AE 528/628 Senior Design Project

Sky Shockers – Team 10

Meet the Team

Justice Ononiwu
Aerodynamics/Structures

Jimmy Herrera
Stability & Control/Structures

Mahmud Khan
Propulsion/Structures

The Bronze Propeller Competition

Mission

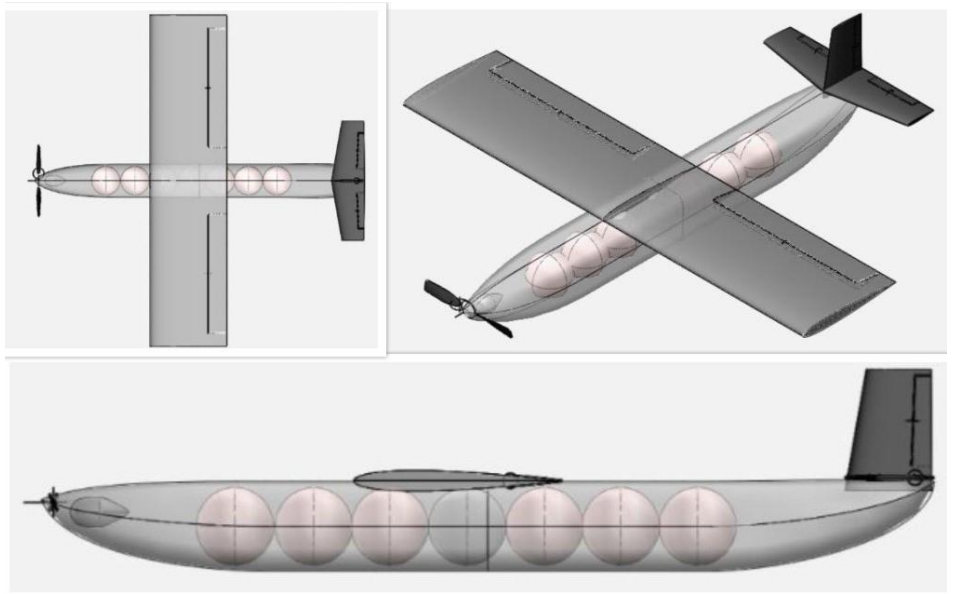
- Theme: *A Storable Semi-Autonomous Emergency Supply Aircraft*
- Mission Profile:
  - Remove aircraft from its storage box
  - Assemble and pass a structural test
  - Hand launch the airplane
  - Autonomously drop tennis ball payload after 2nd lap over target zone (40x40 ft / 20x20 ft)
  - Fly 5 laps around a 400 x 100 ft zone and land successfully
- Score is awarded based on flight time and number of tennis balls that landed in zone (20x20 ft zone receives more points)

Requirements & Constraints (R&C's)

- Aircraft must fit unassembled inside a 11x7x36-inch storage box
- Run with 1 LiPo battery pack/additional for payload release system
- Aircraft to be built of lightweight wood with a thickness of 1/32", 1/16", or 3/32"
- Permanent opening with no use of doors to contain the payload
- Single fuse for motor should be exposed, and easy to access and must be located 6 inches from propeller
- All internal components must be quickly accessible

