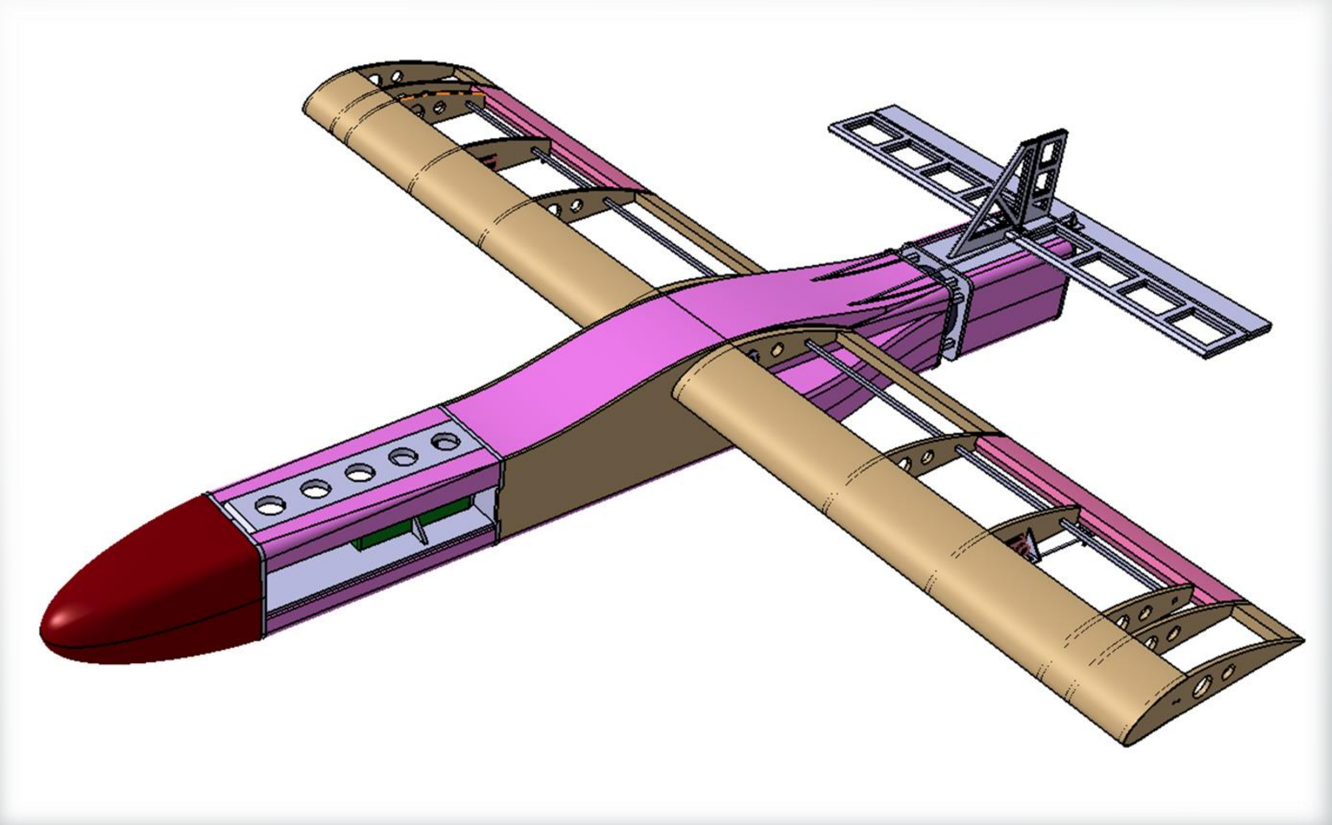
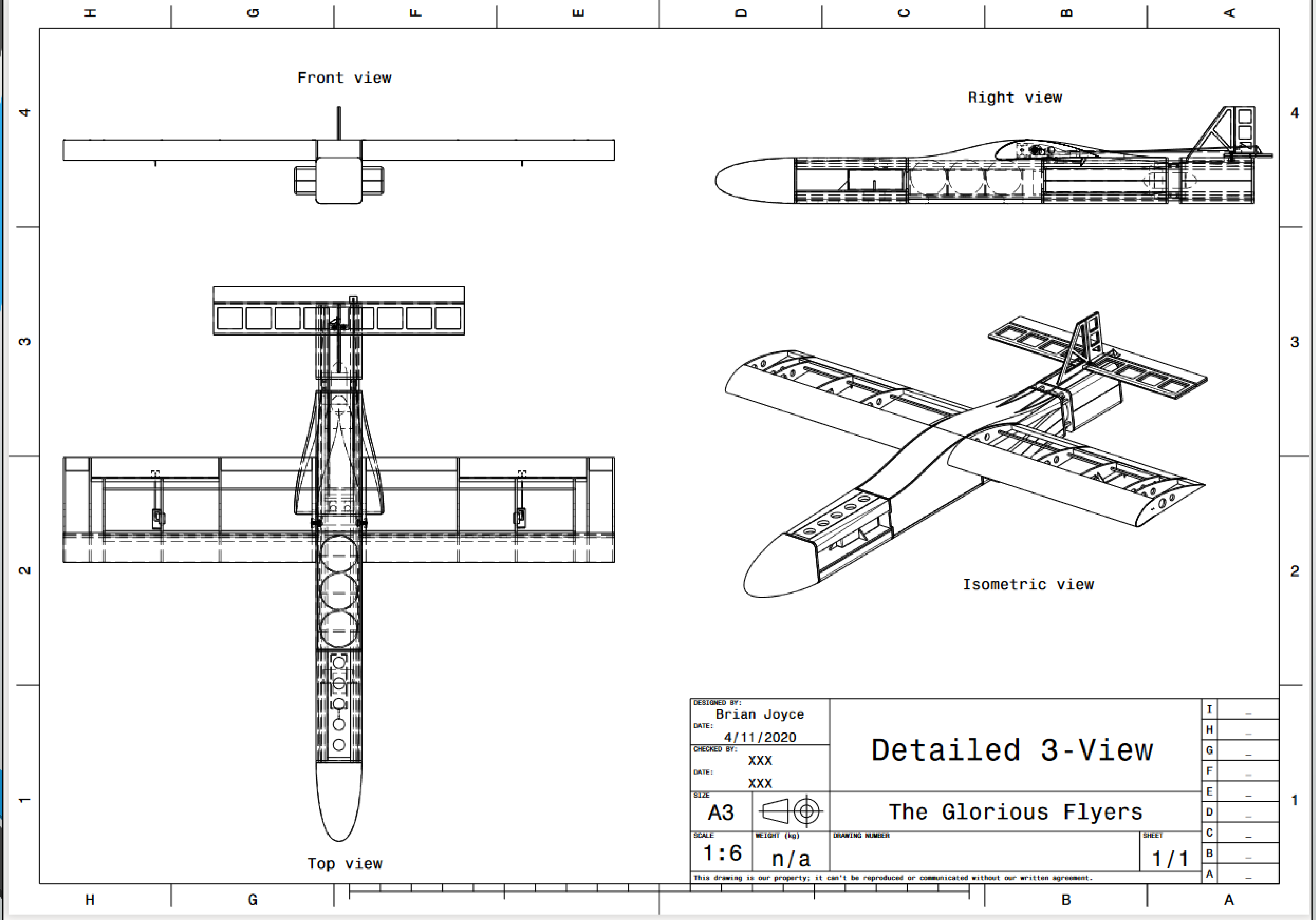
Team #13:
The Glorious Flyers and The EDF Earl




