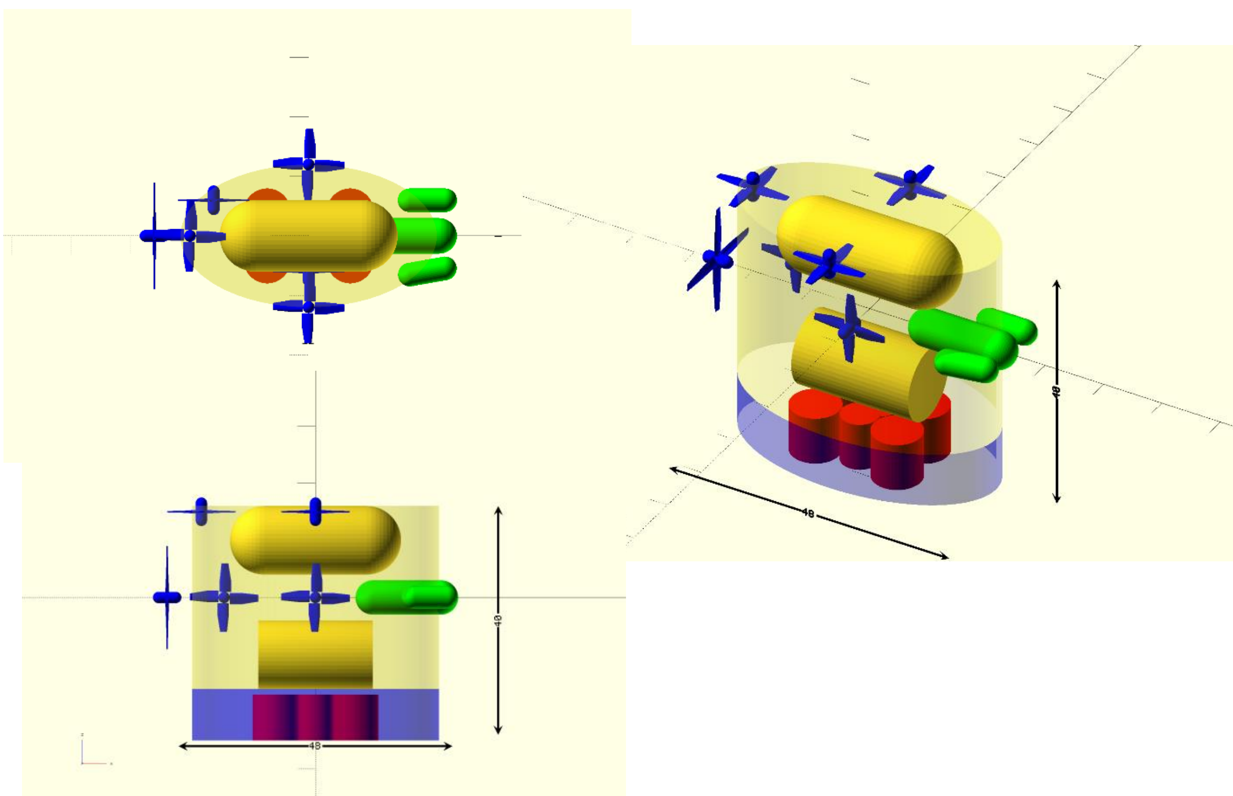
Nov 2, 2017

To: Mesobot
From: Dana
Subject: “Tall boy” design

Here’s a design that I think is responsive to the concerns expressed in our telcon earlier this week. I’ve been struggling a bit to come up with a layout that incorporates the LRAUV components with minimal alteration while also meeting all our other requirements (avoiding disturbances, passive pitch/roll stability, excellent hover performance, etc). As we originally discussed at the proposal stage, we want the SUPR (or any other swappable payload) to be easy to remove and for the vehicle to be uncompromised without it. This favors a design where the add-on payload is in the form of a sled that attaches to the bottom of the vehicle (light blue ellipse). Here’s my latest candidate design (with input from Molly and Jon). We will put a full battery pack (37 cells) in a 12” housing with flat end caps down low which will be heavy. The design has a large, 12” housing up high. It has hemispherical end caps and will be very buoyant. You can find the full sized figures in the configurations directory in the Dropbox (horiz_2housing_stacked3_xxx.png).



