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Titan Dynamics – Buzzard

https://www.titandynamics.org/3dhangar/p/titan-buzzard

Build & User Manual

Revision 1.3

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Section 1: Model Information

The Titan Buzzard is a 1.3m wingspan VTOL in 4+1 configuration, featuring our latest advancements in construction and aerodynamics. There is a removable payload bay which can be modified to fit an array of sensors and access the innards. Lift motor wires can be routed internally through the booms and into the wings, making for a clean build. The Buzzard's small footprint and easy disassembly makes it ideal for a fun-to-fly VTOL that anyone can enjoy – while also being able to complete useful tasks such as mapping or inspections. Structural integrity is at an all-time high with Buzzard, featuring a spar layout that greatly strengthens the airframe and reduces vibration in flight. Special strengthening techniques are applied to the motor mount as well as the belly.

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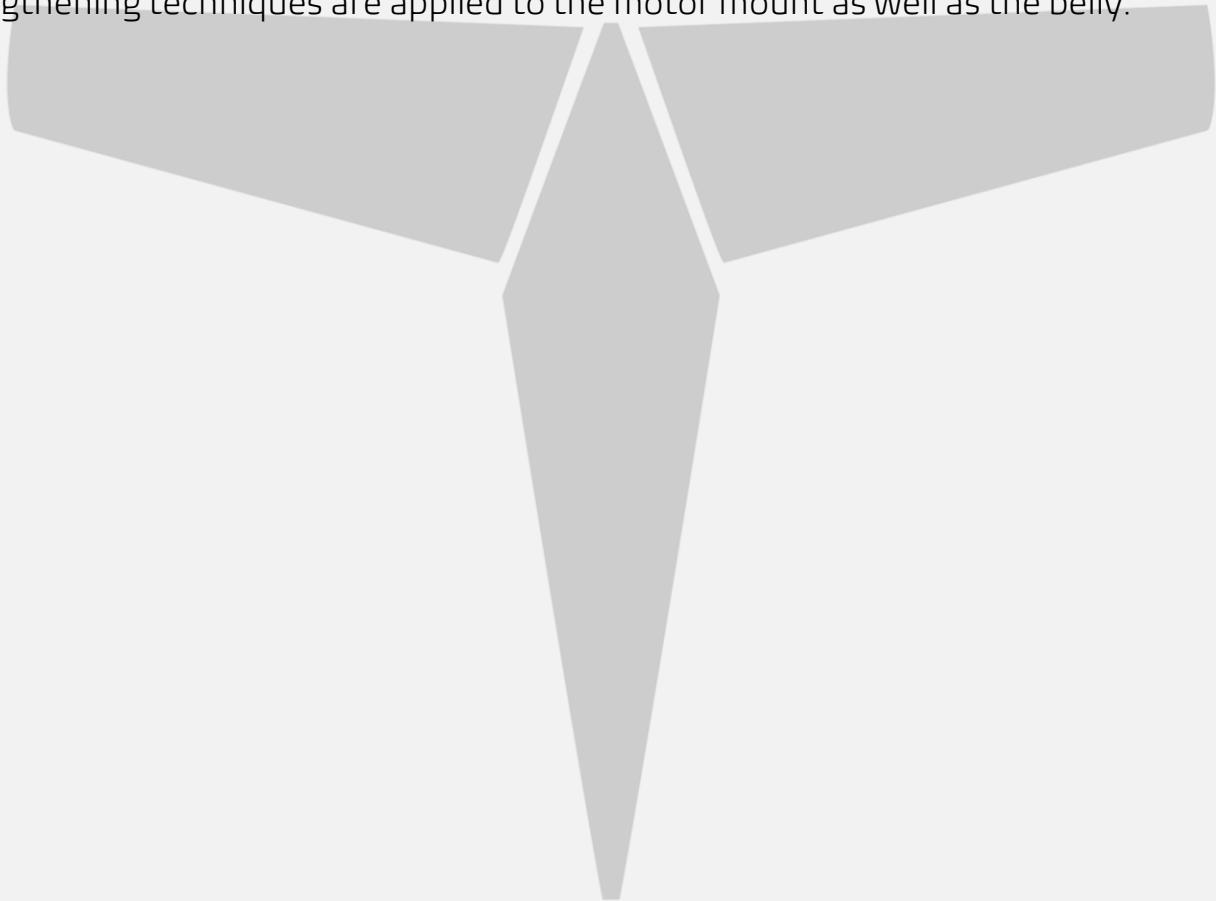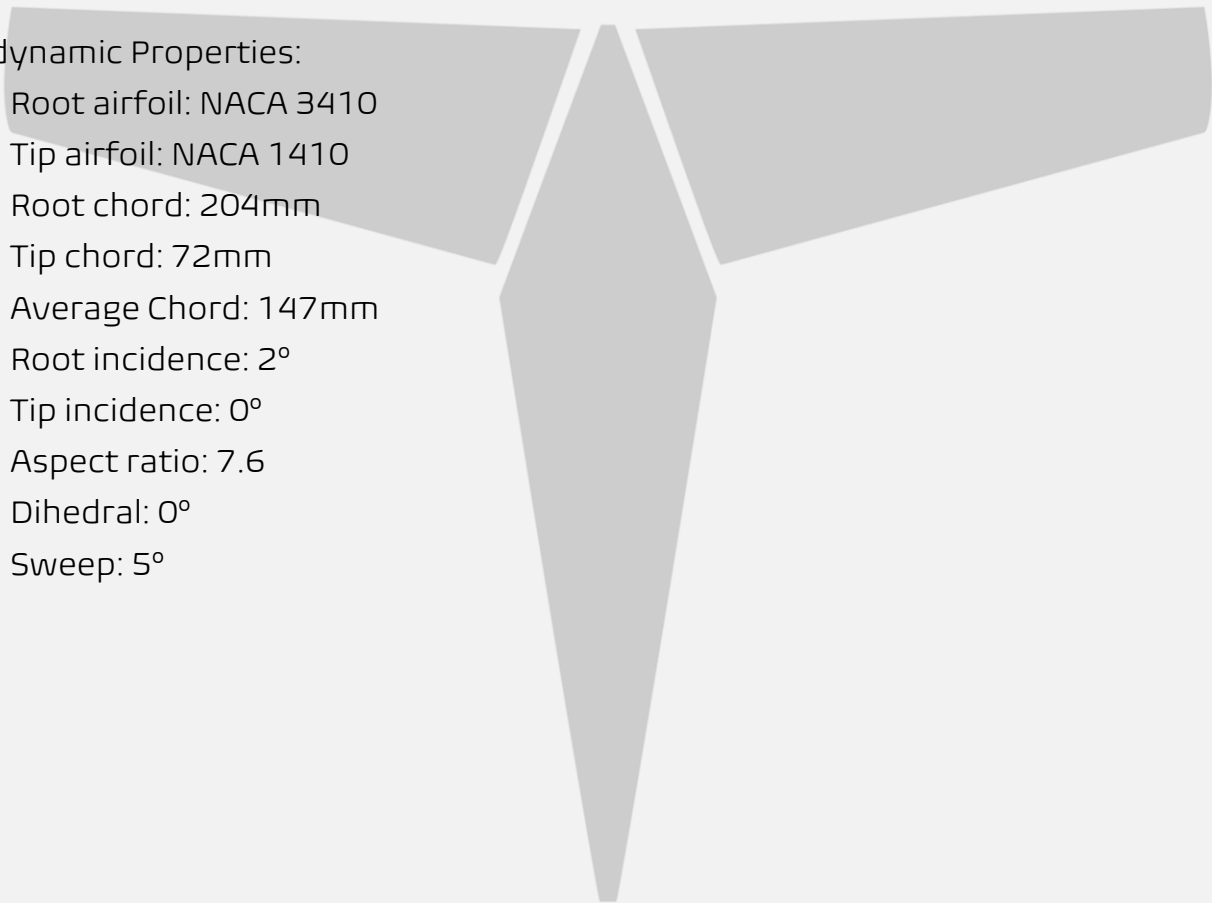
Section 2: Model Specifications & Performance

2.1: Physical Characteristics

General Stats:

- Wingspan: 1295mm

- Wing area: 2210cm^2

- Maximum take-off Weight: 2.5kg

- Efficiency: 2.2 Wh/km

- Cruise speed: 50-75kph

- Recommended prop diameter: 11 inches

Aerodynamic Properties:

- Root airfoil: NACA 3410

- Tip airfoil: NACA 1410

- Root chord: 204mm

- Tip chord: 72mm

- Average Chord: 147mm

- Root incidence: 2°

- Tip incidence: 0°

- Aspect ratio: 7.6

- Dihedral: 0°

- Sweep: 5°

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2.2: Aircraft Performance

Below are some plots showing aircraft performance at different all-up weights. **The values predicted are not perfect, and values like efficiency can vary greatly based on the choice of motor and propeller, among many other factors.** These just serve to give a rough idea of the sort of performance you can expect and give you an idea of the flight envelope of your aircraft before you fly it and help narrow in on the most efficient cruise speed. The stall speed assumes a C_{Lmax} of 1.3, and the minimum speed line is just 20% above stall speed. Below the minimum speed, a tailwind gust can cause the aircraft to stall unexpectedly, so be careful.

Using the drag plot can help figure out how much thrust you'll need in level flight at a given speed. This allows for the use of propeller data from companies like APC to choose the best propeller for the type of flying you want to do.

The plot depicting power required for flight can help you estimate your loiter endurance at a given speed. If you want the maximum time in the air, fly at the speed which uses the least power to stay in the air.

