

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



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

Dickinson State College, Dickinson, ND





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

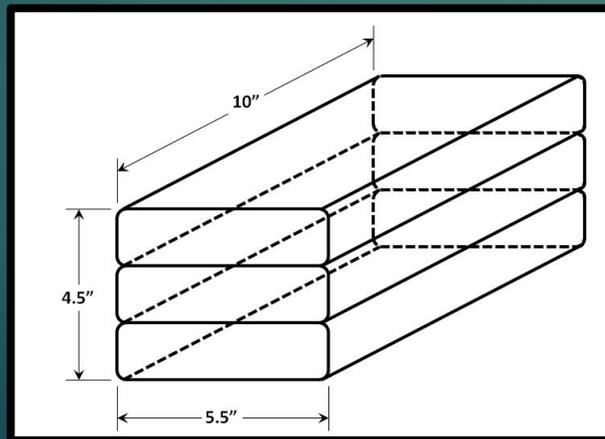
- ▶ AIAA DBF - Cessna & Raytheon
- ▶ Electric, Remote Control Aircraft
- ▶ 1 Ground Mission and 3 Flight Missions
- ▶ Tucson, Arizona



Competition Guidelines

Ground mission – Payload loading time

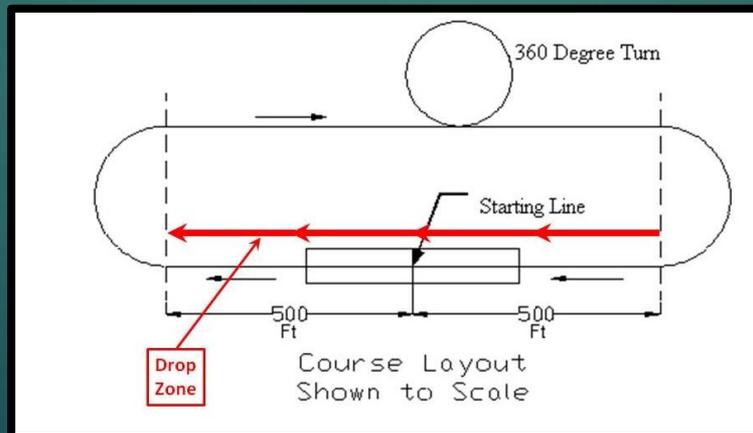
- ▶ Mission starts with airplane empty and hatches closed
- ▶ Payload for mission 2 is applied
- ▶ Remove mission 2 payload and install mission 3 payload
- ▶ Must be completed within 5 minutes from start



