AE 484 Homework 2

Anshuk Chigullapalli, George Petrov, Kenneth Tochihara, Jeffery Zhou

1 Group name and leader

Group Name: Illinois Air Society
Group Leader: George Petrov

2 Existing tailless RC aircraft

Name	Wing area (in^2)	Winglet area (in^2)	Weight (lb)	Loading (oz/in^2)
RQ-170	40512.5	0	8500	3.36
Northrop Grumman Bat	7125	351	350	0.786
Skynetic Neptune II Blue	381.8	0	1.256	0.0526
Northrop Grumman X-47B	137318.4	0	14000	5.127

Name	Sweep	Taper ratio	Root chord (in)	Tip chord (in)	Span (in)
RQ-170	33°	0.187	148	27	463
Northrop Grumman Bat	46°	0.3	73	22	168
Skynetic Neptune II Blue	33°	0.481	13.12	6.310	39.3
Northrop Grumman X-47B	70 °	0.67	456	305.52	744

Name	Motor position	Motor size	Reference
RQ-170	Pusher	General Electric TF34	Wikipedia
Northrop Grumman Bat	Pusher	Hirth Engine	Wikipedia
Skynetic Neptune II Blue	Pusher	ASS2212 KV (1.1" diameter)	MotionRC
Northrop Grumman X-47B	Pusher	Pratt Whitney F100-220U	MilitaryFactory

3 Objectives and Constraints

The overall objective of the mission is to design and build a mini-UAV that deploys a vial of vaccine to a remote area. This UAV shall be hand-launched and shall land without any landing gears. Testing shall remain within line-of-sight (LOS) and shall abide by the Academy of Model Aeronautics (AMA) guidelines. The UAV shall be tailless with only two control surfaces (one elevon on each wing). Propeller/Motor/Speed Controller/Battery combinations are provided and shall be utilized within the design. This UAV shall be capable of achieving altitude quickly. The UAV's wings shall be made with Balsa reinforced foam with a fiberglass covering and shall be propelled with a tractor or pusher configuration. The following points highlight the numerical constraints of the problem statement.

- **Max Altitude (1):** 400 ft

- **Flight Time (2):** 15 min
- **Top Speed (2):** 40 mph
- **Max Thickness (3):** 1.75 in
- **Max Wingspan (1):** 70 in
- **Max Weight (3):** 3 lbs

4 Individual Vehicle Concepts

The engineering drawings of each individual member's CAD designs are attached at the end of the assignment.

5 Weight and Wing Loading of Vehicle Concepts

5.1 Anshuk

Component	Mass (g)
GFORCE E480 BRUSHLESS OUTRUNNER MOTOR (3530 - 1100KV)	100
GFORCE 40A BRUSHLESS ESC (T-CONNECTOR)	35
GFORCE 30C 2200MAH 3S 11.1V LIPO (T-CONNECTOR)	186
Electric Only - 12x6 Propeller	27
Spektrum AR620 DSMX 6-Channel Sport Receiver	8
EMAX ES08MA II ANALOG METAL GEAR MICRO SERVO	36
Wing	560
Fuselage "bump"	350
Vial	5
Total	1307

The weight estimates of the COTS components is based on the parts provided in the problem statement, such as the brush-less motor and the vial. Other COTS components, such as the micro-servo and the propeller, were obtained from providers online (references are hyperlinked in the table above).

For the weight of the wings themselves, the given wing area density of 0.033 oz/in^2 was used. The wing area of this design was 597.753 in^2. With these values, we get the weight of the wing to be 19.73 oz = 560 grams. The aircraft has no winglets. There is also no explicit fuselage, however the fused "bump" that houses the vial and all electric components adds the additional weight of roughly 350 grams that includes the weight of the skin and any required supports. The aircraft also doesn't have a vertical stabilizer, and so no additional mass is added there.

The total weight of the weight of the aircraft is approximated to be 1307 grams, or 2.88 lbs. Therefore, the design is currently under the weight limit. The wing loading based on the wing area and the calculating weight of the aircraft is 0.077 oz/in^2.

5.2 George

Component	Mass (g)
GFORCE E480 BRUSHLESS OUTRUNNER MOTOR (3530 - 1100KV)	100
GFORCE 40A BRUSHLESS ESC (T-CONNECTOR)	35
GFORCE 30C 2200MAH 3S 11.1V LIPO (T-CONNECTOR)	186
Electric Only - 12x6 Propeller	27
Spektrum AR620 DSMX 6-Channel Sport Receiver	8
EMAX ES08MA II ANALOG METAL GEAR MICRO SERVO	36
Winglet	91
Wing	660
Vial	5
Total	1148

The COTS parts were gathered from their specified weights. For the wing's mass estimates, the planform area was found to be 697 in^2 . Therefore, for the wing, from our given mass per area was 0.033 oz/in^2, the weight is 660 grams. For the winglets, the planform area was 26.75 in^2 and the mass per area is 0.06 oz/in^2. And since there are two winglets, their mass in total is estimated to be 91 grams.

The total mass of the aircraft is 1148 grams which is about 2.5 lbs. The final wing loading based on the planform area and the total weight, the wing loading is about 0.057 oz/in^2. This design is currently below to the weight limit of 3 lbs.