The efficiency plot shows you what sort of efficiency to expect at each speed. With it, it's possible to choose the best cruise speed for your setup and see how changes in that speed may affect your efficiency.
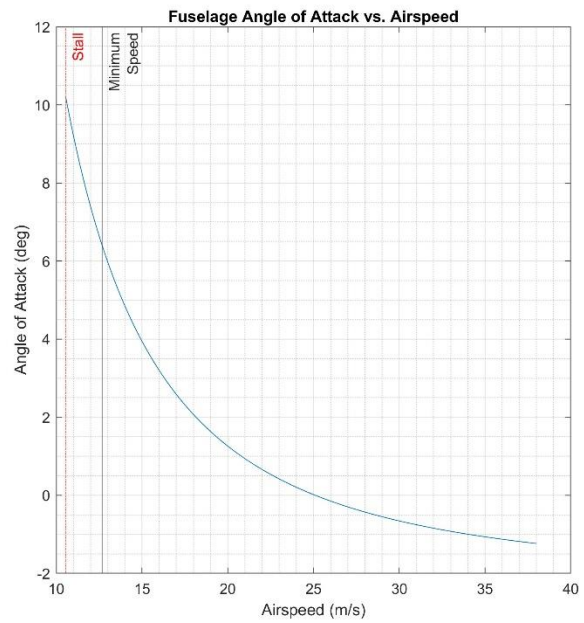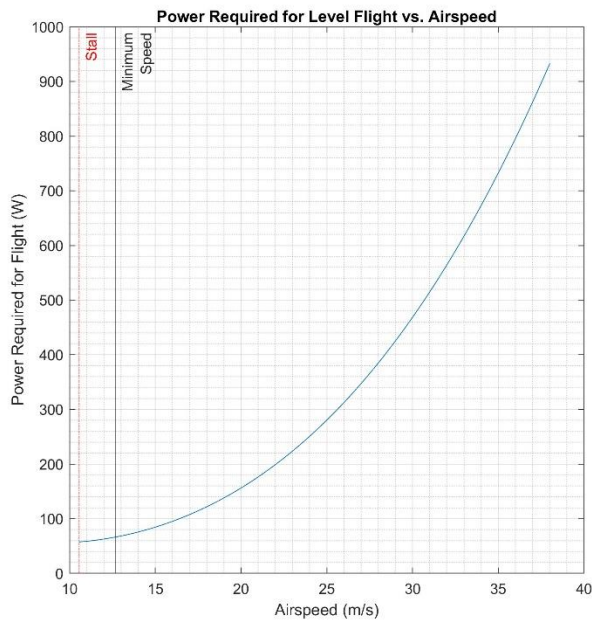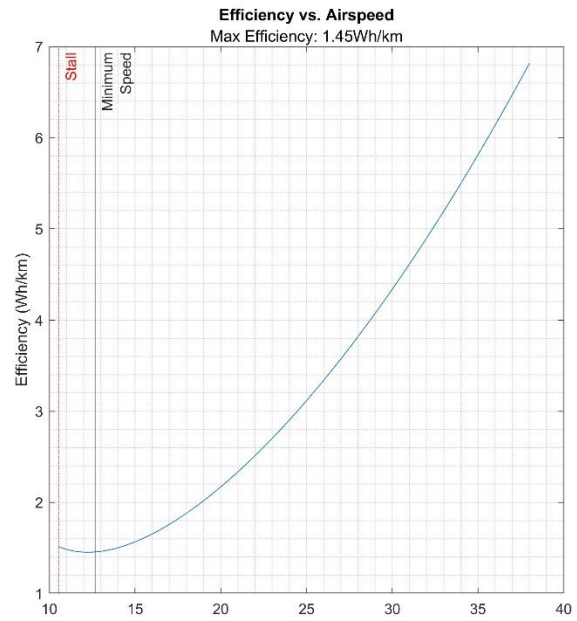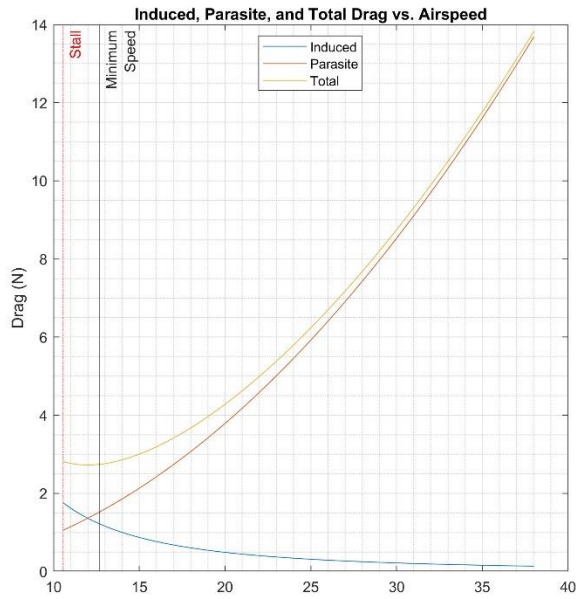
The fuselage angle of attack plot shows you what angle of attack the fuselage will be at a given speed. This can be useful when setting the TRIM_PITCH_CD parameter in Arduplane to the angle of attack value that corresponds with your cruise speed.

The plots in section 2.2.2 are just to give an idea of the sort of performance that can be expected for certain battery configurations. **They are not a guarantee of performance**, as there are too many variables to account for when individuals build the aircraft. Extra draggy antennas, inefficient motors, print quality, etc. can all change flight performance drastically.

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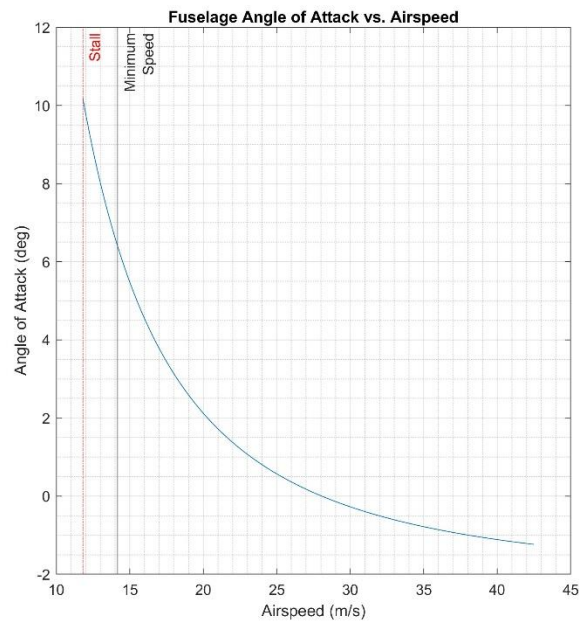Visit our Facebook page
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2.2.1: Drag, Efficiency, Power, and Angle of Attack at Varying All-up-weights:

Titan Buzzard | AUW = 2kg

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Titan Buzzard | AUW = 2.5kg

Induced, Parasite, and Total Drag vs. Airspeed

Efficiency vs. Airspeed
Max Efficiency: 1.78Wh/km

Power Required for Level Flight vs. Airspeed

Fuselage Angle of Attack vs. Airspeed

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Titan Buzzard | AUW = 3kg

Induced, Parasite, and Total Drag vs. Airspeed

Legend:
- Induced
- Parasite
- Total

Efficiency vs. Airspeed
Max Efficiency: 2.1Wh/km

Power Required for Level Flight vs. Airspeed

Fuselage Angle of Attack vs. Airspeed

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2.2.2: Turn rate, range, endurance, and max climb rate for a variety of different battery configurations:

Titan Buzzard Hybrid Battery | AUW = 2.55kg | 4S3P LG MJ1 | Payload: 0.17kg 5W
Empty Mass: 1.718kg | Propulsion Efficiency: 56.616%

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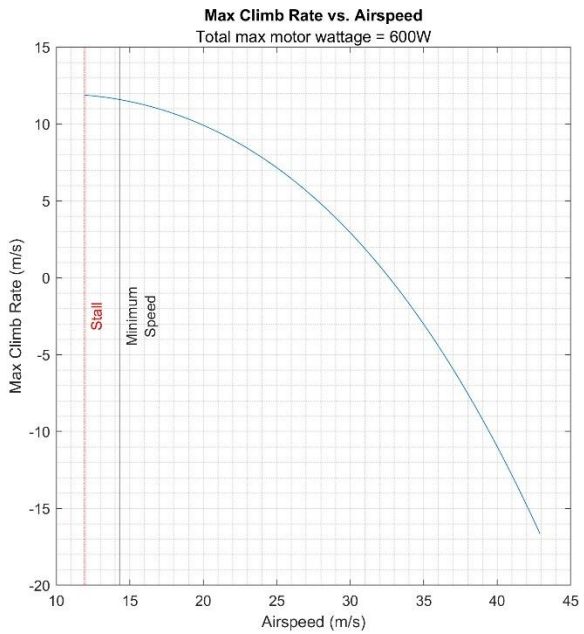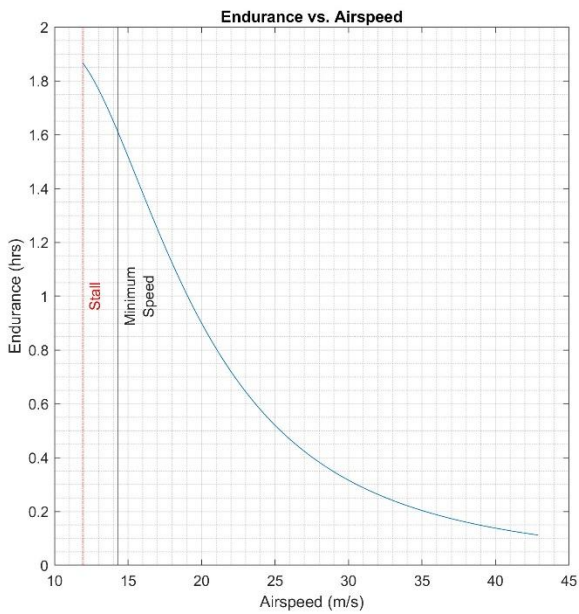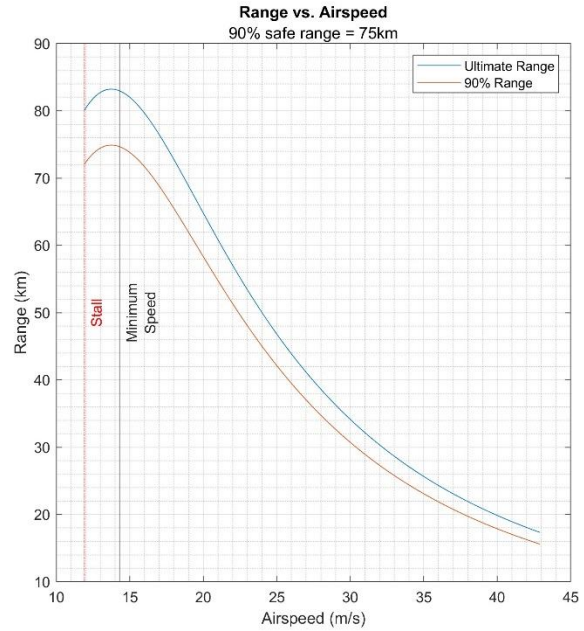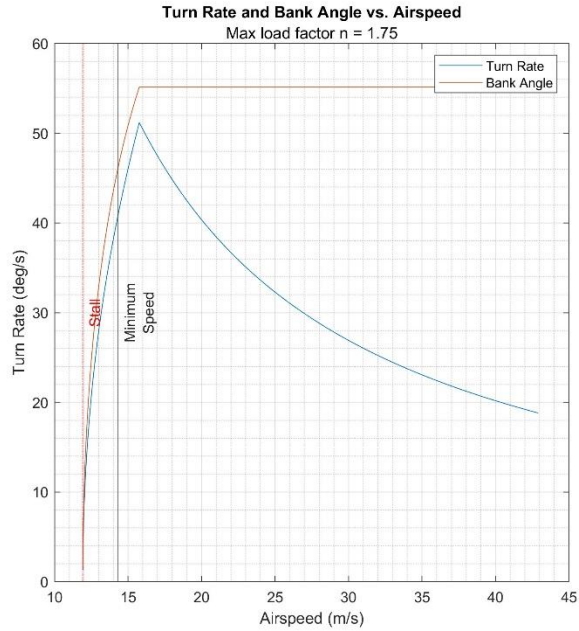
Titan Buzzard | AUW = 2.58kg | 4S3P Molicel P45B | Payload: 0kg 5W
Empty Mass: 1.718kg | Propulsion Efficiency: 56.616%