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



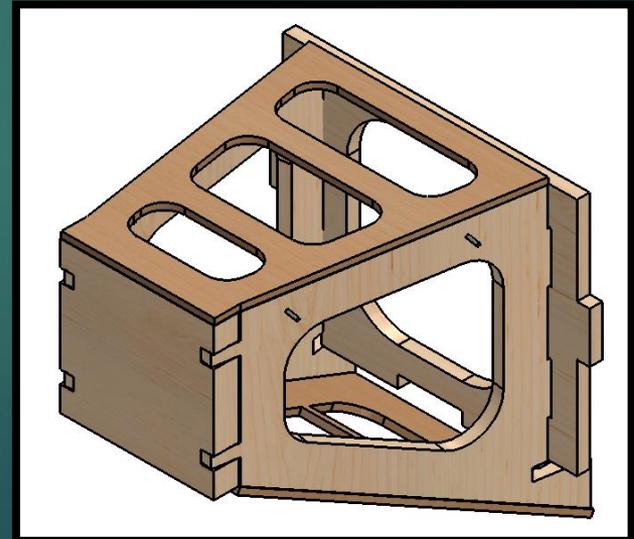
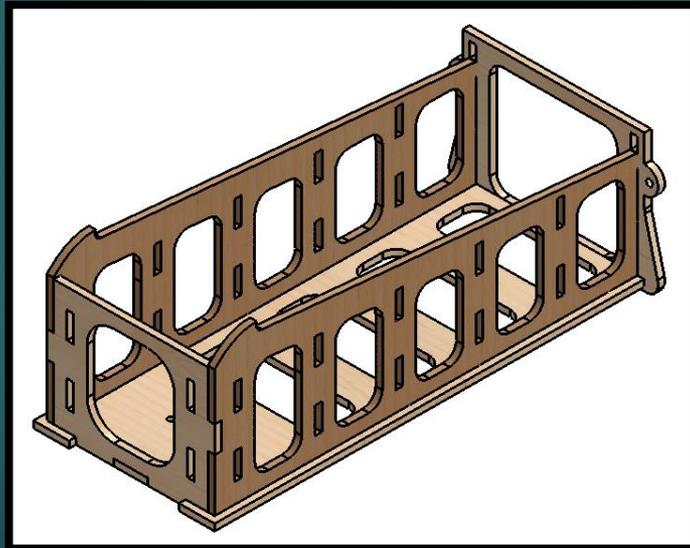
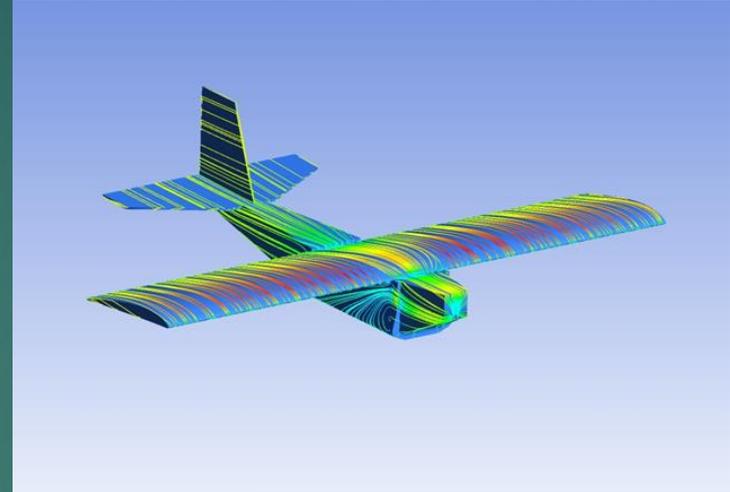
Constraints

- ▶ 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

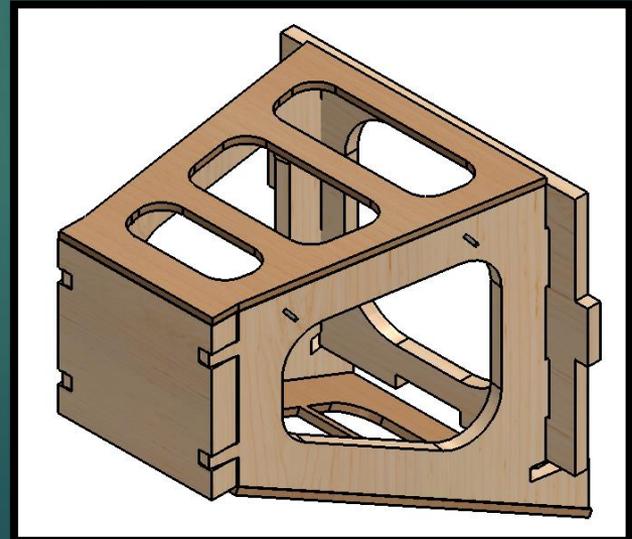
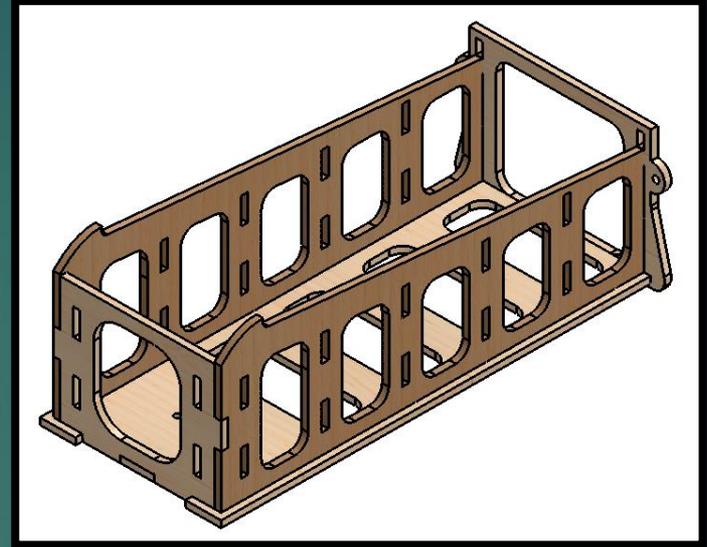
Spars/Nose

