Report on issues caused by 3D printed mounts without margins and how it is solved by the current design

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Introduction and Overview

This report aims to outline the issues caused by 3D-printed mounts without margins, and the use of Vaseline as a sealant in the previous year and to discuss how the current version, G2.2, solves these issues.

Issues from G2.0

1 Parts being 3D printed

Reliability

3D printed parts are less reliable for long-term or heavy load applications. 3D printed things are made layer by layer and the bonds *between layers are usually weaker than other materials. Including metal, aluminum, carbon ect. It may also break very easily under stress.*

Accuracy

3D prints generally have a low accuracy of ~0.2 mm.This may cause parts that require precise fits, such as mounts or other components.They may not fit correctly. Leading to loose or tight fits, which worsens the balance of the ROV and makes assembly harder.

Solutions by G2.2

This year, we had a materials sponsor to CNC manufacture our parts out of aluminium. Aluminium parts can be made to very high precision (up to ±0.005mm), so the parts can be made to fit more accurately (reducing vibrations in the structure) or even 0-tolerance machining (though it is not very practical).

2 Incorrect Margins

What is Margin?

Margin is the small amount of extra space designed into a part to make sure that it can fit into another object.

Why does a margin matter?

Margin matters because it provides a space that lets materials fully cover and seal joints. This overlap creates a barrier so that water cannot go in, making sure that compartment stays dry.

What will happen with a margin that is too small?

Without a margin, spaces where things meet couldn't have any gaps, delaying installment of components. Which is exactly what happened to the G2.0. As there was no margin, the watertight compartment holder and the thruster mounts did not fit onto the PVC ring-shaped mainframe, delaying the installment as replacement parts had to be made and printed. The G2.0 ultimately had a week of extra delay before it could go for water testing, which led to problems in the sealing component going undiscovered and a catastrophic breakdown in the competition.

3 Use of Vaseline Sealants

Material of O-rings and the chemical reaction

O-rings are made out of Silicone. Silicone is notable for its weakness to oils but is generally very good at sealing against water, and can perform in a wide range of temperatures. The chemical reaction between Vaseline and O-rings is due to the chemical property of "like dissolves like". Vaseline is a petroleum jelly, and the hydrocarbons in it are incompatible with the silicone polymers of O-rings. This causes it to swell, lose its shape, or even crack in extreme cases of degradation, and will most certainly lose its sealing power.

What Went Wrong in the Competition

On 27th April 2025, the Gyrodos G2.2 made its first successful powered run on the competition day. Previous non-powered water testings on the 25th at La Salle College and 26th on the competition venue (IVE) were successful, and no visual issues were found with the *craft. Significant degradation in the O-ring's sealing capability began when Vaseline was first used to seal the flange of the watertight compartment. Two days later, the craft had almost lost its sealing capability. Although the vacuum test proved to be successful, water pressure meant that water ingress took place in fewer than 5 minutes into the actual competition. This meant the craft was rendered inoperable, and the run had to be stopped due to safety concerns, and Gyrodos Robotics scored only 9 marks in the demonstration part.*

PTFE-based Sealants

PTFE-based grease solves this problem as they are compatible with silicone O-rings. They do not have any reaction, and hence they will not degrade the sealing compatibility but enhance it when it is applied onto the flange in a thin, even coating. It is worth noting that silicone O-rings themselves are also degraded by repeated compression and non-compression, so they should be replaced after 10 use cycles (1 use cycle is considered by removal and re-insertion of the flange), or any sooner if visual inspection shows flattening, cracking, loss of elasticity, or if the flange fails a vacuum seal test.

Conclusion

3D-printed parts in G2.0 had low strength and low accuracy (~0.2 mm), resulting in poor fits. The lack of margin led to gaps being too thin, making the watertight compartment holder unable to fit into the PVC mainframe. As extra development time had to be taken to fix these issues, a safety issue in the sealant went unnoticed and was not fixed until the ROV leaked water in the actual competition, costing us *our 2024 run.*

Measures to be taken

It is recommended that ME department engineers receive additional training in Fusion and 3D printing, enabling them to develop stronger skills. They should also learn more about ROV safety so they can identify issues and fix them promptly to ensure the competition runs smoothly. As sealing was one of our costliest issues last year, we must focus heavily on water safety so that our efforts to make Gyrodos will not be in vain.