Concept Selection Stage

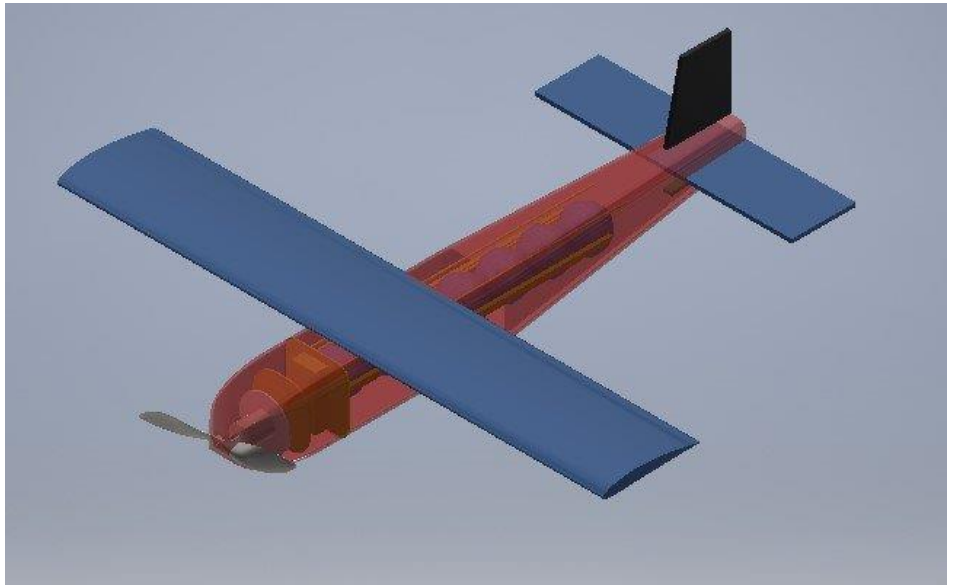
- Team proposes multiple designs that were hand-sketched and evaluated for how well they could perform the mission
- Selection criteria included belly landing capabilities, ease of assembly, accessible internal components, payload storage capabilities, and hand launching capabilities
- A screening process was done to reduce potential candidates from 20 to 6
- A final scoring process further reduced designs and final design was chosen
- Final design was named EL-Simpleton and is a simple, high-wing, tractor configuration airplane



First image of design developed during concept selection stage using VSP

Conceptual Design Stage

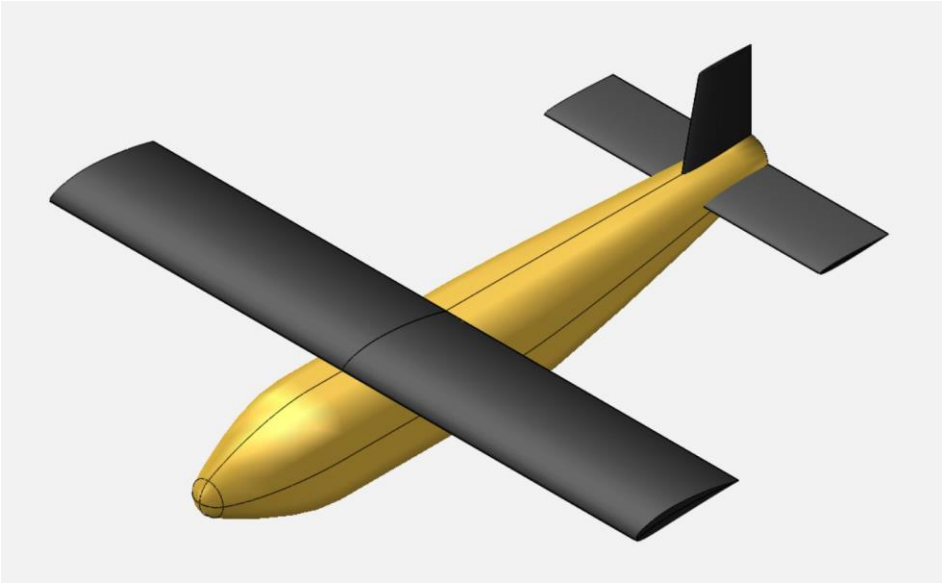
- Airplane is sized based on storage box and required wing loading/thrust-to-weight ratios
- Basic design questions are answered and design must meet R&C's
- Functional Area Work Goals:
  - Aerodynamics – Lift curve and Drag polar
  - Structures – Shear/Bending Moment diagrams, deflections, and flight envelope
  - Propulsion – Determine power required and evaluate a variety of components for analysis
  - Stability & Control – Size the tail and analyze pitching moment behavior
- Some resources used for this stage were: AE 333 (Mechanics of Materials), AE 324 (Fundamentals of Atmospheric Flight) & VSPAero
- Weight and CG were estimated using a component buildup approach



Second image of design generated during concept design stage using AutoDesk Inventor