5.3 Kenneth

Component	Mass (g)
GFORCE E480 BRUSHLESS OUTRUNNER MOTOR (3530 - 1100KV)	100
GFORCE 40A BRUSHLESS ESC (T-CONNECTOR)	35
GFORCE 30C 2200MAH 3S 11.1V LIPO (T-CONNECTOR)	186
Electric Only - 12x6 Propeller	27
Spektrum AR620 DSMX 6-Channel Sport Receiver	8
EMAX ES08MA II ANALOG METAL GEAR MICRO SERVO	36
Vertical Stabilizer	32
Wing	382
Fuselage	712
Vial	5
Total	1523

For COTS components, the mass values were determined by the given product specifications. The components have been hyperlinked for ease of reference. For the wing mass estimates, planform area was found to be 408 in^2, therefore determining the mass via the given mass per area of 0.033 oz/in^2. A similar approach was done with the vertical stabilizer with a planform area of

18.9 in^2 with a given mass per area of 0.06 oz/in^2. These were properly converted to grams after calculation. To calculate the mass of the fuselage, the density for Depron foam was asserted within the model which utilizes the volume to determine the mass of the component.

For the final weight of the aircraft, it was around 1523 g which is about 3.3 lbs. The final wing loading based on the surface area of the wing (also accounting for units) is roughly 0.13 oz/in^2. This puts the design slightly overweight, but the fuselage is likely the culprit as the mass overage since it was estimated as a solid component, where in reality, it is made of mostly empty space to reduce the mass.

5.4 Jeffery

Component	**Mass (g)**
GFORCE E480 BRUSHLESS OUTRUNNER MOTOR (3530 - 1100KV)	100
GFORCE 40A BRUSHLESS ESC (T-CONNECTOR)	35
GFORCE 30C 2200MAH 3S 11.1V LIPO (T-CONNECTOR)	186
Electric Only - 12x6 Propeller	27
Spektrum AR620 DSMX 6-Channel Sport Receiver	8
EMAX ES08MA II ANALOG METAL GEAR MICRO SERVO	36
Fuselage	15.79
Wing	538.641
Vial	5
Total	951.431

The COTS components of this aircraft can be found by the given specifications and the desired vehicle performances from the user of this aircraft. For the wing's platform area, it was found that 578.016 in^2 would provide sufficient payload capacity for the aircraft. Therefore, given a desired wing loading of 20 oz/ft ^{2}, this configuration could provide a wing loading of 0.1389 oz/in^2 with a maximum take off weight of 80.27 oz. For the given mass per area of the wing of 0.033 oz/in^2, the total weight of the wing is 538.641 g.

Using the density of depron foam and the volume of the fuselage obtained from Siemens NX, it is found that the total weight of the fuselage is 15.79 g. Since this aircraft does not have a vertical tail or stabilizer, there is no additional mass required for those components. As shown in the table above, the total weight of the aircraft is 951.431 grams which is about 2.1 lbs which is well below the weight limit of 3lbs.

6 Vehicle Concept Evaluation

6.1 Anshuk

- Meeting objectives
  - **Max Thickness (3):** Met
  - **Max Wingspan (1):** Met
  - **Max Weight (3):** Met

- Pros
  - Large volume with easy access to vial and batteries
  - Wing aspect ratio of 7, optimal for sport gliders
  - Bump is ideal for sensor and vial placement
- Cons
  - Lack of yaw stability due to absence of vertical stabilizers or winglets
  - Difficult manufacturing of the storage bump
  - Aft heavy

6.2 George

- Meeting objectives
  - **Max Thickness (3):** Met
  - **Max Wingspan (1):** Met
  - **Max Weight (3):** Met
- Pros
  - Can store components in wing volume
  - Has yaw stability
  - Manufacturing main wing is relatively easy
- Cons
  - Weight will be too far rearwards
  - Difficulty to manufacture winglets
  - Difficult to hand launch with propeller at back (Don't get your hand caught Professor)

6.3 Kenneth

- Meeting objectives
  - **Max Thickness (3):** Met
  - **Max Wingspan (1):** Met
  - **Max Weight (3):** Not met
- Pros
  - Manufacturability of vertical stabilizer, fuselage
  - Tractor configuration puts masses forward

  - Lots of volume for components

- Cons
  - Manufacturability of the wings (too high aspect ratio)
  - Structural stability of the wings (spars don't go all the way through)
  - Overweight

6.4 Jeffery

- Meeting objectives
  - **Max Thickness (3):** Met
  - **Max Wingspan (1):** Met
  - **Max Weight (3):** Met
- Pros
  - Can store components in the fuselage
  - Very light weight
  - Has high maximum payload capacity
- Cons
  - The center of gravity is too far rearwards
  - Fuselage not large enough to accommodate larger payload
  - No yaw stability control

7 Proposed Designs

7.1 Design 1

Kenneth's design was selected as one of the top designs. This design includes a tractor motor position which will allow for a much easier mass distribution within the aircraft itself. In any aircraft design, the center of gravity should be in front of the neutral point and this design allows for this. Another reason this design was chosen was due to its overall stability. The inclusion of a vertical stabilizer allows for yaw stability as well as the sweeping nature of the wings.

We do still need to have some adjustments to the overall design in the name of manufacturability and weight saving. The fuselage needs to be manufactured in a way where it is mostly a hollow shell rather than a solid block of foam. Also, the aspect ratio of the wings is too high and will need to be decreased. In doing this, we will decrease the sweep of the wings and it allows us to a horizontal spar that spans much more of the wingspan than the current design.

Overall, this design offered a unique solution to the other proposed designs and with some alterations and design iterations, this will be a viable and well-engineered flying wing.

