VORON

GALILEO 2 EXTRUDER

Planetary power for your gardening-tool-built space shuttle.

VERSION 25SEPT2023

PART PRINTING GUIDELINES

Galileo 2 follows the Voron Team standards. The Voron Team has provided the following print guidelines for you to follow in order to have the best chance at success with your parts. There are often questions about substituting materials or changing printing standards, but we recommend you follow these.

3D PRINTING PROCESS

Fused Deposition Modeling (FDM)

MATERIAL

ABS/ASA

LAYER HEIGHT

Recommended: 0.2mm

EXTRUSION WIDTH

Recommended: Forced 0.4mm

INFILL TYPE

Grid, Gyroid, Honeycomb, Triangle or Cubic

INFILL PERCENTAGE

Recommended: 40%

WALL COUNT

Recommended: 4

SOLID TOP/BOTTOM LAYERS

Recommended: 5

FILE NAMING

By this time you should have already downloaded the STL files from the Galileo 2 GitHub repository. You might have noticed that we have used the Voron standard naming convention for the files. This is how to use them.

PRIMARY COLOR

front_body_ECAS_coupler.stl
These files will have nothing at the start of the filename.

ACCENT COLOR

[a]_front_bearing_holder.stl
We have added “[a]” to the front of any STL file that is intended to be printed with accent color.

HOW TO GET HELP

If you need assembly assistance, we're here to help. Head on over to the Voron Discord group and post your questions. This is our primary medium to help Voron Users and we have a great community that can help you out if you get stuck.

Discord https://discord.gg/voron

VORON FORUM https://forum.vorondesign.com

REPORTING AN ISSUE

Should you find an issue in the documentation or have a suggestion for an improvement please consider opening an issue on GitHub (https://github.com/JaredC01/Galileo2/issues). When raising an issue please include the relevant page numbers and a short description; annotated screenshots are also very welcome. We periodically update the manual based on the feedback we get.

https://github.com/JaredC01/Galileo2

WHAT IS GALILEO?

Galileo is a series of planetary-geared projects designed for use in Voron printers designed by JaredC01. This document covers Galileo 2, or G2, which has an incredible 9:1 gear ratio in a custom-designed planetary gearbox. This manual covers the Galileo 2 Extruder, or G2E, specifically. There are also other G2-based projects, such a G2Z drives and a standalone extruder design, which will be covered in separate manuals.

WHAT BIG GEARS YOU HAVE!

In addition to the planetary gear reduction, G2E also features a custom 16mm RNC-coated filament drive gear. This means more grip on the filament, helping to minimize filament slip and maximize extruder output.

DROP IN REPLACEMENT FOR CW2

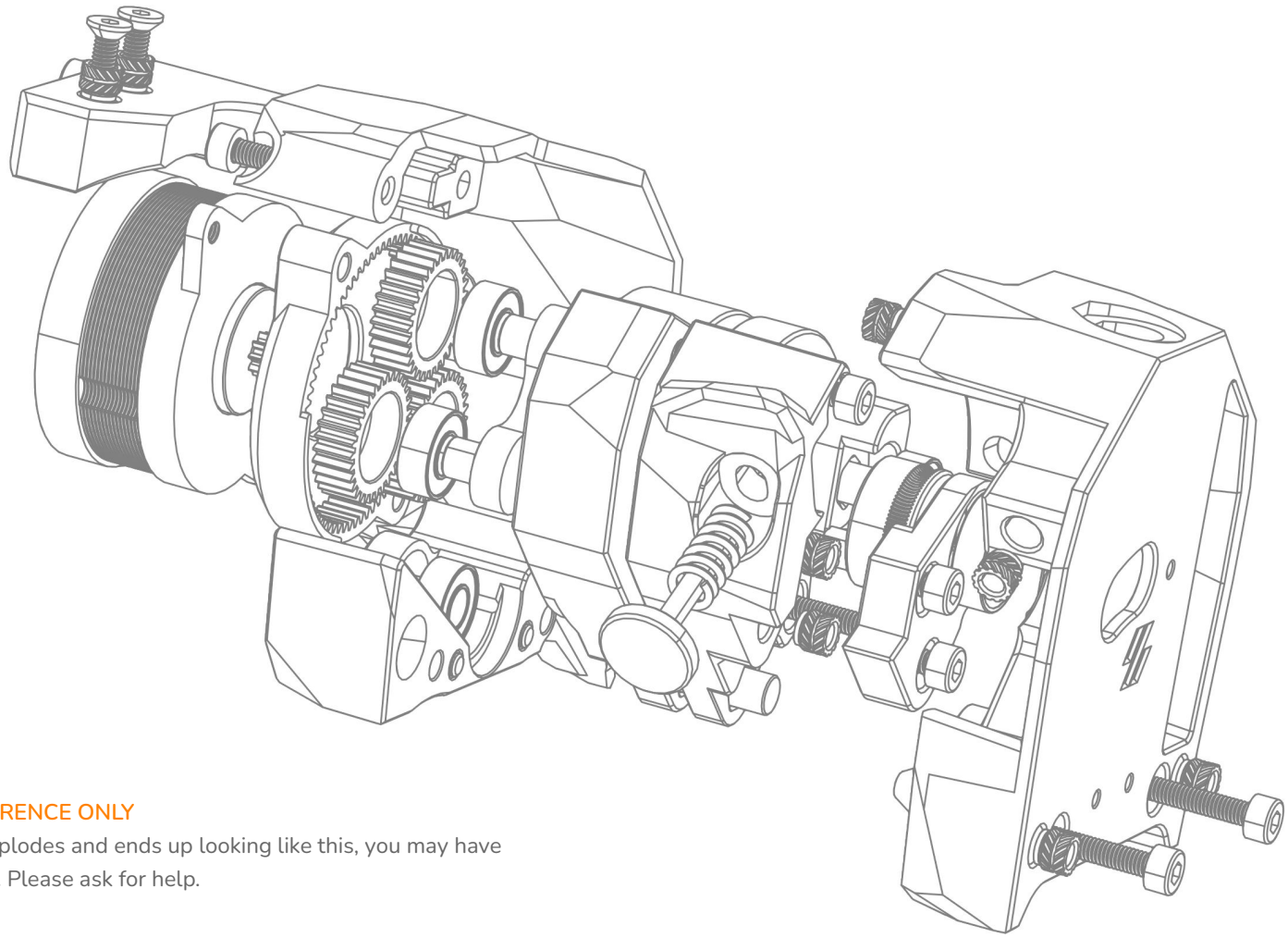
The G2E assembly is already “stealthed” so it aesthetically matches Clockwork 2, and with a few configuration tweaks, drops right in on a Stealthburner MGN12 Toolhead. This makes it compatible with Voron Tap as well as the standard inductive probe carriages.

G2E CONFIGURATION

You must update both the gear_ratio and rotation_distance in your Klipper configuration and do a standard extruder calibration after installing the Galileo 2 Extruder. Additionally, your run_current will need to be updated.

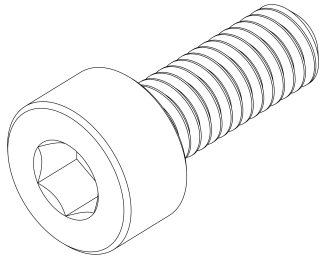
```
[extruder]
rotation_distance: 47.088
gear_ratio: 9:1
microsteps: 16

[tmc2209 extruder]
run_current: 0.6
```



FOR REFERENCE ONLY

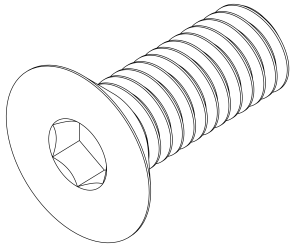
If yours explodes and ends up looking like this, you may have a problem. Please ask for help.



SOCKET HEAD CAP SCREW (SHCS)

Metric fastener with a cylindrical head and hex drive. The most common fastener used on the Voron.

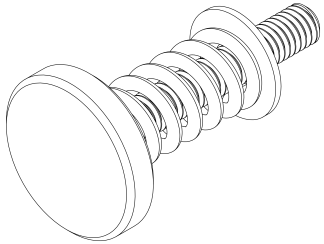
ISO 4762



FLAT HEAD COUNTERSUNK SCREW (FHCS)

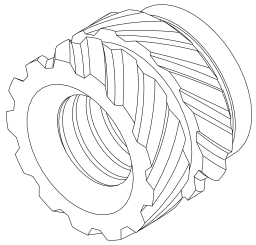
Metric fastener with a cone shaped head and a flat top.

ISO 10642



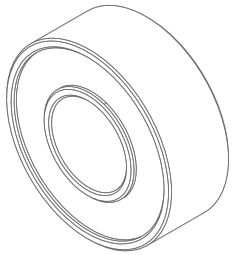
EXTRUDER THUMBSCREW

Spring will be stiff



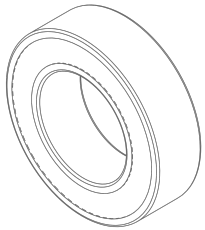
HEAT SET INSERT

Heat inserts with a soldering tip so that they melt the plastic when installed. As the plastic cools, it solidifies around the knurls and ridges on the insert for excellent resistance to both torque and pull-out.



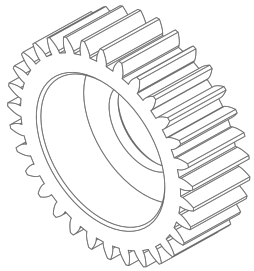
MR148 BEARING

Main shaft support

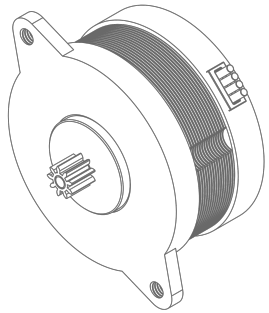


MR115 BEARING

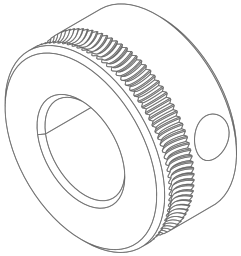
Planetary and idlers



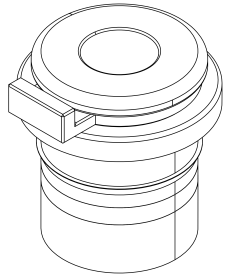
PLANETARY GEAR
31-Tooth MJF Gear



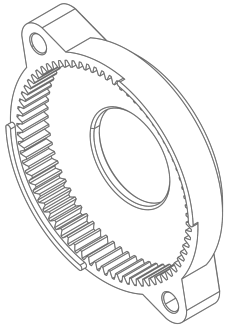
NEMA 14 PANCAKE STEPPER
9T, 20mm



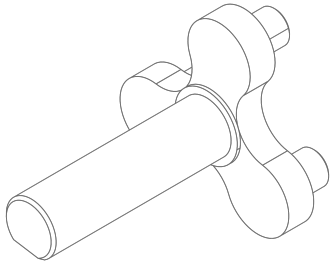
GALILEO 2 EXTRUDER GEAR
RNC-Coated 16mm Drive Gear



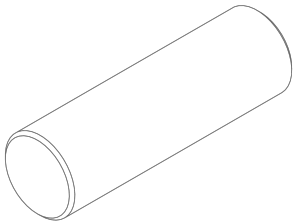
ECAS fitting
You won't need the black rubber part on the bottom



RING GEAR HOUSING
72-Tooth MJF Housing



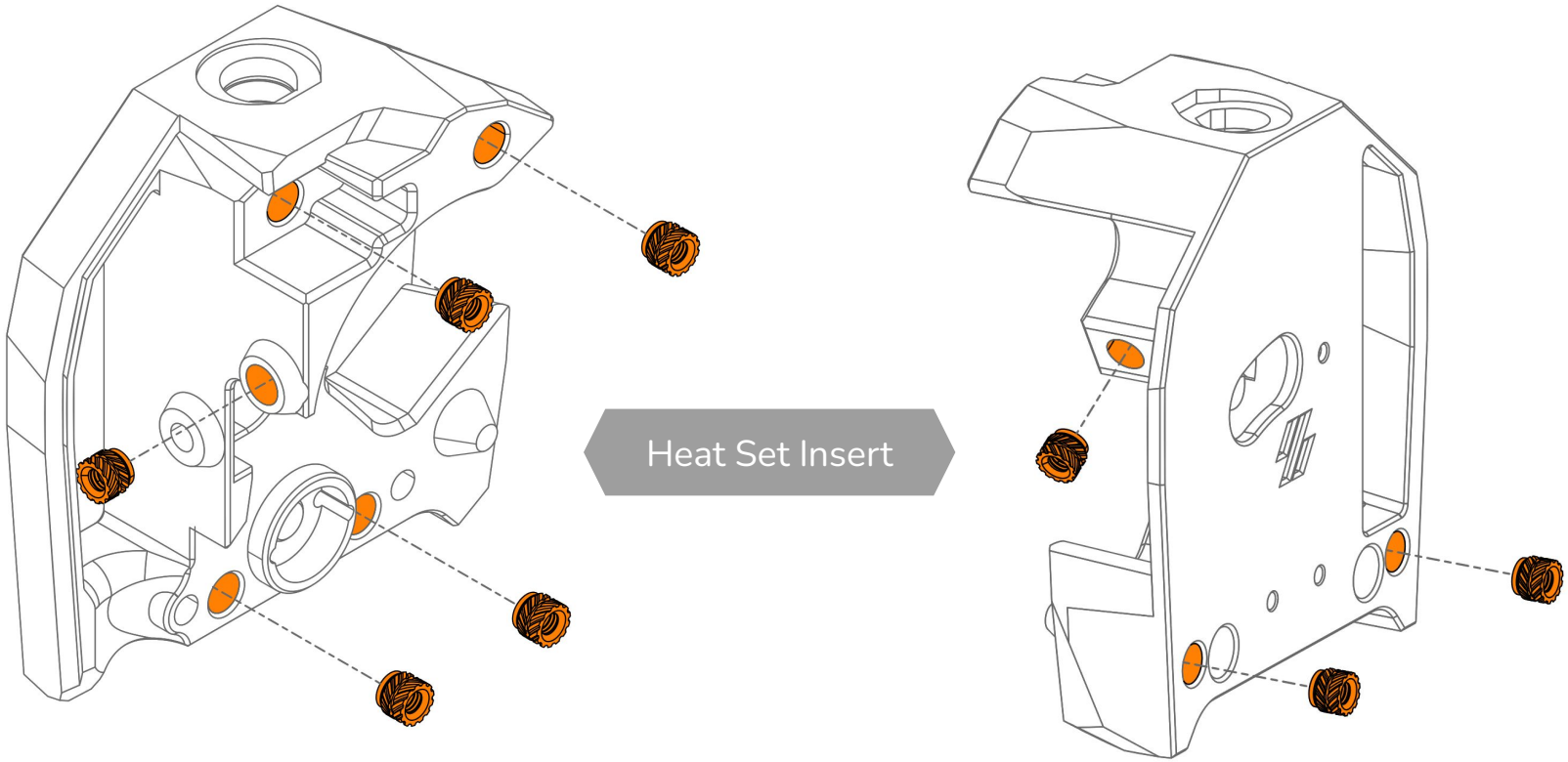
PLANETARY CARRIER SHAFT
Aluminum Carrier