Preliminary Design Stage

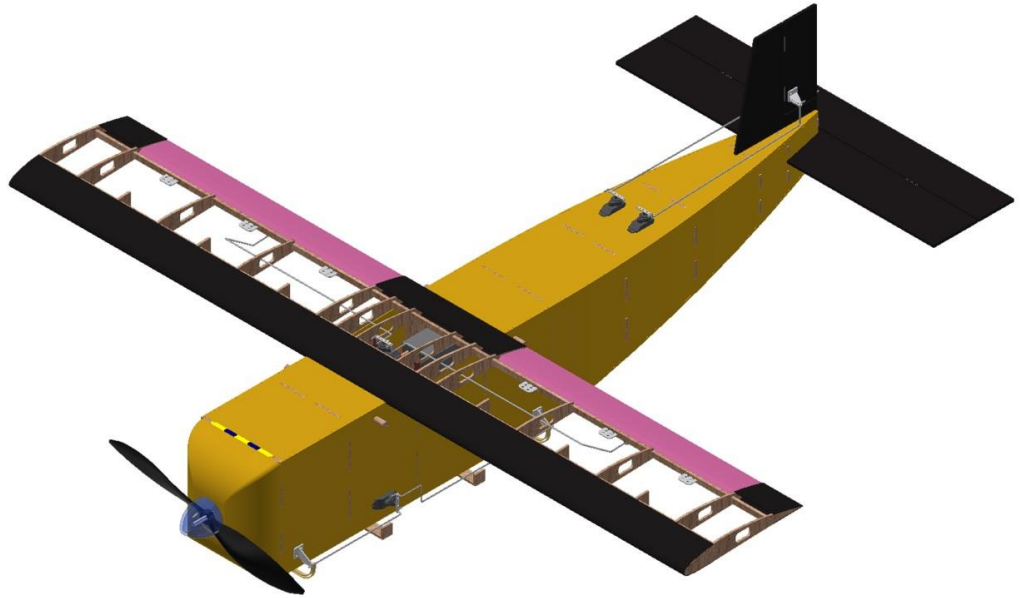
- Goal of this stage is mature the design and improve/add more details than previous stage
- Functional area work improvements:
  - Aerodynamics – Drag/lift coefficients and finalizing fuselage geometry
  - Structures – Internal structure defined and materials are selected
  - Propulsion – Components such as battery and propeller are selected
  - Stability & Control – Static margin, pitching moment, and CG improvement
- More advanced calculation methods were used in this stage; AE 525 (Flight Structures I), Nicholai Drag Prediction method, X-Plane, etc.
- Payload storage and release mechanism is defined
- Design is frozen with no major changes after this stage and team transitions to making aircraft "buildable"



Improved version of design generated during preliminary design stage using VSP

Detailed Design Stage

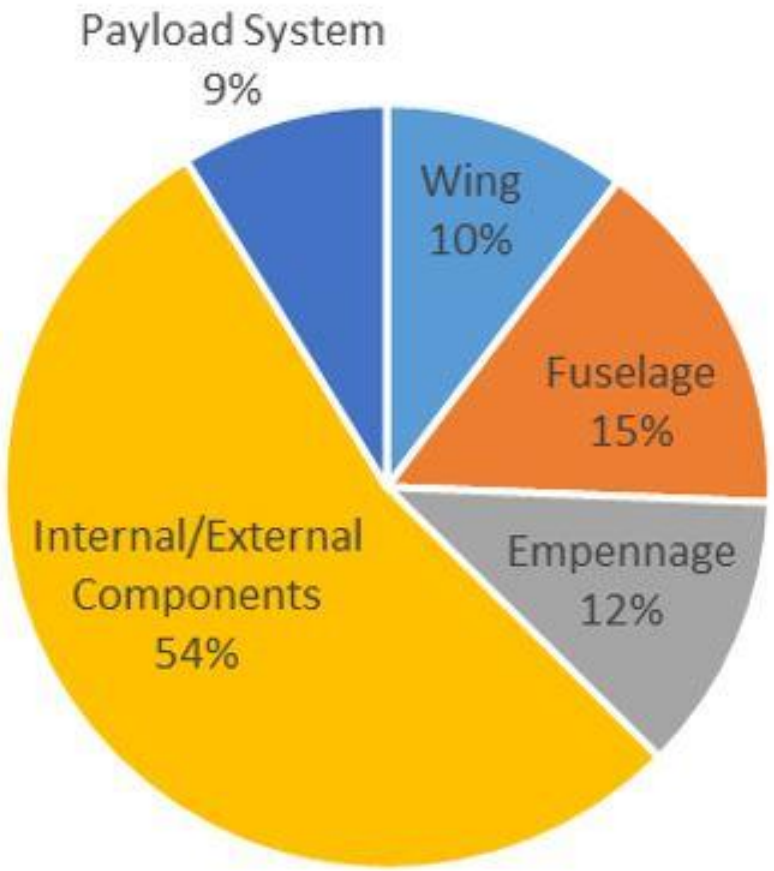
- Detailed questions about the manufacturing process were addressed
- Entire aircraft was created in CAD using AutoDesk Inventor with drawings generated as well
- Tooling to help with construction and ease of assembling components with precision was made
- A detailed guide on how to construct the aircraft was composed
- Laser cutting and foam cutting files were generated for the parts and tooling
- An inventory and spreadsheet with a list of components was made showing their cost as well
- A final and much improved weight prediction and CG estimation was made to define exact locations of internal components