Here are the strengths of the design in my view:

1. The vehicle will be passively stable in pitch and roll, which will be critical for good imagery. When we use optics with a tighter field-of-view, stability will be even more important. The battery housing (37 cells) with flat end caps with batteries will be about 50 lb heavy and the upper electronics housing will be about 70 lb buoyant before we put the electronics in. The

SUPR (or equivalent ballast) may weigh as much as 20 lb in water (hopefully less). The vehicle will also have a foam pack on the top. This is the best design I've come up with in regard to the amount of weight low and buoyancy high. I'm working on some calculations now, but I anticipate that the vehicle will be very stable.

2. The vehicle will be reasonably streamlined for our principal motions, forward and vertical. I've shown a simple elliptical skin, the top and bottom would be faired.
3. The thruster paths are clean, except for the aft thruster.
4. The thrusters are all well back from the imaging volume. The aft thruster is naturally baffled when driving the vehicle back. If we needed to further baffle the aft thruster, we could.
5. The SUPR will sit in a removable sled on the bottom. When setup for imaging-only runs without sampling, we can remove the SUPR completely probably substituting a small sled containing some ballast. This complicates things a bit, for example the drop weights will be part of the baseline vehicle and they need to fall out the bottom. But I'm certain we can find a solution to those problems.
6. The housings are horizontal, which makes service as sea easier than vertical housings.
7. We can make the vehicle taller if we want to carry larger payloads.
8. The vehicle has payload space forward (under the cameras) that could be used for other imaging systems.
9. The biggest reason I liked the vertical housing layouts is that they lend themselves to having a forward and aft vertical thruster. If we have a horizontal housing at the top of the vehicle, we can't have a single vertical through the middle and putting two vertical thrusters on the vehicle midline makes the vehicle long and puts the forward vertical close to the imaging volume. If our depth control uses only verticals on each side of the upper housing, we have no way to make a pitch moment. If the vehicle is not perfectly balanced, then it will wobble in pitch when the vertical thrusters are engaged. The amount of wobble will depend on the vehicle's pitch/roll stability and the offset of the vertical thrusters from the "perfect position" fore-and-aft. Unfortunately, there is usually no perfect position for both drag and inertial effects. This design has three verticals. The fwd pair (port and stbd) will do most of the thrusting during vertical movements or to makeup for ballasting error. The fwd pair is centered on the vehicle (center of inertia or drag?). The aft vertical will allow us to trim the pitch.
10. The battery pack could be removable for fast swapping.
11. The upper housing has lots of room for the motherboard, LCB, TX2, Ethernet switch, motor controller, etc.
12. The science camera is on the roll center of the vehicle (Steve's suggestion).
13. The vehicle doesn't want to naturally turn (in heading) about the science camera (Steve's suggestion again), but I think it will be able to accomplish that if we allocate the two laterals properly. With the laterals as shown, I think we will be able to rotate about the target very well.
14. If we make the height of the aft thruster adjustable, we can align it for minimal induced pitch when accelerating or in steady transit even when the sampling payload changes.

Some negatives

1. The port and starboard vertical thrusters look to be vulnerable during launch and recovery. We could protect them with a crash bar at the expense of drag.
2. Compared to other designs, we need an extra thruster to have control of pitch. Alternatively, we could create pitch moment with upper and lower fwd/aft thrusters in the

stern. Upper and lower aft thrusters would allow us to prevent pitch during fwd/aft acceleration.

Summary: I think this design addresses most of our concerns at the expense of adding one more thruster. I think the extra vertical is the best answer, but having two aft thrusters is another solution. The sampler is completely removable and I think the sampler sled concept will give us lots of versatility. The design has room for additional forward-looking imagers. The vehicle will be passively stable in pitch and roll and reasonably streamlined for forward and vertical movements. The thruster paths are nearly clean except for the aft thruster. The housings are horizontal for easier access and the battery housing could be removable.