PIN

16mm x 5mm OD


GALILEO 2



https://voron.link/m5ybt4d

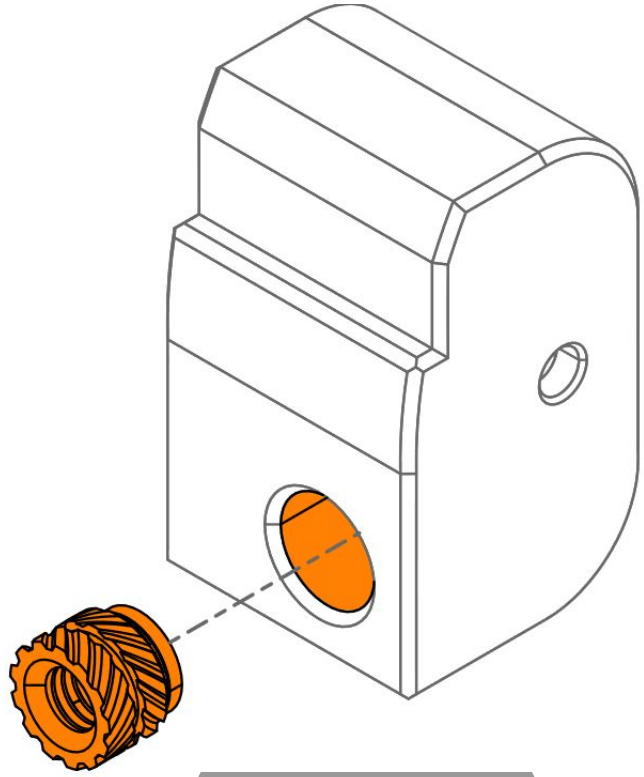
HEAT SET INSERTS

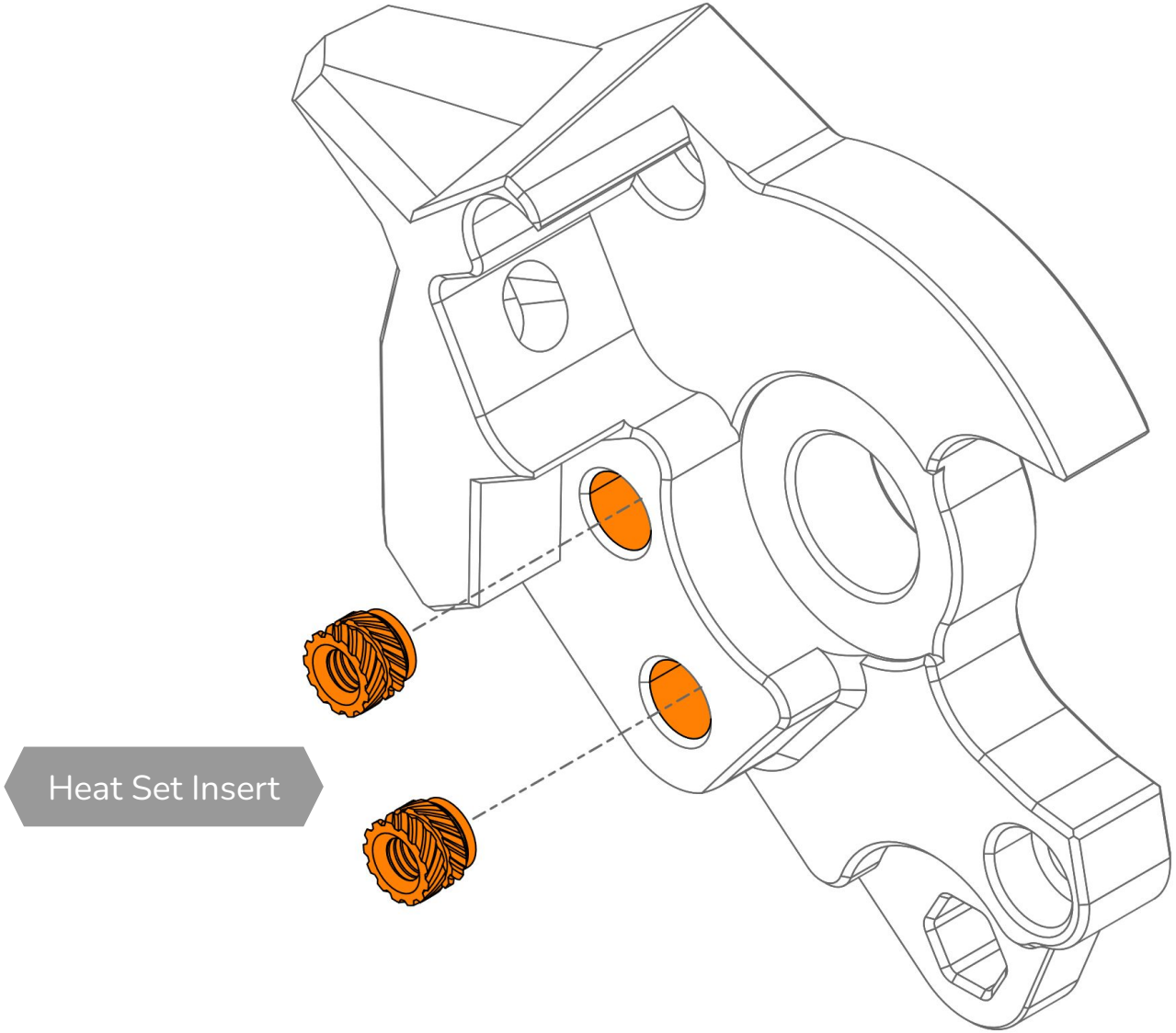
This design relies on heat set inserts. Make sure you have the proper inserts (check the hardware reference for a close-up picture, and the BOM for dimensions).

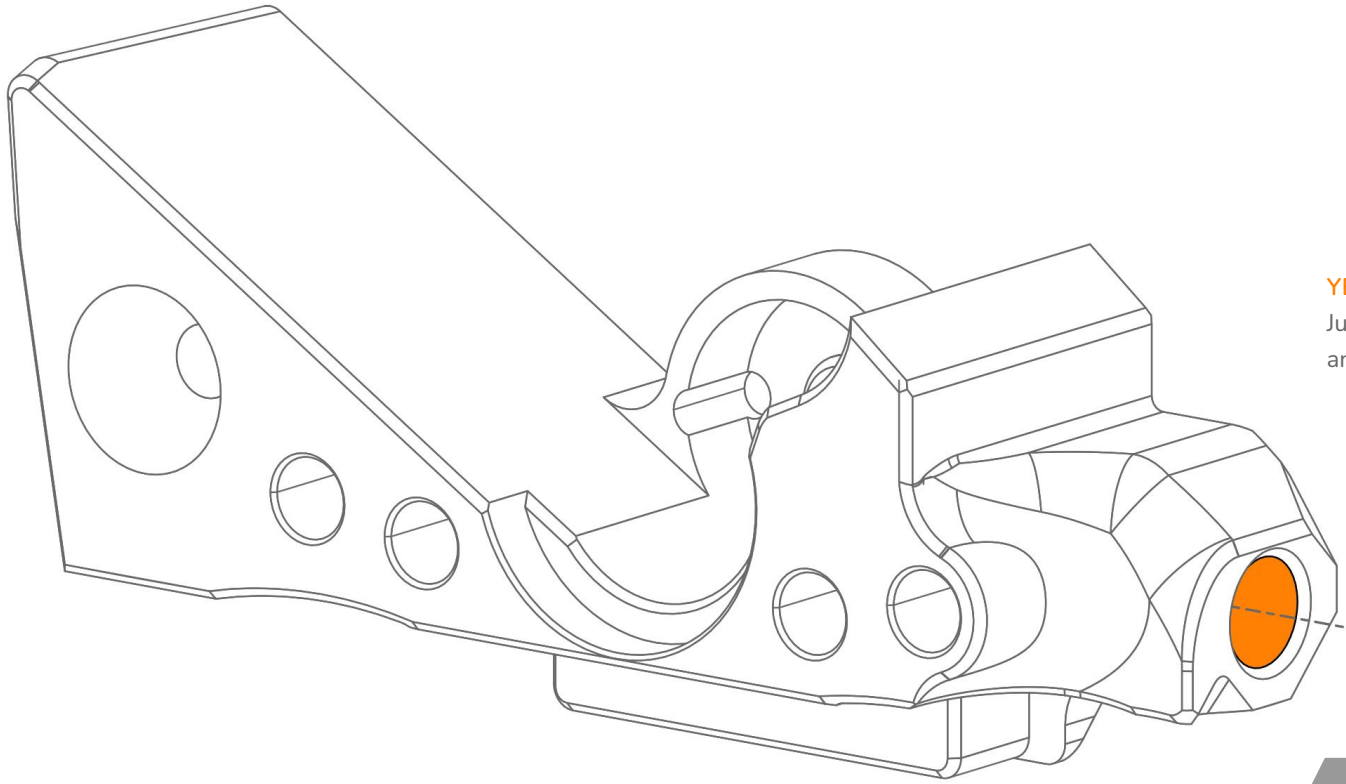
If you've never worked with heat set inserts before, we recommend you watch the linked guide.

THAT LITTLE GUY?

Don’t forget the heatset in the idler bearing cover, which is also part of the front body assembly.




Heat Set Insert



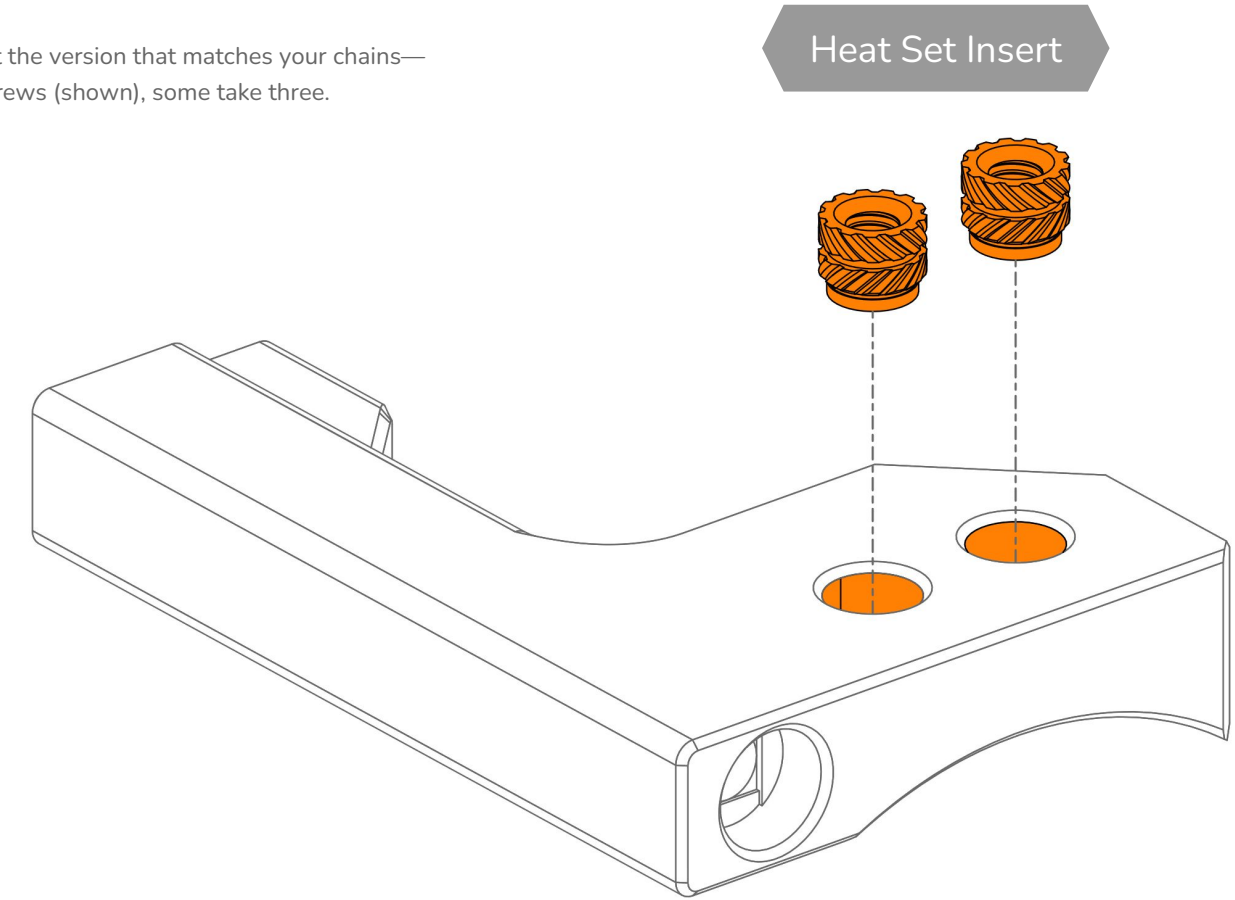
YES..MORE HEAT SETS

Just when your your iron timed out and shut off, we found another.