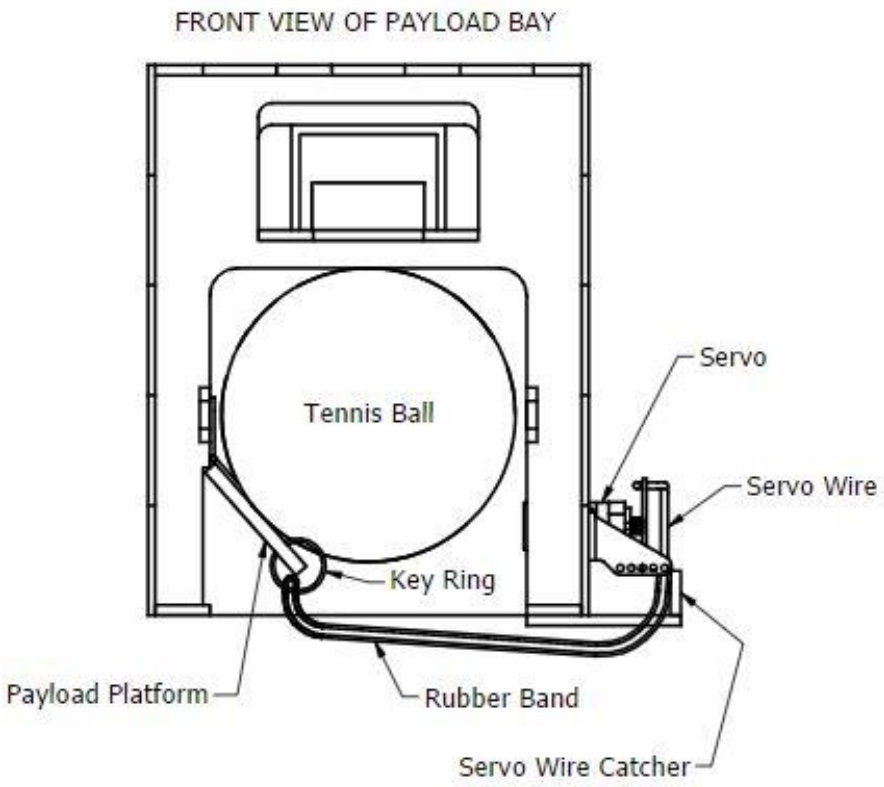
Final version of design generated during detailed design stage using AutoDesk Inventor showing all the parts assembled together