Turn Rate and Bank Angle vs. Airspeed
Max load factor n = 1.75

Range vs. Airspeed
90% safe range = 89km

Endurance vs. Airspeed

Max Climb Rate vs. Airspeed
Total max motor wattage = 600W

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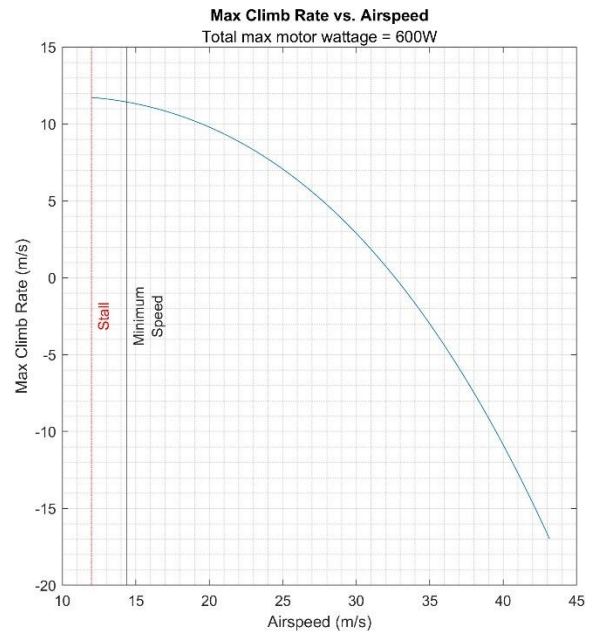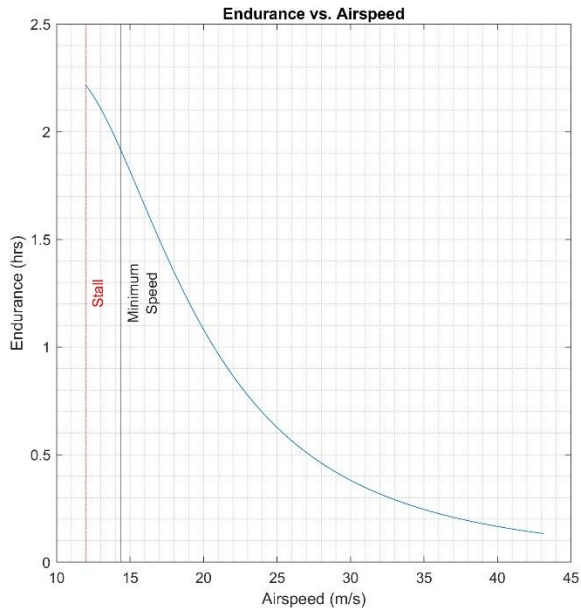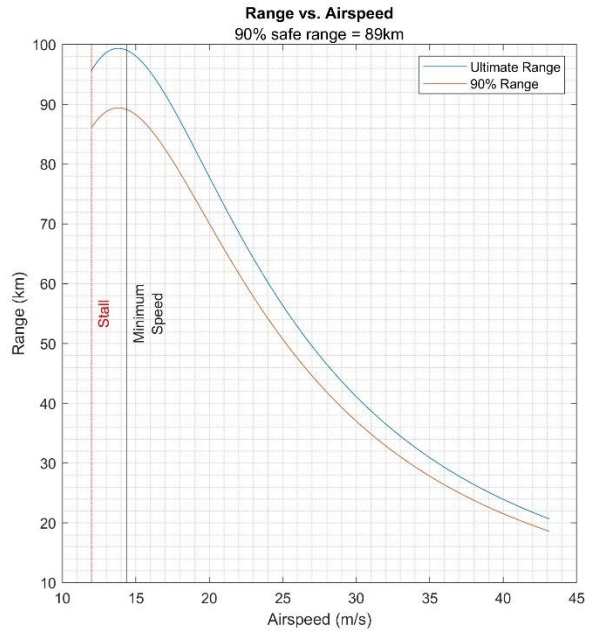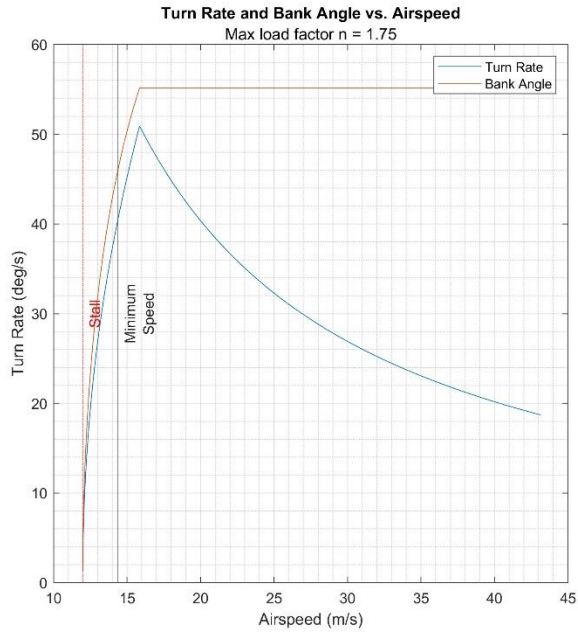
Section 3: Required Build Materials

Spars needed:

(1) 8 OD x 6 ID x 800mm – front main wing spar

(1) 8 OD x 6 ID x 1000mm – rear main wing spar

(2) 4x250mm solid – aileron hinge

(2) 16 OD x 14 ID x 500mm – VTOL lift booms

(2) 4x150mm solid – vtail support

(2) 2x200mm solid – taileron hinge

Recommended motor / prop / esc:

Lift motors: Emax 2213 or Sunnysky 2212 (kv 920-1000)

Lift propellers: APC 9x6 CW and CCW

Forward motor: Brotherhobby 2816 or any similarly sized motor (kv 800-1200)

Forward propellers: APC 10x8 – 12x8

Lift motor ESC: Tmotor 4-in-1 F55A (any other 4in1 ESC >= 45A will work)

Forward motor ESC: Tmotor F35A (any other ESC >= 35A will work)

Recommended electronics:

TBS crossfire / ELRS

5.8ghz / 1.2ghz analog or digital (19x19 camera)

Matek F405-WTE flight controller or similar

Matek M8Q-5883 GPS/Compass or similar

4-in-1 35A ESC for lift motors

35A BLHELI ESC for forward motor

(4) Emax ES08MAII servos

Batteries:

Hybrid: 10500mah 4S3P 18650 + 1500mAh Li-Po

Li-Ion: 12,600mah 4S3P Molicel P45B 21700

Li-Po: 6000mAh 4S

Misc:

Polymaker Polylite prefoamed LWPLA

Polycarbonate or other high-temp filament for the motor mount

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Medium CA glue

200x200x200 minimum size print bed

Control horns ([this one](#)).

M3 threaded inserts (max 6mm height)

M3 bolts of various sizes

6x3mm magnets

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Section 4: 3D printing

4.1: Things to know before you start printing.

1. Titan Dynamics strongly recommends using Polymaker Polylite prefoamed LWPLA for the best results. This filament is much easier to tune your printer for and has less stringing than active foaming filaments. If you aren't able to purchase Polymaker filament, many members of our Facebook group and Discord server have had success.
2. You likely will not get good results unless your printer is well maintained and calibrated, we would suggest learning how to check and adjust your printer to perform at its absolute best before starting. This website has useful guides: https://teachingtechyt.github.io/calibration.html#intro.
3. **All the below guidance should be taken as a starting point only. Print a test piece** and check things like retraction settings and fitment of the carbon rods in the wings for yourself as every printer is different. If the carbon rods are too tight, increase the "Hole Horizontal Expansion" setting in Cura (or the equivalent setting in other slicers).
4. All our models are designed to be printed predominantly in LW-PLA filament. All fuselage, tail, and wing parts should be printed in LW-PLA unless otherwise noted in the file name.

There are 3 levels of infill / wall settings that we recommend for the LWPLA parts:
1. Maximum efficiency: 3% cubic subdivision, single wall
2. Balanced efficiency and strength: 5% cubic subdivision, single wall
3. Maximum strength: 8% cubic subdivision, single wall

WE RECOMMEND PRINTING BUZZARD WITH 3% CUBIC SUBDIVISION INFILL

Notes:
*   For the best flight characteristics and maximum range, LWPLA parts should be printed with single wall and 3% cubic subdivision infill.
*   Cubic subdivision infill can be increased to 5 or 8% to increase durability, but this will have an impact on maximum payload capacity (battery), and range by extension. We recommend and use 3% cubic subdivision infill as it has been tested to survive 6.4G in flight, but some may desire greater general durability when handling/carrying the model around etc. It will still break if you crash it!
*   Because the fuselage takes the most abuse during landings, some may choose to just print the fuselage sections in higher infill. Using a higher infill just for the fuselage (4%-8%) can greatly increase the longevity of the plane without as much of a weight penalty as printing the entire plane in high infill.
*   Gyroid infill brings a significant weight penalty with it even at the same percentage. For the highest strength-to-weight ratio part, stick to cubic

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subdivision or cubic. A part printed at 3% gyroid is comparable weight to the same part printed at 7% cubic subdivision.

**Polycarbonate, PETG or other high-temp filament should be used for the motor mounts and wing bay covers.**

- High temp Polycarbonate or PETG parts should be double wall and high infill (25%).

We recommend using the newest version of Ultimaker Cura. This Link can be used to download our own slicer profile.

4.2: Part Orientation

It is necessary to orient each part correctly on the build plate to avoid disconnected overhangs. Take care when doing this as the entire model is designed to be printed with no supports. If you orient some parts wrong, the print will fail. It may also be necessary to rotate and carefully position some parts to fit within the build area on smaller printers.

