NDSU AIAA Chapter's Competition Teams
- AIAA Design/Build/Fly Competition 2015
- AHS Micro Air Vehicle Competition 2015

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NDSU MECHANICAL ENGINEERING

AIAA

North Dakota Space Grant Annual Meeting, April 8-9 2016

Dickinson State College, Dickinson, ND

NORTH DAKOTA SPACE GRANT CONSORTIUM

American Institute of Aeronautics and Astronautics

- Started out as two societies in the 1930s
  - American Rocket Society 1930
    - Science fiction writers and editors, performed own experiments
  - Institute of the Aeronautical Sciences 1932
    - Scholars and professionals, amazing library/collection
- Merged in 1963 to form AIAA
  - 30,000 professional members in 85 countries
  - Over 7,000 student members in over 190 student branches worldwide
  - 20 technical conferences, 8000 papers per year
  - Hundreds of books, 7 technical journals, short courses, standards, public policy
  - Electronic library of all papers and journal articles since 1963
- AIAA Foundation
  - Established to ensure enduring focus on education of practicing and future aerospace professionals
  - Concentrates on three areas of student programs
    - Design Competitions
    - Scholarships
    - Student Conferences

NDSU AIAA Student Chapter

- Established in 2010
  - In order to increase student interest in aerospace related technologies and research areas
  - to provide research experiences through activities
    - Design competitions
    - Student paper competitions
  - Recruit students for graduate studies in aerospace related topic
  - Provide guidance and opportunities for aerospace related careers

Competitions:

- AIAA Design/Build/Fly (since 2011) (Senior Design)
- CanSat (since 2013)
- AHS Micro Air Vehicle (since 2014) (Senior Design in 2016)

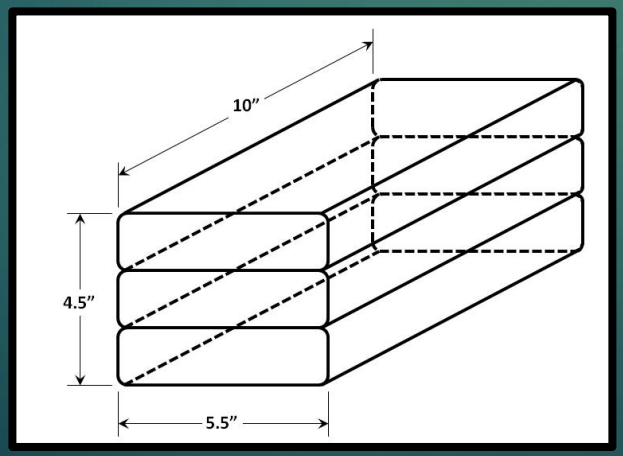
DESIGN/Build/Fly - 2015

- AIAA DBF - Cessna & Raytheon
- Electric, Remote Control Aircraft
- 1 Ground Mission and 3 Flight Missions
- Tucson, Arizona

Competition Guidelines

Ground mission – Payload loading time

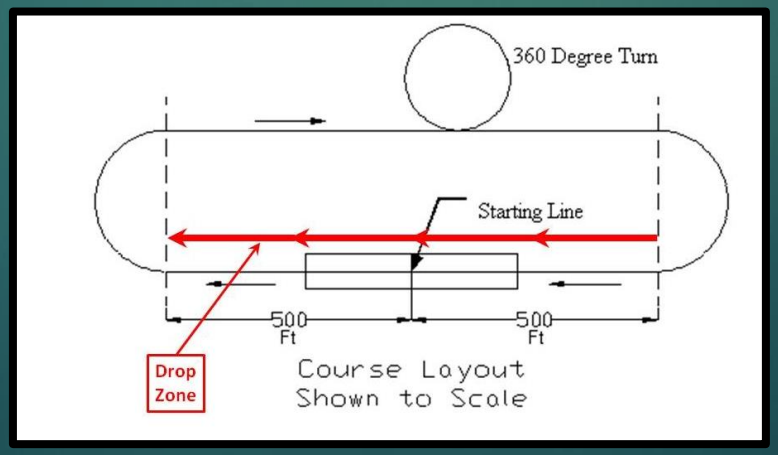
- Mission starts with airplane empty and hatches closed
- Payload for mission 2 is applied
- Remove mission 2 payload and install mission 3 payload
- Must be completed within 5 minutes from start



Competition Guidelines

Flight Missions

- Mission 1 – Ferry Flight
  - Maximum number of complete laps within 4 minutes
- Mission 2 – Sensor Package Transport Mission
  - 3 lap timed flight with sensor package
- Mission 3 – Sensor Drop Mission
  - On each lap, the plane will remotely drop a single ball