7.2 Design 2

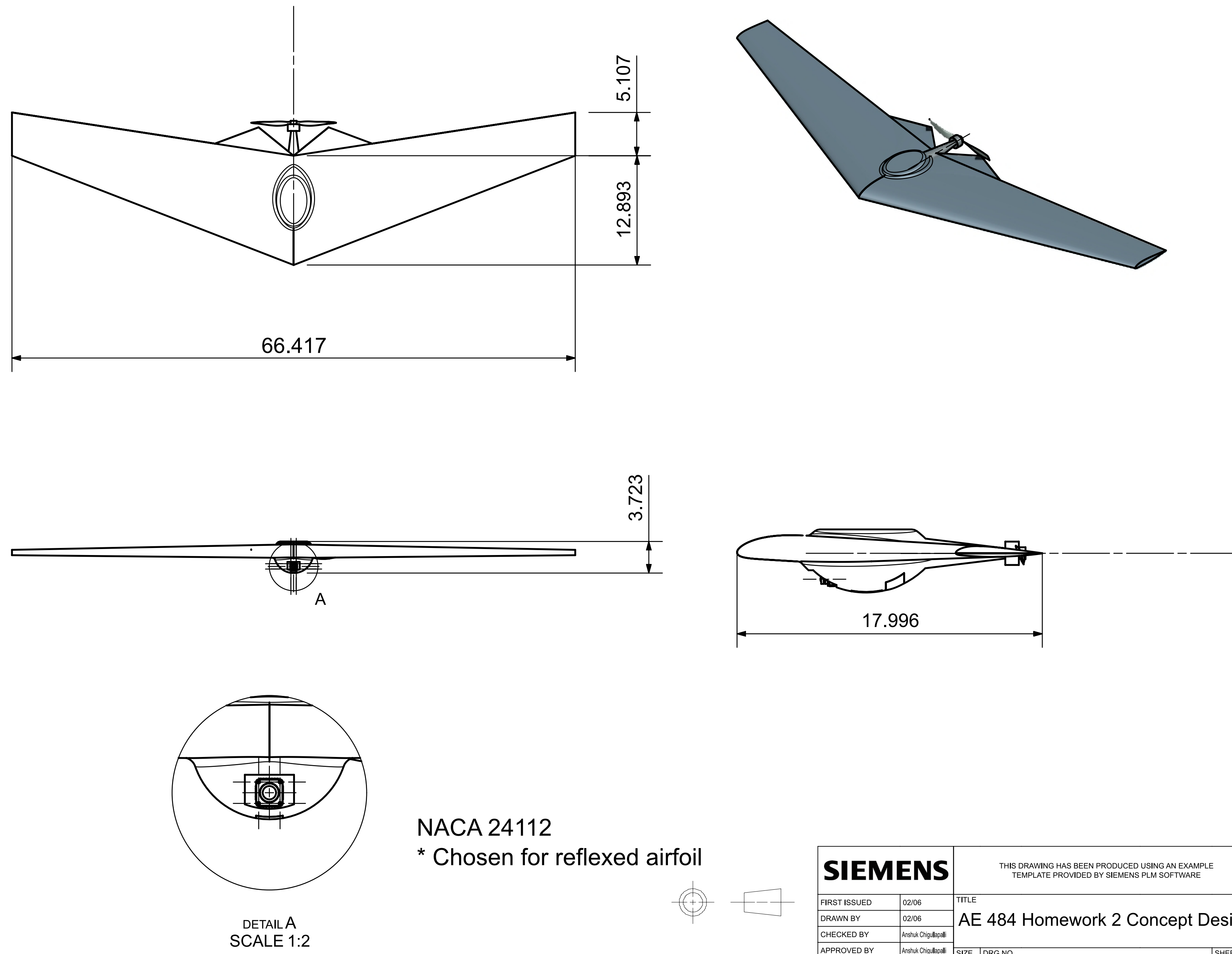
George's design was the other design that was selected. This design was similar to both Jeff's and Anshuk's designs but also included winglets which the team was excited to include. This design includes a pusher motor location which offers some difficulty in arranging the center of gravity in front of the neutral point, but due to the lack of a fuselage, the team believes much of the equipment can be placed in the forward end of the wing. Taking inspiration from Jeff and Anshuk's designs, a small addition like a "semi-fuselage" can be made that attaches itself to the bottom of the wings and can be used to store electronics and payload. The stability offered by the sweep of the aircraft and winglets is another reason for choosing this design. The ability to make the aircraft structurally sound with the fact that the planform area is so large is a benefit.

There will need to be some design adjustments due to manufacturing. The winglet still where it directly molds from the main wing and the tip of the winglet sweep far back is also quite hard to manufacture. The sweeping nature of the winglet was done purely for aesthetic reasons and is not expected to hurt the performance of the aircraft.

Overall, this design offers a different design than Kenneth's design. It will need to be evaluated to see which design proves to have better performance as each of the designs evolve.

8 Group Member Contributions

Group Member	**Contribution**
Anshuk Chigullapalli	Authored individual design and evaluation section, fact and numerical values checking of all sections, paper editing
George Petrov	Authored Proposed Designs, individual design and evaluation
Kenneth Tochihara	Authored Objectives and Constraints, individual design and evaluation
Jeffery Zhou	Authored individual design and evaluation section