Front view
Right view
Top view
Isometric view
DESIGNED BY:
Brian Joyce
DATE:
4/11/2020
CHECKED BY:
XXX
DATE:
XXX
SIZE
A3
SCALE
1:6
WEIGHT (kg)
n/a
DRAWING NUMBER
SHEET
1/1
Detailed 3-View
The Glorious Flyers
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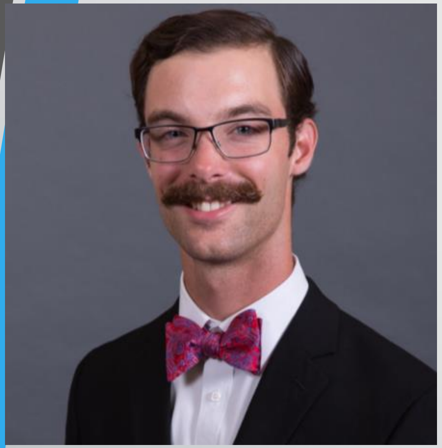
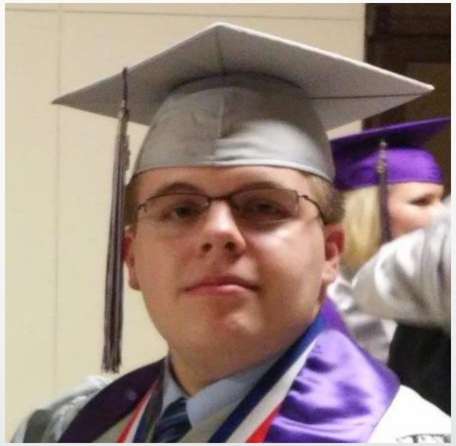
Team Members