Examples for part orientation:
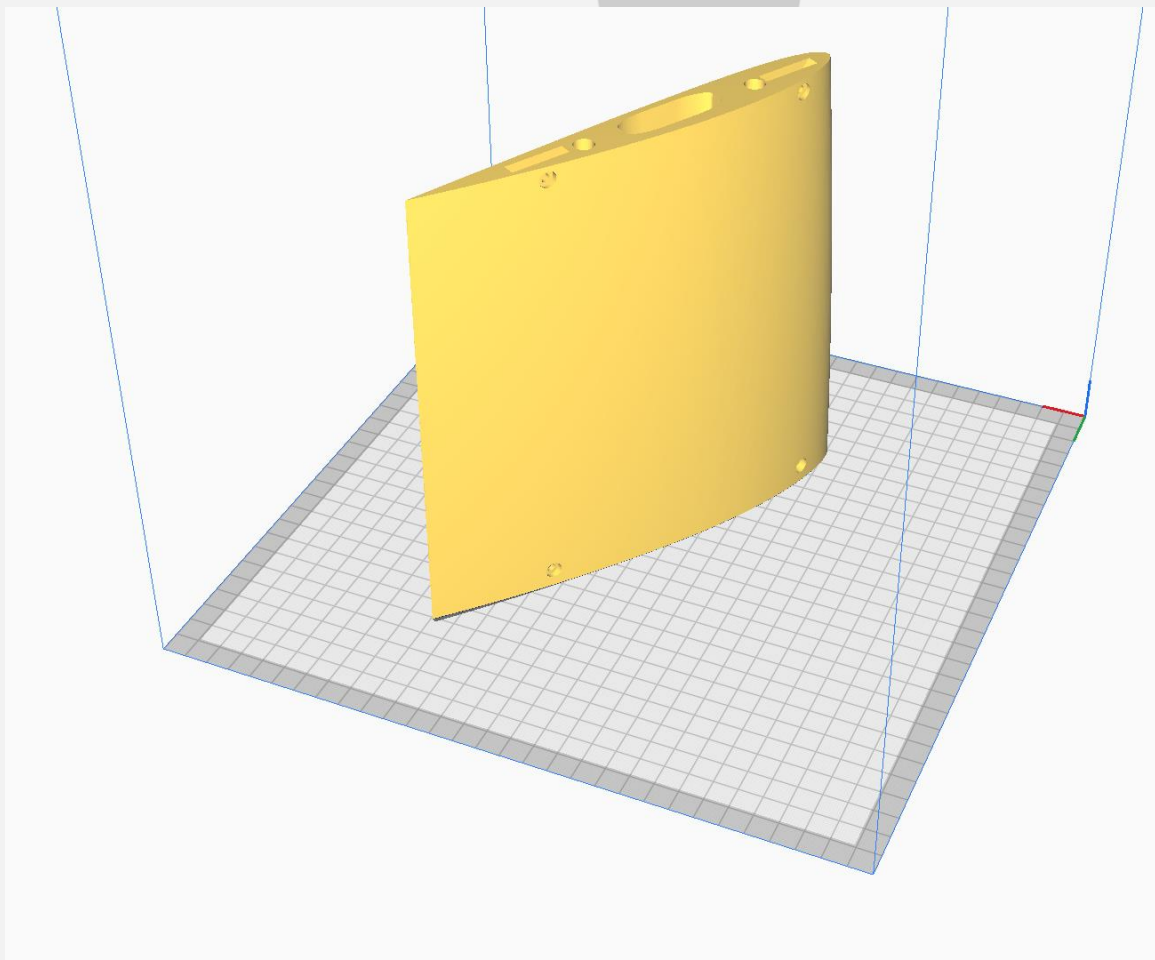
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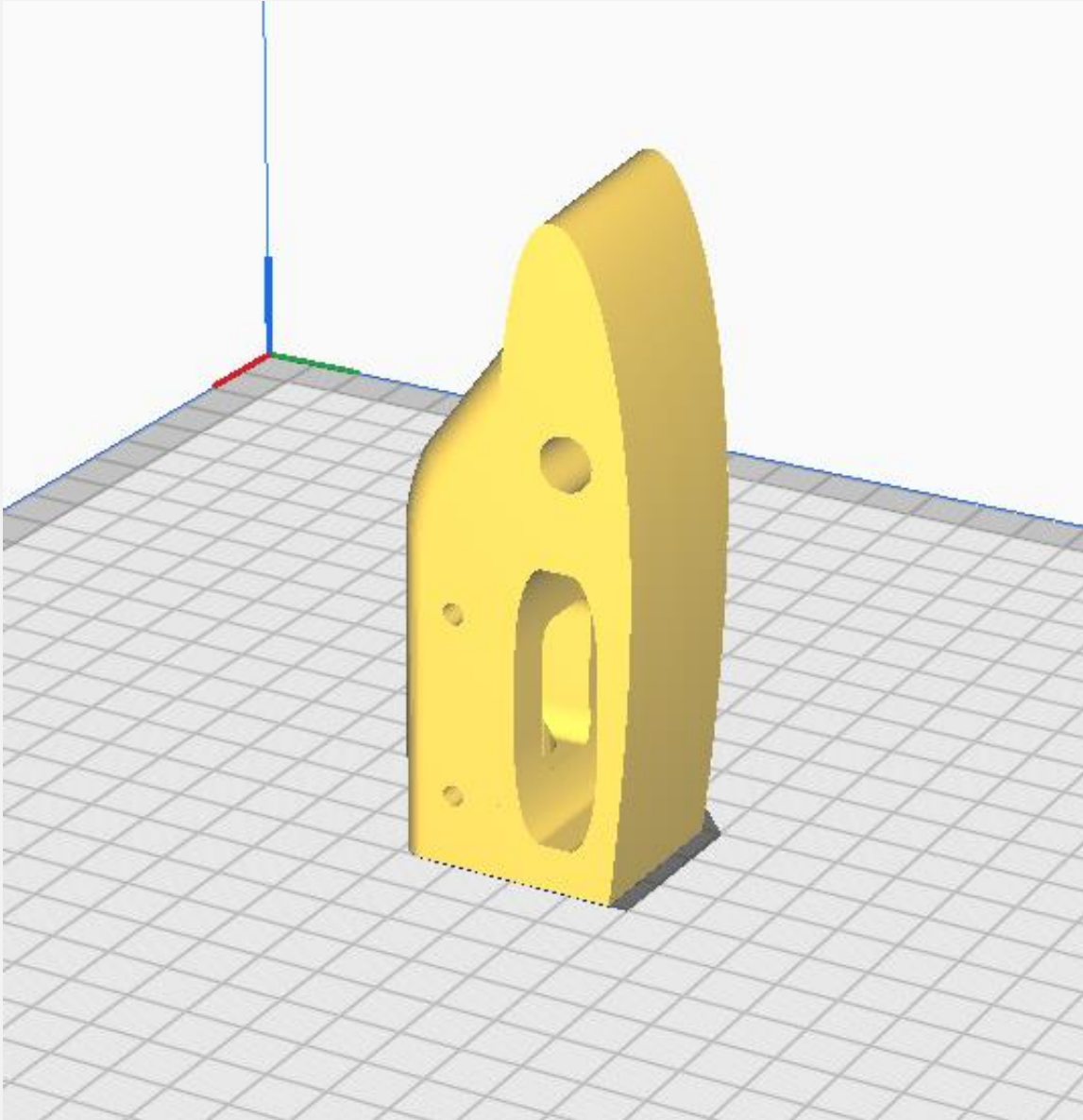Visit our Facebook page
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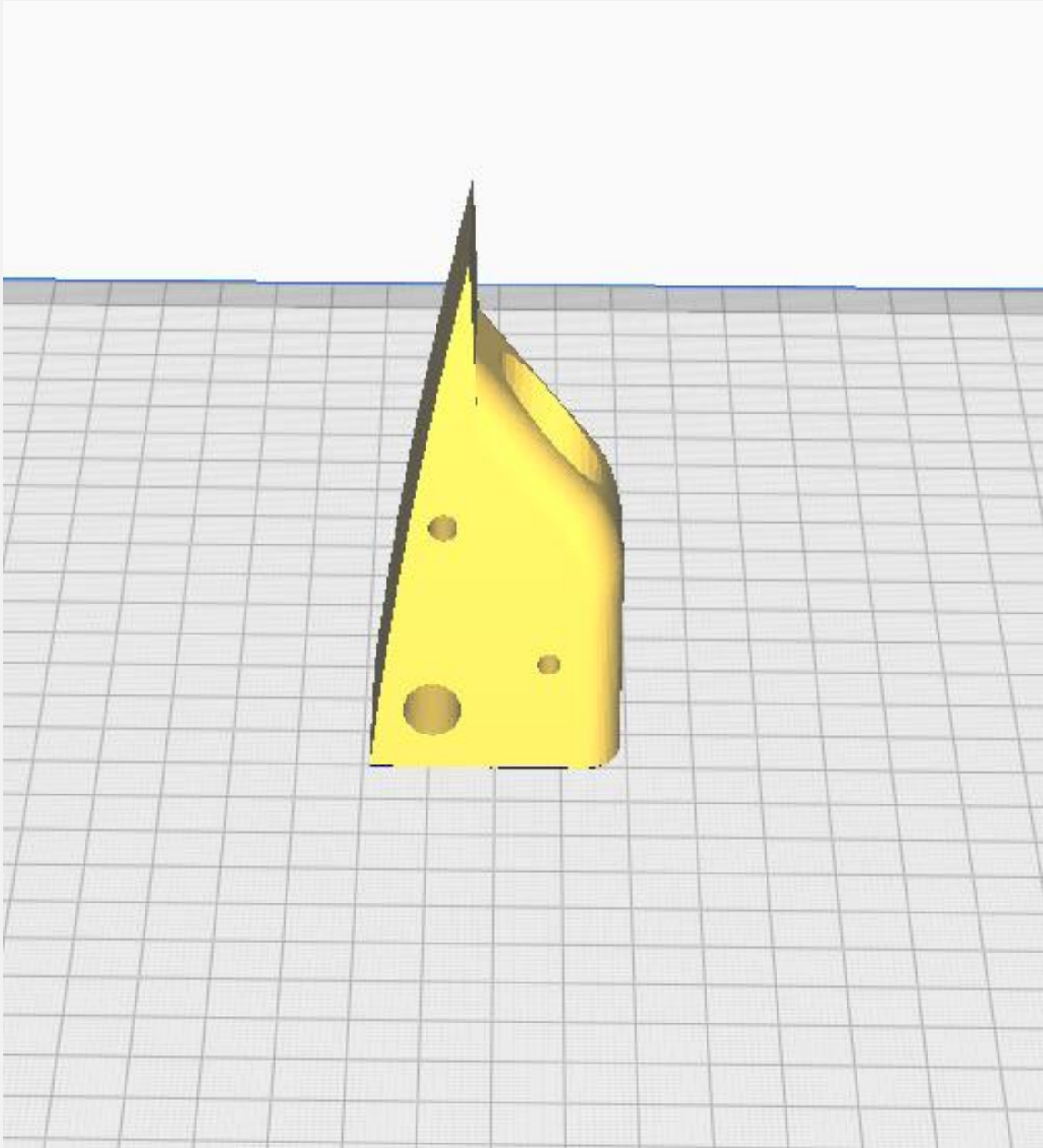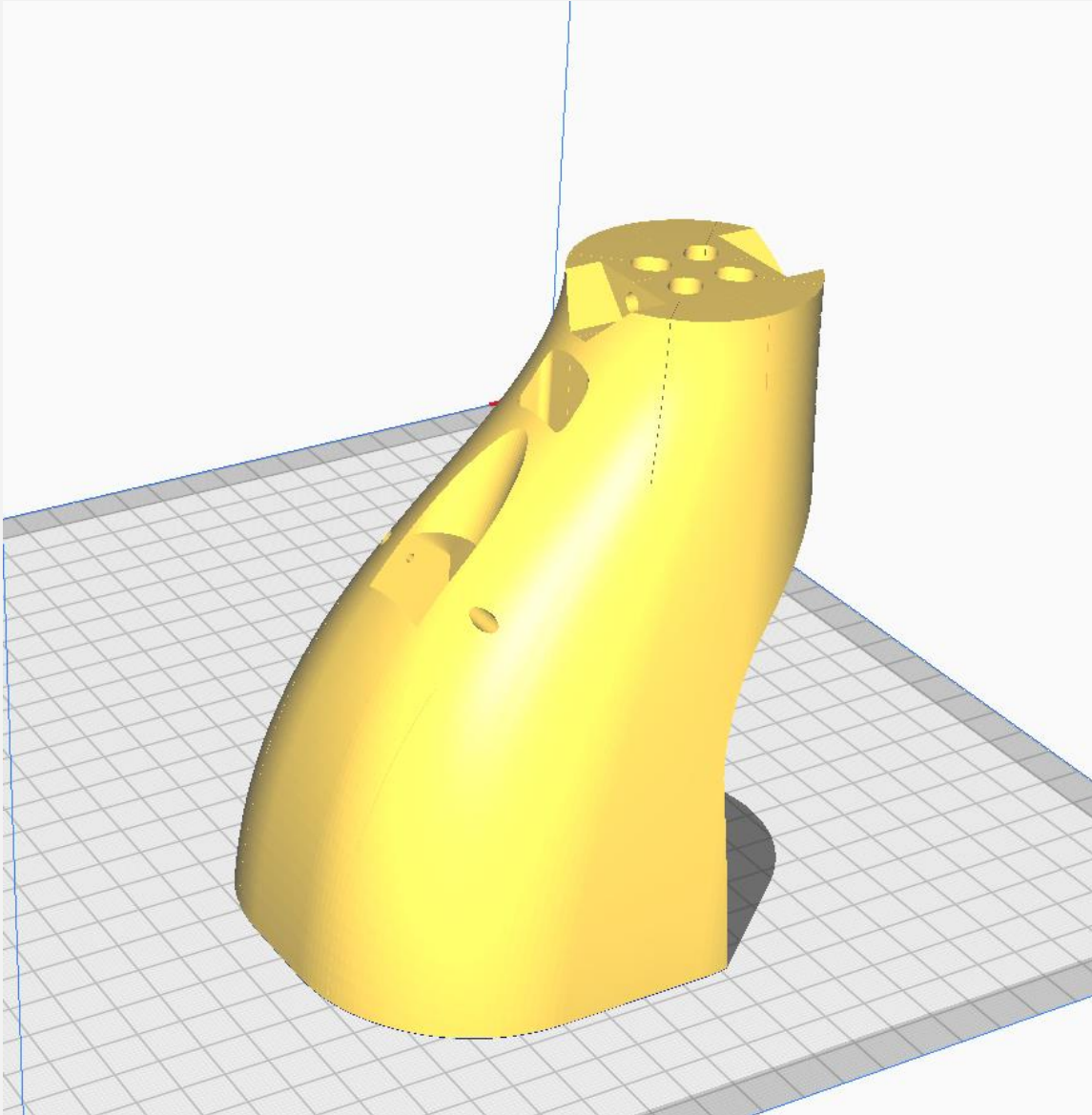[Titan Dynamics Webpage](#)
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4.3: Tuning "hole horizontal expansion"

It is very important to check the fitment of the carbon rods in their holes on the first parts you print. Because everyone may be using different printers, materials and slicer settings, it is not possible to provide the models with a slicing profile and hole size that will work for everyone.