NACA 24112
* Chosen for reflexed airfoil

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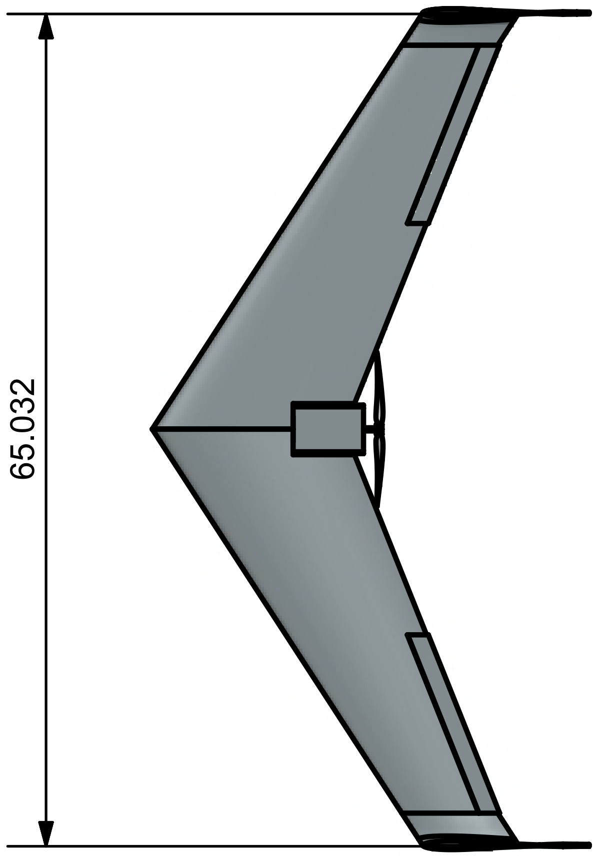
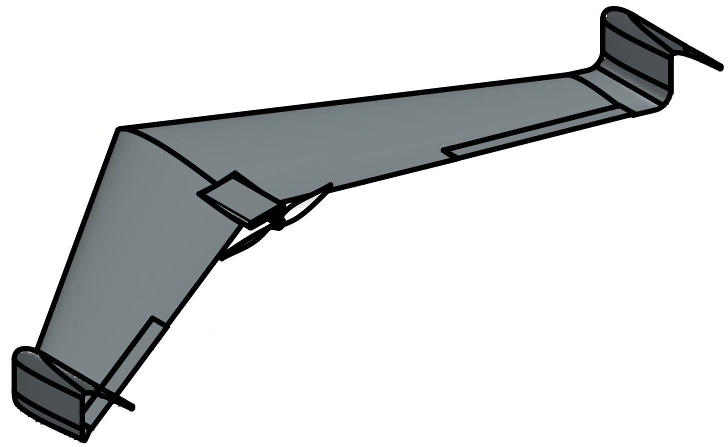
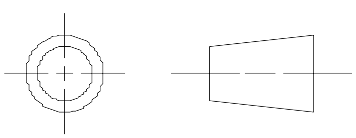




Wing Airfoil: S5010
Vertical Airfoil: EH 0.0/9.0
Root Chord: 15"
Tip Chord: 7.5"
Sweep Angle: 33 deg



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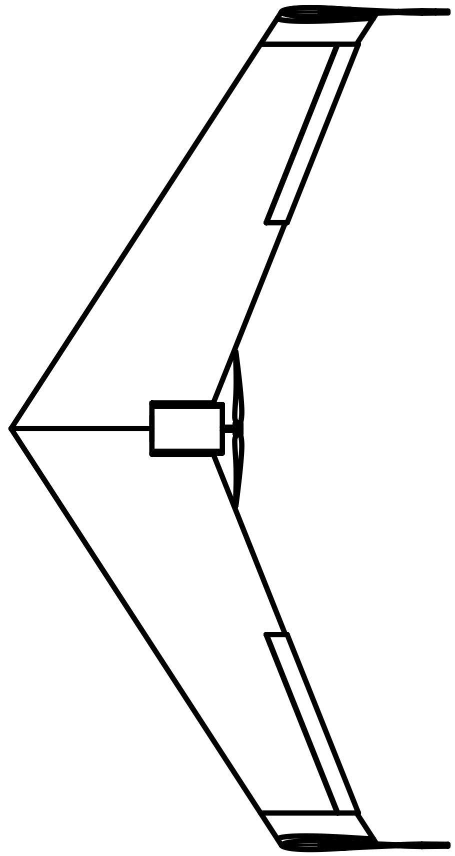