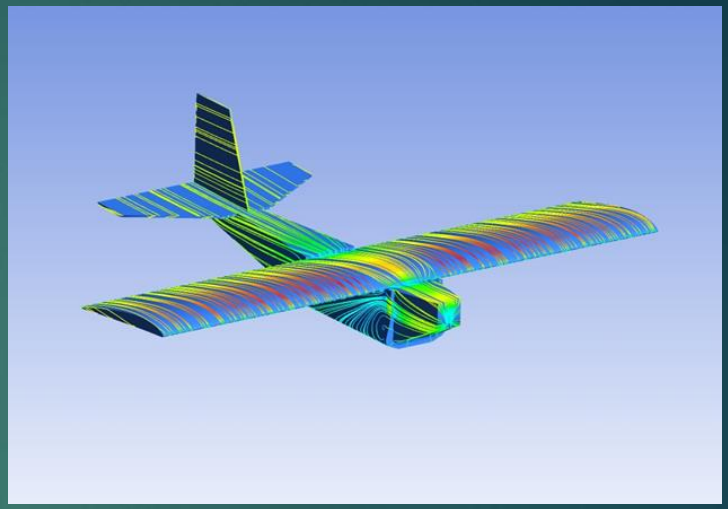


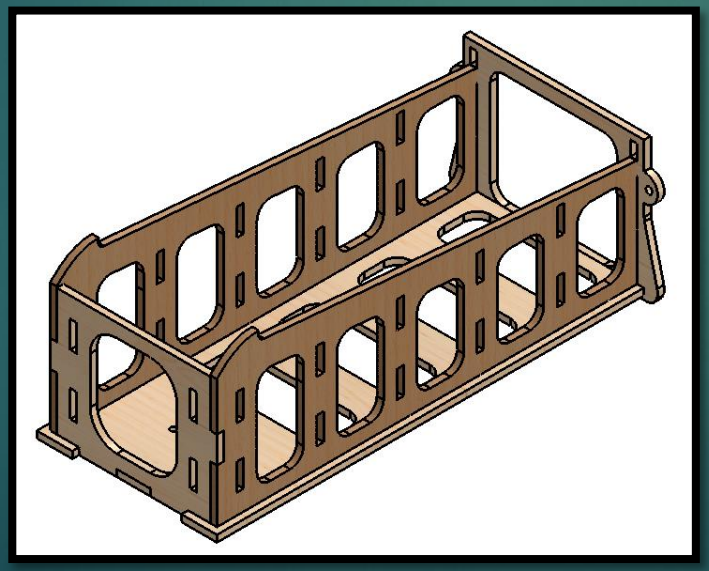
Constraints

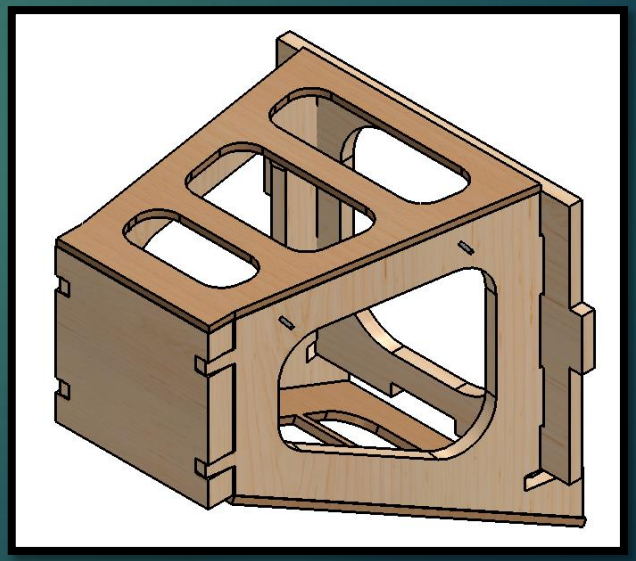
- Contest
  - Efficient transitions between flight mission configurations
- Manufacturability
  - Laser cut parts
  - Simple assembly-tabs
- Performance
  - High carrying capacity
  - Aerodynamically sound
- Budget