Print your first part with carbon spar hole and check fitment, if it is too tight increase the hole horizontal expansion setting in the "walls" section in Cura (or your slicer's similar setting). A good starting point is 0.25mm. If it is too loose, just decrease the setting until you can reliably push the rods in and still get a snug fit.

4.4: Bed Adhesion and warping

When printing tall parts like this and other models require, having good print adhesion to the bed is a necessity. Ideally you will print each part without any extra aids, however

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this may not be possible for many, especially those printing without an enclosure for their printer. A full brim can be used but this will typically have mixed results. If it works for you, use a glue stick on the print surface to improve adhesion. Cura also has a plugin that can be used to help with bed adhesion and to avoid warping.

Cura Marketplace: TabAntiWarping Plugin.
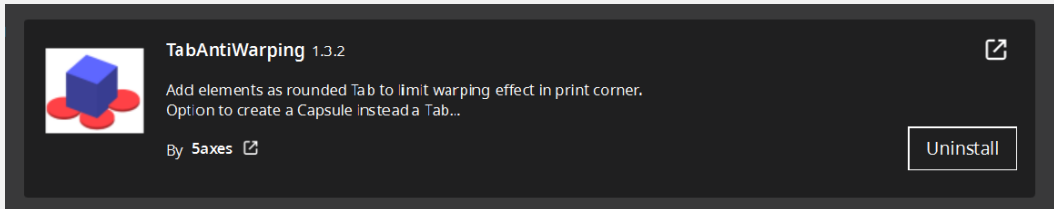
When installed, use the new icon at the bottom of the left menu to choose tab diameter and thickness, then click on the model to add a tab at each point you think is at risk of warping or poor adhesion (typically parts with low surface area in contact with the print surface in relation to their height). These new tabs can now be moved around to fine tune their position using the normal move controls on Cura.
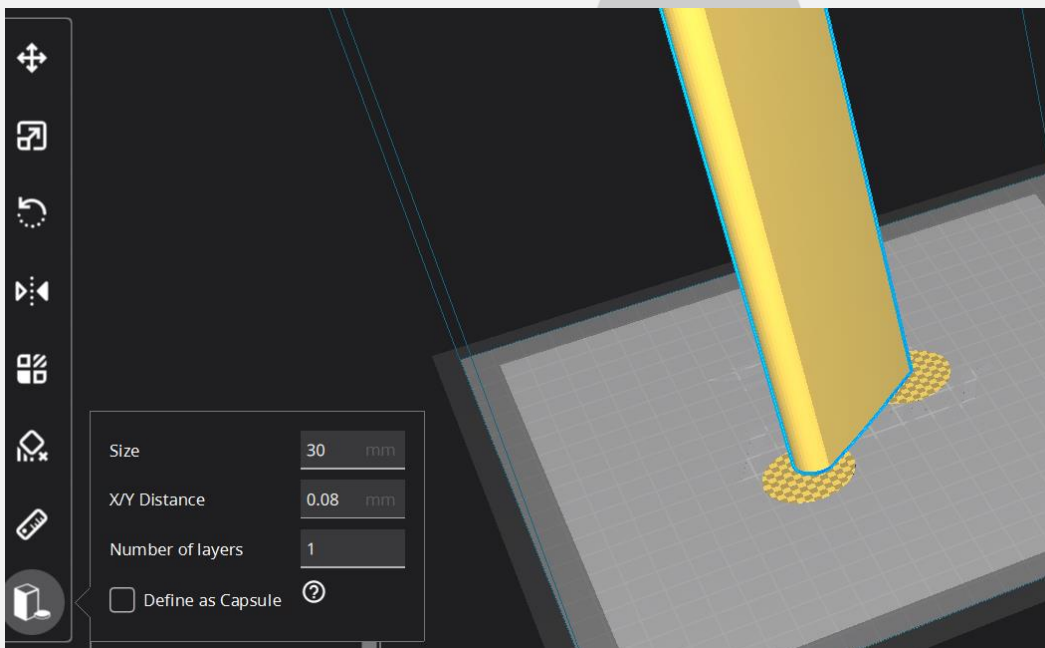

Once completed, be careful when removing these tabs from the print as they are quite strong and can damage the bottom of your part if not removed carefully. Re-open any holes the tab may have filled on the bottom of the print.

If you find these hard to remove from the print bed, select the "Define as Capsule" option. This makes the edge of the tabs raised, so you can get a scraper underneath them.

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Section 5: Assembly of 3D Printed Parts