▶ Spars

- ▶ Aerodynamic
- ▶ Strength

▶ Nose

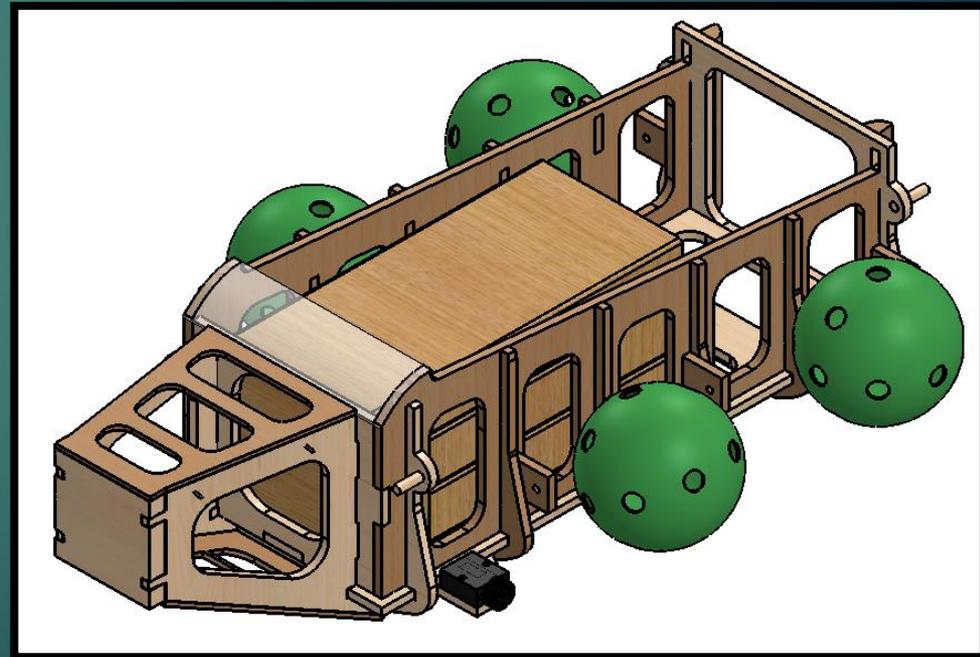
- ▶ Holds batteries and ESC
- ▶ Primarily basswood
- ▶ Removable top