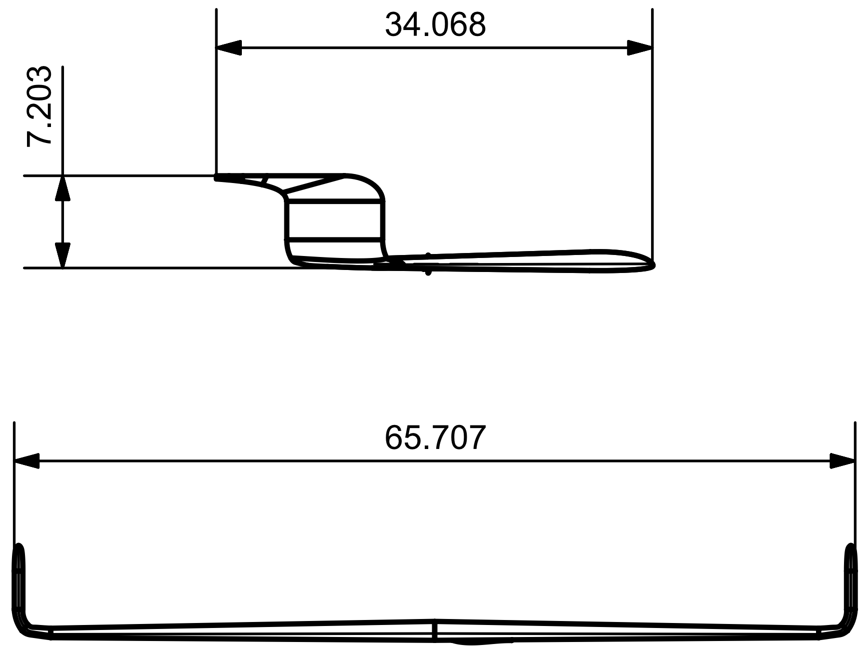

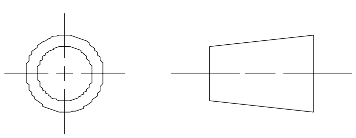

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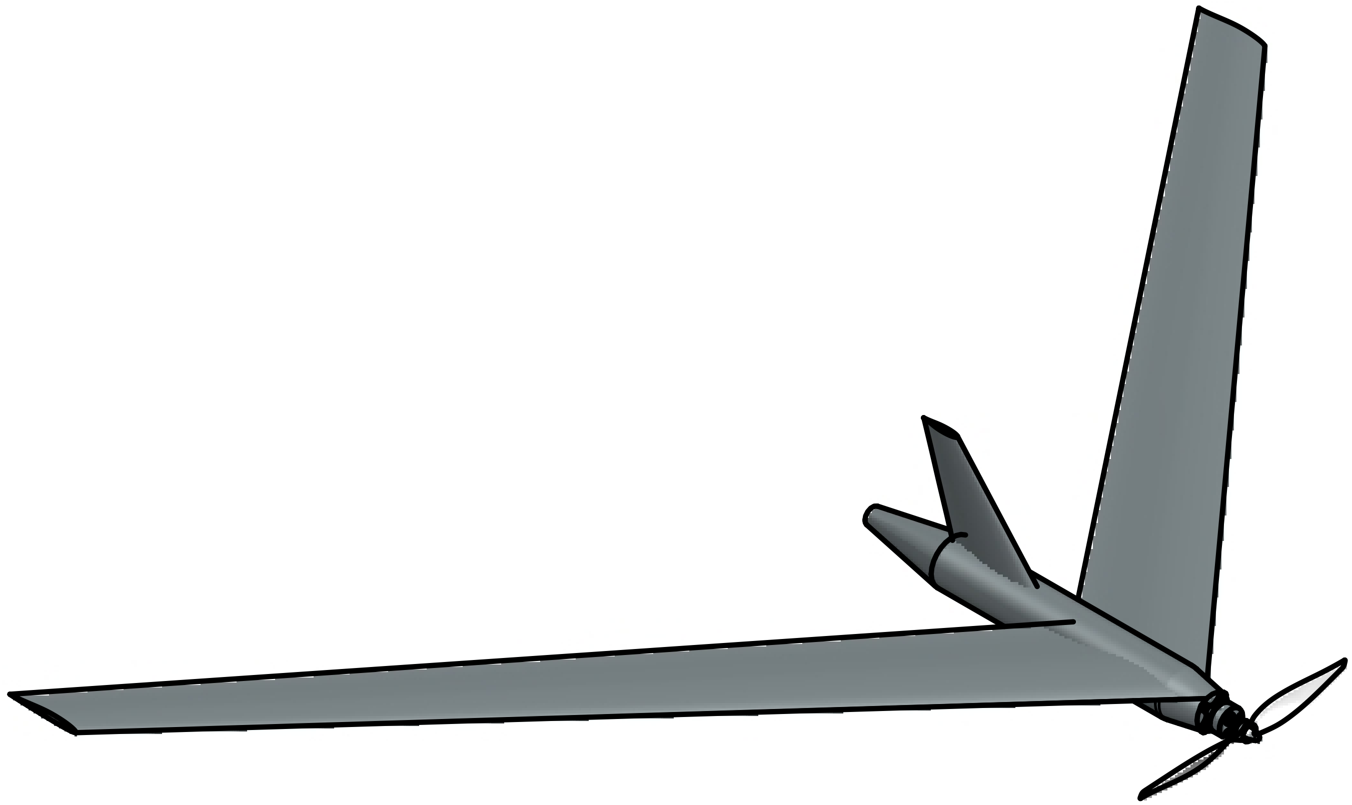

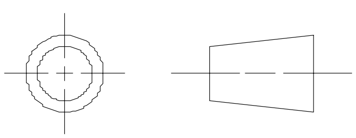

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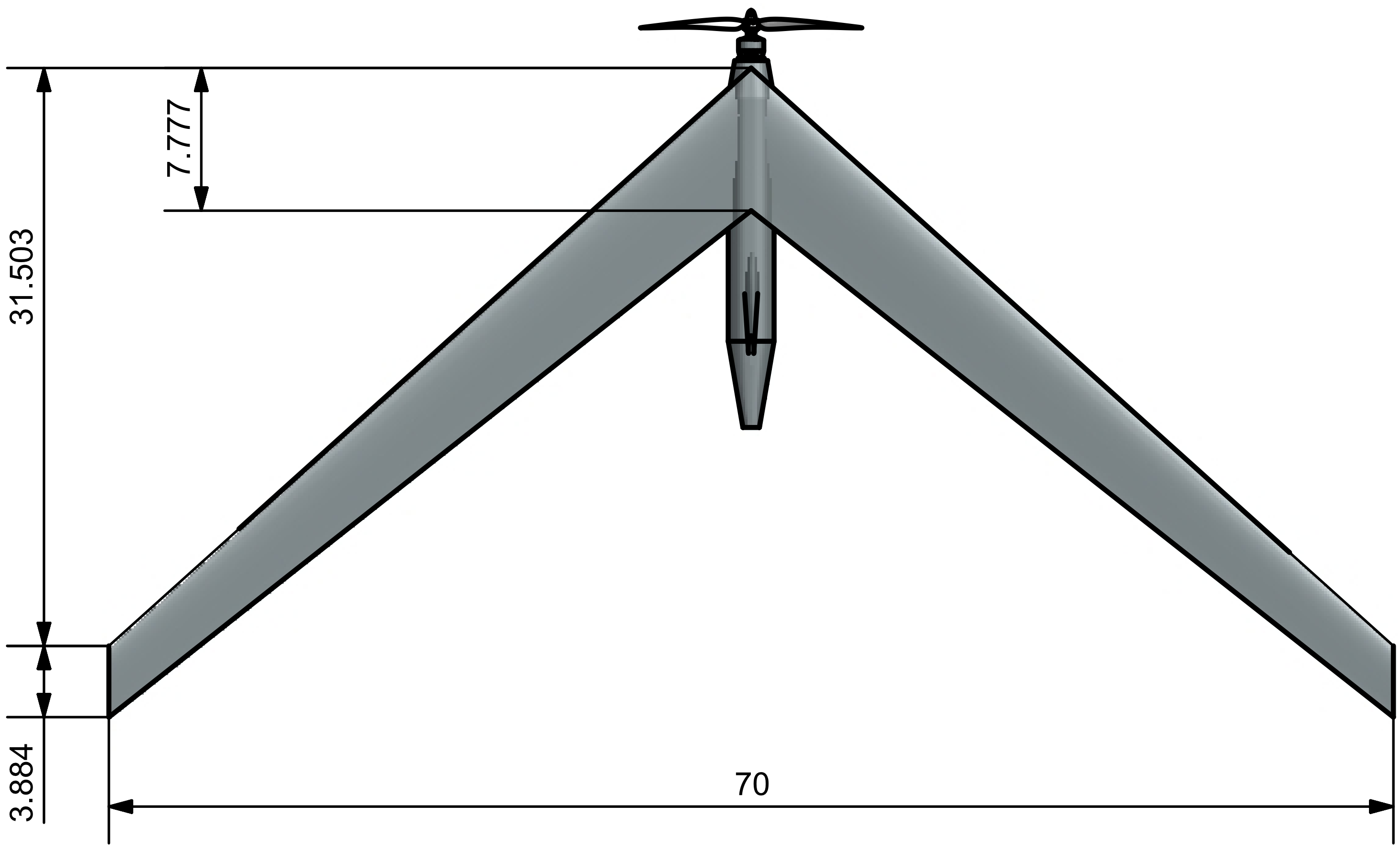