Below are a few exploded views of the Buzzard to help with assembly.
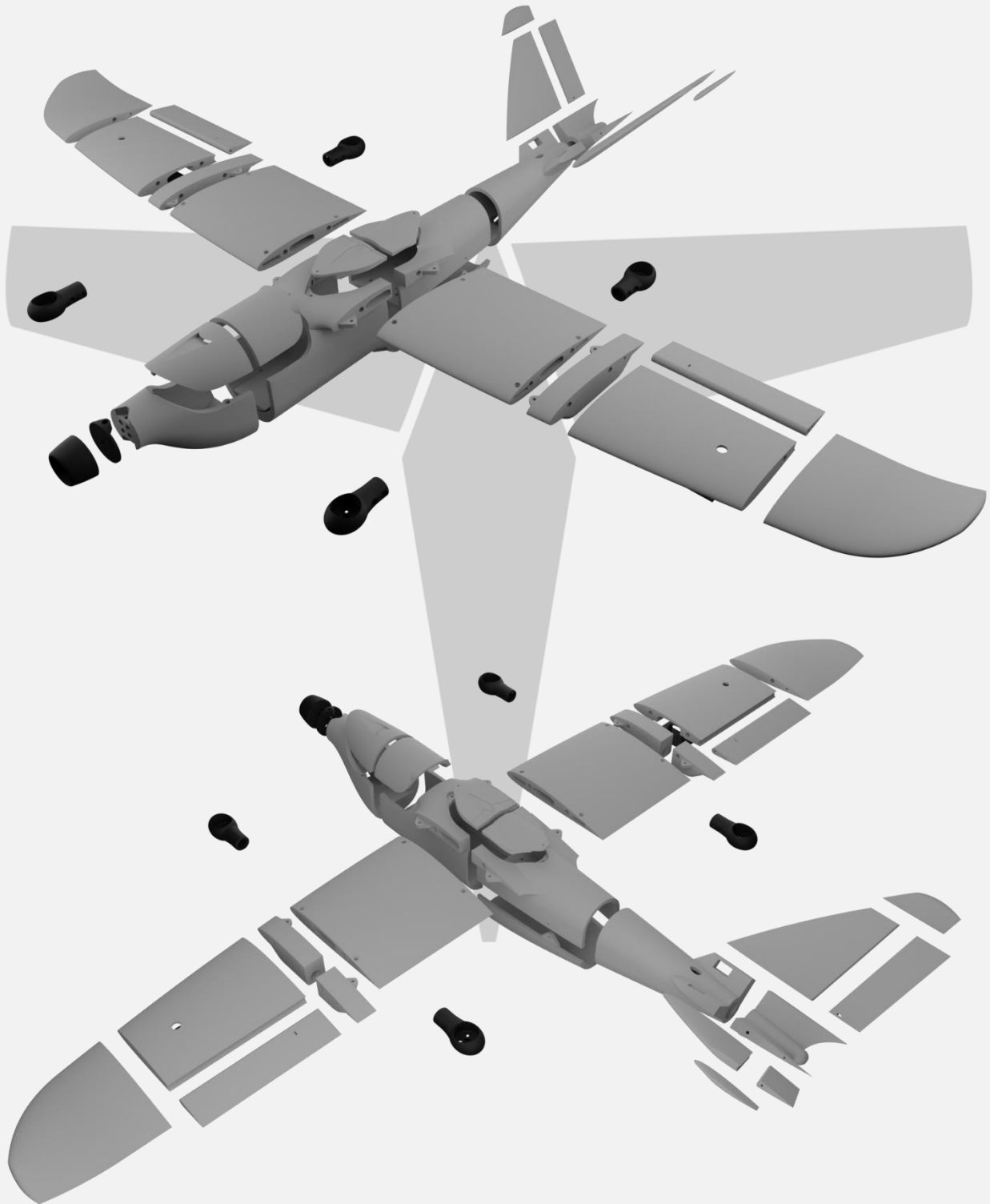
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The spar layout for Buzzard is as depicted below. None of the spars need to be glued in, they will all be retained by the printed parts.
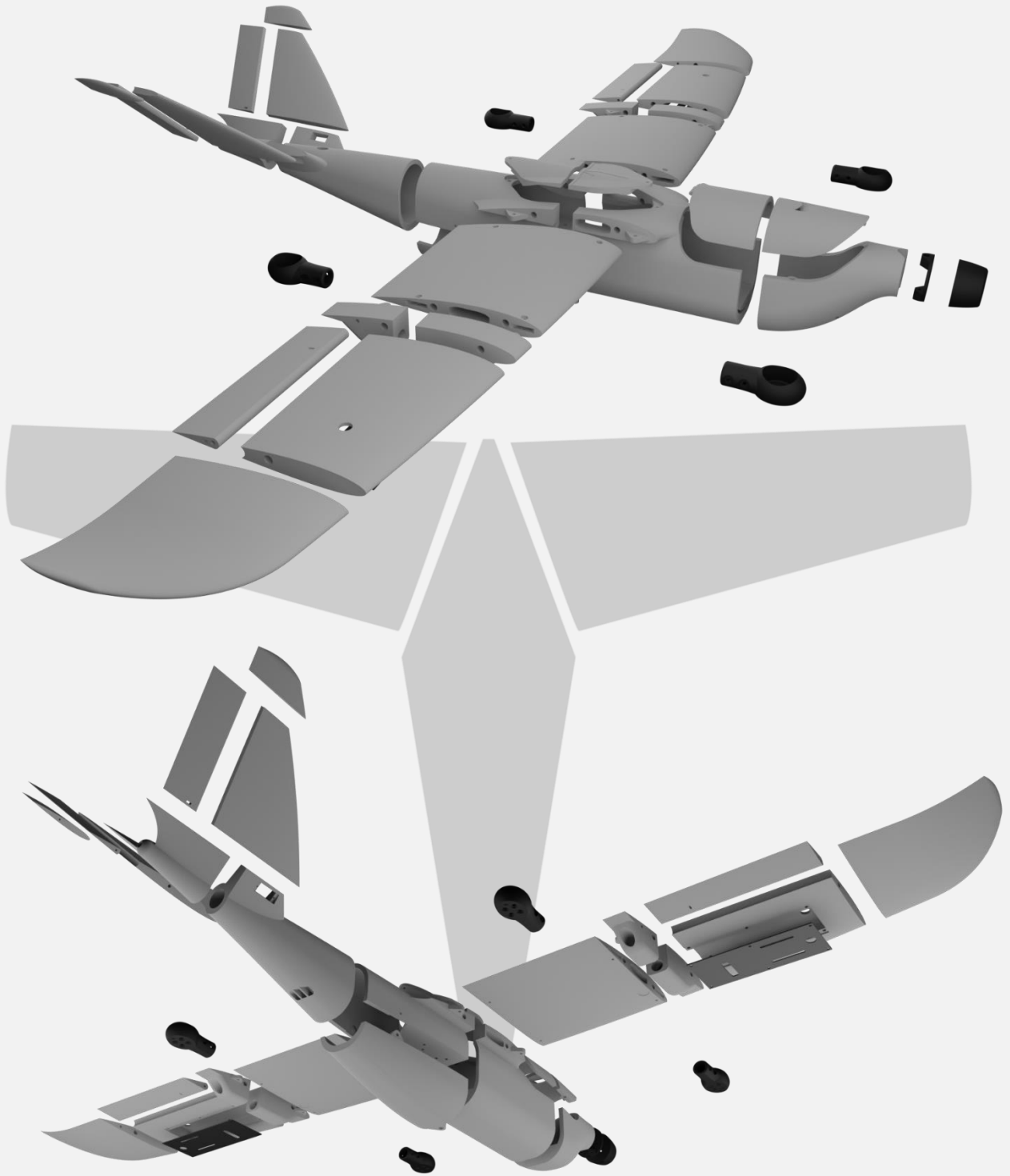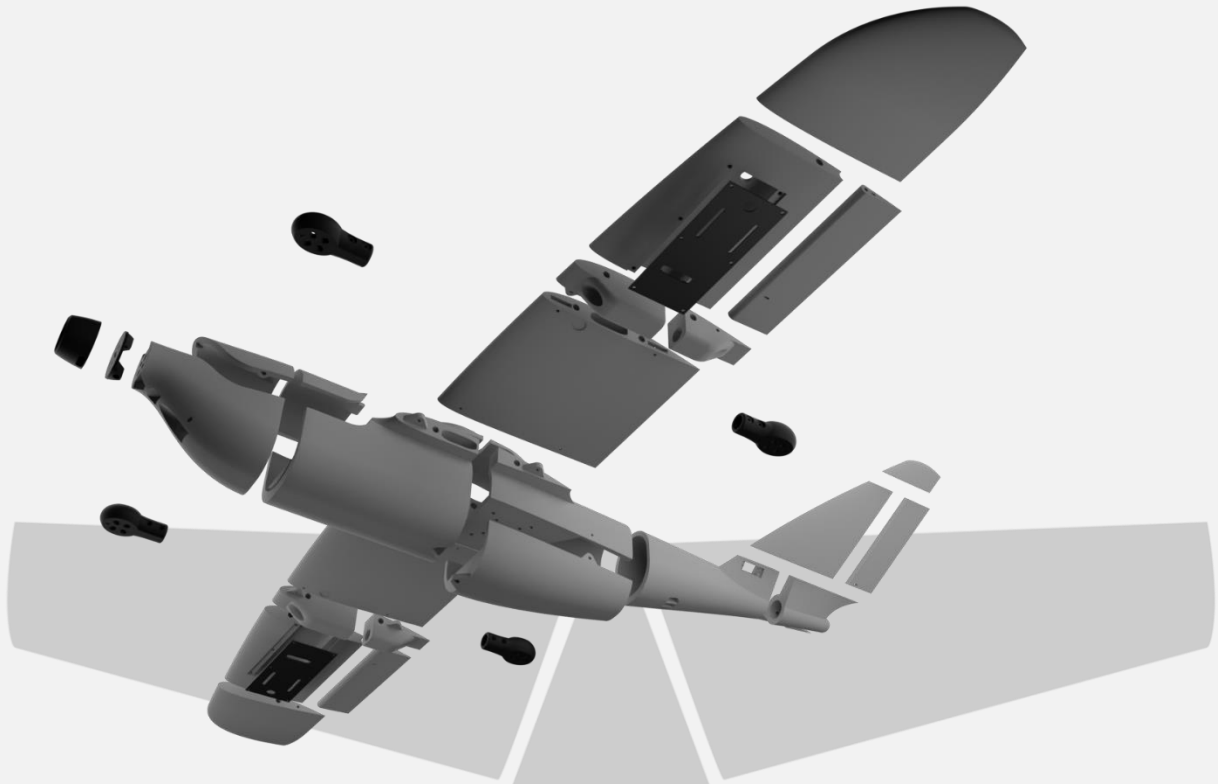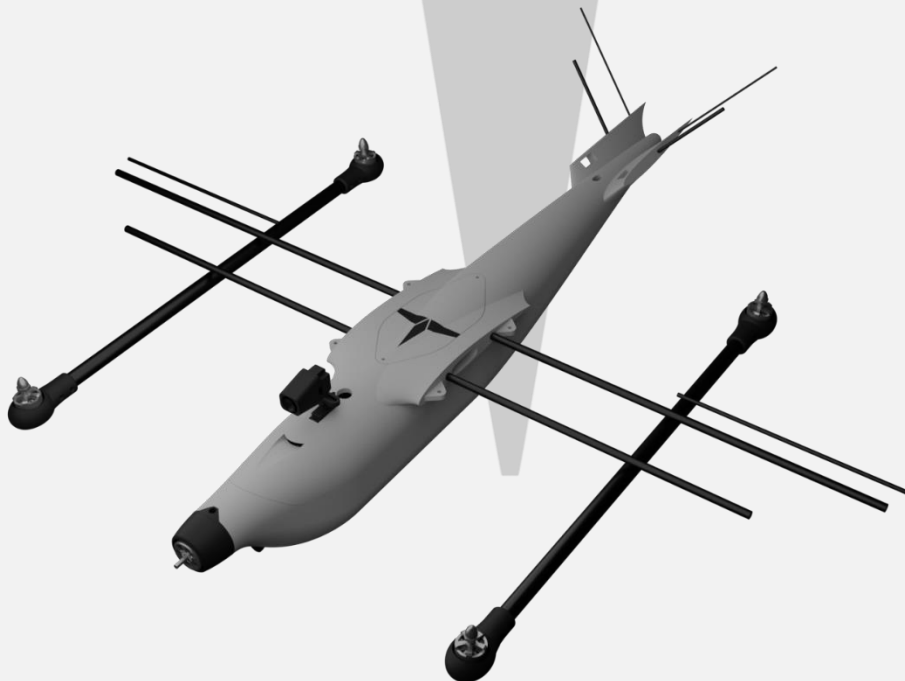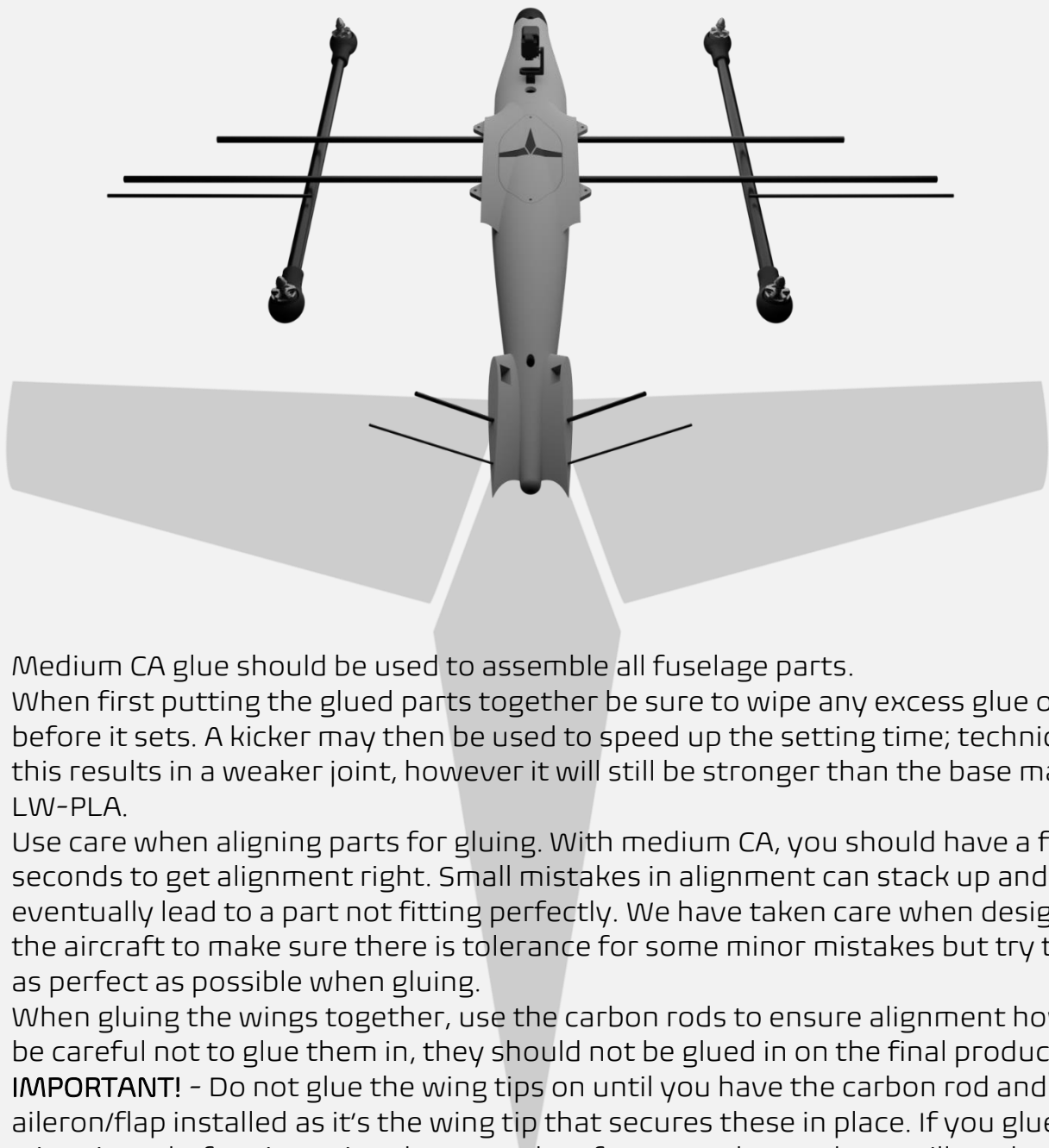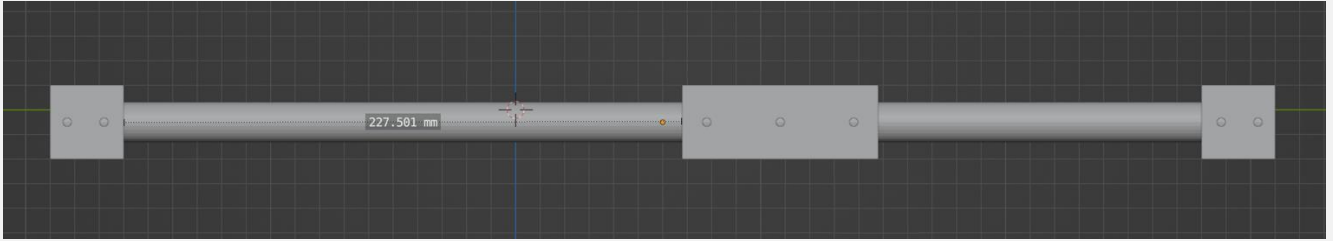
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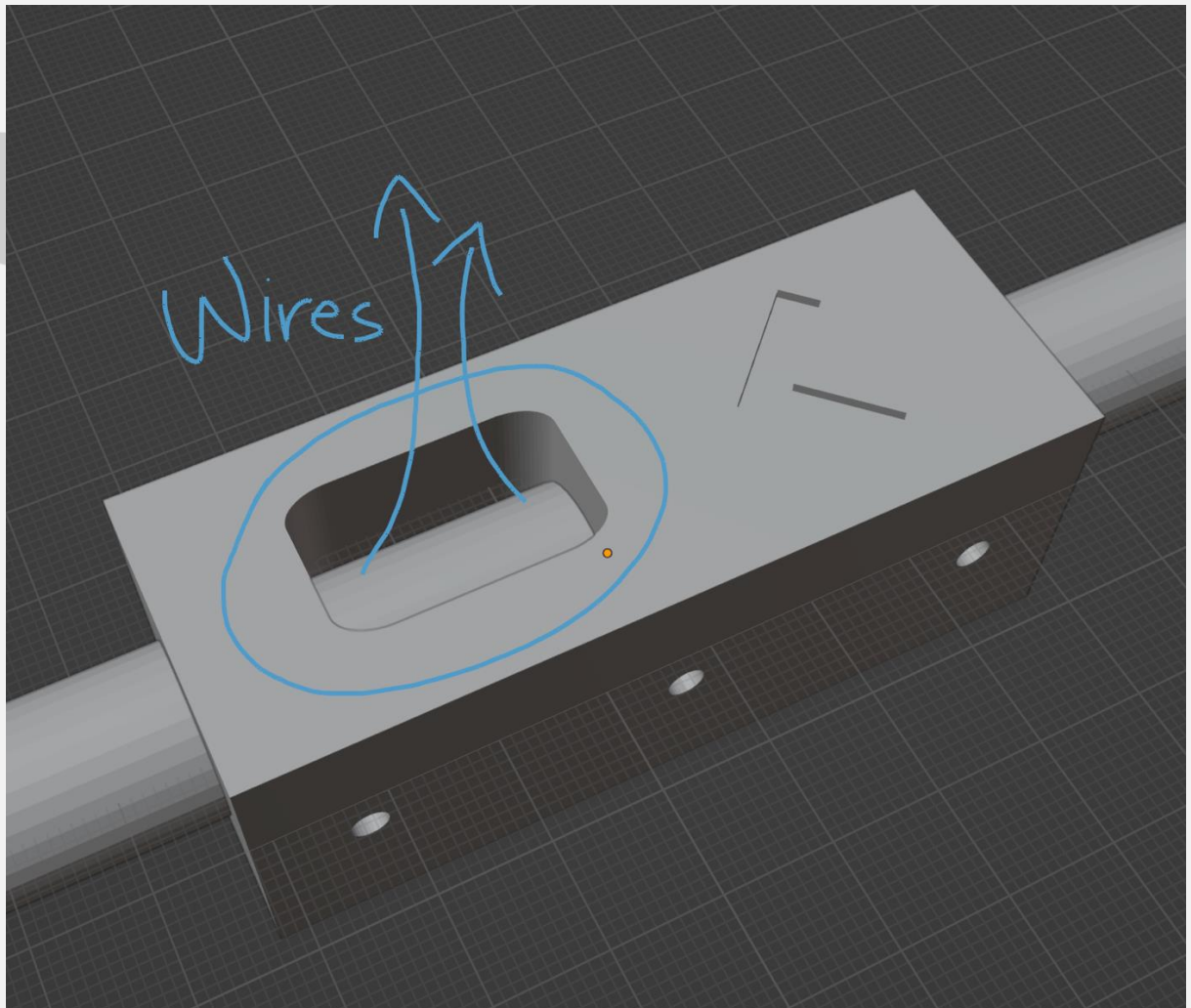[Visit our Facebook page](#)
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- Medium CA glue should be used to assemble all fuselage parts.
- When first putting the glued parts together be sure to wipe any excess glue off before it sets. A kicker may then be used to speed up the setting time; technically this results in a weaker joint, however it will still be stronger than the base material LW-PLA.
- Use care when aligning parts for gluing. With medium CA, you should have a few seconds to get alignment right. Small mistakes in alignment can stack up and eventually lead to a part not fitting perfectly. We have taken care when designing the aircraft to make sure there is tolerance for some minor mistakes but try to be as perfect as possible when gluing.
- When gluing the wings together, use the carbon rods to ensure alignment however be careful not to glue them in, they should not be glued in on the final product.
- IMPORTANT! - Do not glue the wing tips on until you have the carbon rod and aileron/flap installed as it's the wing tip that secures these in place. If you glue the wing tip on before inserting the control surfaces + carbon rod you will not be able to insert them afterwards.
- Threaded inserts can be properly installed by using a soldering iron at low heat setting, a good guide for doing this can be found at [this link.](#)