Design and Analysis

- Aerodynamics Design
- Structural Design
- Propulsion
- Control and stability



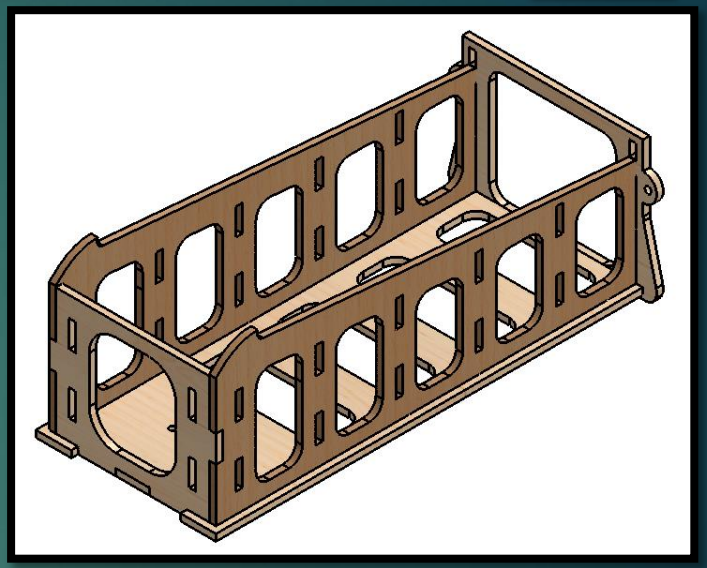


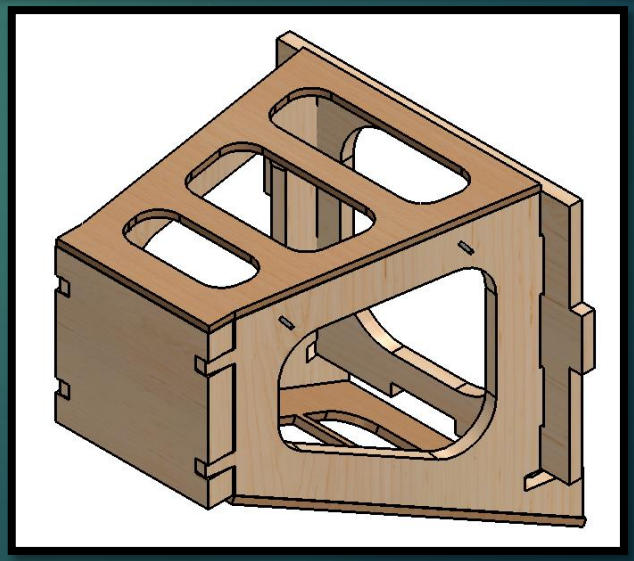


Design - Fuselage

Spars/Nose

- Spars
  - Aerodynamic
  - Strength
- Nose
  - Holds batteries and ESC
  - Primarily basswood
  - Removable top