Design - Fuselage

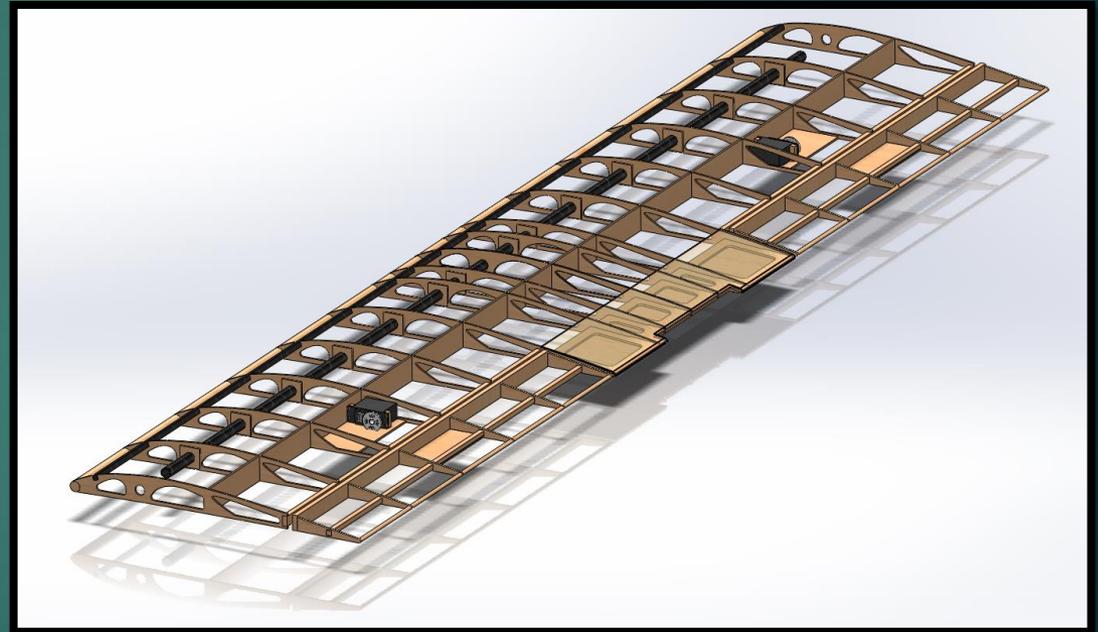
Final Design

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



Design - Wing Structure

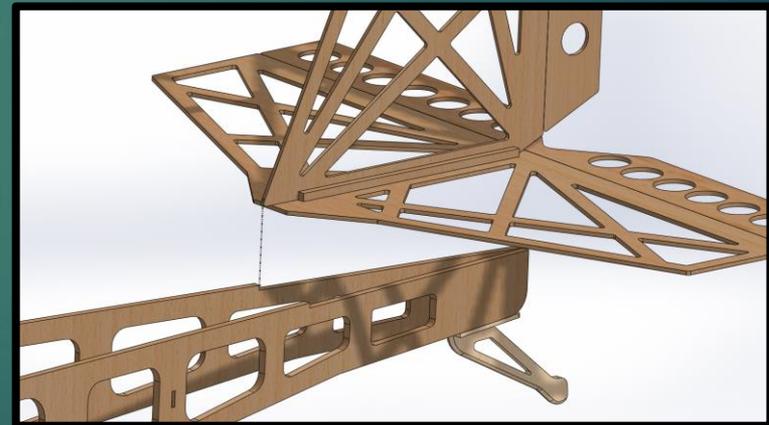
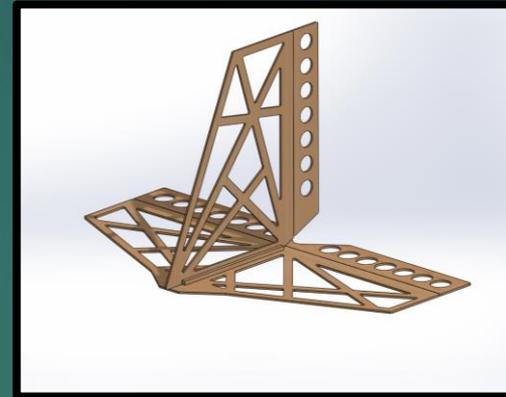
- ▶ Balsa Dowel For Leading Edge
- ▶ .5" Carbon Fiber Hollow Tube
- ▶ Ailerons Sized 19% of Planform Area



Design - Tail

Assembly & Controls

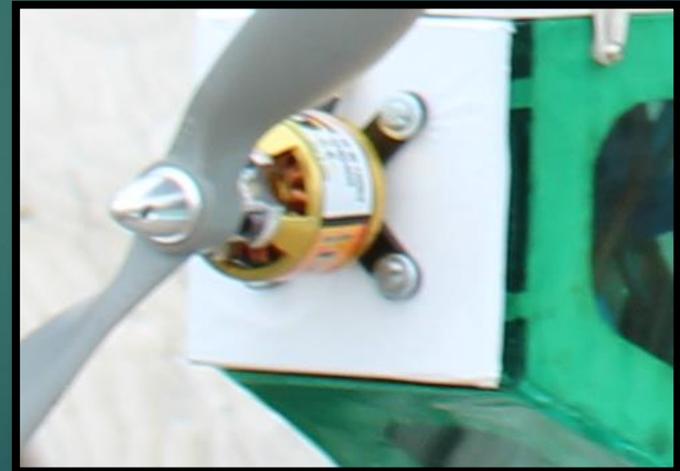
- ▶ Weight & Strength
- ▶ High strength, rounded corners on most parts
- ▶ Hole cutouts & truss- like system
- ▶ Elevator controls – 20% of chord
- ▶ Deflection TBD
- ▶ Tail drops into notch on fuselage