Aircraft Weight Distribution

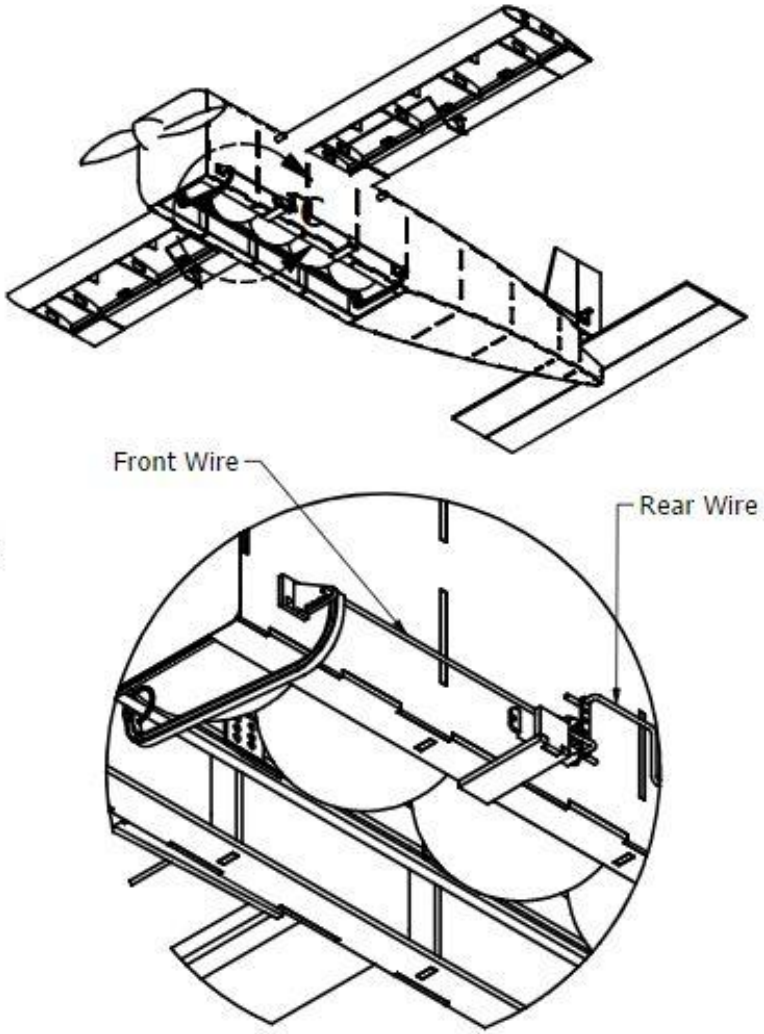
- To calculate the airplane's weight, estimates were made by using specific weight data from wood
- A list of all parts was made and their respective geometry used to estimate weight based on a known plank of wood dimension
- Their locations relative to a fixed point were used to generate moments that resulted in a CG location
- The figure shows the distribution of weight by each category of items within the airplane