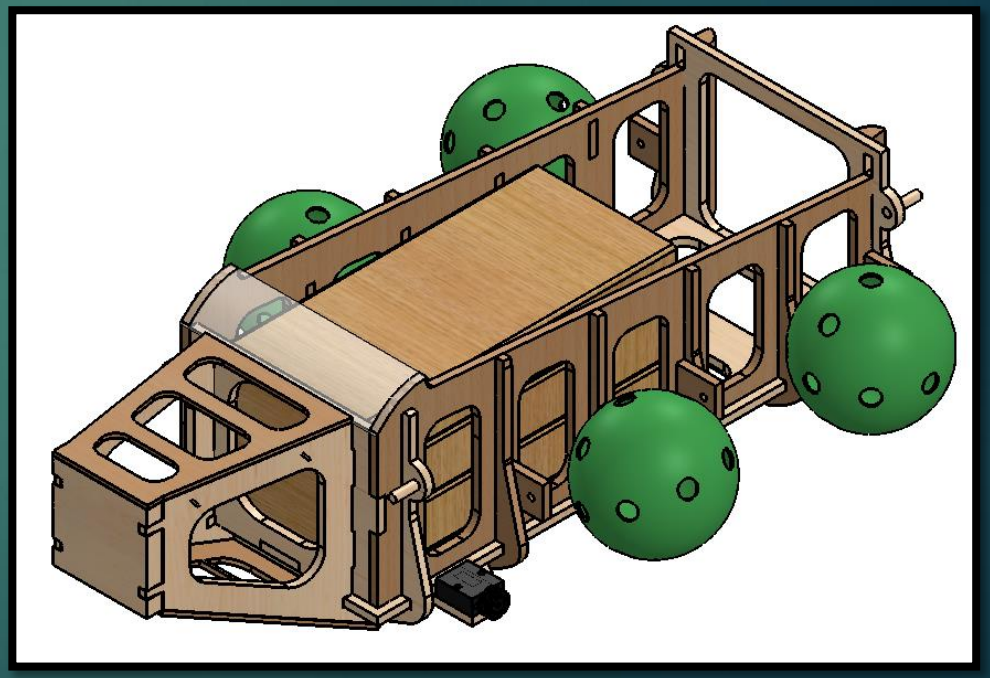




Design - Fuselage

Final Design

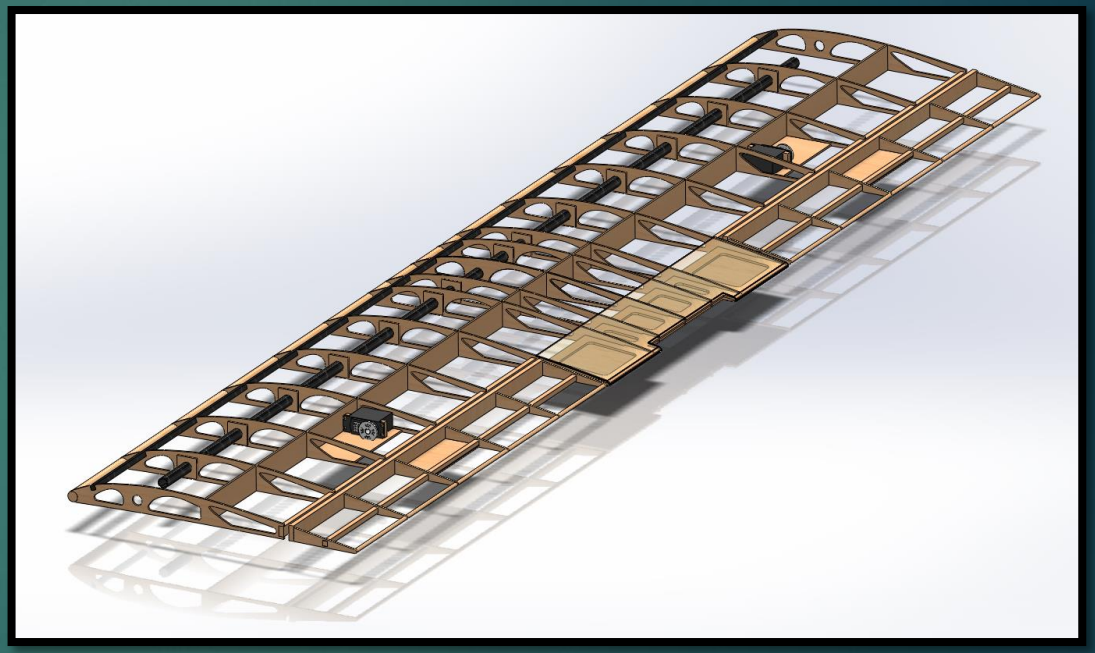
- Design revolves around mission requirements
  - Mission 2 payload
  - Mission 3 sensor drop



Design - Wing

Structure

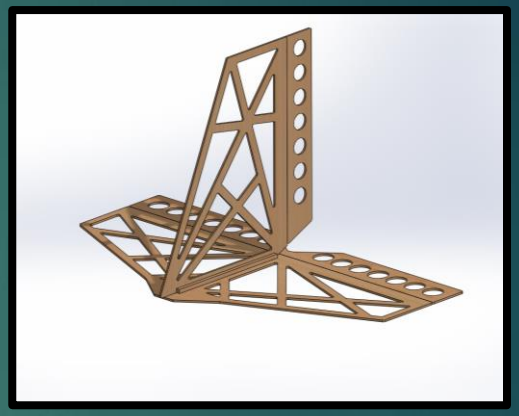
- Balsa Dowel For Leading Edge
- .5” Carbon Fiber Hollow Tube
- Ailerons Sized 19% of Planform Area

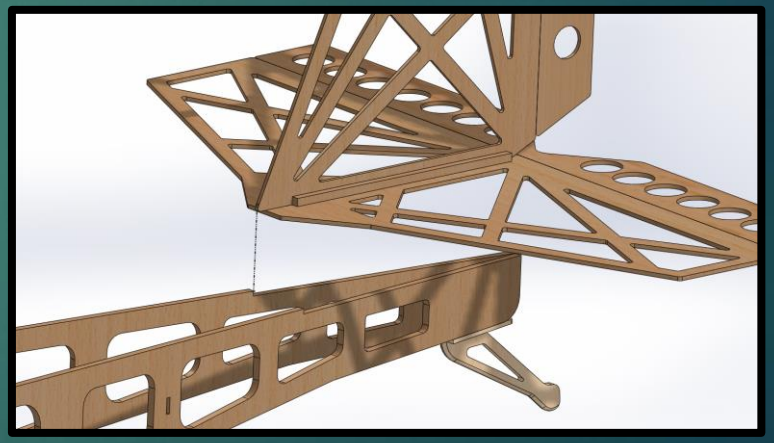


Design - Tail

Assembly & Controls

- Weight & Strength
- High strength, rounded corners on most parts
- Hole cutouts & truss- like system
- Elevator controls – 20% of chord
- Deflection TBD
- Tail drops into notch on fuselage