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



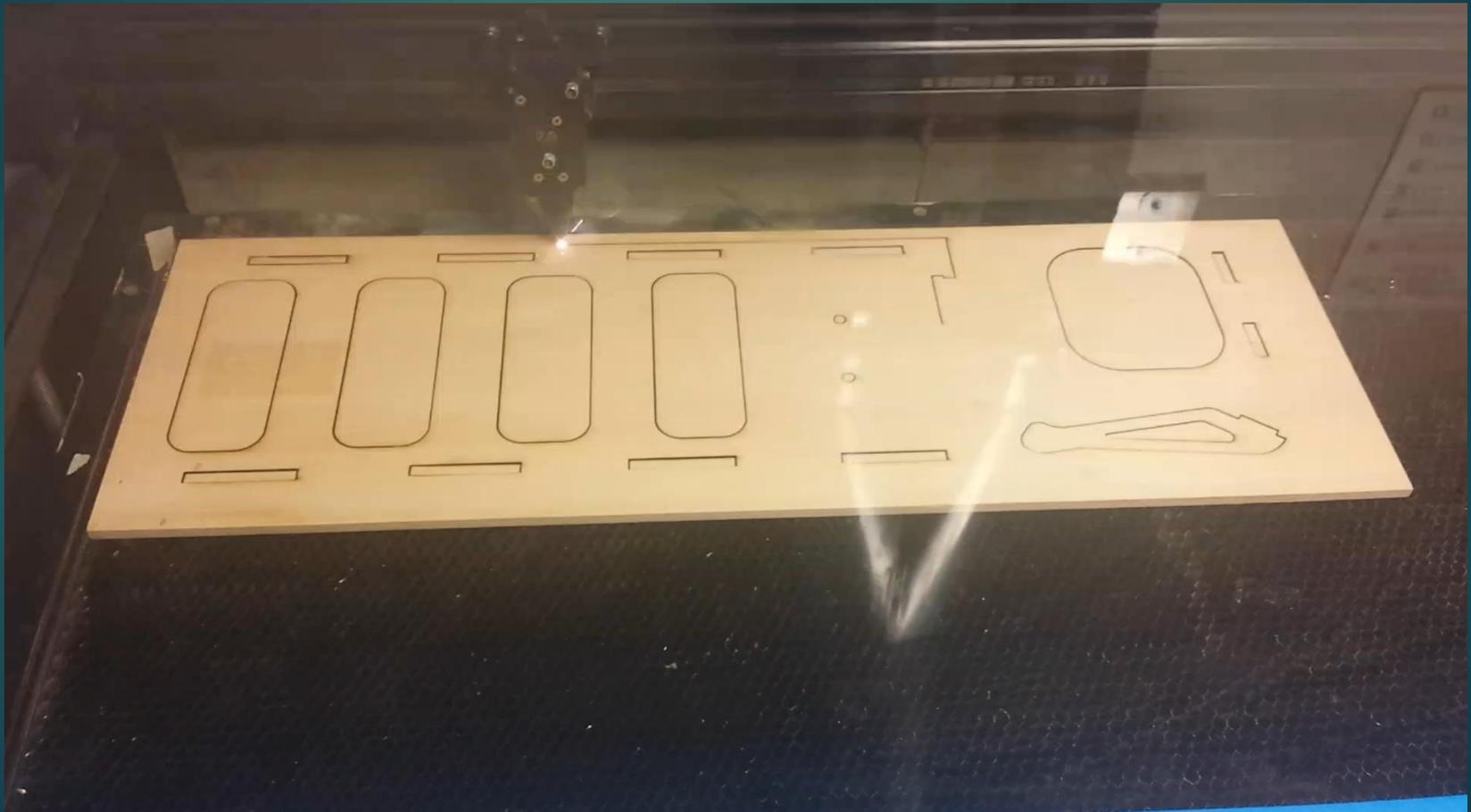
Final Design

- ▶ 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

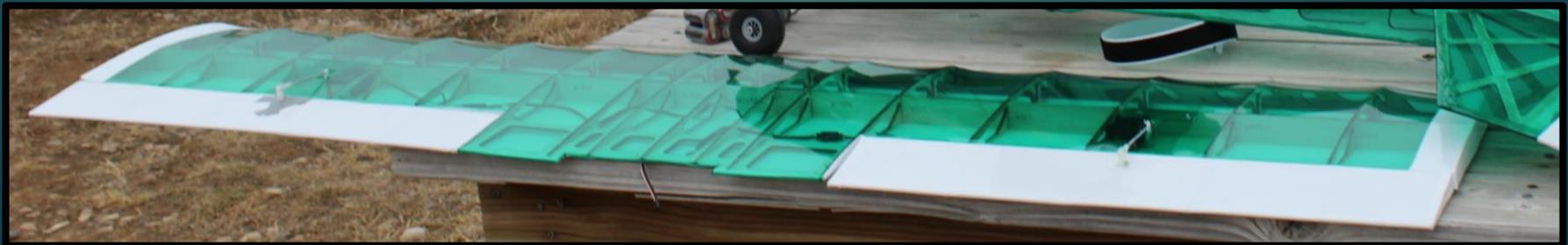
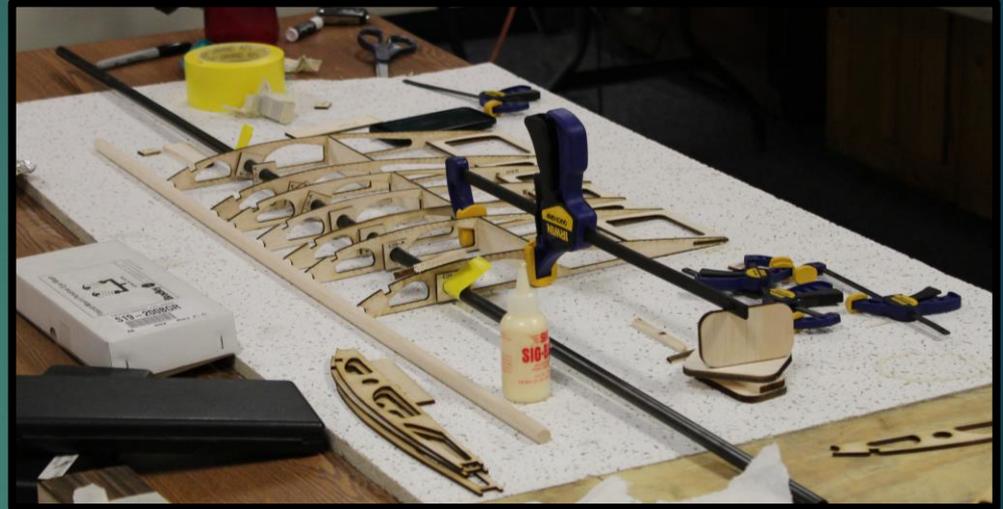