Payload Release Mechanism

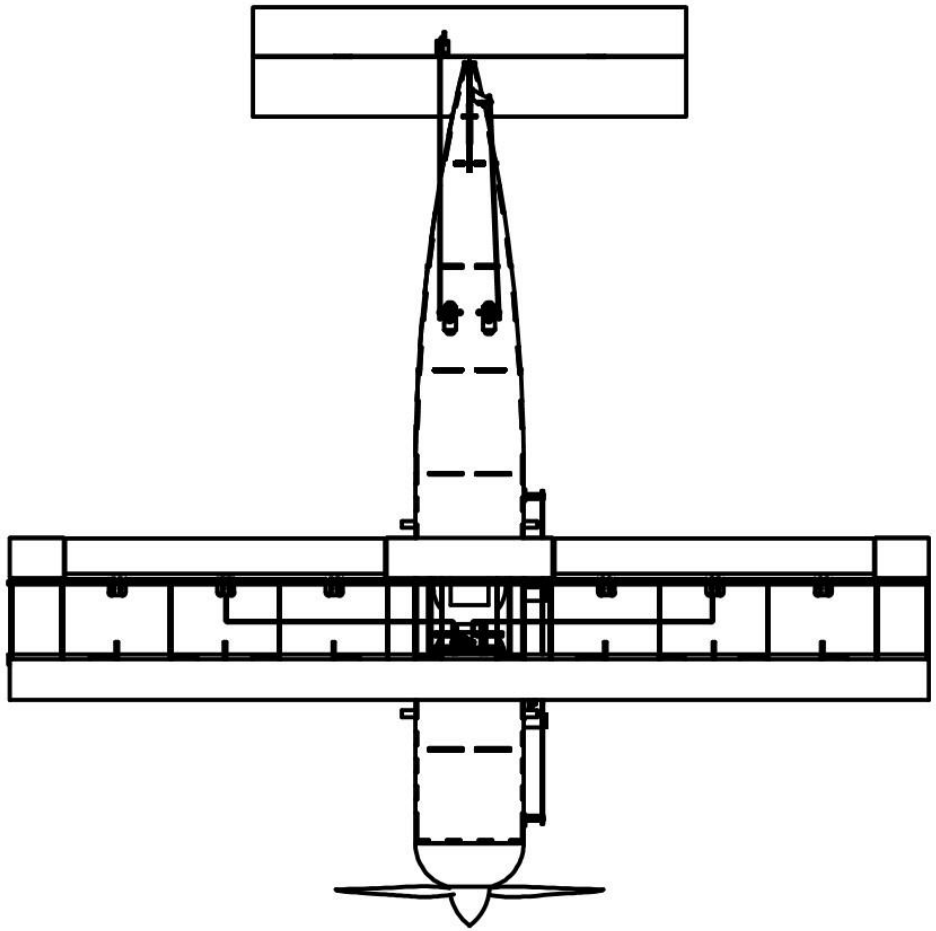


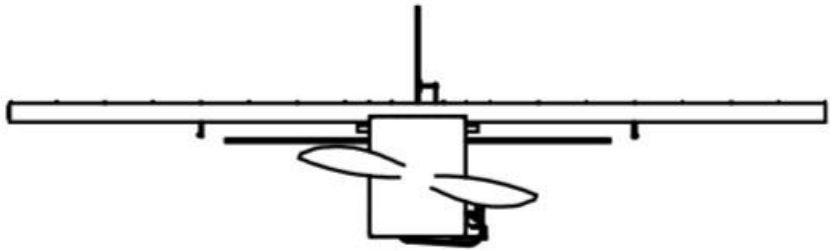
Payload Release Process:
1) Servo arm moves front wire back and rear wire forward
2) Both wires come out of control horn, tilt down, and are caught by catcher
3) Rubber bands slide off wires due to slight tilt
4) Payload platform moves out of the way, permitting balls to fall