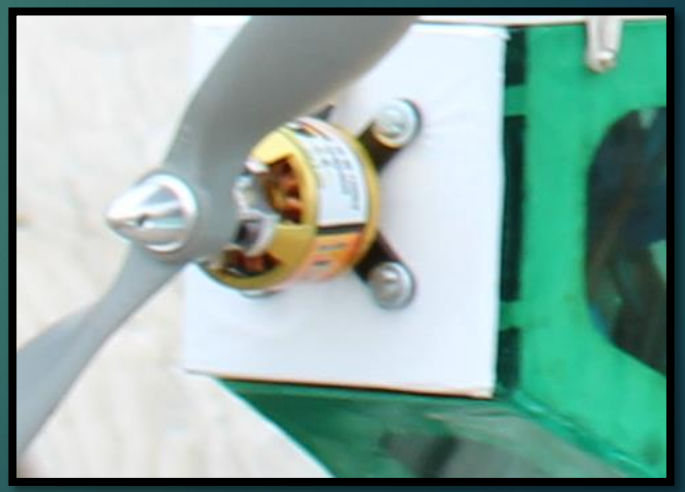


Design - Propulsion

Motor and Battery

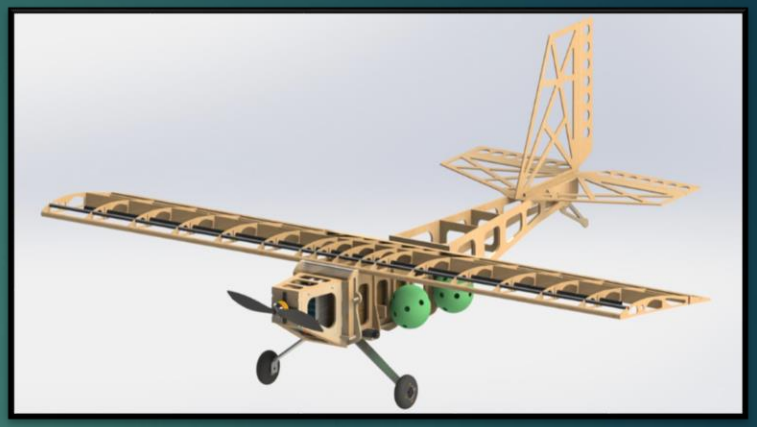
- Battery limit-2lb
- Initial range = 350 W-500 W

  (Initial Battery)
- Final range = 1000 W - 1500 W (Final Battery)
- G.P Rimfire => Axi Gold 20-30 Cell
- 1500mAh battery & 50 amp ESC ==> 1080 W, 33.6 V
- ~3.5 minutes flight time @ full power



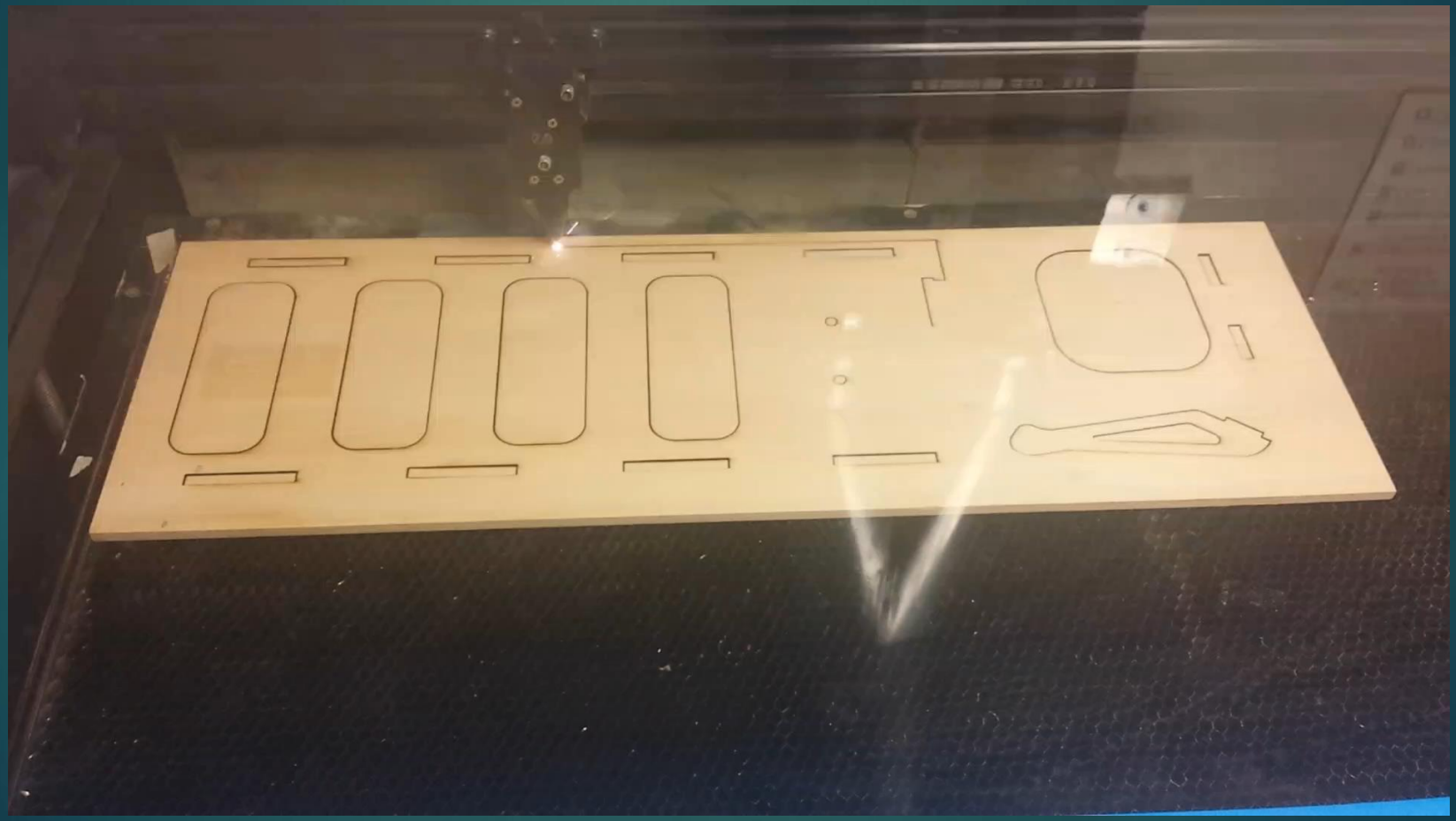
Final Design

- Overall length = 51.2"
- Overall Wingspan = 64.9"
- Dry Weight = 5.53-lbs
- Cruise Speed of 40-50 MPH
- Capable of 7 Minute Flight at Full Power
- Capable Dropping 4 Champro Balls