- Laser Cutting



Manufacturing

- Wing Group

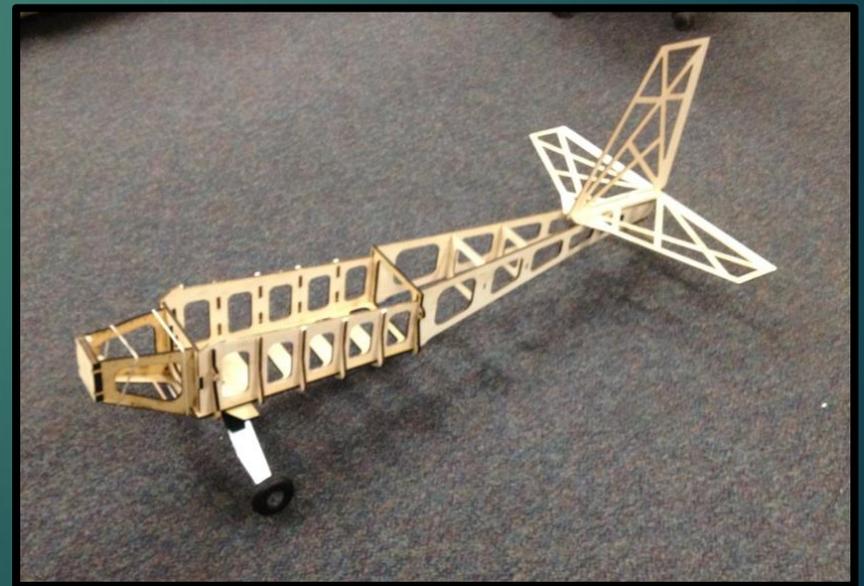
- ▶ Simple, tabbed assembly using SIG Bond glue
- ▶ Wing group => Structure, controls covering, electronics
- ▶ Proved strong with only one carbon fiber rod