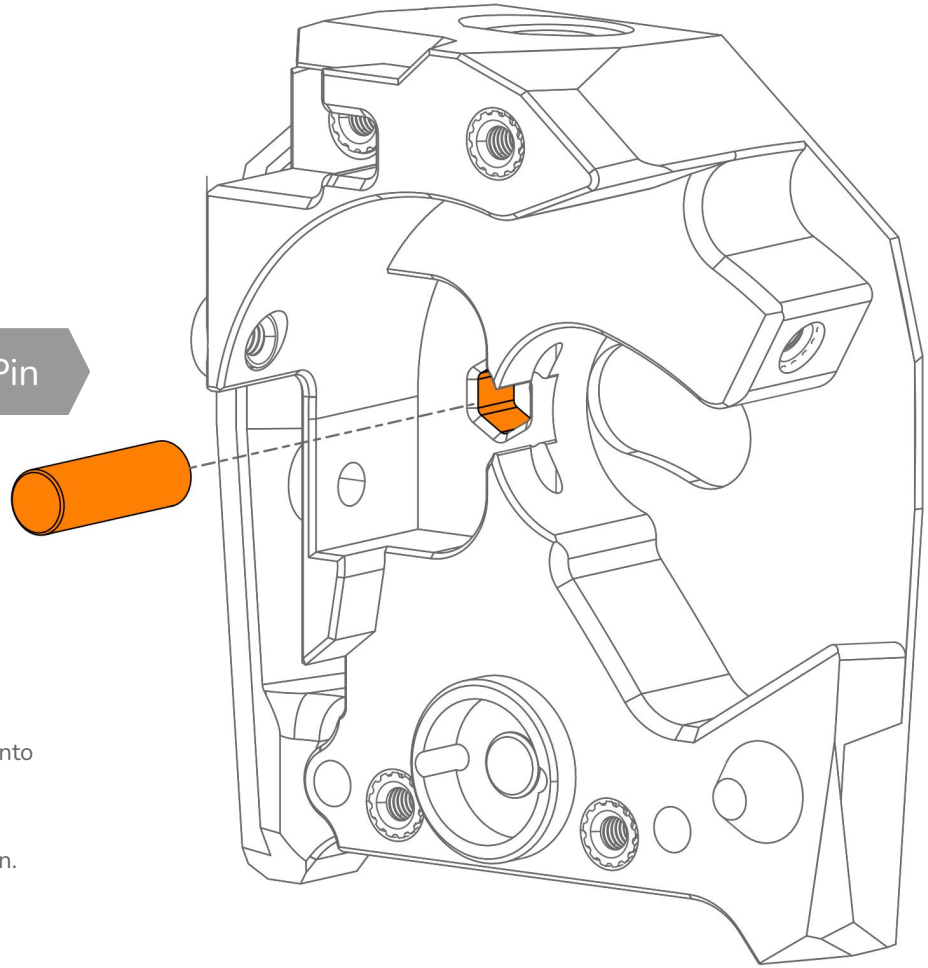
Heat Set Insert

GOT CHAINS?

Make sure to print the version that matches your chains—some take two screws (shown), some take three.

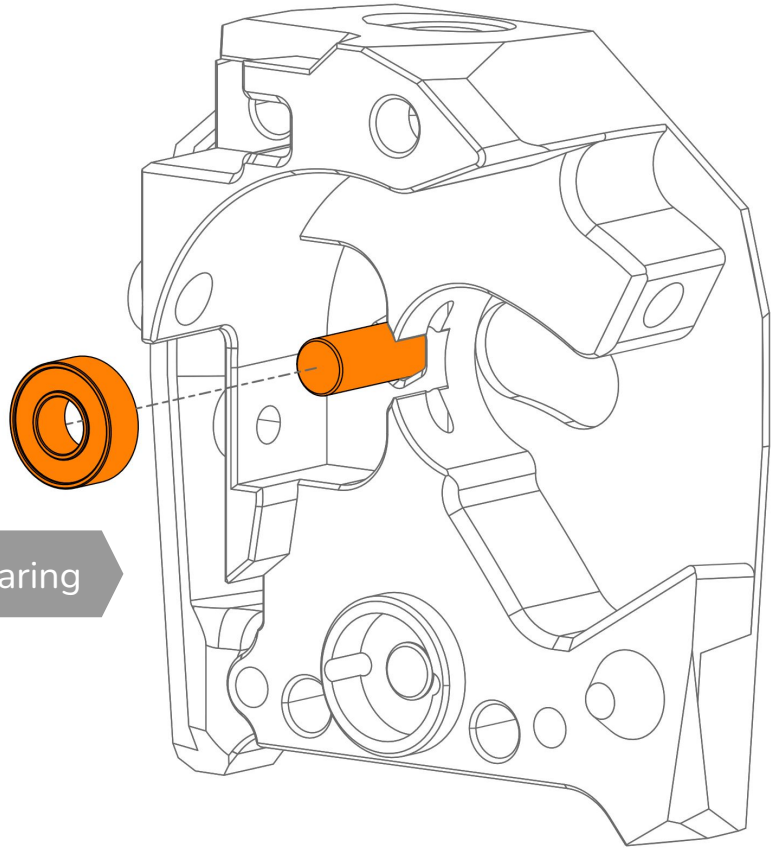



GALILEO 2

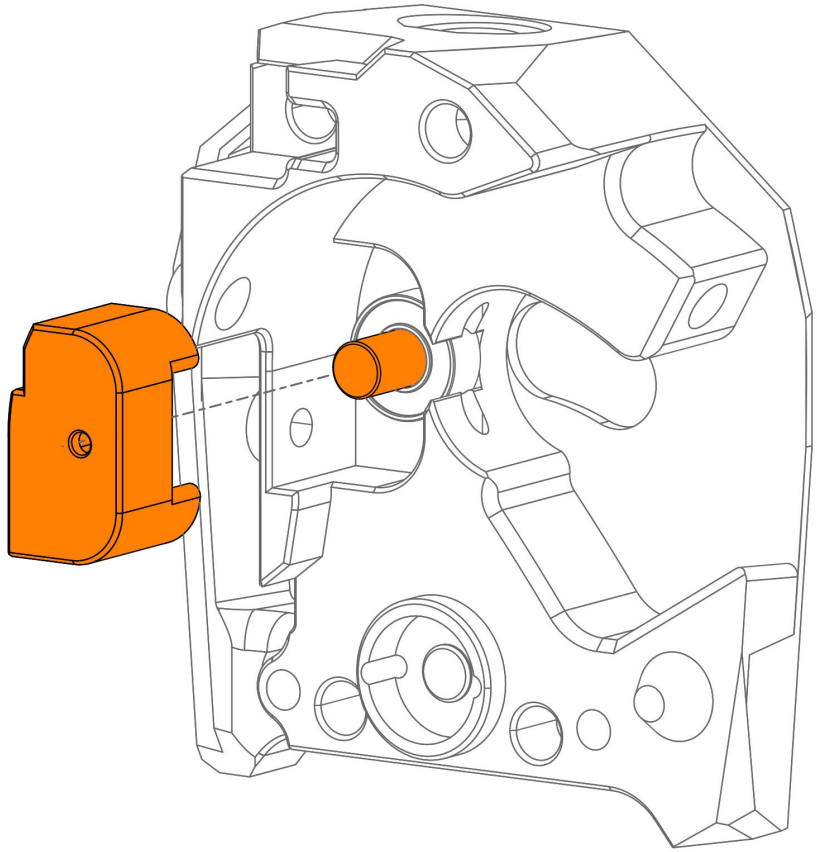


PUT A PIN IN IT

Install the first of the two pins included with the kit into the hexagonal hole in the front body until it's fully seated into the housing. This pin will hold the idler bearing opposite the drive gear in G2 extruder design.



MR115 Bearing



IDLING ON BY

Seat the idler bearing onto the pin, taking care to fully seat the bearing until it is flat against the printed part.

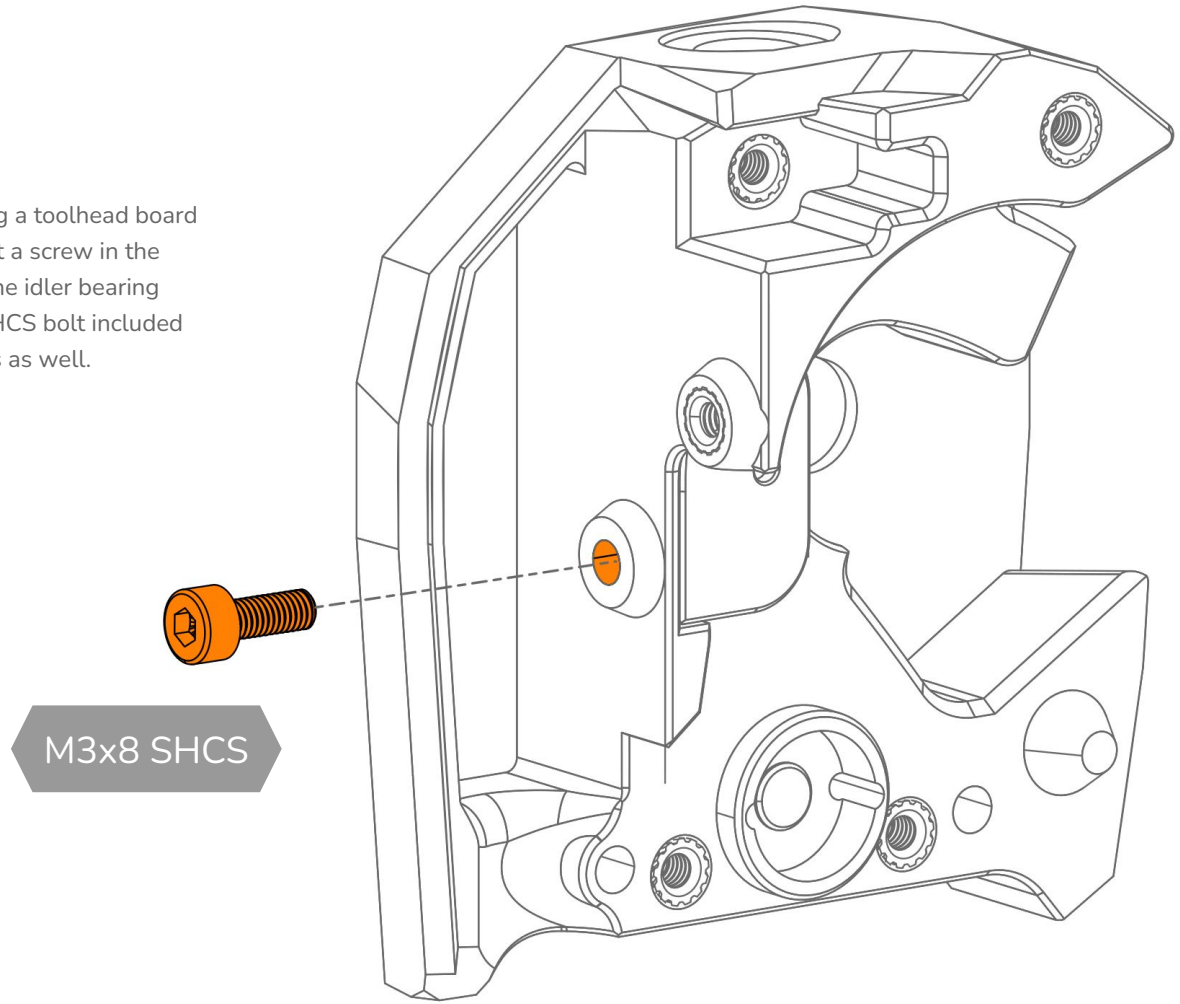
NOTE: The pin and bearing have very tight tolerances; if you notice the bearing is hard to install, remove the bearing, clean the pin and bearing, then assemble again.

TAKE COVER!

Install the idler bearing cover onto the back of the 5mm pin, seating it fully into place. When fully inserted, the heatset insert on the idler bearing cover should align with the screw hole on the front body.

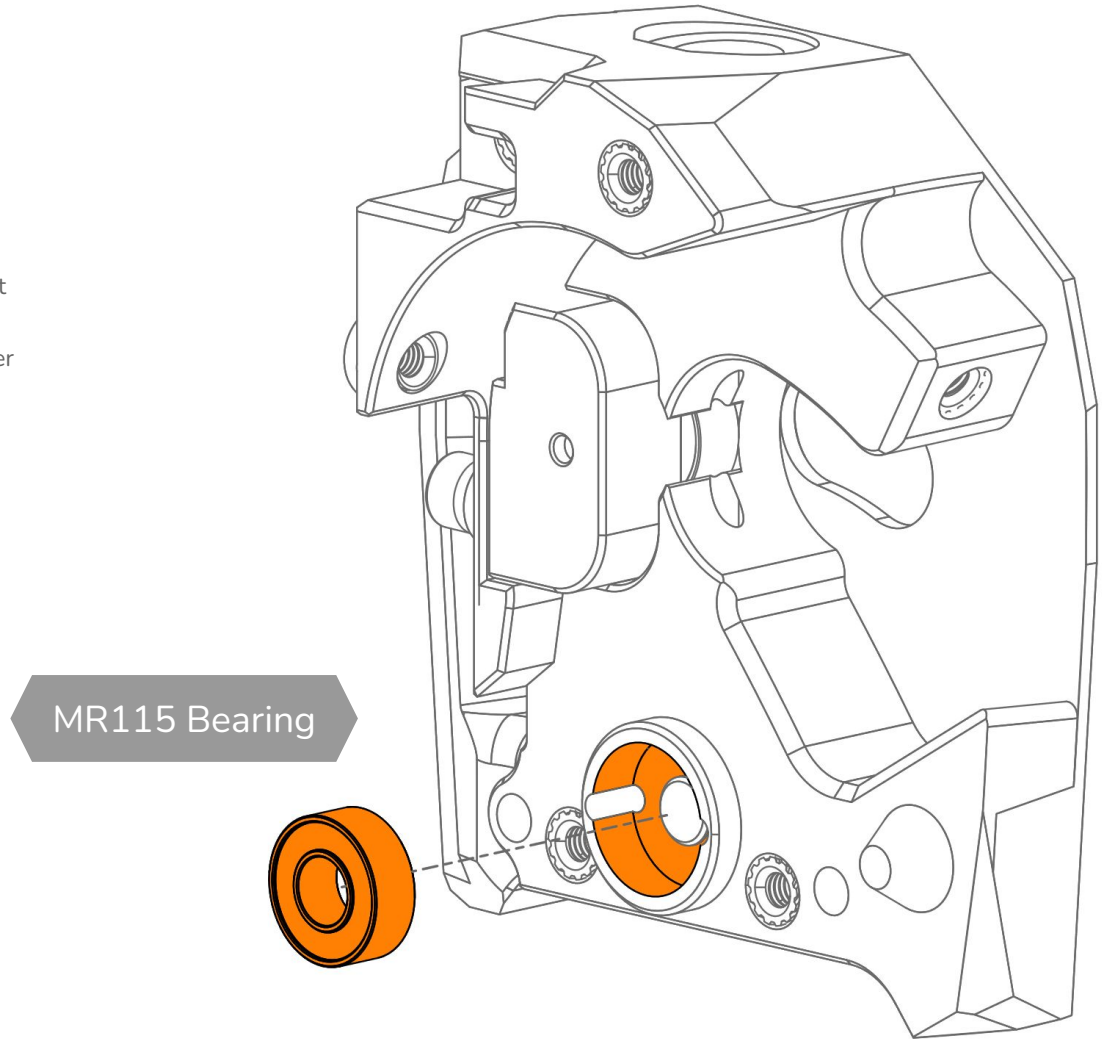
BEARING SECURITY

Whether or not you are using a toolhead board with G2, you will need to put a screw in the front mount hole to secure the idler bearing cover properly. The M3x8 SHCS bolt included will fit most toolhead boards as well.



PIVOT BEARING

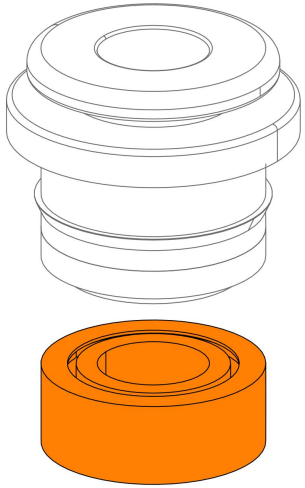
Insert the bearing into the front body. This should install with a small amount of force and should sit flush with the raised lip around the bearing. If you ever need to remove this bearing, use the ejecto-seato holes in the front!