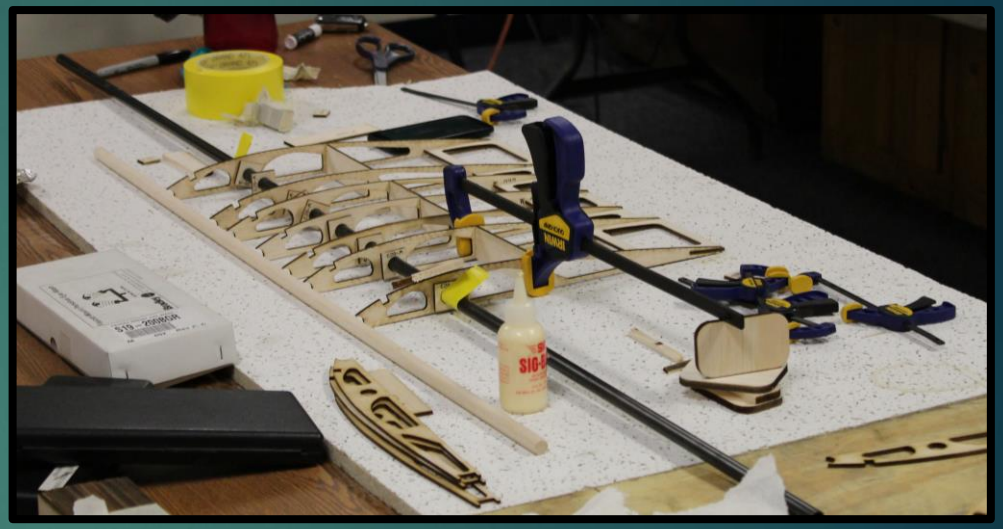
Manufacturing

- Laser Cutting

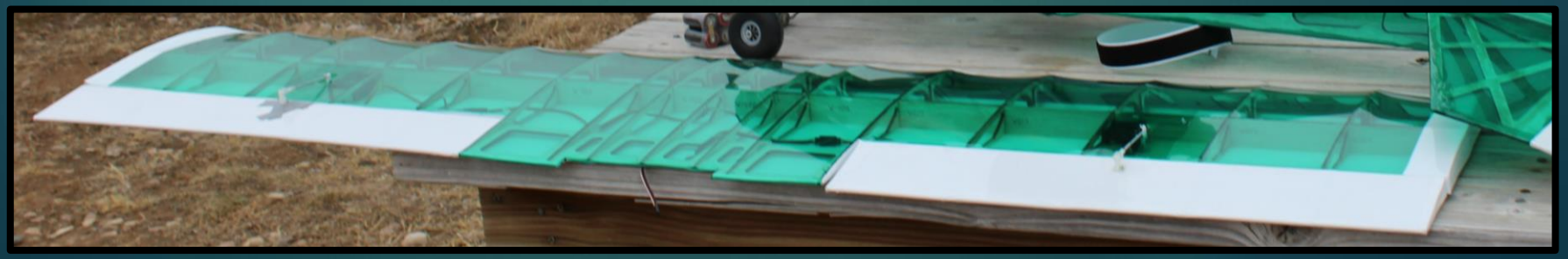


Manufacturing

- Wing Group

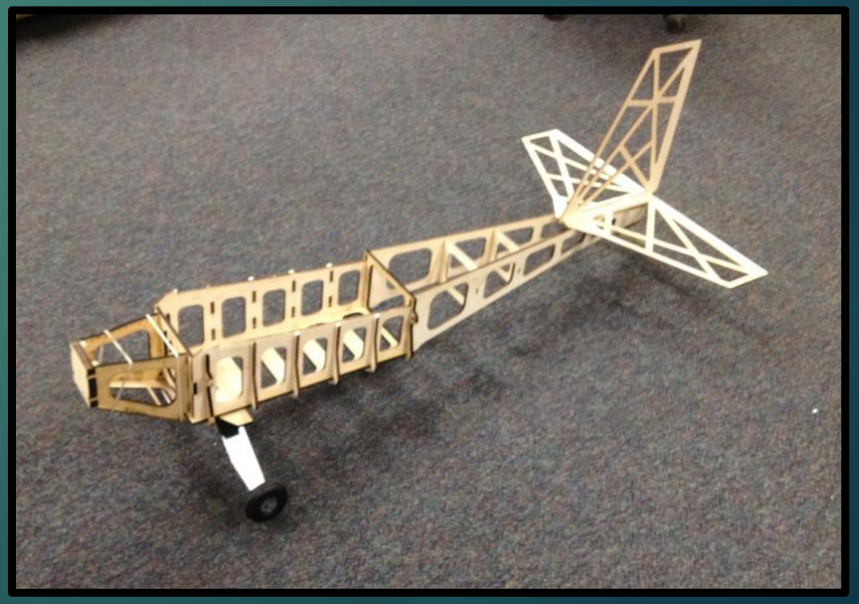


- Simple, tabbed assembly using SIG Bond glue
- Wing group => Structure, controls covering, electronics
- Proved strong with only one carbon fiber rod