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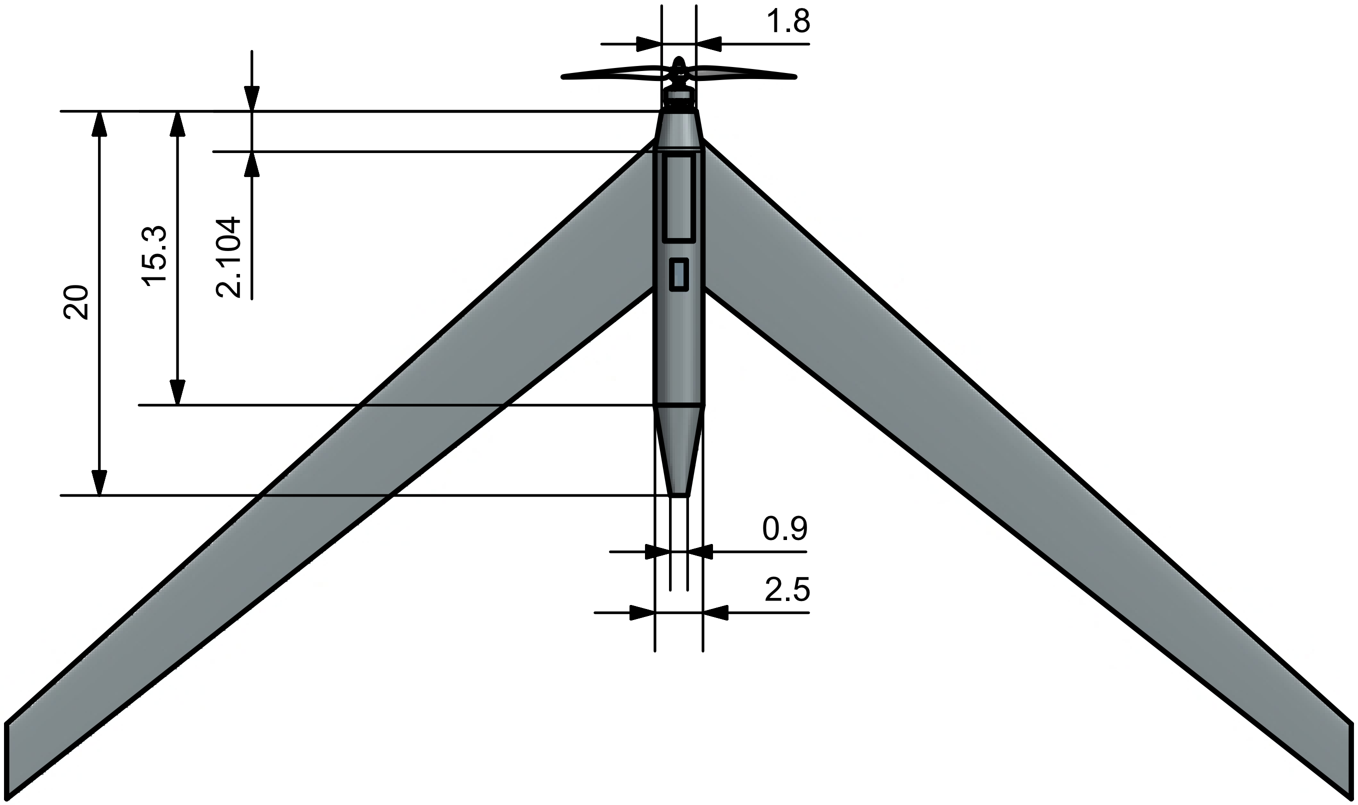