BOOM ASSEMBLY: There are 3D printable jigs included in the files. Please print them and distance them according to the drawing below. Lay them on a flat surface and drill straight through them into the boom to ensure all holes are perfectly where they need to be. Arrows point outwards. For mounting to the booms, please use long m3 bolts (30-35mm) and locknuts.

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The lift motor wires must be routed through the boom by cutting a box into the boom. The dimensions of the suggested box cutout are built-in to the middle jig.

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Section 6: Final Setup & Tuning Tips

- Titan Dynamics strongly recommends the use of Arduplane for all our models. If you encounter an issue in flight, the data logs Ardupilot creates are invaluable for finding the root cause of any issue and increasing future chances of success.
- Give all control surfaces +- 30 degrees or more throw.
- CG is marked under the wing and should be kept very close to that point.
- Add duct tape or other abrasion resistant material to bottom of the fuselage to increase durability if landing on rough surfaces.

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Ardupilot setup:

Please read in detail the documentation for setting up quadplanes on Ardupilot: https://ardupilot.org/plane/docs/quadplane-building.html. Buzzard is a traditional 4+1 setup. Other than setting Q_ENABLE = 1 there are no other changes required for a maiden flight. However, pay close attention to the below parameters:

Q_FRAME_CLASS = 1
Q_FRAME_TYPE = 1

Also read the QuadPlane setup guide: https://ardupilot.org/plane/docs/quadplane-frame-setup.html

Since Buzzard is so rigid, feel free to increase the hover pitch/roll PID values to more responsive ones such as:
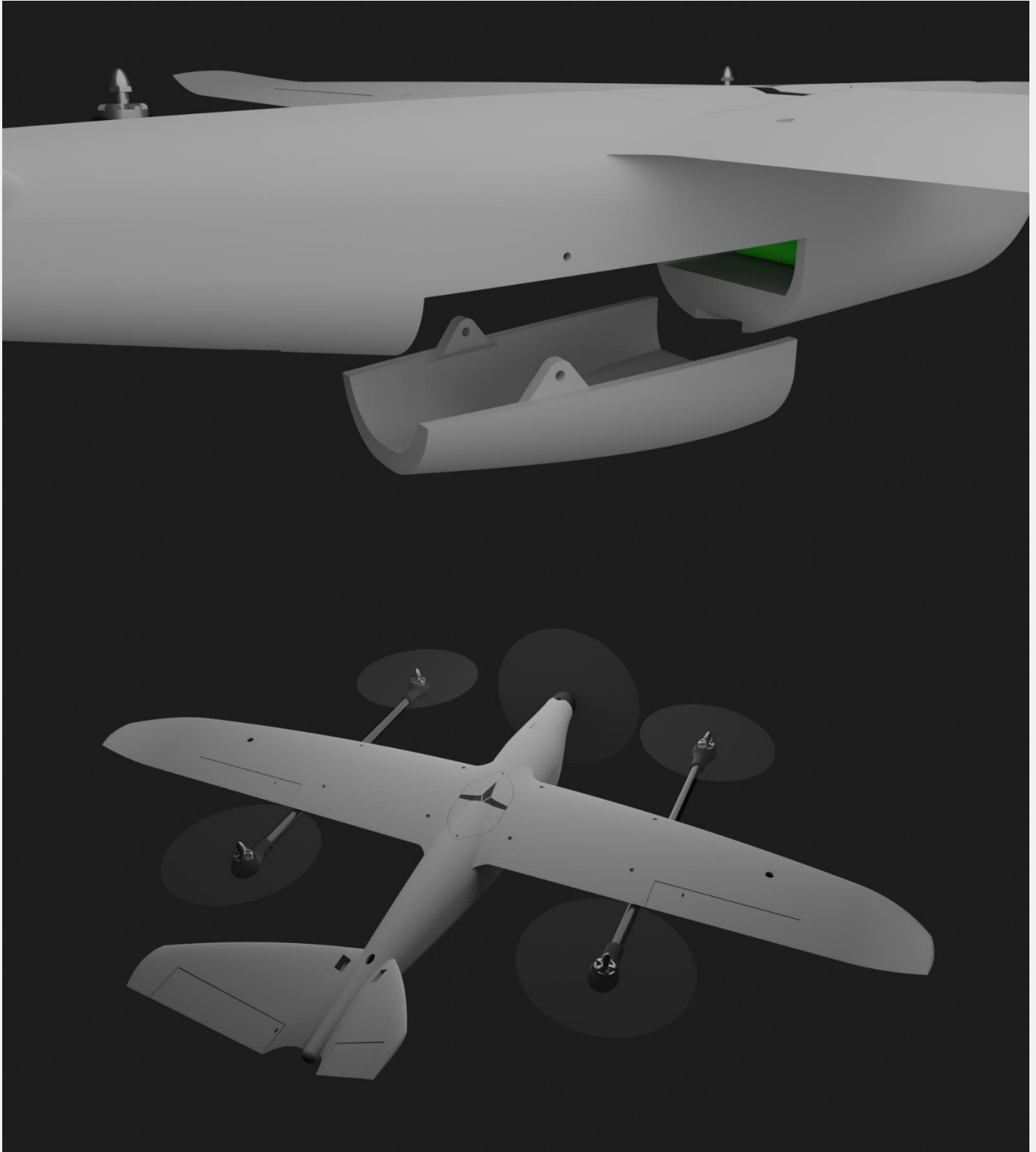
P: 0.22

I: 0.125

D: 0.002

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Section 7: Additional Images