Brian Joyce
Structures

Cole Lynch
Propulsion



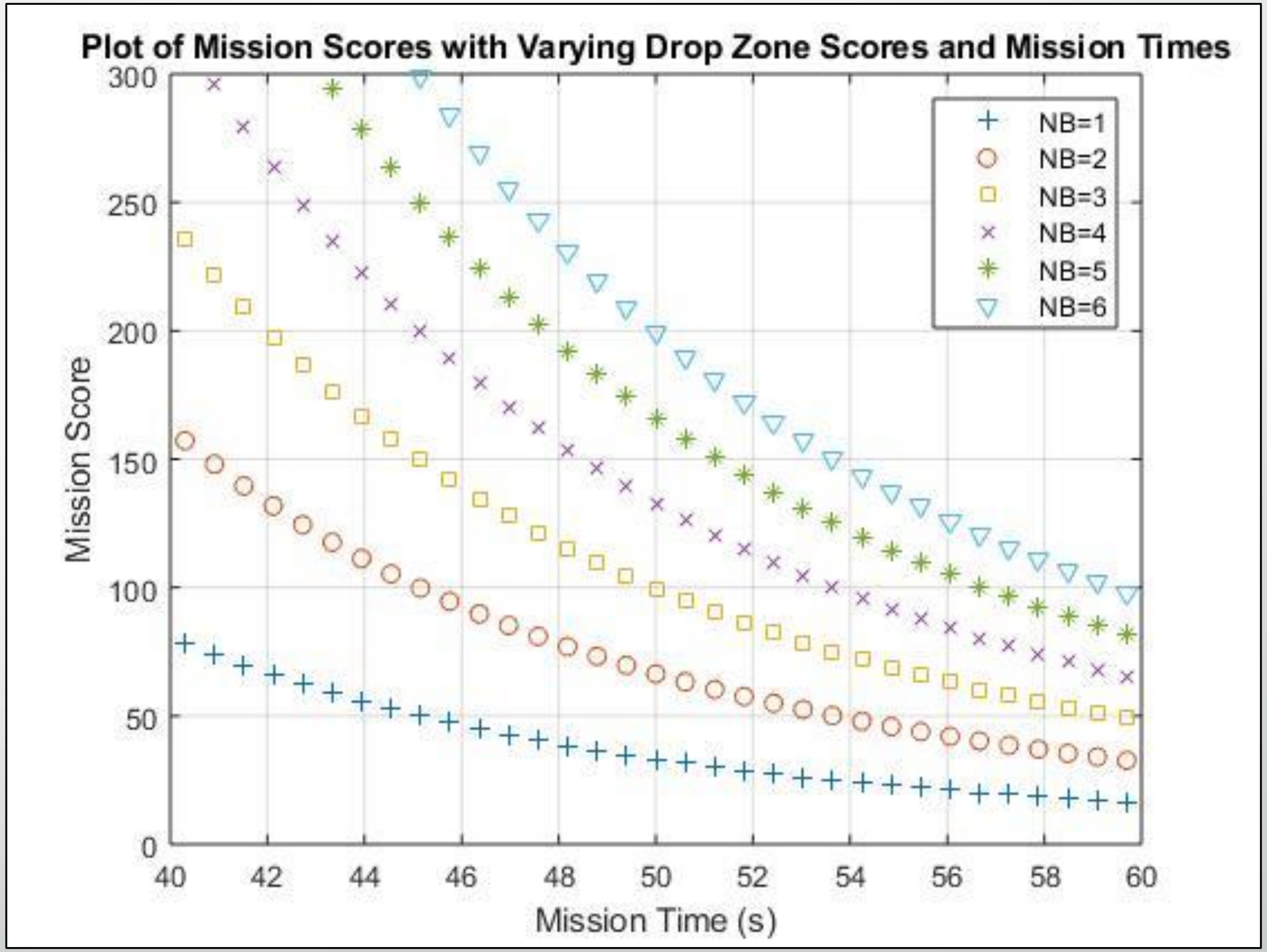
Dale Palmitier
Stability and Controls

Brendan Lajza
Aerodynamics

Mission Description and Requirements

- Design and build a remote-controlled aircraft that was planned to participate in the 2020 Boeing Bronze Propeller Competition, hosted at Wichita State University.
- Competition Requirements:
  - The aircraft is transported to the flight zone inside a 11''x7''x36'' box and assembled on-site.
  - Inside a 400'x100' fly zone, complete 5 laps around two cones spaced 300' apart.
  - After the second lap, deposit of payload of tennis balls into a target zone of a marked 40' square. (Double points for dropping within a small 20' square zone located inside the first zone.)
  - The payload dropping mechanism must be completely autonomous, and the vehicle must be hand-launched.
  - Each separate flight adds to the team's overall score.
- Mission Scoring (MCSR) Equation:
  - MSCR = $NB * \left({}^{120}/_{MT}\right)^4$
  - NB = Number of tennis balls landed in the target zone
  - MT = Mission Time, beginning when the plane is launched and stopping when it comes to stop after landing.

- The team expects this design to complete the mission in under 60 seconds, and the aircraft is designed for 3 tennis balls, leading to the yellow, box line in the figure to the right.