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





2016 Competition

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



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

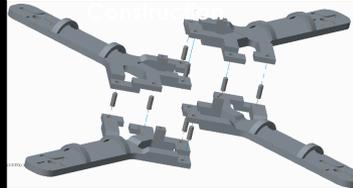
New & Progressive

- 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

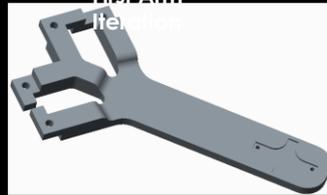
Frame



Completed



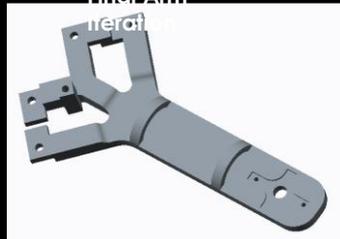
First Arm



Camera & 3D Printed Case



Final Arm



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



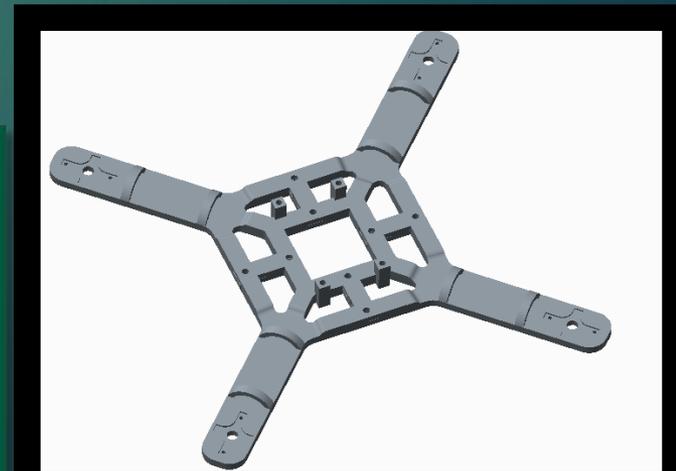
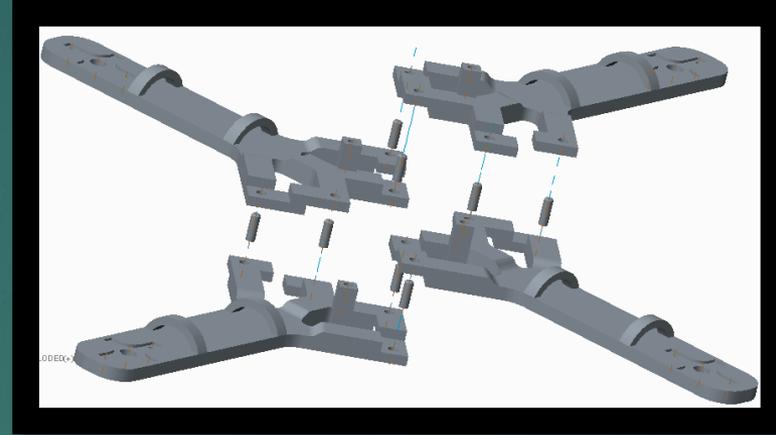
Competition 2015



- ▶ 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.





NDSU MECHANICAL ENGINEERING

AHS MAV: NDSU Predator Quad

Advisor: Dr. Bora Sluzen
 Students: Michel Nordahl, Luke Novak,
 Adam Slot, Emily Nordahl



<p>Innovation</p> <ul style="list-style-type: none"> 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 	<p>Frame Construction</p> 	<p>Completed Frame</p> 	<p>Electronics</p> <ul style="list-style-type: none"> The Quad System utilizes the APM 2.6 control board & Mission Planner software to maintain a stable flight. 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
<p>Goals</p> <ul style="list-style-type: none"> To produce a micro aerial vehicle that is capable of: <ul style="list-style-type: none"> 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 			<p>Structure</p> <ul style="list-style-type: none"> 3D printed frame - PLA Four motor arms Battery & sonar below frame Controller, Receiver, & Transmitter above frame Custom camera holder
<p>New & Progressive</p> <ul style="list-style-type: none"> Quadrotor design Low weight & ease of flight Innovative 3D printed frame 	<p>First Arm Iteration</p> 	<p>Camera & 3D Printed Case</p> 	

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.