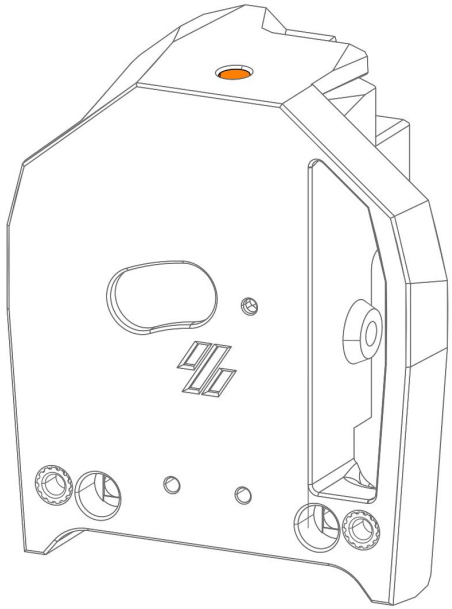


ECAS PREP

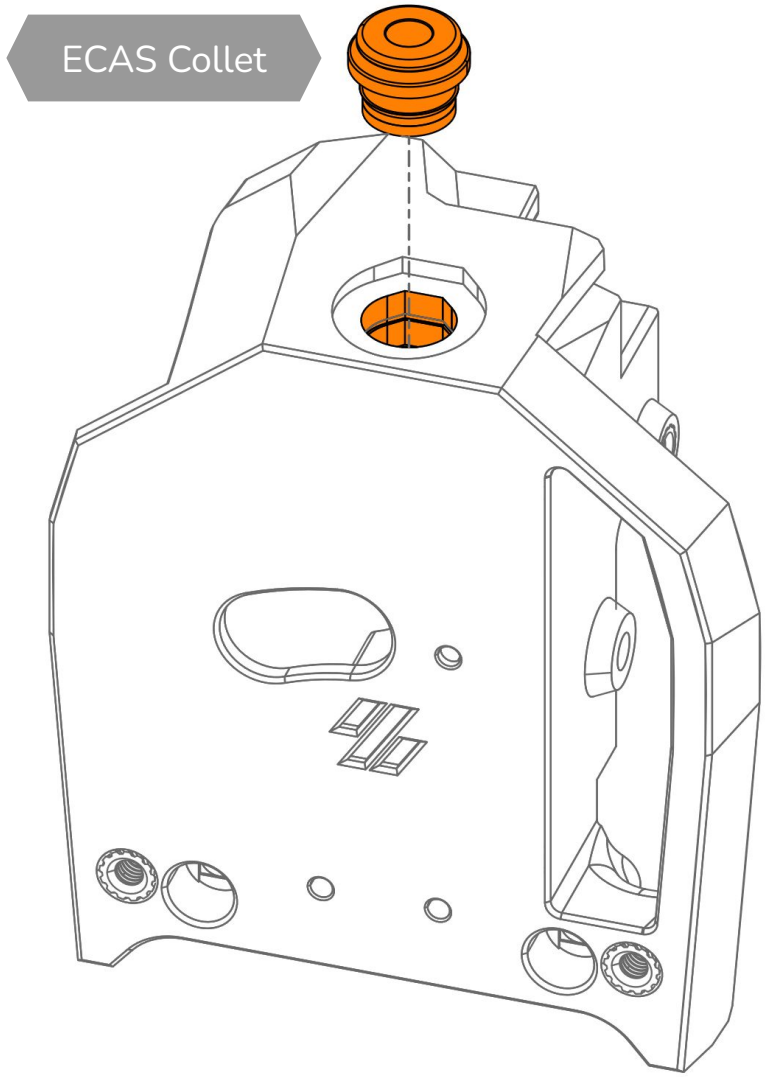
The rubber donut on the bottom highlighted here is not used in this build. Pry the rubber donut off and set it aside where pets won't find a way to use it to increase your vet bill.

Press the collet straight down into the extruder body. This may be a tight fit—you can start it by hand, then push against it using a doorway, the floor, etc. Just try not to ding the pointy top of the printed part.





NOTE: If you're using the press-fit front body, you can skip this step!



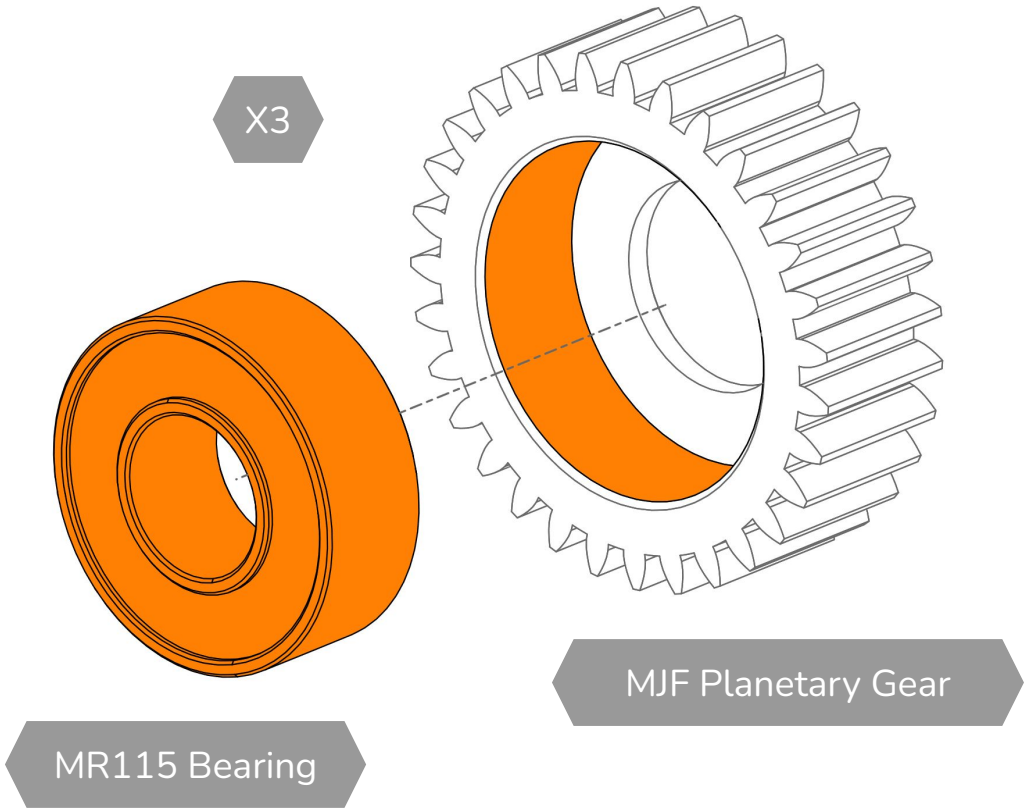

GALILEO 2

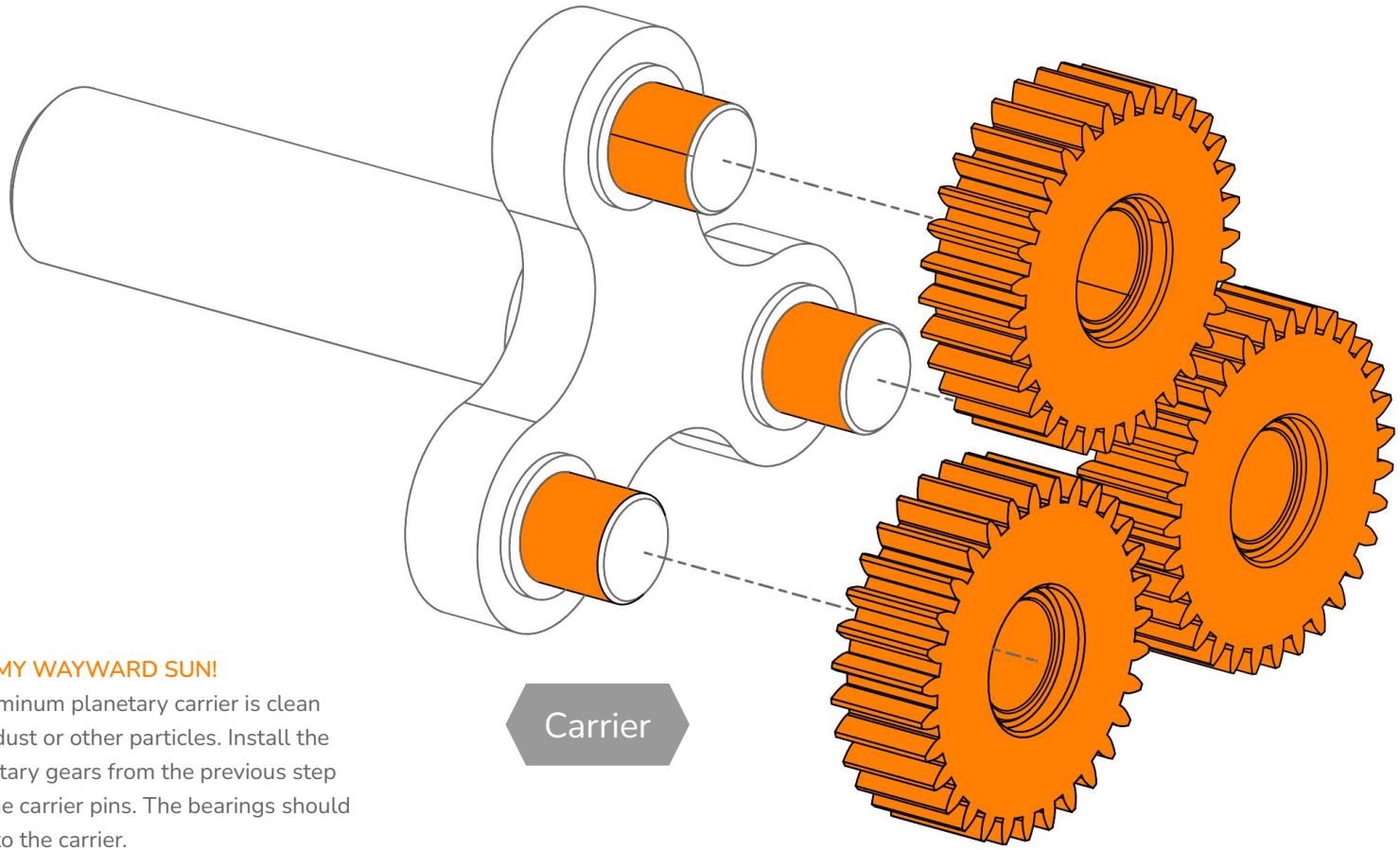
HOW DO YOU THROW A PARTY ABOUT SPACE?.....YOU PLANET!

Planetary gearbox assembly can be a tedious process, but following these steps closely will ensure a smoothly running gearbox!

INTERGALACTIC, PLANETARY!

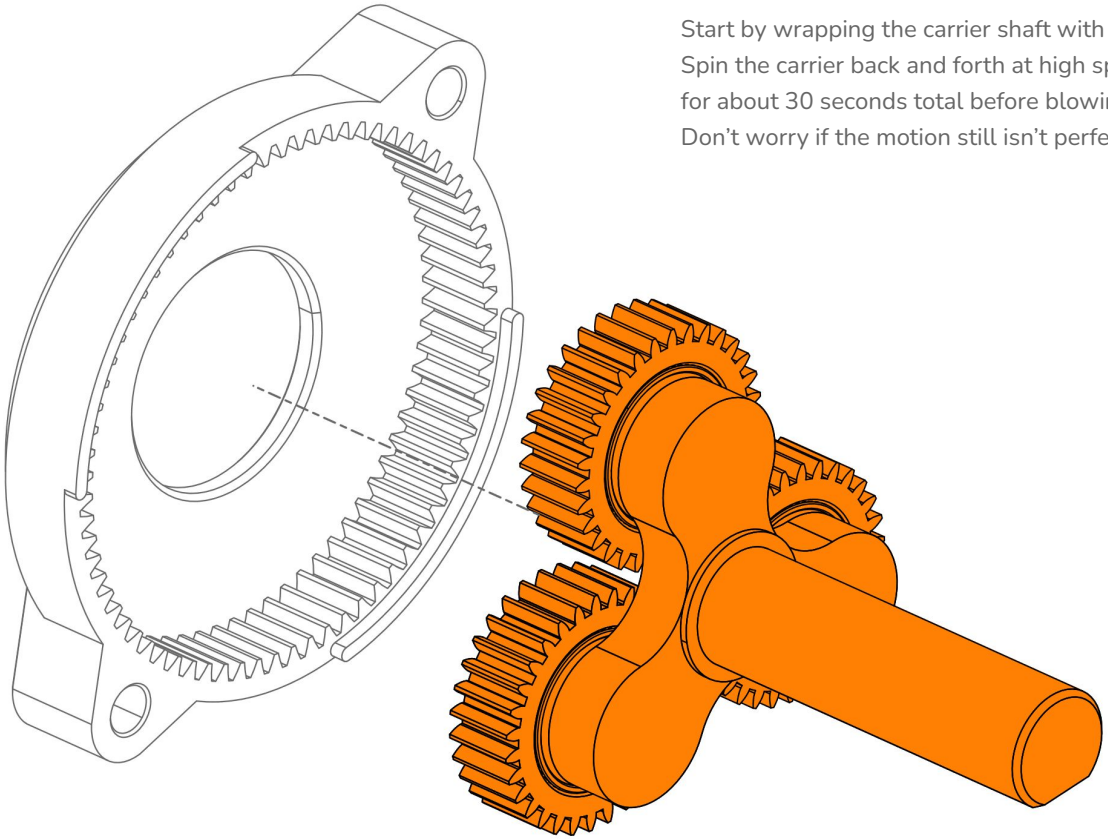
Start by inserting the bearings for each of the three (3) planetary gears. The bearings should press fit into place with little effort. It's okay if the bearings are loose enough to fall out on their own; they will be held captive when the gearbox is assembled.





CARRIER ON MY WAYWARD SUN!

Ensure the aluminum planetary carrier is clean and free from dust or other particles. Install the three (3) planetary gears from the previous step onto each of the carrier pins. The bearings should slide easily onto the carrier.



YOU KNOW WHAT REALLY GRINDS MY GEARS?

The G2 gearbox is made from MJF Nylon, and as such, is subject to printed part tolerances just like any other printed part. Unfortunately this means that some gearboxes will be tighter than others out of the box.

The best way to ensure a smooth-running gearbox is to manually run-in the gears using a drill!

Start by wrapping the carrier shaft with a strip of paper to protect it, then loosely chuck it into your drill. Spin the carrier back and forth at high speed in short bursts while you hold the ring gear in place. Do this for about 30 seconds total before blowing out any residual MJF dust and proceeding with assembly. Don't worry if the motion still isn't perfectly smooth after 30 seconds.