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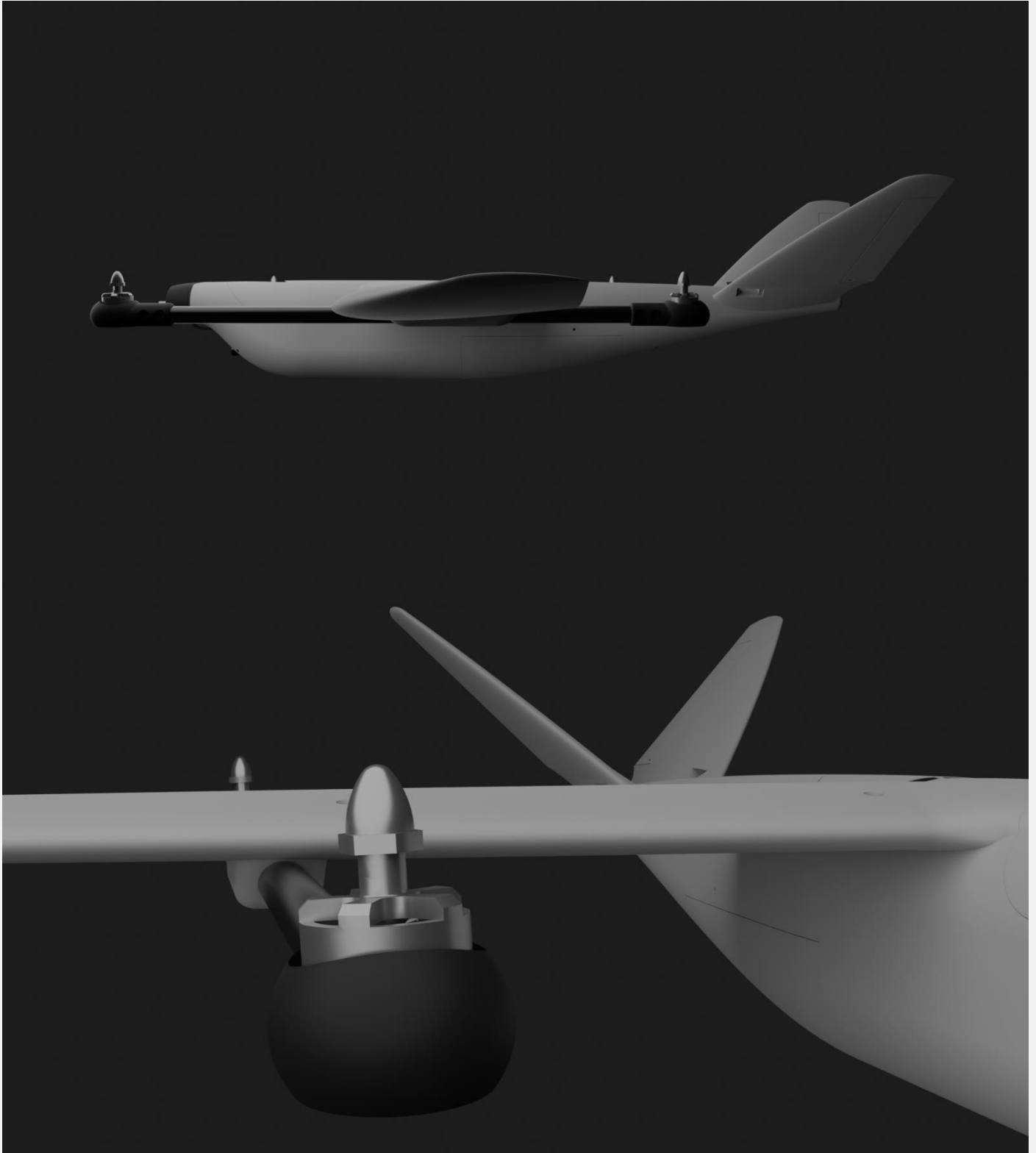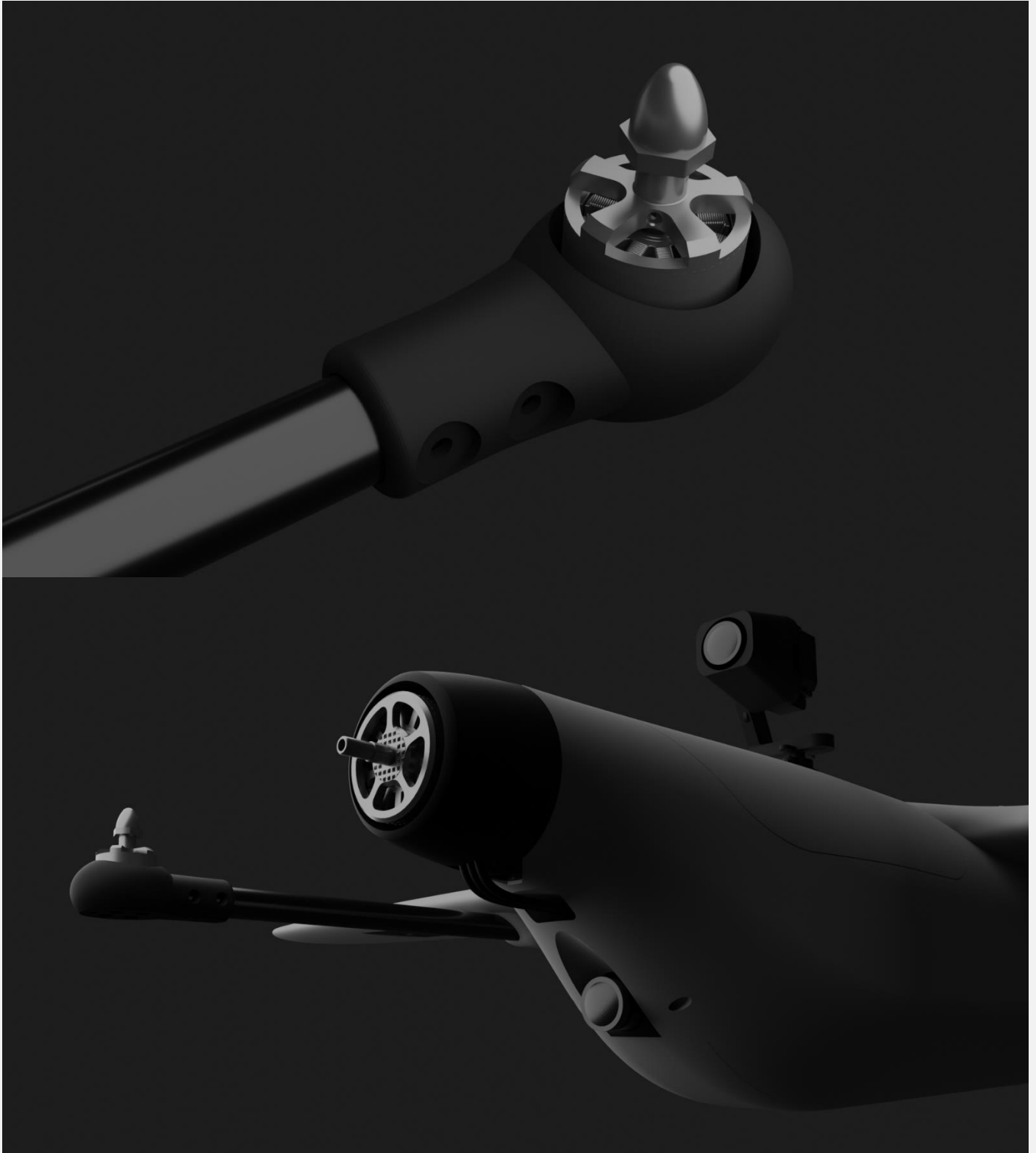
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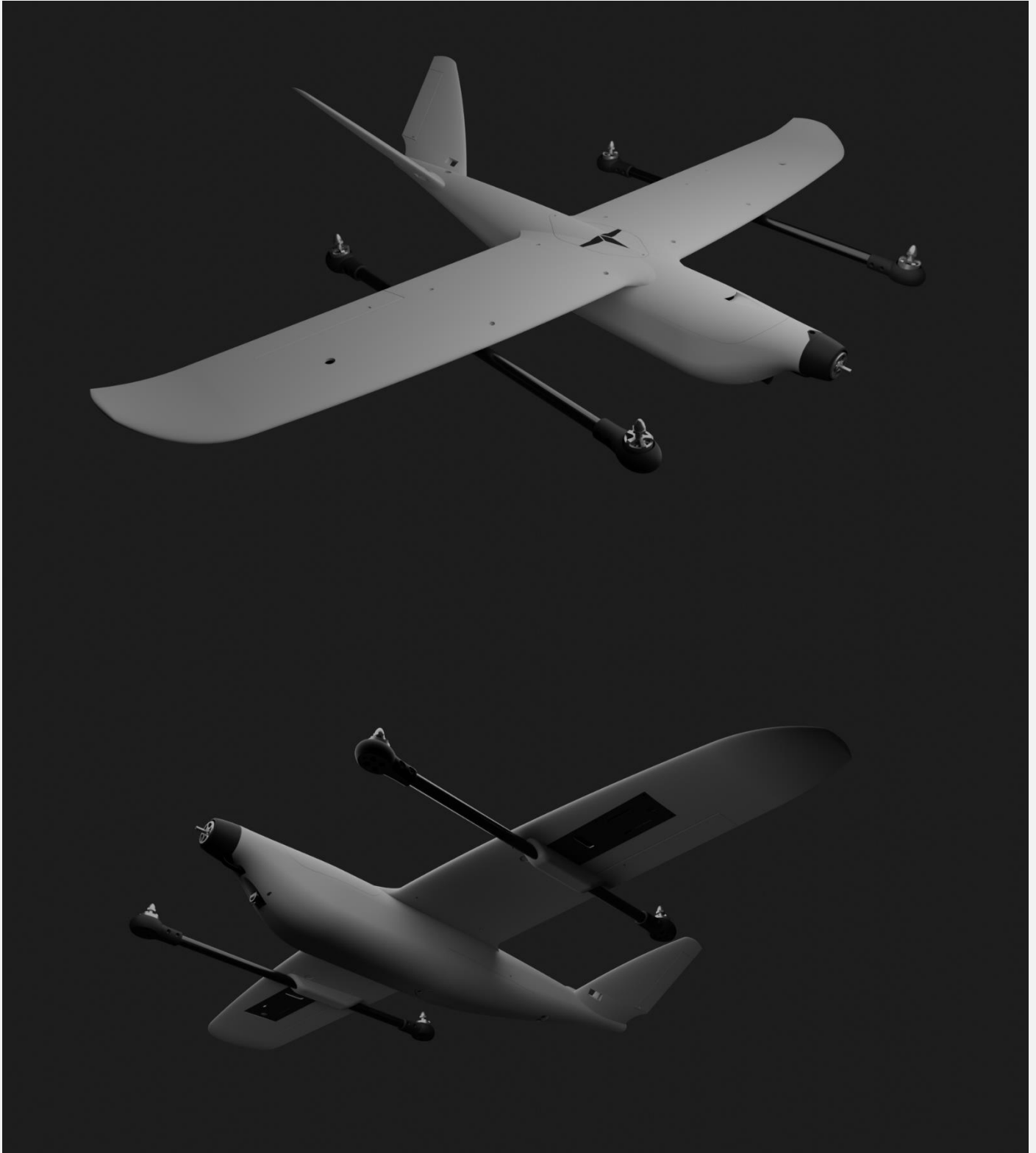
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