Manufacturing
- Fuselage Group

- Additional use of tabs
- Lightweight, strong SIG glue
- Simple, fast assembly



Manufacturing
- Complete Assembly

Testing

- Maiden Flight: Fort Collins, CO
- Initial flight testing:
  - flight time
  - speed
  - flight characteristics
- Propeller testing
  - 10x8
  - **11x7**
  - 12x6

Testing

- Mission testing
  - 5 lb payload test
  - Increments
- Ball drop ground test
  - Payload load time
- Wing extensions, 16 in.
  - More lift, less speed
  - Dominated by wind
- Extensions removed
  - Less drag
  - Could pass tip test

Competition

- Friday through Sunday
- 84 Teams Competed
- Process:
  - Tech Inspection
  - Flight Line
  - Ground Mission

Competition

- Emergency Purchases
- Battery Charging
- Repairs
- Discussion with Fellow Competitors
- Chaotic

Competition

- Chaotic

Competition

- Ground Mission
  - Reattempt
- Flight Mission 1
  - Battery Issues
  - Very Stable Aircraft
- Flight Mission 2
  - Takeoff Box
  - Battery Capacity

Competition

- Crash!
  - Unrepairable
  - No Ground Mission Reattempt
- 56th out of 84 Teams


NDSU
AIAA

2016 Competition

- Design/build/fly two planes
- One will be transported inside the other plane
- Assembled on the ground and flown additional missions

NDSU MECHANICAL ENGINEERING

AHS MAV: NDSU Predator Quad

Advisor: Dr. Bora Suzen
Students: Mitchel Nordahl, Luke Novak, Adam Stolt, Emily Nordahl

Innovation

- Flying a micro air vehicle under 500g that is capable of a reasonably long flight time
- Ability to be flown out of the line of sight

Goals

- To produce a micro aerial vehicle that is capable of:
  - Vertical take off and landing
  - Flown out of view of the pilot
  - Successfully acquire a target
  - Hover over target location for set time
  - Maintain stable flight

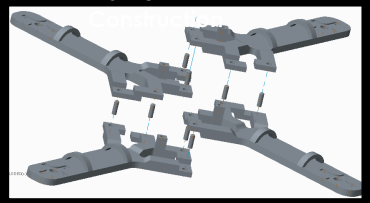
New & Progressive

- Quadrotor design
- Low weight & ease of flight
- Innovative 3D printed frame
- Parts made to be integrated easily
- Camera hinge & housing
- OpenCV used for visualization
- Python scripted commands

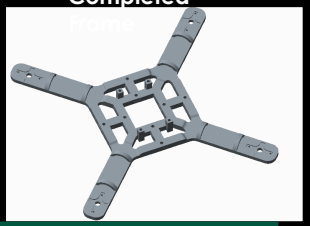
Methods Tested

- Carbon fiber frame
  - Not precise & sturdy enough
- Higher pitch props
  - Too much wobble
- Lighter motors
  - Not enough thrust
- 3DR Pixhawk Setup
  - Two batteries needed

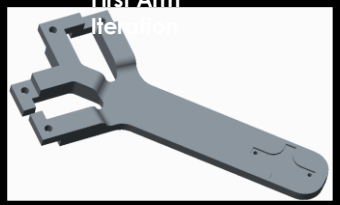
Frame



Completed

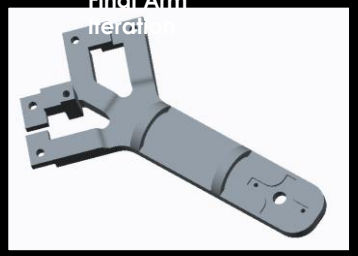


First Arm Iteration



Camera & 3D Printed Case

Final Arm Iteration



Target Acquisition

Electronics

- The Quad System utilizes the APM 2.6 control board & Mission Planner software to maintain a stable flight.
  - Camera(1.8 mm focal length)
  - 3DR Transmitter
  - 6A UBEC Speed Controllers
  - AR610 Receiver
  - Eflight 250 2200kv Motors
  - 5x3 Props
  - 11.1 V 1000 mAh Battery
  - Turnigy Volt Meter
  - Custom Kill Switch

Structure

- 3D printed frame - PLA
  - Four motor arms
  - Battery & sonar below frame
  - Controller, Receiver, & Transmitter above frame
  - Custom camera holder

