testing Overview

- Three point bending materials test
- Static Thrust
- Endurance Testing
- Wind Tunnel lift coefficient testing
- AVL Performance simulations
- Drop Test Simulations
- Applied Force Structural Simulations
- Iron Bird Test
- Three Point Bending Materials Simulation
- Flight Test
- Full Assemble Static Test

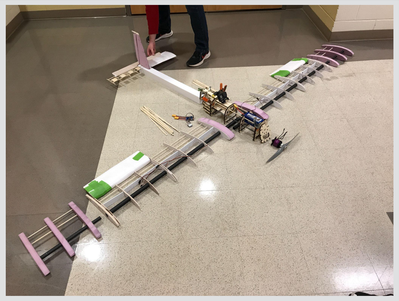
Manufacturing

Methods

- Fuselage constructed from laser-cut basswood sheets and epoxied
- Wing ribs rough cut out of balsa with band saw and sanded to an desired airfoil shape
- Vertical fin interpolated and sculpted from solid foam
- Tail boom constructed from 7/16" foam board, joined with hot glue
- Extension ribs rough cut out of foam with band saw and belt sanded to desired airfoil shape

Resources

- NCSU AE Fixed-Wing Senior Design Lab was the primary resource for manufacturing
- E-Garage



Final Prototype & Flight

Test Flight Report

- Construction was a success
- The FALCON was fully disassembled and transported via car trunk to the test site where it was reassembled on site and exhibited full functionality
- Test flight was a mixed result
- Initial hand launch failed causing moderate damage
- After repairs, second launch was a success but damaged elevator ceased operation mid-flight resulting in an irreparable crash landing
- Pilot reported that the FALCON responded to input desirably prior to the elevator failure
- Total Flight time was 20 seconds

To see our flight videos, as well as other images, documents, and information, please visit our website by using the QR code on the right or by going to…
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