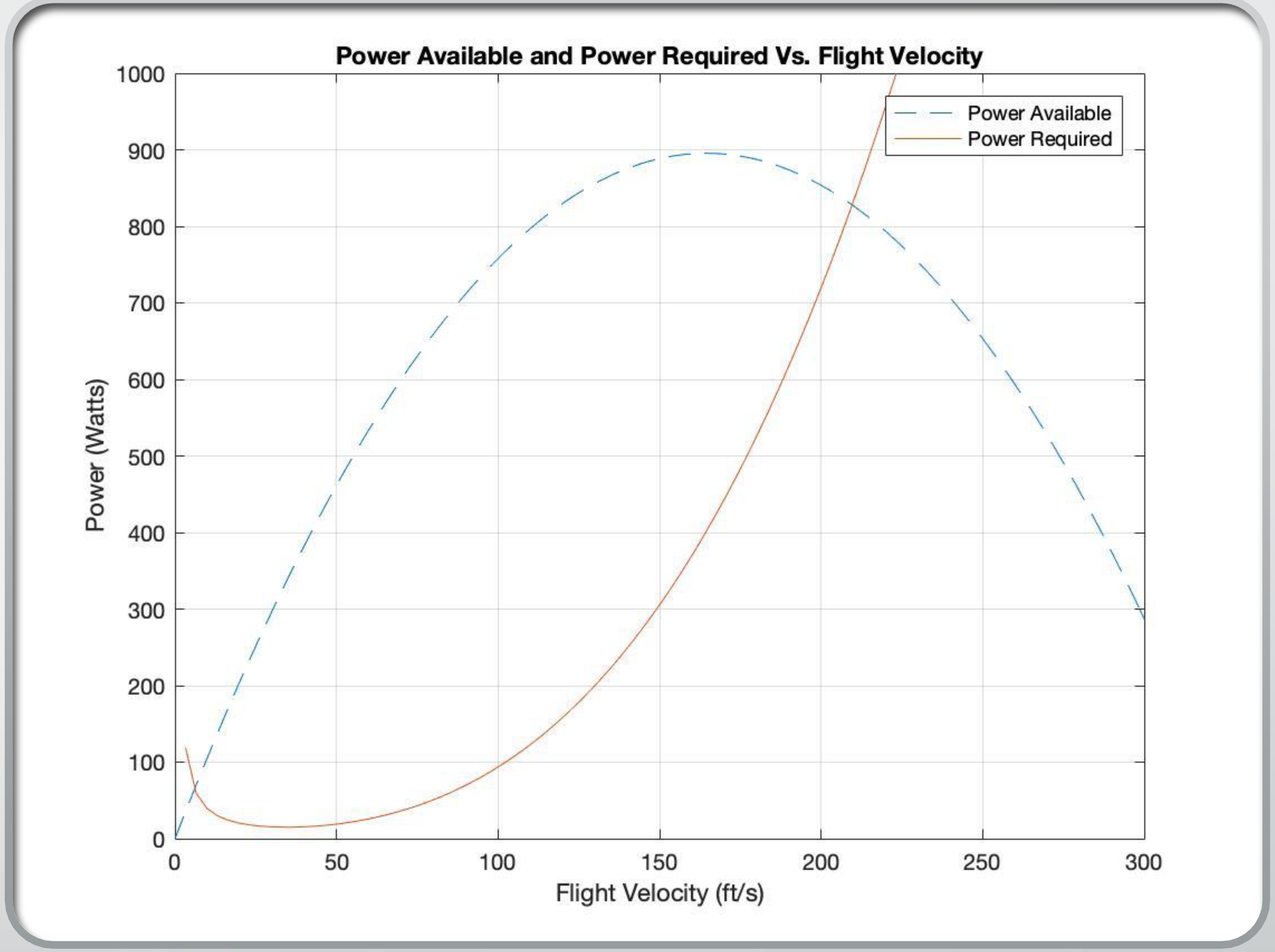


What is an EDF?

- EDF is an acronym for Electrically Ducted Fan
  - In this case, the ducted fan pulls outside air through inlets on the side of the aircraft, and creates thrust by pushing the air out the rear of the aircraft through a thrust tube
- EDFs can spin an extremely high RPM and generate large amounts of thrust; they possess good performance at relatively low airspeeds
- The use of an EDF allows for a low drag profile and reduces the chance of damage to the propulsion system upon landing
- The model shown here can produce 6.5 lbf of static thrust at 50,000 RPM
- Power is supplied via a 6-Cell, 22.2 V, 1800 mAh, 65 C battery, and is controlled via a 120A ESC (Electric Speed Controller)
- Air is fed into the EDF via a split normal inlet, which was designed using 3D CAD software

Why a Ducted Fan?