PUT A RING ON IT AND DON'T FORGET THE LUBE

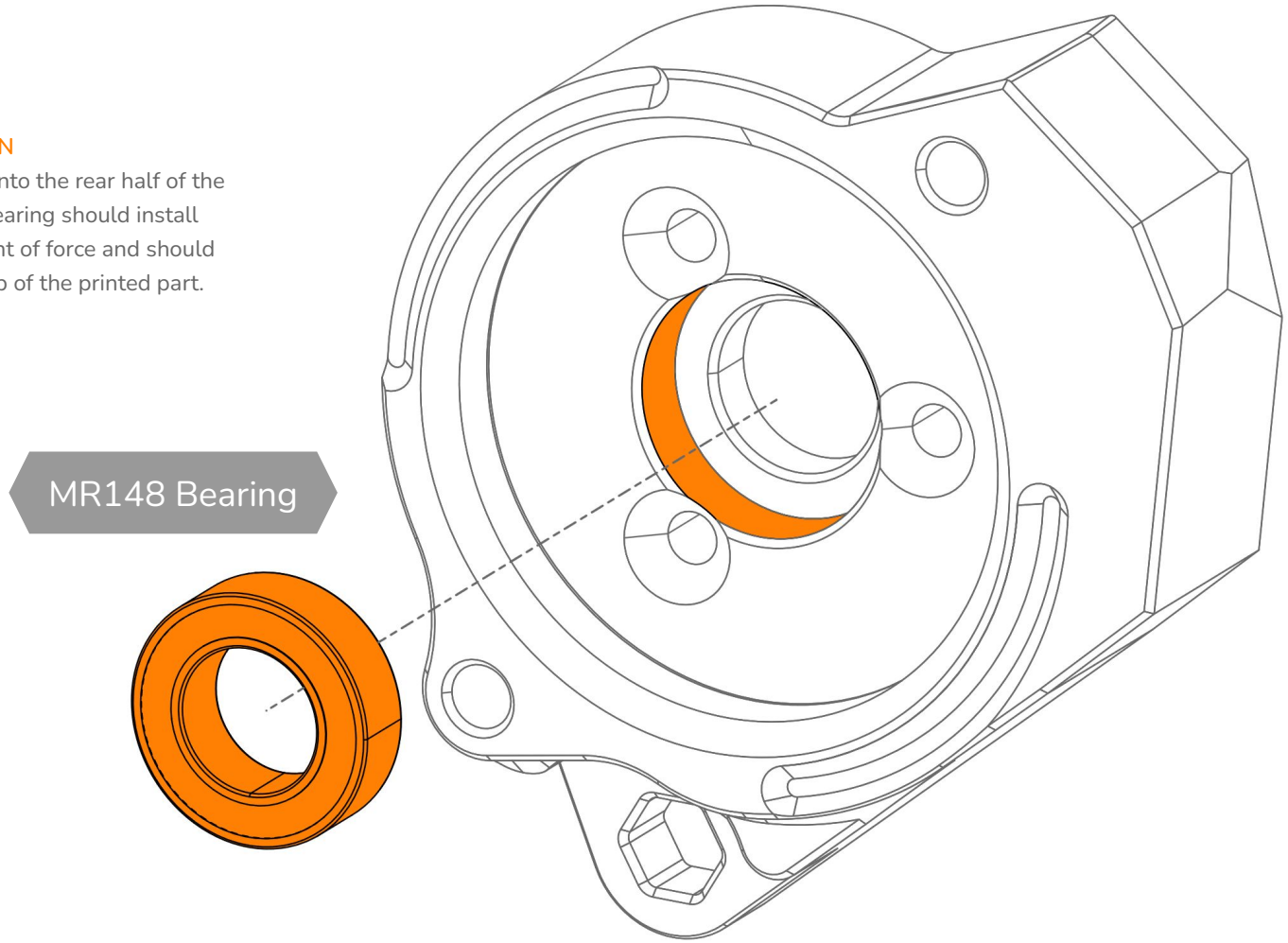
After running in the gearbox manually above, double check for and remove any residual MJF dust that may be in the gearbox before moving on to lubing the gearbox assembly.

To lube the gearbox, put a pea-sized blob of grease on the bottom flat surface of the ring gear housing, then insert the carrier with planets into the ring gear housing, rotating while installing. Give the carrier 10-20 full rotations to allow the grease to move around and fill all of the nooks in the gear faces. You can use the drill for this step as well, but do take care not to sling grease everywhere!


GALILEO 2

BEARING IT DOWN

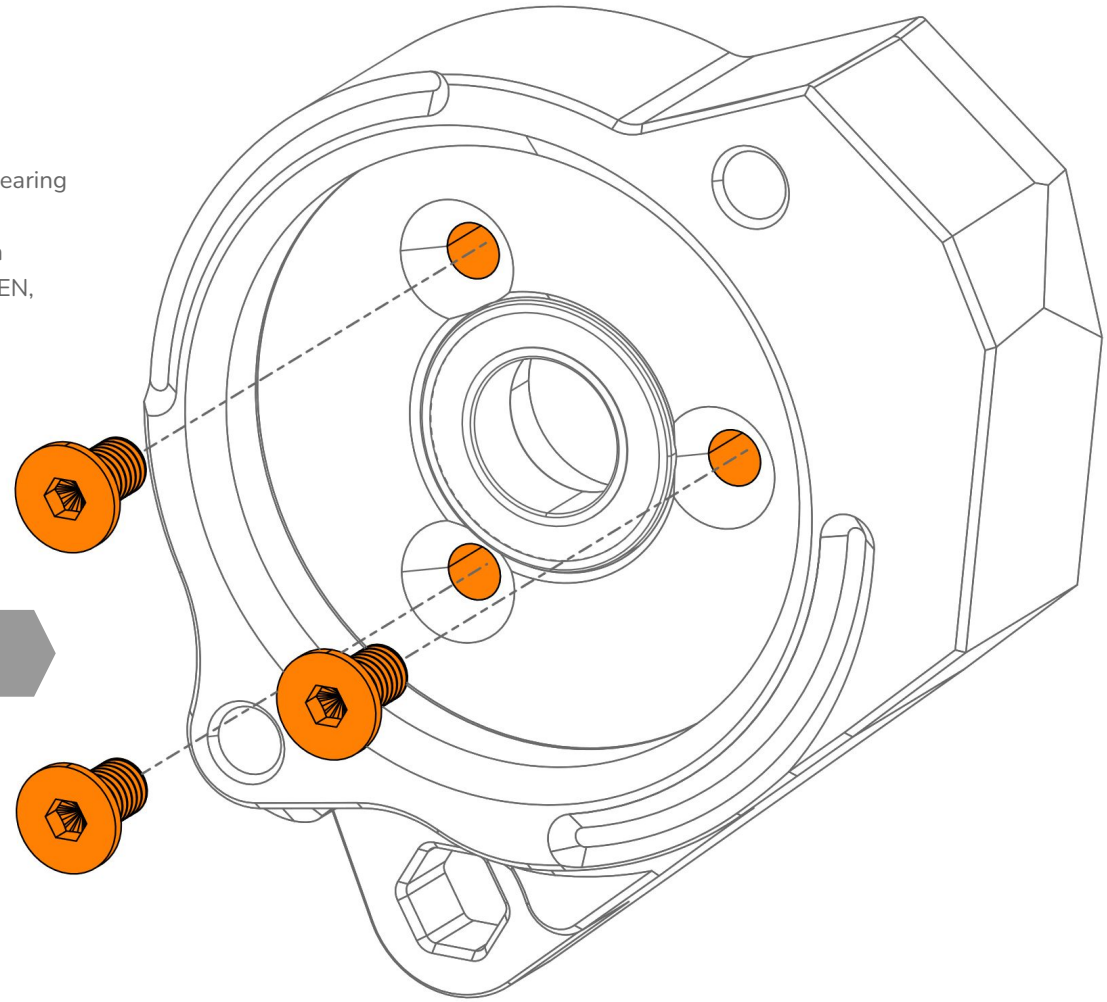
Insert the bearing into the rear half of the G2 Module. This bearing should install with a small amount of force and should sit flush with the lip of the printed part.



BEARING RETAINER SCREWS

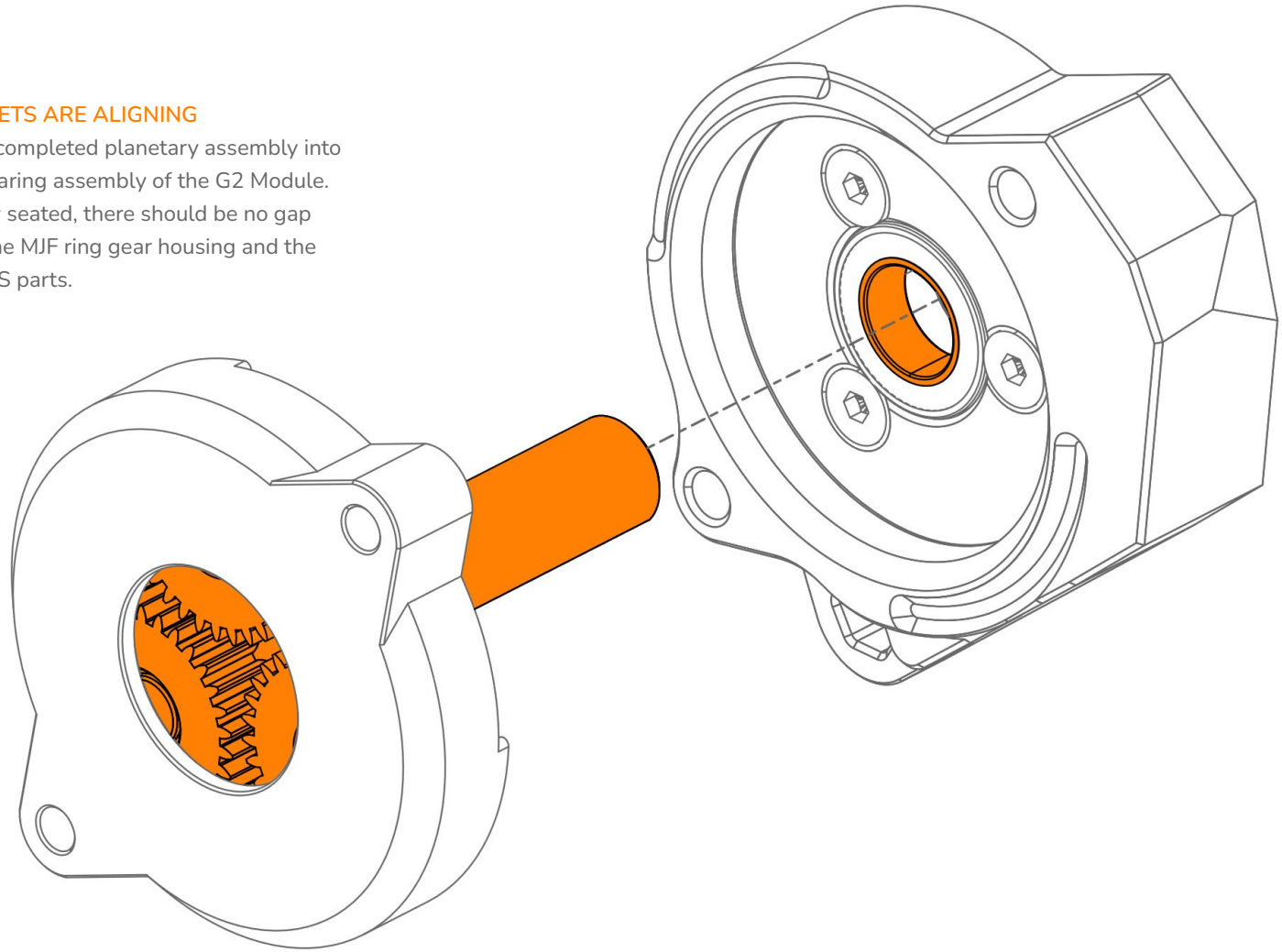
These capture the outer edge of the bearing and will retain it in the printed part. They should be just above flush when fully tightened. DO NOT OVERTIGHTEN, they are threaded into plastic!

M3x6 FHCS



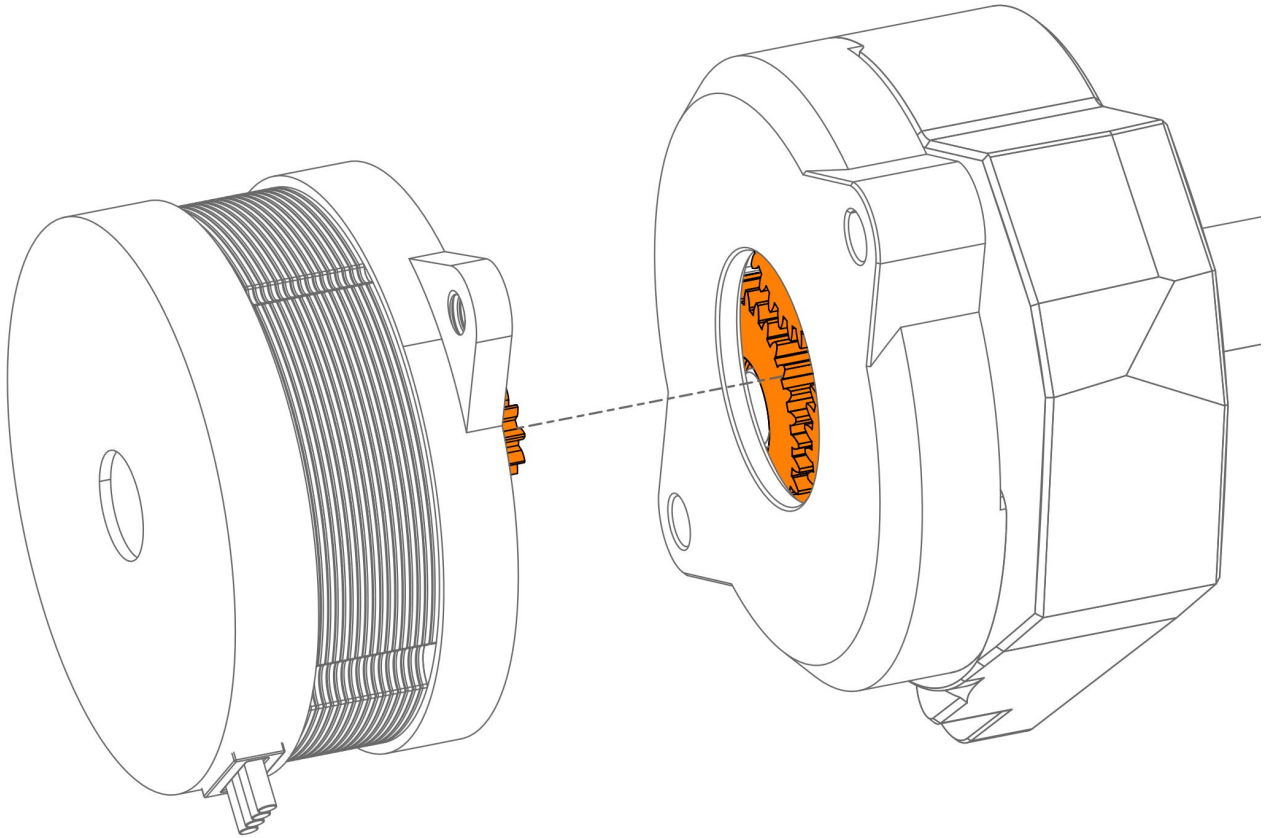
THE PLANETS ARE ALIGNING

Install the completed planetary assembly into the rear bearing assembly of the G2 Module. When fully seated, there should be no gap between the MJF ring gear housing and the printed ABS parts.