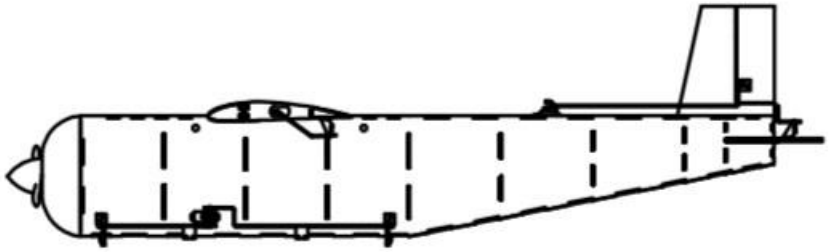


DETAIL VIEW OF UNDERSIDE

EL-Simpleton 3-View

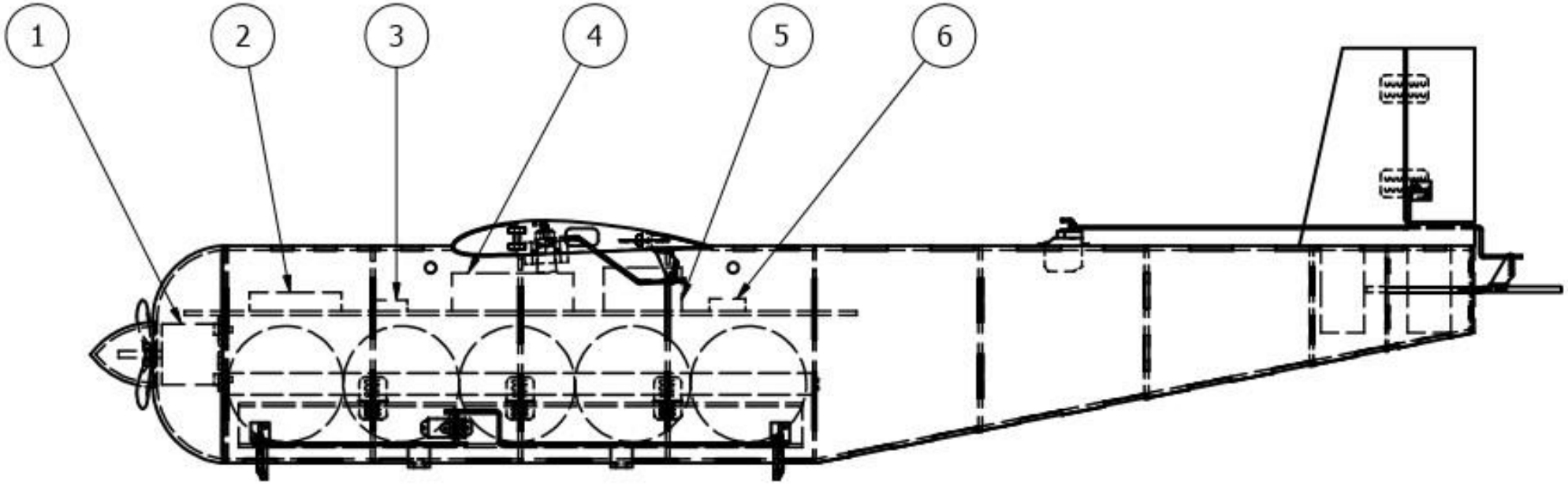




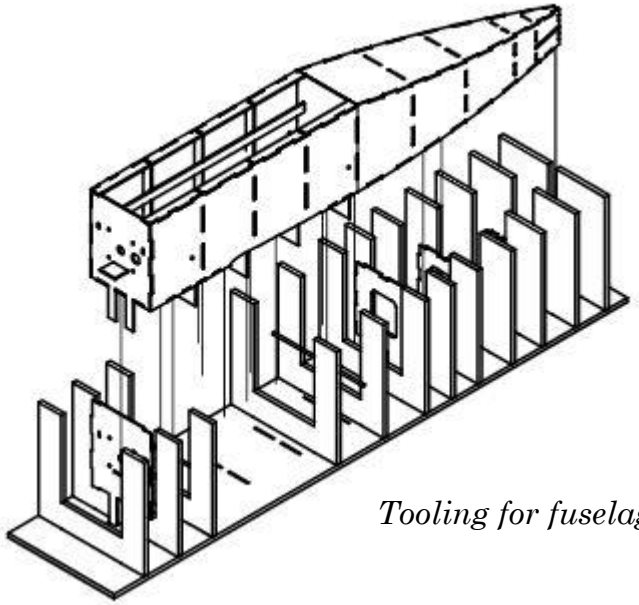


EL-Simpleton Layout

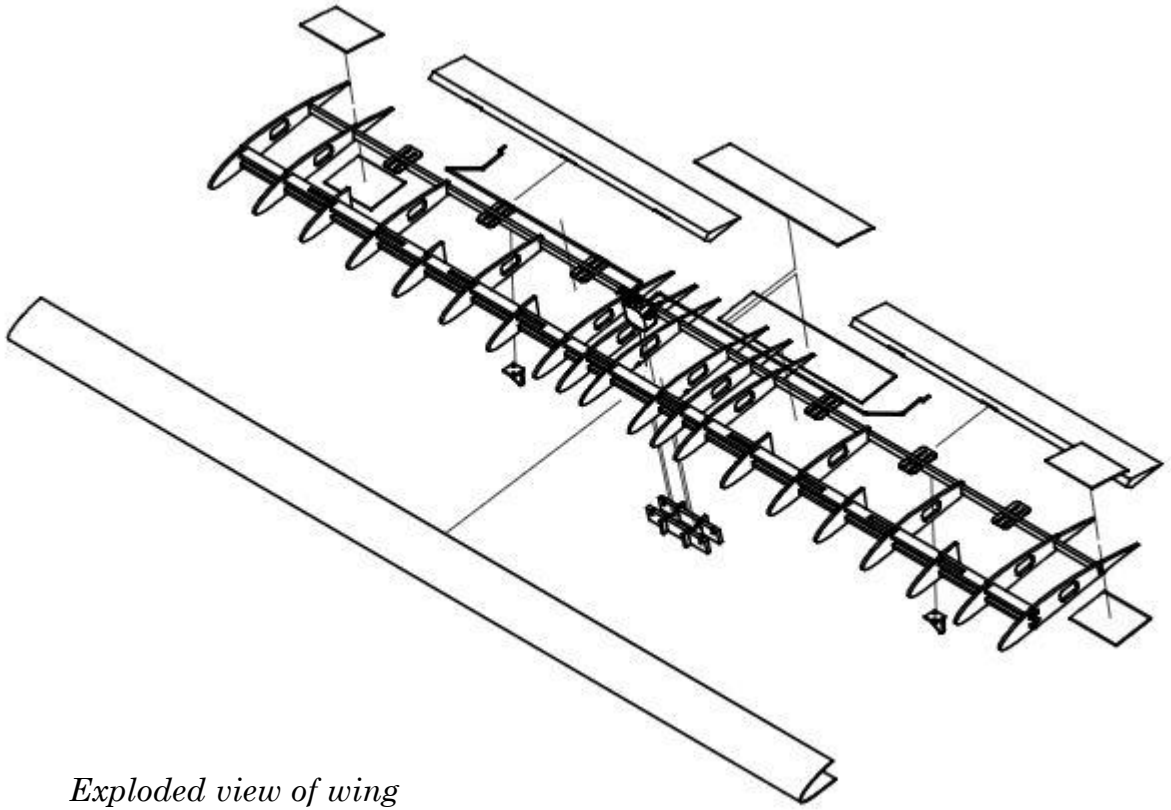
Part Number	Part Name
1	Motor
2	ESC
3	Fuse
4	Battery
5	Arduino/GPS
6	Receiver