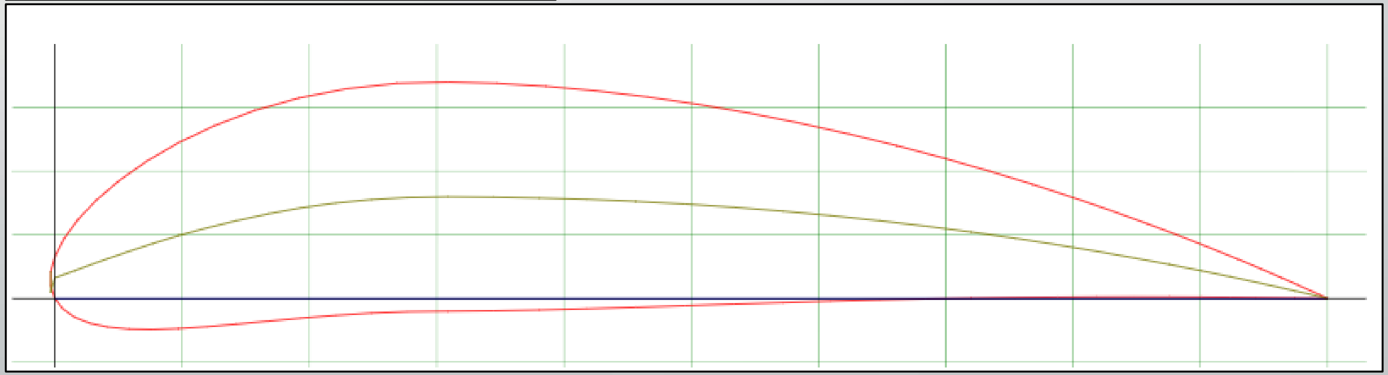
- Utilizing an EDF as the propulsion system over a tradition propeller eliminates the danger of the propeller being damaged during a belly landing of the aircraft
- Hand launching is made safer since the fan is shrouded in the fuselage of the EARL; there is no open propeller to avoid
- In exchange for generating large amounts of noise and quickly consuming power, the ducted fan enables relatively high-speed flight and fast turning
    - The EDF Earl possesses a cruise speed of 127 ft/s (86.6 mph) and is designed to make turns at an average loading of 10 g
    - Due to the equation used for scoring, a low mission time is favored over a larger payload; [MSCR = $NB * (^{120}/_{MT})^4$] flying at high speed enables a satisfactory mission score even when the payload is small (only 3 tennis balls)
- The EARL has a top speed of roughly 140 mph.



Aerodynamic Specifications

- The main wing of the aircraft is composed of a NACA 8318 airfoil with an area of 2.32 ft^2, and possesses no taper of twist.
    - The horizontal tail is a flat plate with an area of 0.49 ft^2 and no taper and the vertical tail is a NACA 0012 airfoil with an area of 0.22 ft^2, and a taper ratio of 0.45.
- The fuselage cross-section is a rounded rectangle, while the nose shifts from a rectangular prism to a cone.
- $C_{D,0} = 0.022$; $C_{Lmax} = 1.33$; $(L/D)_{max} = 12.75$