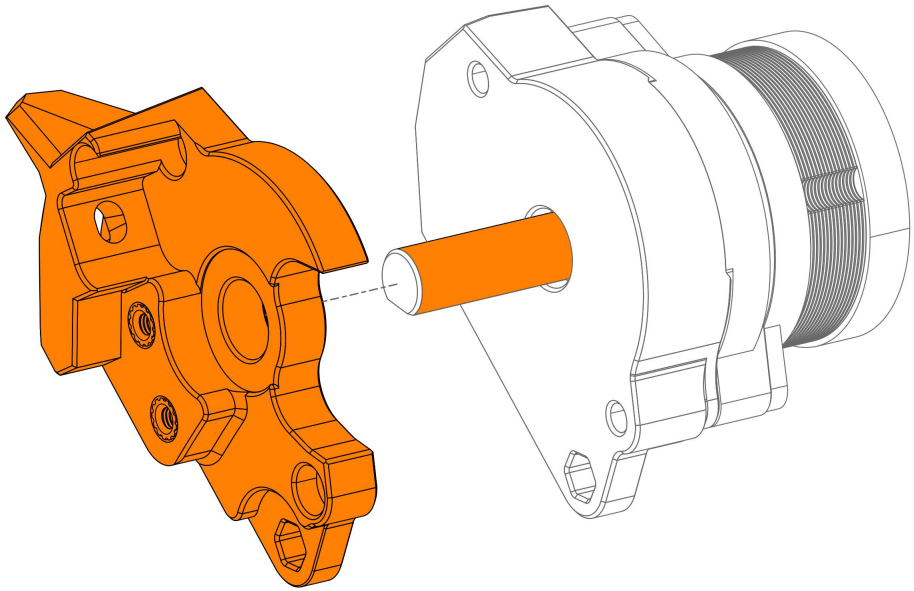


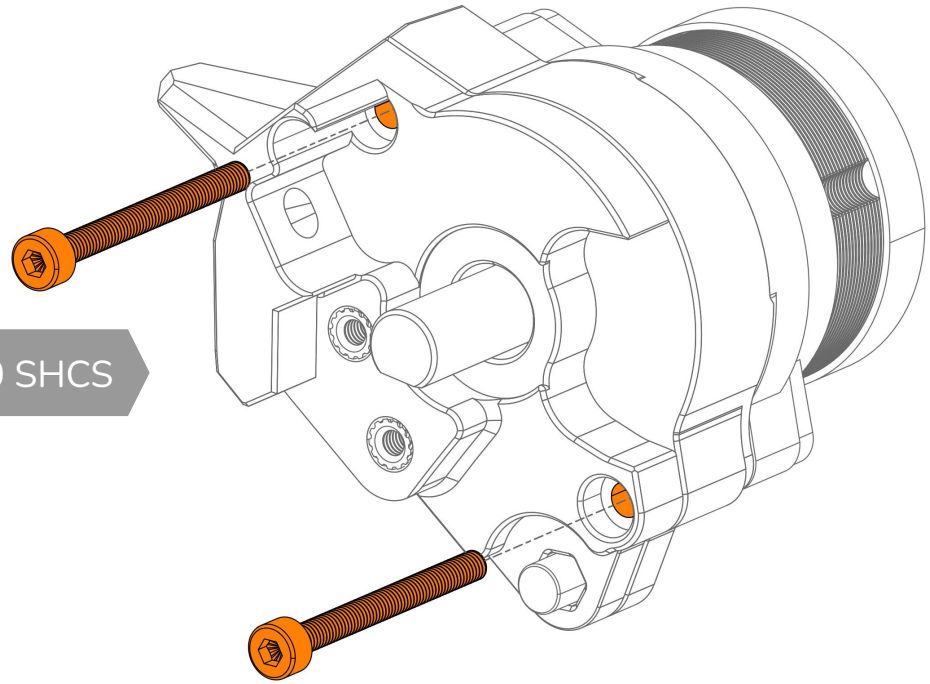
ONE SMALL STEP FOR THE MOTOR,
ONE GIANT REVOLUTION FOR THE GEARBOX.

Aligning the stepper is one of the more challenging parts of G2, as it can be installed a tooth off, which will cause binding during operation.



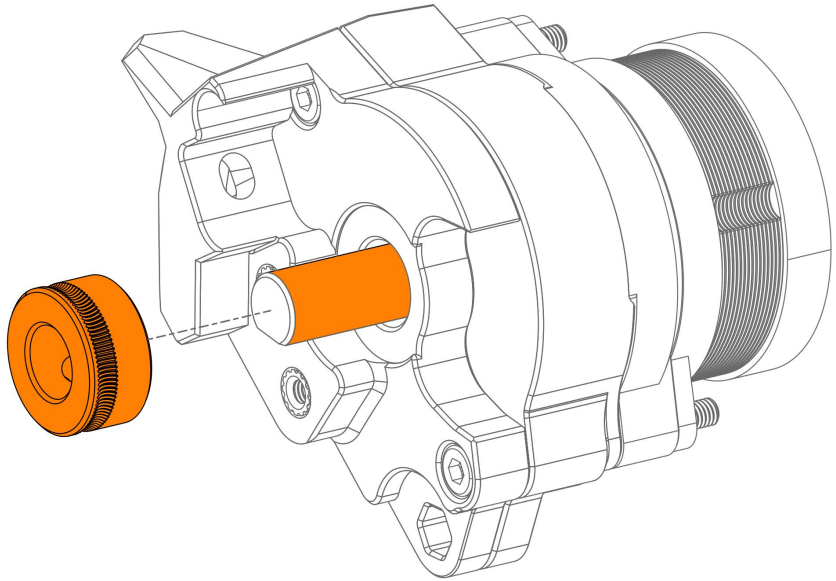
To properly align the stepper, press the stepper DIRECTLY into the ring gear housing, making sure to NOT rotate the stepper. If the teeth don't line up, pull the stepper back, rotate it slightly, then insert directly again. When aligned, the stepper should go in with zero effort. If the stepper has ANY resistance when installing, there's a good chance it's misaligned! Once you're sure the stepper is seated properly, give the carrier shaft a spin to verify alignment; if the carrier is smooth, you've aligned it properly.





EVERY STEP COUNTS

With the rear-half of the G2 Module assembled, it's time to put on the front! Slide the front half of the G2 module onto the carrier shaft and fasten everything together with 2x M3x30 SHCS. Snug the screws down for now, but they may need adjusting in a later step when installing the pivot pin!



GEARS SPIN, GRUB SCREWS PIN!

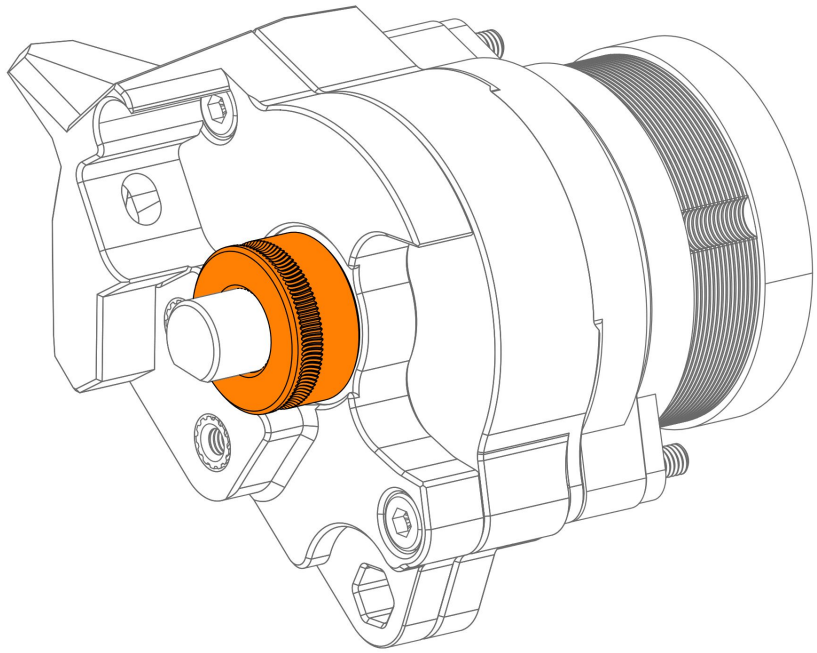
VERY IMPORTANT STEP!

To properly align the drive gear and the carrier shaft, PRESS FIRMLY down on the carrier shaft, until it won't move any further. There should be roughly 1-2mm of total travel in the carrier shaft in the in/out direction.

With the carrier shaft fully seated, press the drive gear flat against the printed surface, then tighten the grub screw. Use a small drop of threadlocker to ensure the grub screw doesn't come loose over time.

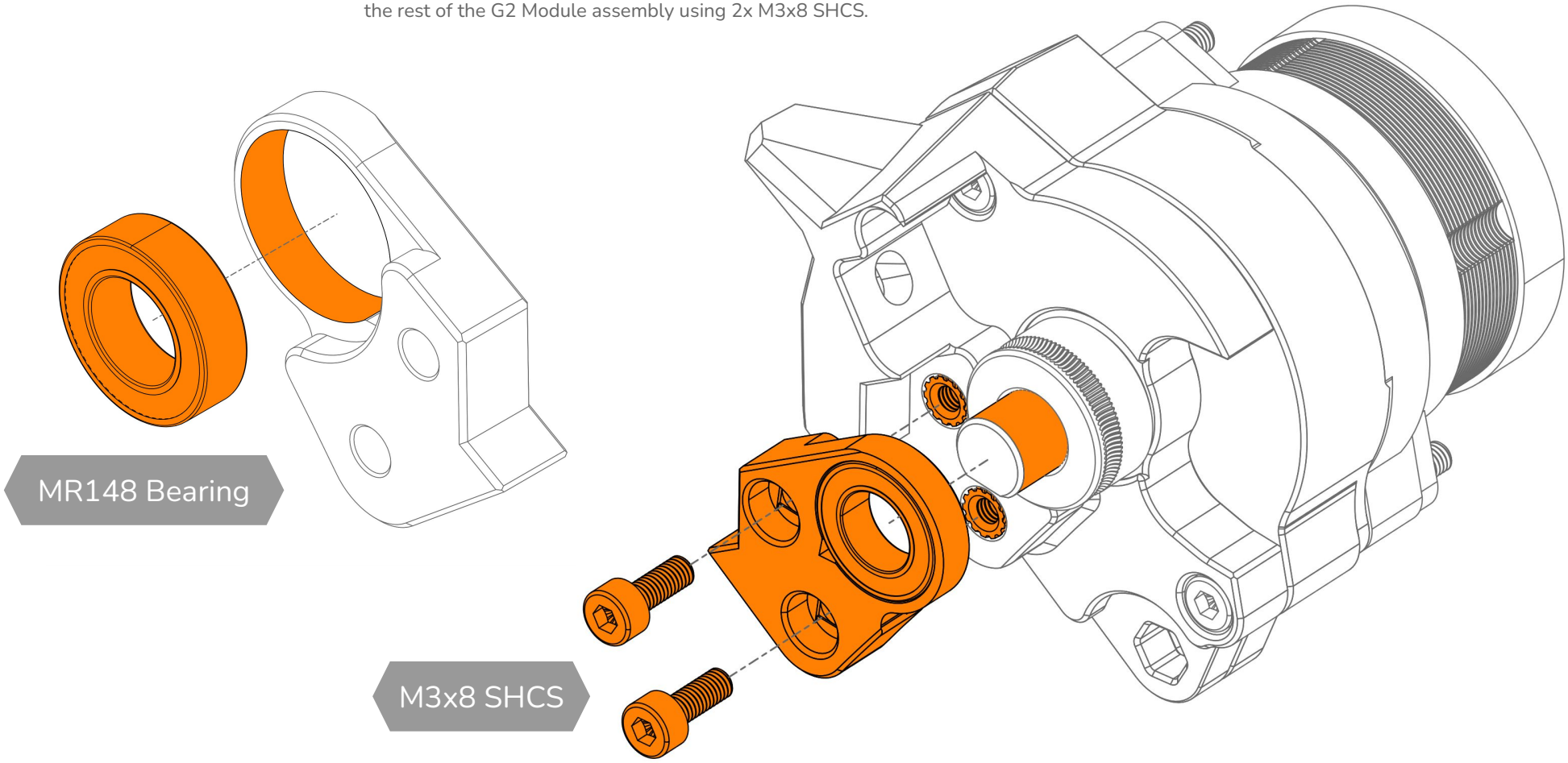
PLANETARY EXTRUSION? IT'S OUT OF THIS WORLD!

Ensure the flat face of the carrier shaft is facing out towards the opening in the G2 Module so that the drive gear grub screw is accessible. Install the custom 16mm drive gear onto the carrier shaft, ensuring the filament path is facing outward. Leave the grub screw loose for the next step.