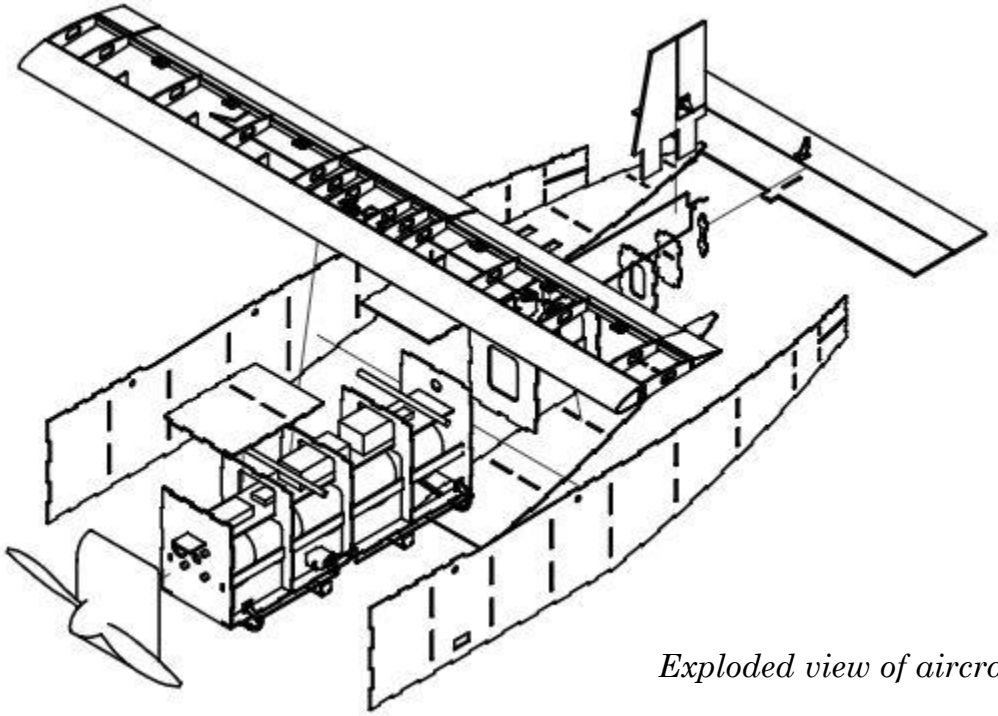
Detailed Views



Tooling for fuselage construction



Exploded view of wing



Exploded view of aircraft

Parameter	Design Prediction
Wing Area	204 sq-inches
Wingspan	34 inches
$C_{D,0}$	0.038
$C_{L\ max}$	0.96
$(L/D)_{max}$	10.1
Wing Airfoil/s	NACA 4412
Aerodynamic Center Location	12.1 inches
$C_{M,0}$	0.085
$C_{M\text{-}alpha}$	-0.017
Static Margin	15.2 %
Required Elevator Deflection for Trim at V_{Cruise}	1.52 deg
Required Elevator Deflection for Trim at $1.2V_{Stall}$	-4.16 deg
Required Elevator Deflection for Trim at Maneuver Point	1.29 deg
Power Available	214 W
Motor Power	277 W
Propeller Diameter	10 inches
Total Propulsion System Weight	0.61 lb
Battery Pack	11.1 V, 3S, 1,300 mAh
Maximum Current Draw	35 A
Endurance	156 sec
Stall Speed	36 ft/s
Max Speed	125 ft/s
Corner Speed (V')	82 ft/s
Minimum Turn Radius	39 ft
Take-off Distance	Hand launch
Landing Distance	Belly landing
Empty Weight (ready to fly, no payload)	1.42 lb
Maximum Payload	0.65 lb
CG Location	11.62 inches
Wing Tip Deflection at V'	0.57 inches
+/- n_{max}	+5.3 g, -2.12 g

Design Data Table

Final values for critical design parameters

Team 10

Sky Shockers