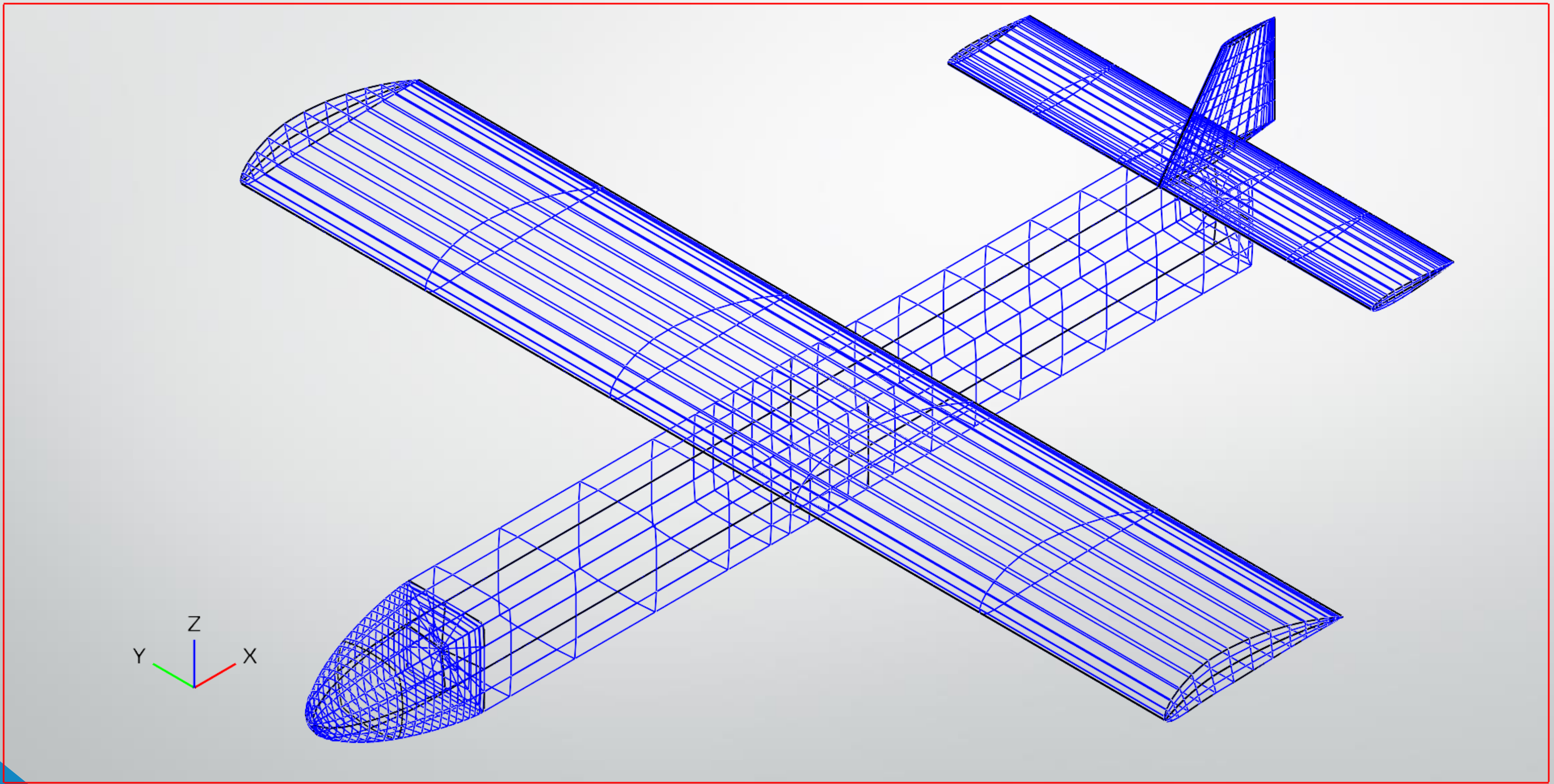
(NACA 8318 AIRFOIL)



Stability and Control Specifications

- The aircraft is designed such that the CG (center of gravity) is located over the payload. This will minimize shifting of the CG once the payload has been released.
- The aircraft was determined to be longitudinally and laterally stable by generating a model of it using VSPAero, where it was confirmed to possess a static margin of 11.18% The same simulation also resulted in the following equations:
  - $C_L = 5.27\alpha + 0.80\delta_e$
  - $C_Y = -0.08\beta + 0.00\delta a - 0.07\delta_r$
  - $C_M = 0.01 - 0.59\alpha + 1.58\delta_e$
  - $C_N = 0.03\beta - 0.62\delta_a - 0.03\delta_r$
  - $C_{\mathcal{L}} = -0.05\beta + 0.28\delta_a + 0.02\delta_r$