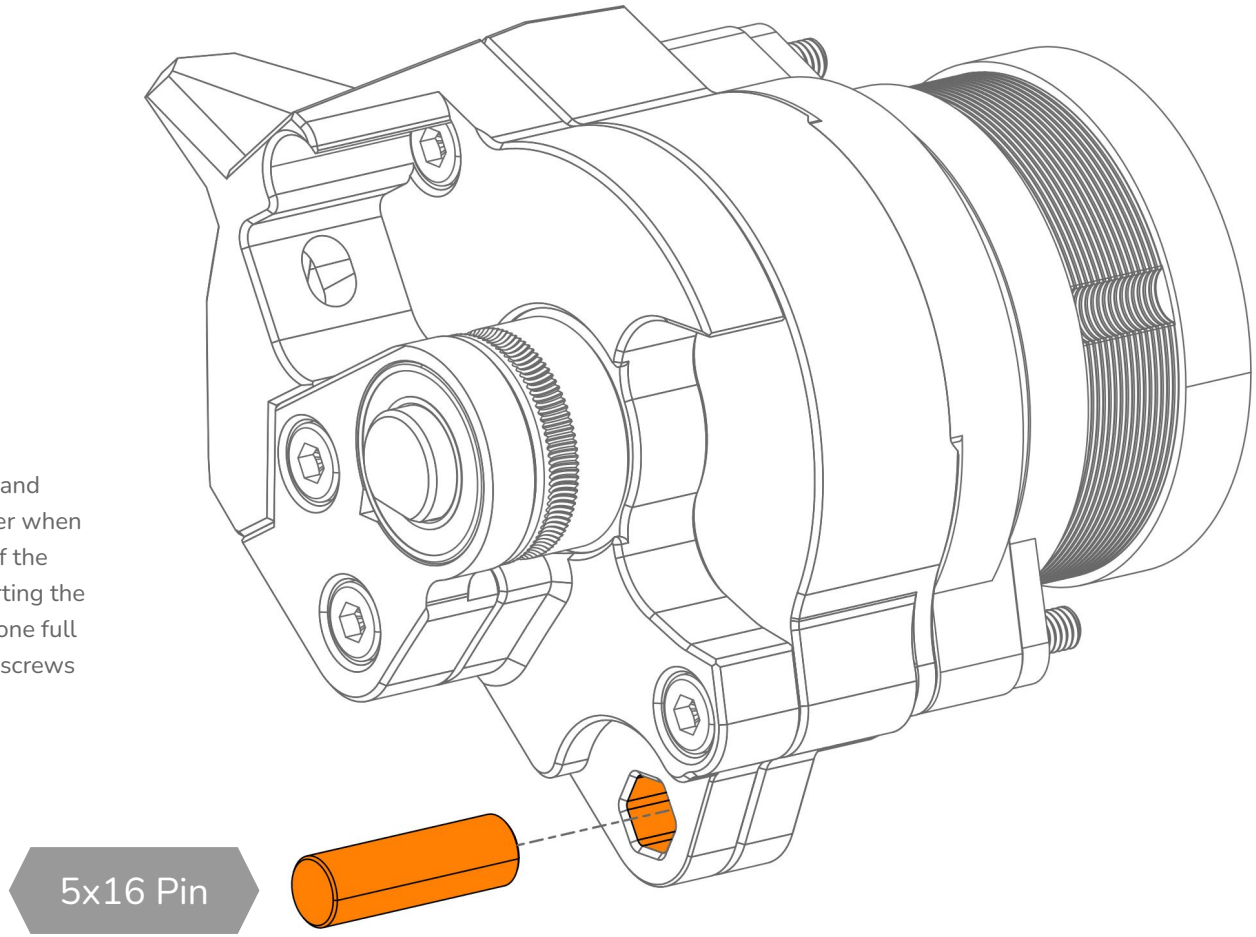
SHAFT SUPPORT

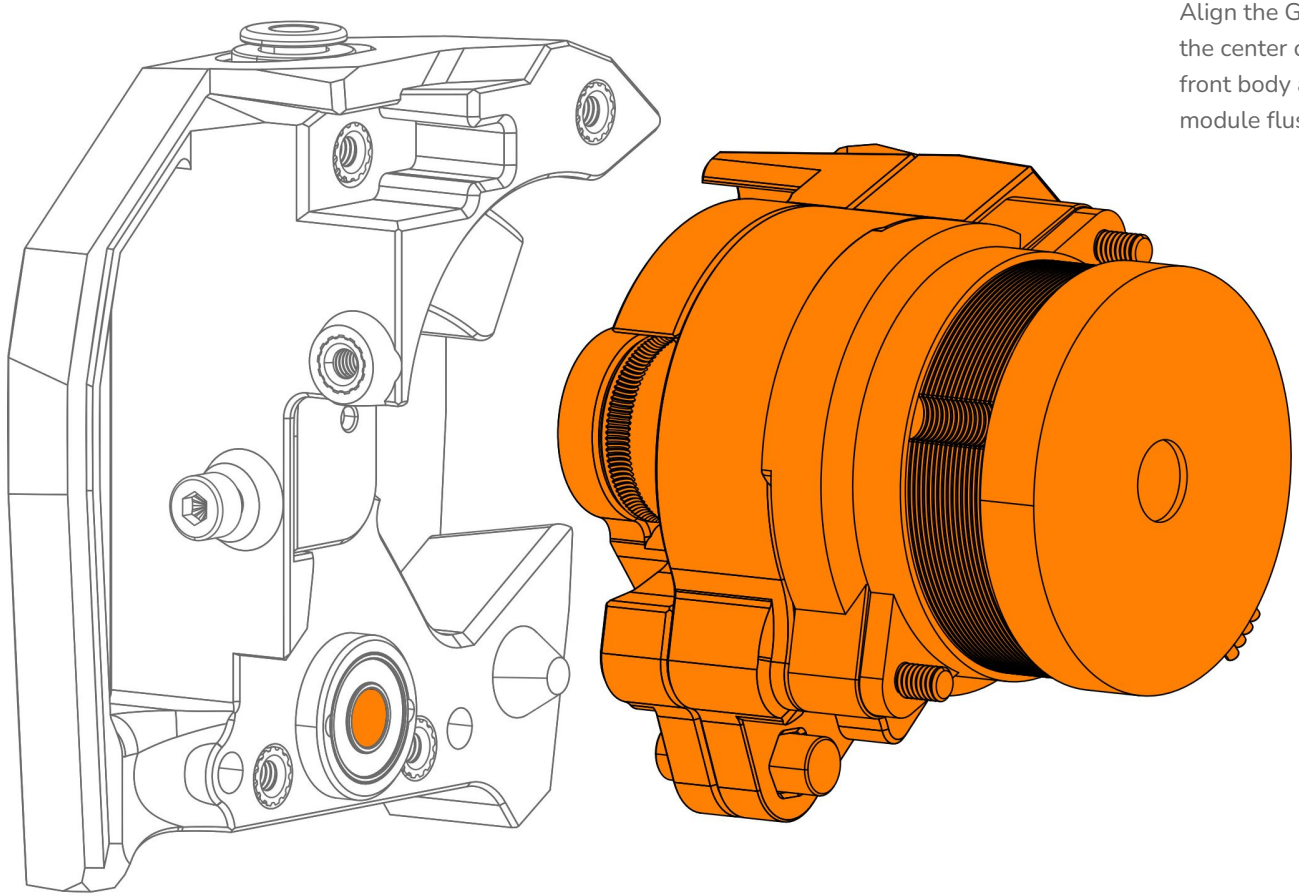
The shaft support bearing needs to be pressed into the front bearing holder until it is flush with the outside face of the printed part. Slide the completed front bearing holder over the carrier shaft, align the screw holes, then attach to the rest of the G2 Module assembly using 2x M3x8 SHCS.



PIVOT! PIVOT! PIVOT!

Insert the pivot pin into the G2 module and roughly center it. The pin will self-center when installing the G2 module into the rest of the extruder parts. If you have trouble inserting the pin, loosen each of the stepper screws one full turn and try again. Tighten the stepper screws again after inserting the pivot pin.





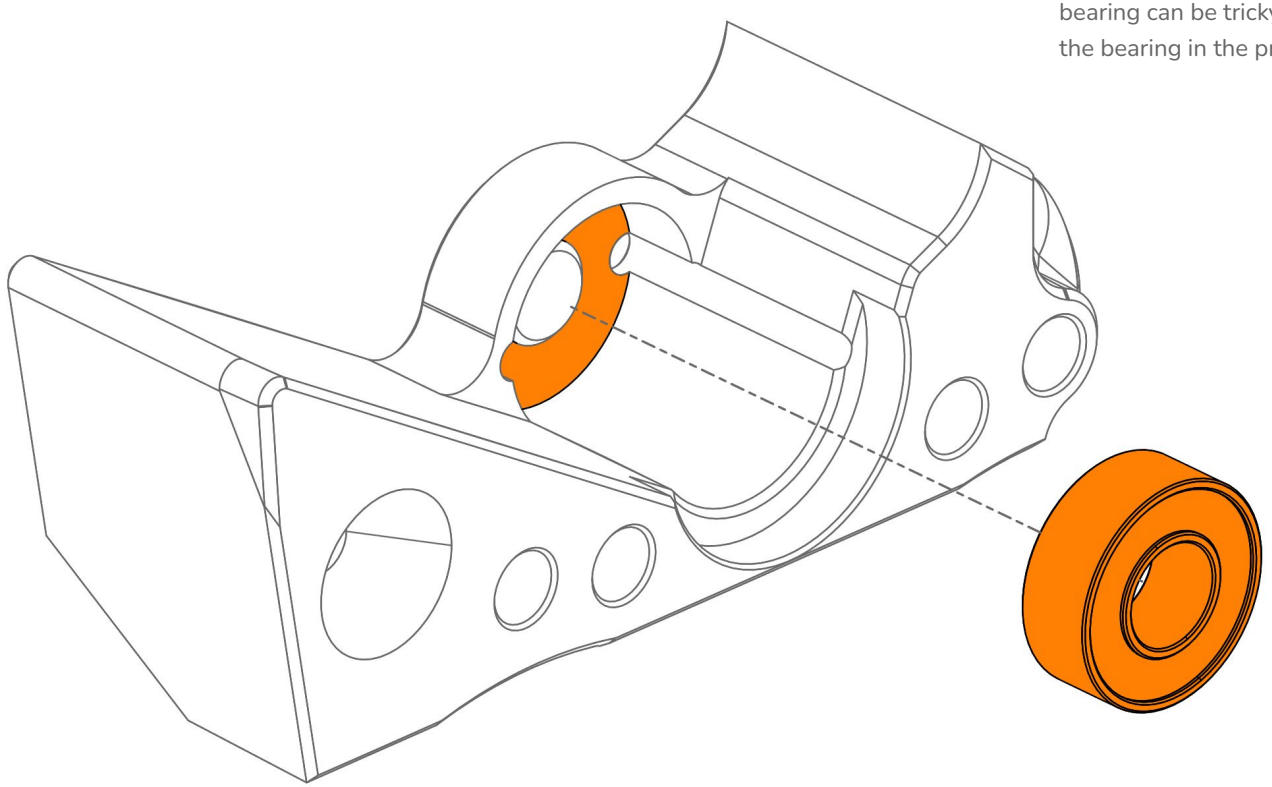
PREPARE FOR DOCKING!

Align the G2 module's pivot pin with the center of the pivot bearing in the front body and install the G2 module flush to the bearing.


GALILEO 2

LOST IN SPACE? BETTER FIND YOUR BEARINGS!

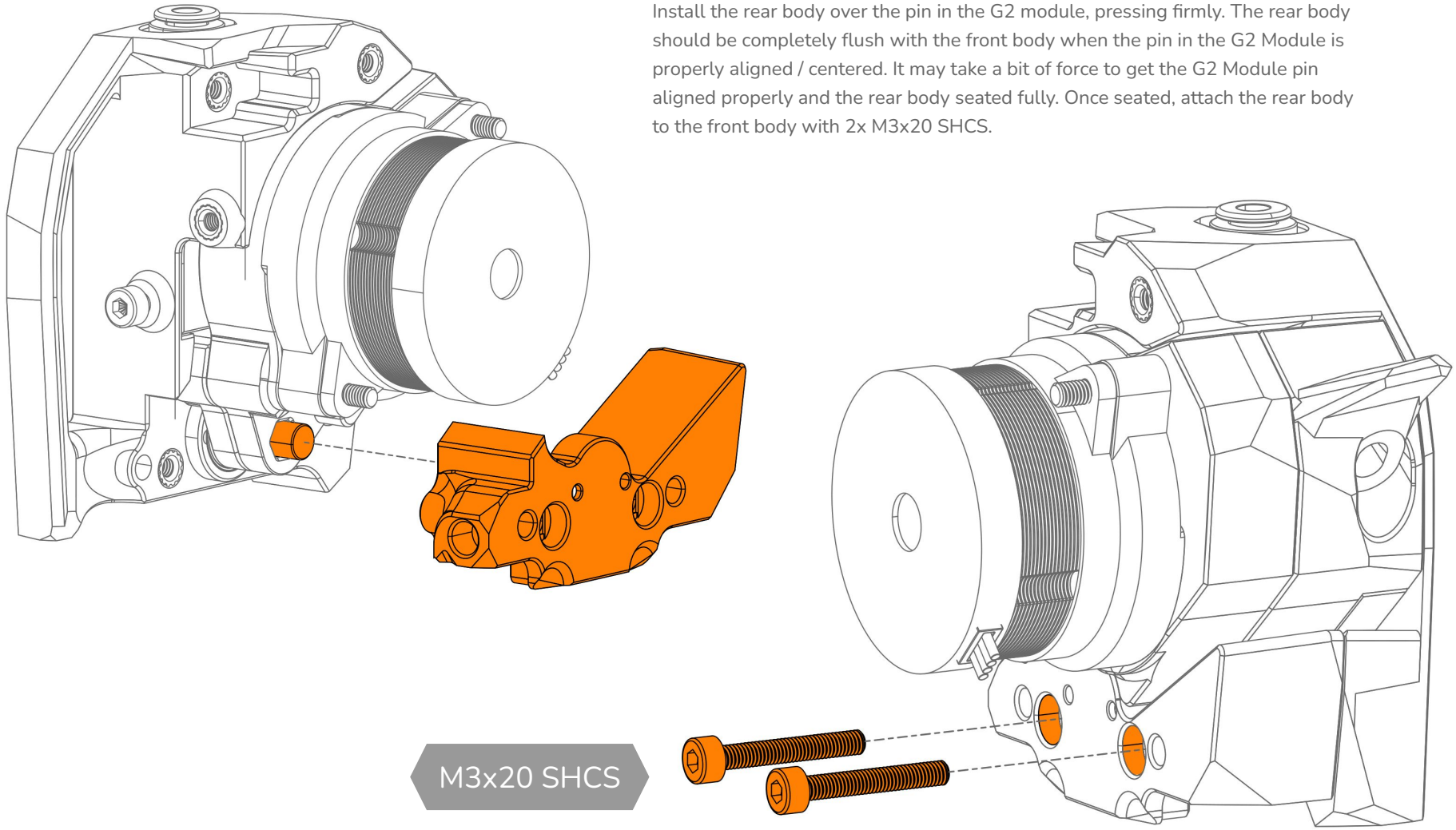
Install the FINAL bearing, making sure to prevent the bearing from tilting sideways while inserting. This bearing can be tricky to install due to the position of the bearing in the printed part.