→ 470 grams weight

Top Electronics

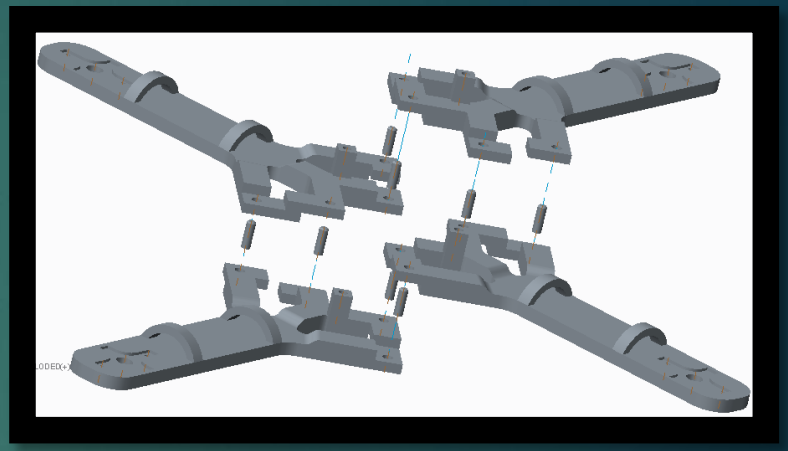
Bottom Electronics

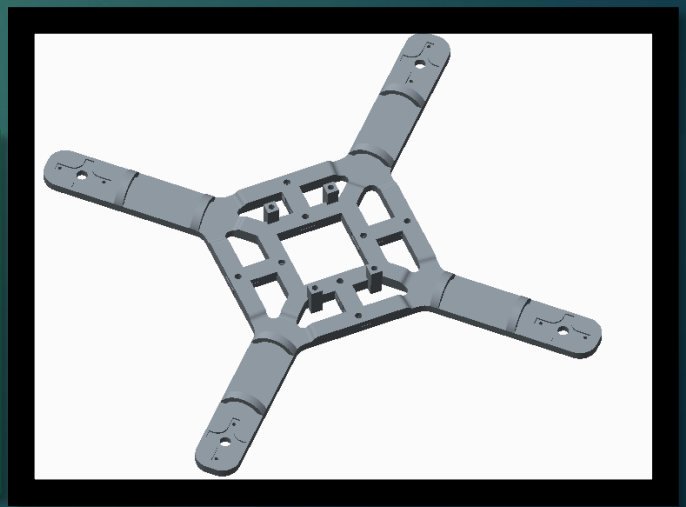
Competition 2015

- Vertical take-off and land capable
- Must be less than 500 grams
- Must be no larger than 17.7inches in any direction
- Must detect 1 target and return to home

2015 Design

- Consisted of four identical wings.
- Were pinned together with breakable pins. This reduced damage to the vehicle because the pins would fail before the wings would.
- Was entirely 3D printed.
- The entire vehicle system weighed 470 grams.
- Incorporated a camera and a sonar sensor for video and altitude detection.



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3D printed frame - PLA
Four motor arms
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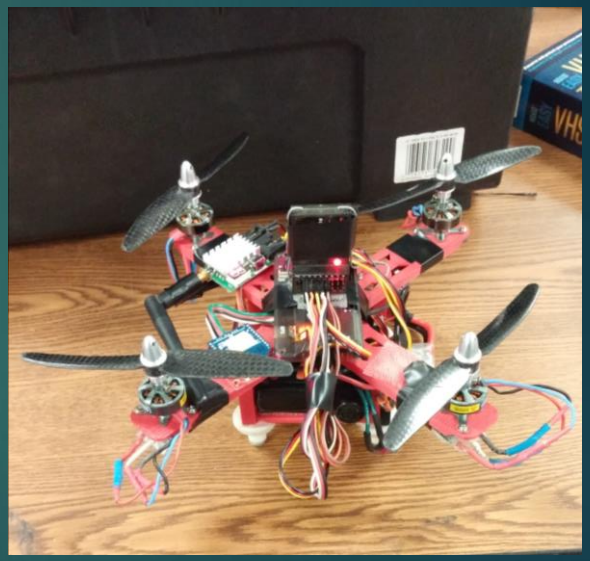
Custom camera holder

Competition 2016

- Vertical take-off and land capable
- Must be less than 500 grams
- Must be no larger than 17.7inches in any direction
- Must find 3 targets individually
- Must avoid an obstacle in the search area
- Must return to home after finding all the targets

2016 Design

- Similar to last year's design in regards to electronic components.
- Added another sonar sensor for obstacle detection
- This year has one solid piece frame.
- Vehicle weighs about 475 grams.
- This year we will be attempting fully autonomous flight.



Students *Involved*

- AIAA DBF Team:
  - Eric Cochrane
  - Mathew Sharpe
  - Ryan Solstad
  - Jake Williams
  - Greg Matson
  - Luke Novak
- MAV Team:
  - Mitch Nordahl
  - Emily Nordahl
  - Adam Stolt
  - Luke Novak
- AIAA student members

Thanks to North Dakota Space Grant Consortium making these experiences possible.