VSPAero Model



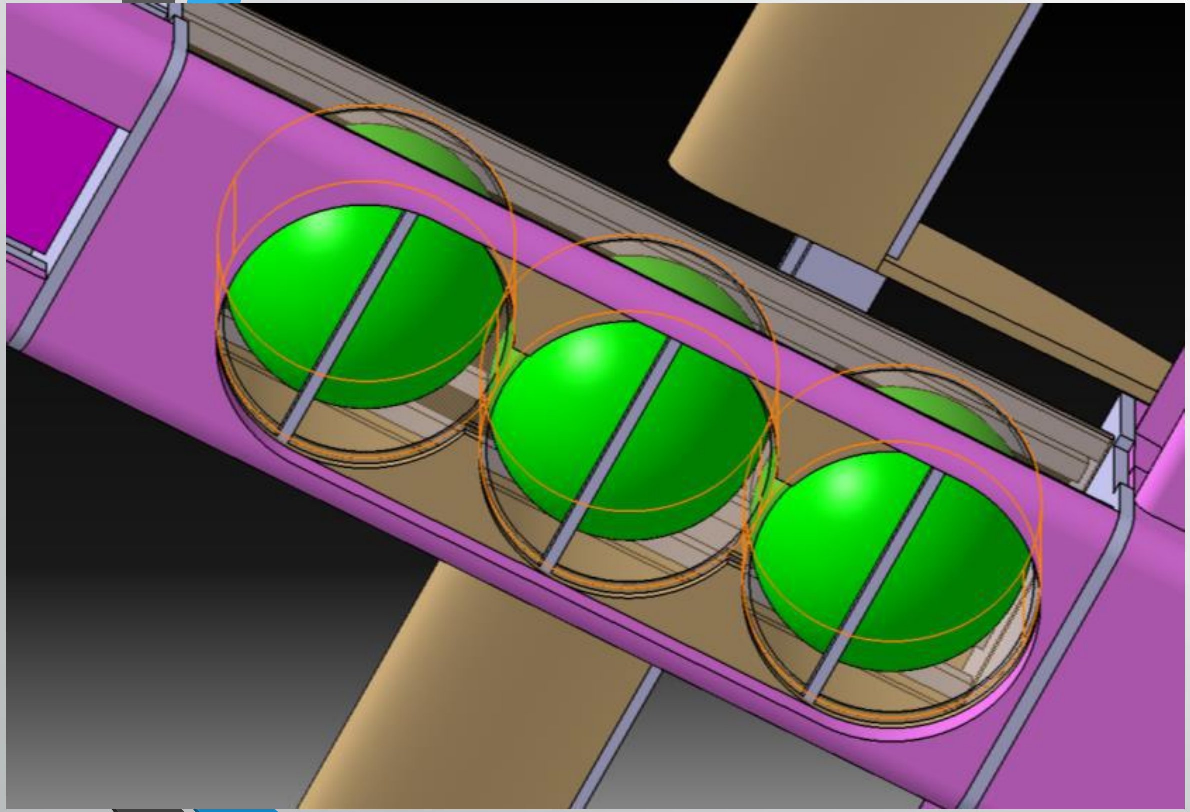
Structures

- Main fuselage composed of 8 longerons to minimize frontal area and maximize internal room
- Main wing breaks down into two halves for fitting inside the box
- Front nose cone is removable to keep fuselage length within the box limits
- Everything designed for withstanding 10g's (turning) plus 3g's (wind turbulence) all with a factor of safety of 1.5

Payload Release System Details

- The payload is kept within the aircraft until it is to be released via a sliding bar mechanism. The unit has 3 bars that hold the tennis balls in place; these bars slide out of the way upon the drop command, ensuring a snag free drop.
- The system will utilize an Arduino with a GPS module to determine its speed and location in real time and then use this data to determine when the payload would need to be released for the tennis balls to land in the center of the target zone.

Unreleased Payload Mechanism



Released Payload Mechanism