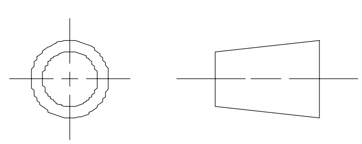

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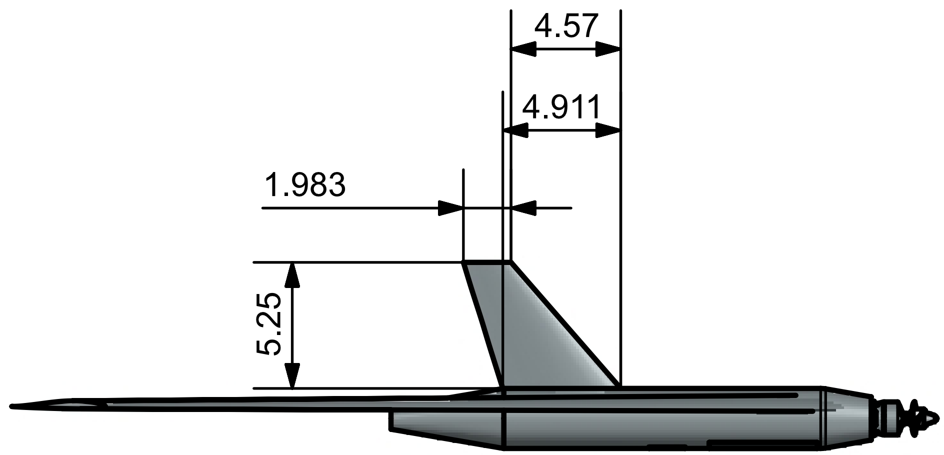

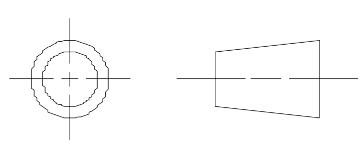

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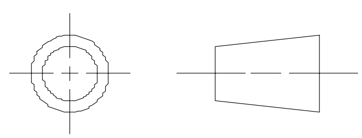
PC NO	PART NAME	QTY
5	APC 12X6 EP PROP_SLDPRT	1
4	E-FLITE PARK 480	1
3	VERTICAL_STABILIZER	1
2	WING	1
1	FUSELAGE	1

QUALITY	VALUE
WING AIRFOIL	E182
STABILIZER AIRFOIL	E520
ASPECT RATIO	12
TAPER RATIO	0.5



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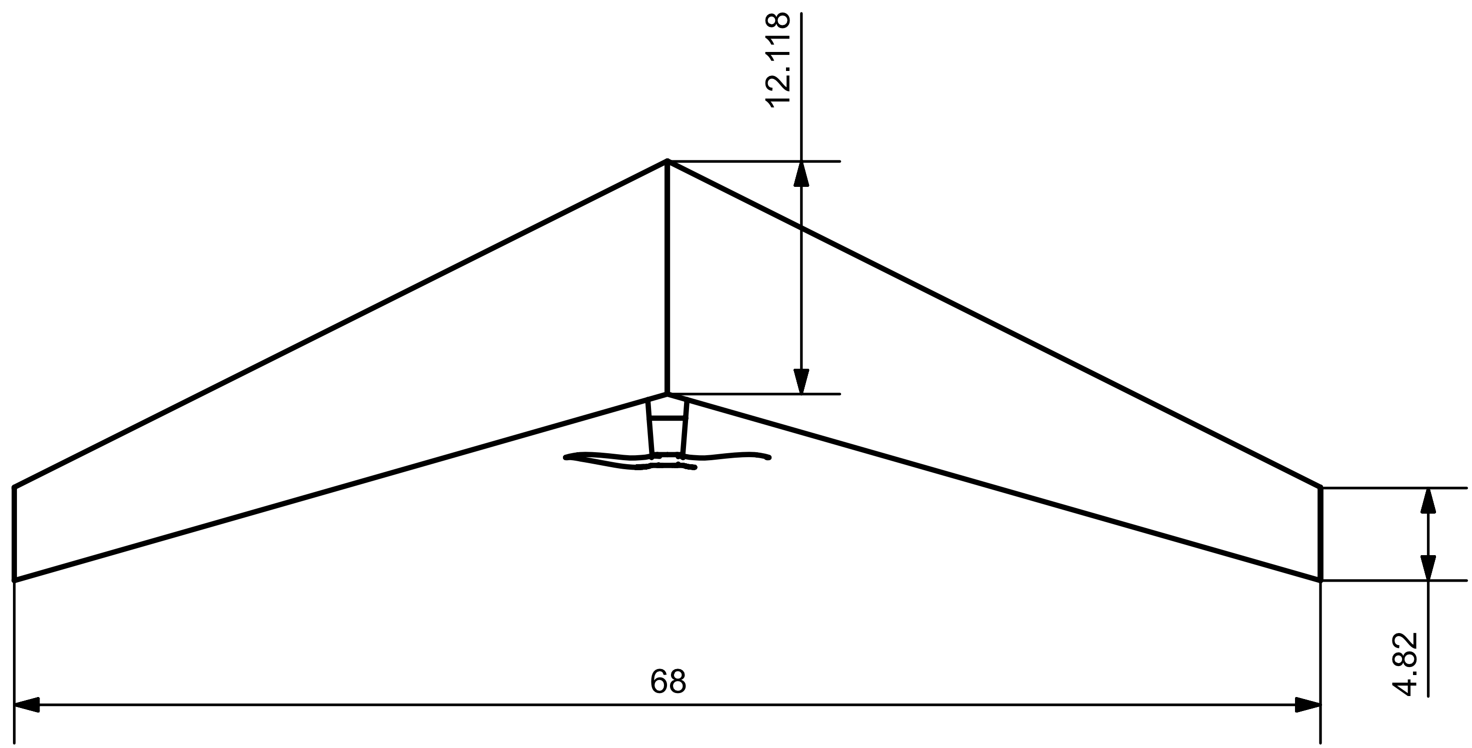

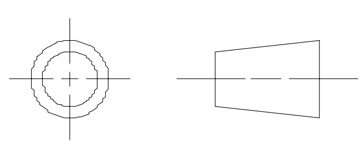

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Flying Wing - Jeffery Zhou

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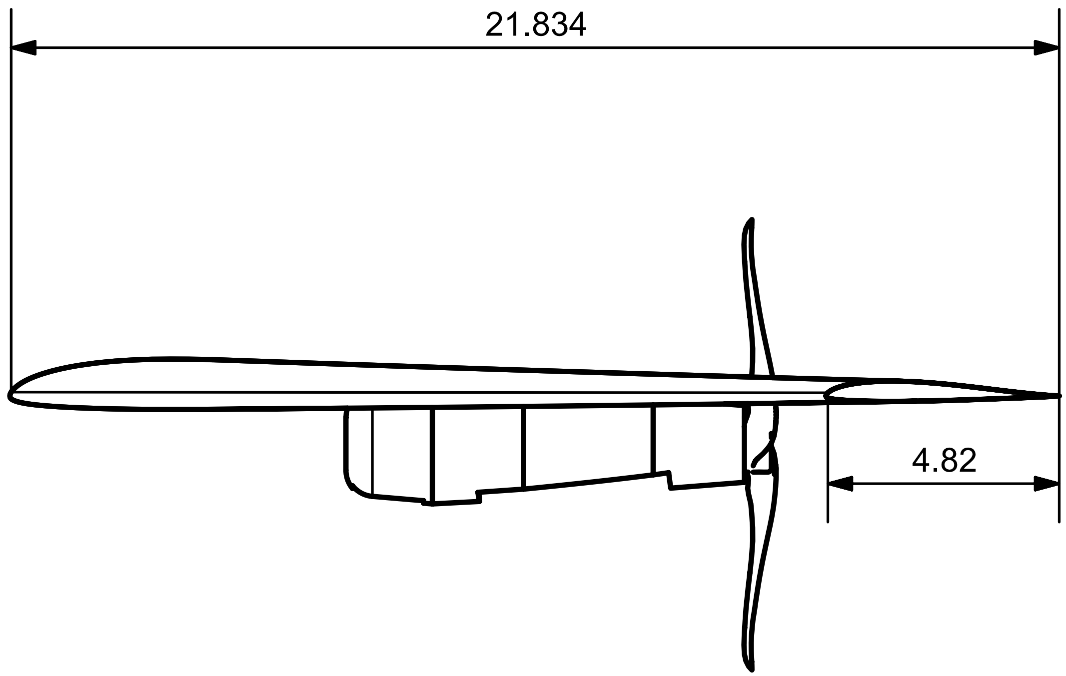

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Flying Wing - Jeffery Zhou

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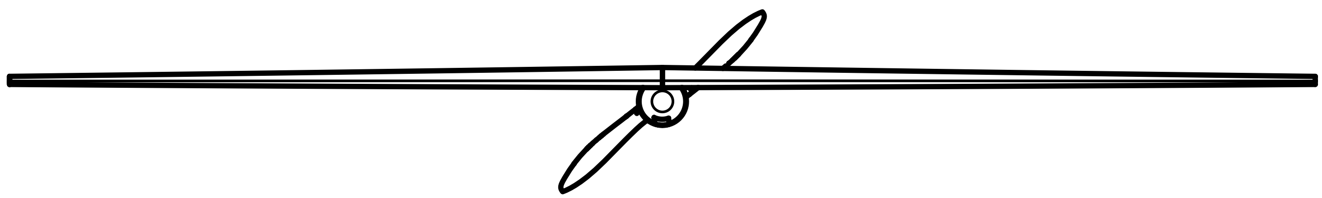

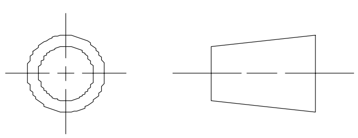

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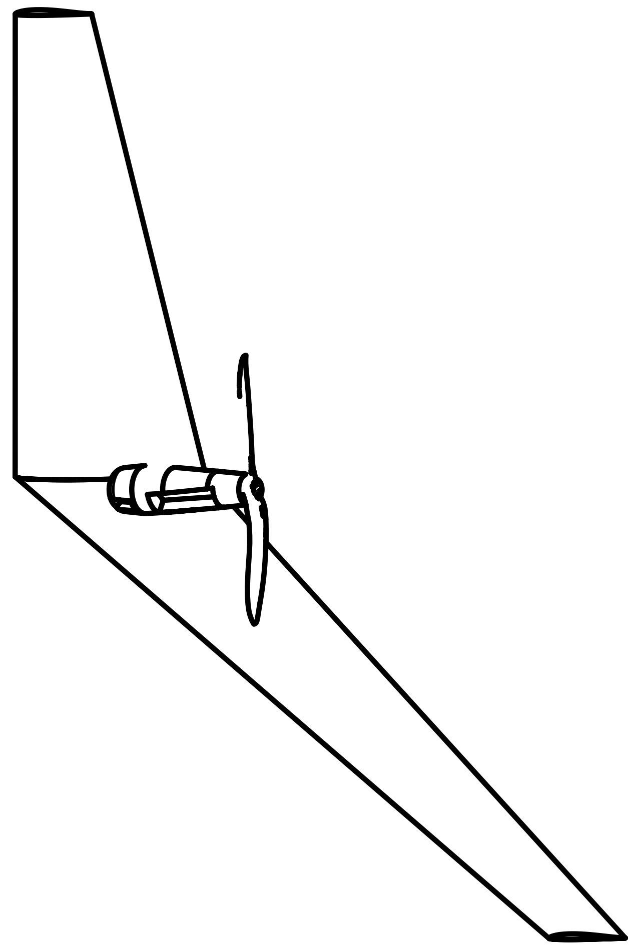

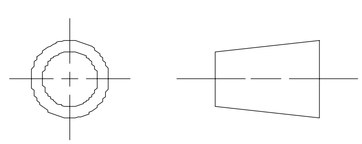

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Flying Wing - Jeffery Zhou

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