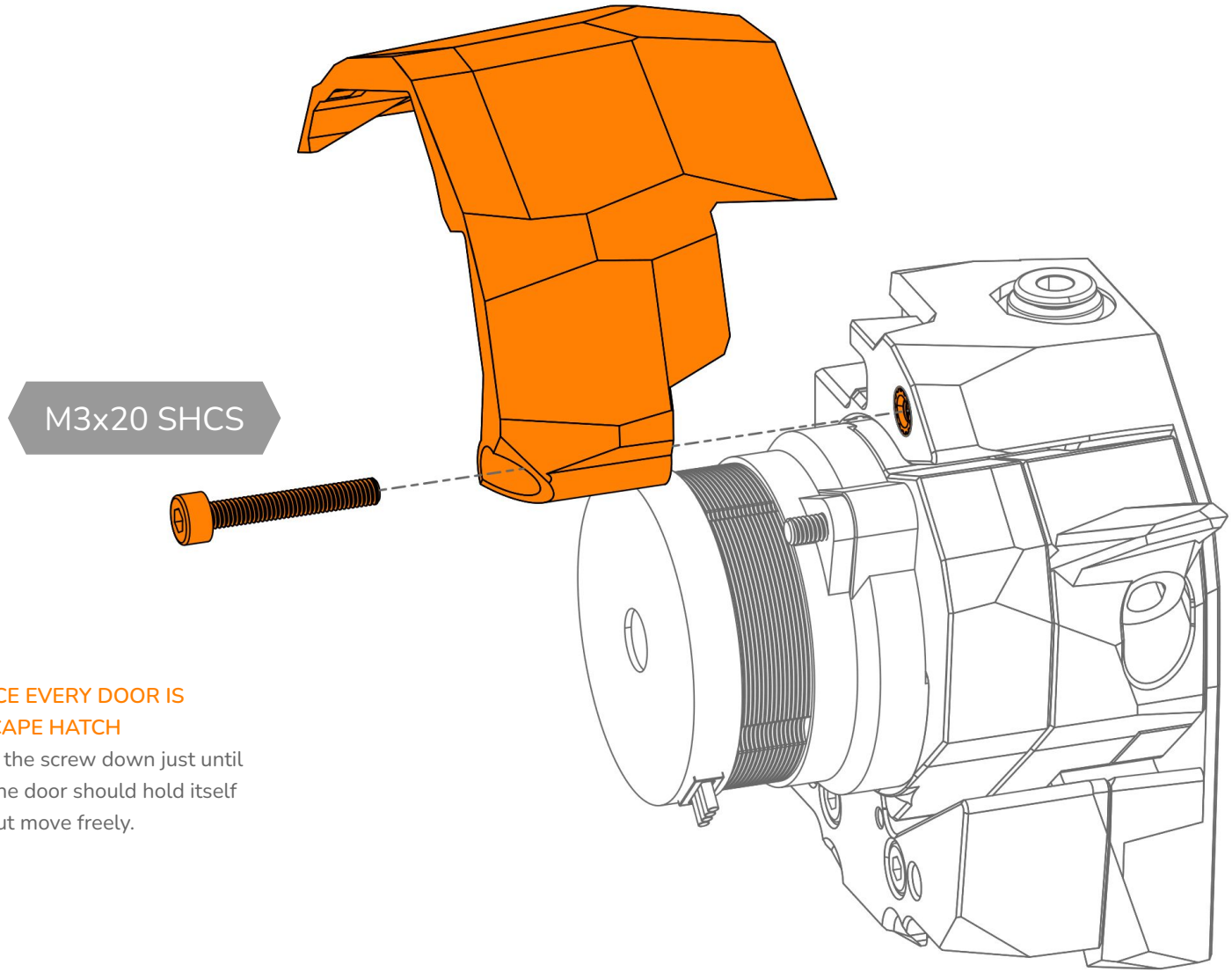


MR115 Bearing

DOCKING SEQUENCE INITIATED

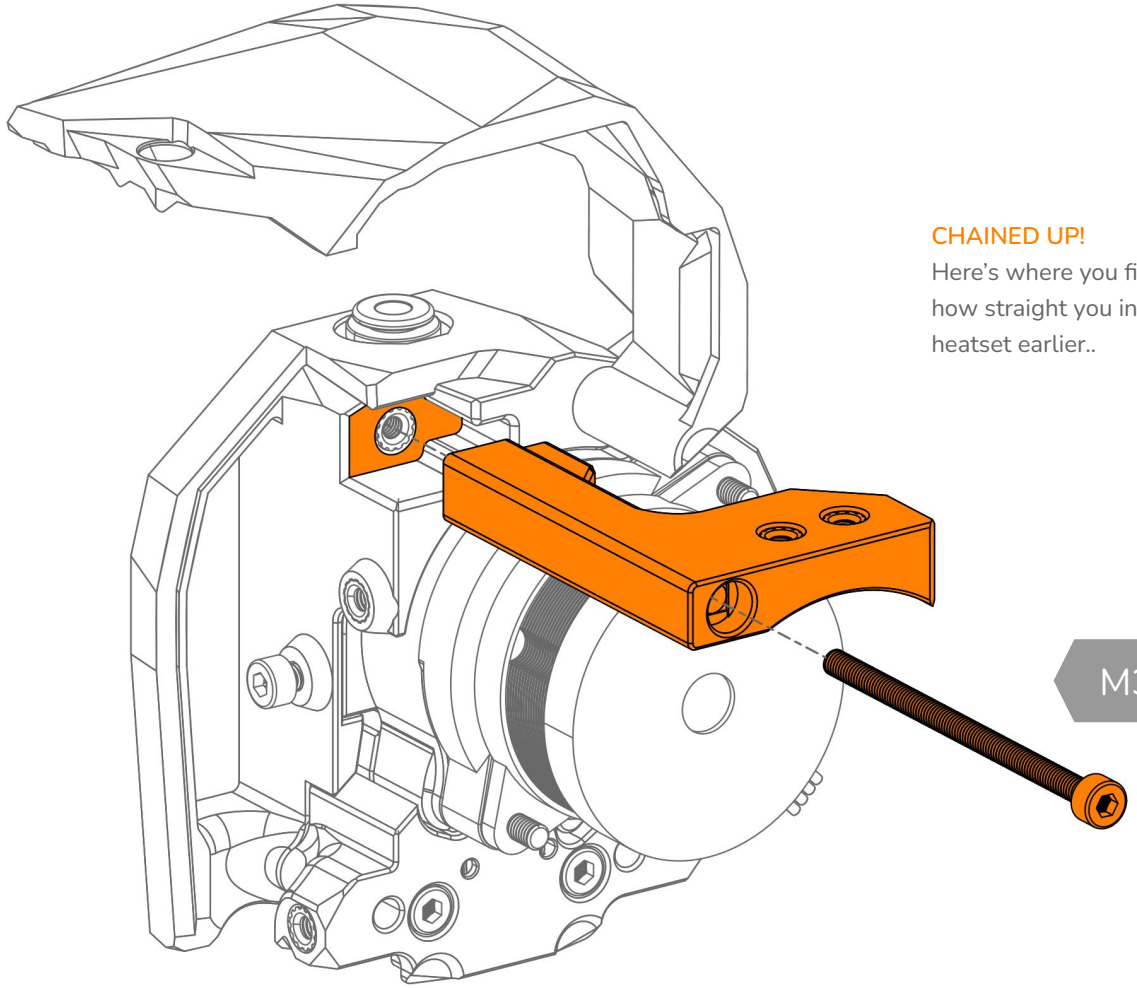
Install the rear body over the pin in the G2 module, pressing firmly. The rear body should be completely flush with the front body when the pin in the G2 Module is properly aligned / centered. It may take a bit of force to get the G2 Module pin aligned properly and the rear body seated fully. Once seated, attach the rear body to the front body with 2x M3x20 SHCS.





IN SPACE EVERY DOOR IS AN ESCAPE HATCH

Tighten the screw down just until snug. The door should hold itself open, but move freely.



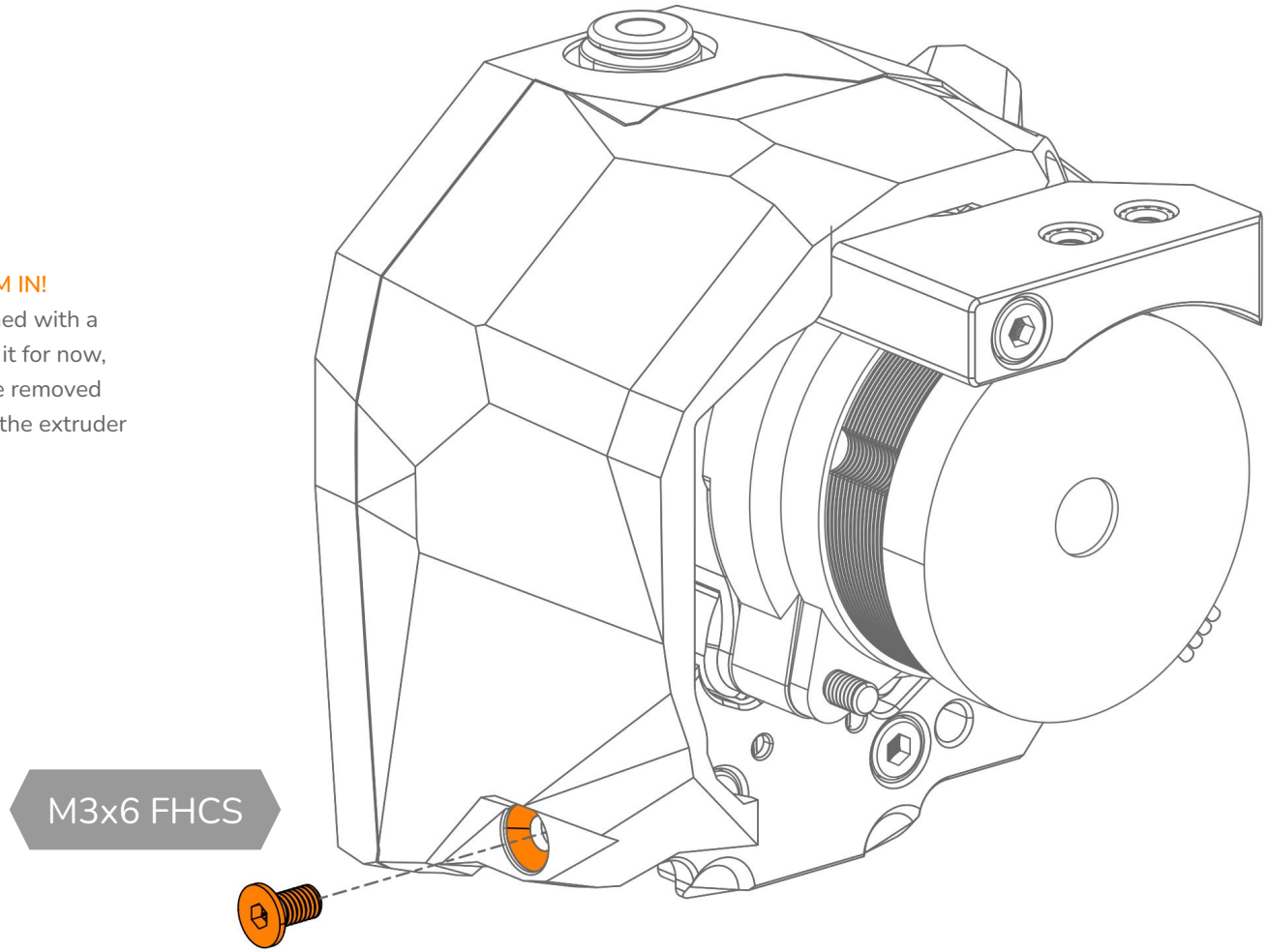
M3x50 SHCS

CHAINED UP!

Here's where you find out just how straight you installed the heatset earlier..

SHUT THAT DOOR...
YOU'LL LET THE VACUUM IN!

The wire cover gets fastened with a single M3x6 FHCS. Install it for now, but know it will need to be removed for wiring when installing the extruder to the toolhead.

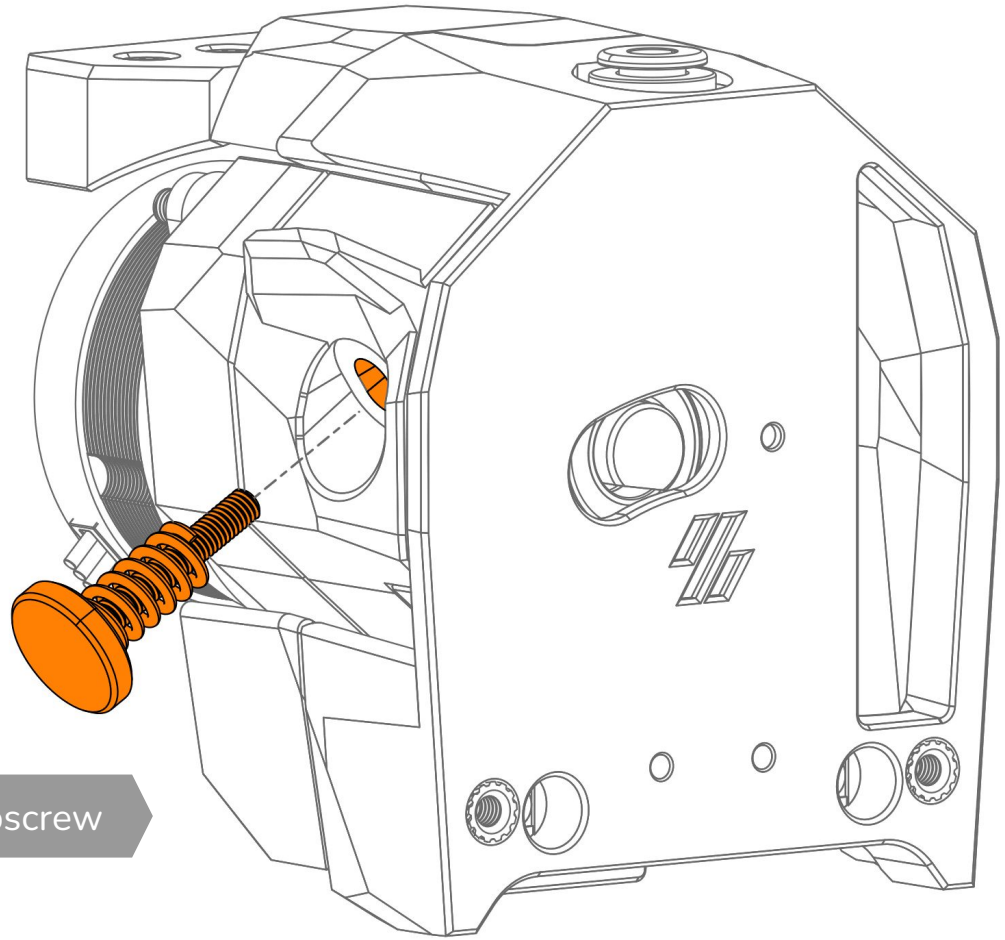


LATCHES? WHERE WE'RE GOING, WE DON'T NEED LATCHES

G2E does away with the latch and instead uses the M3 Thumbscrew and a finger hold to load/unload filament.

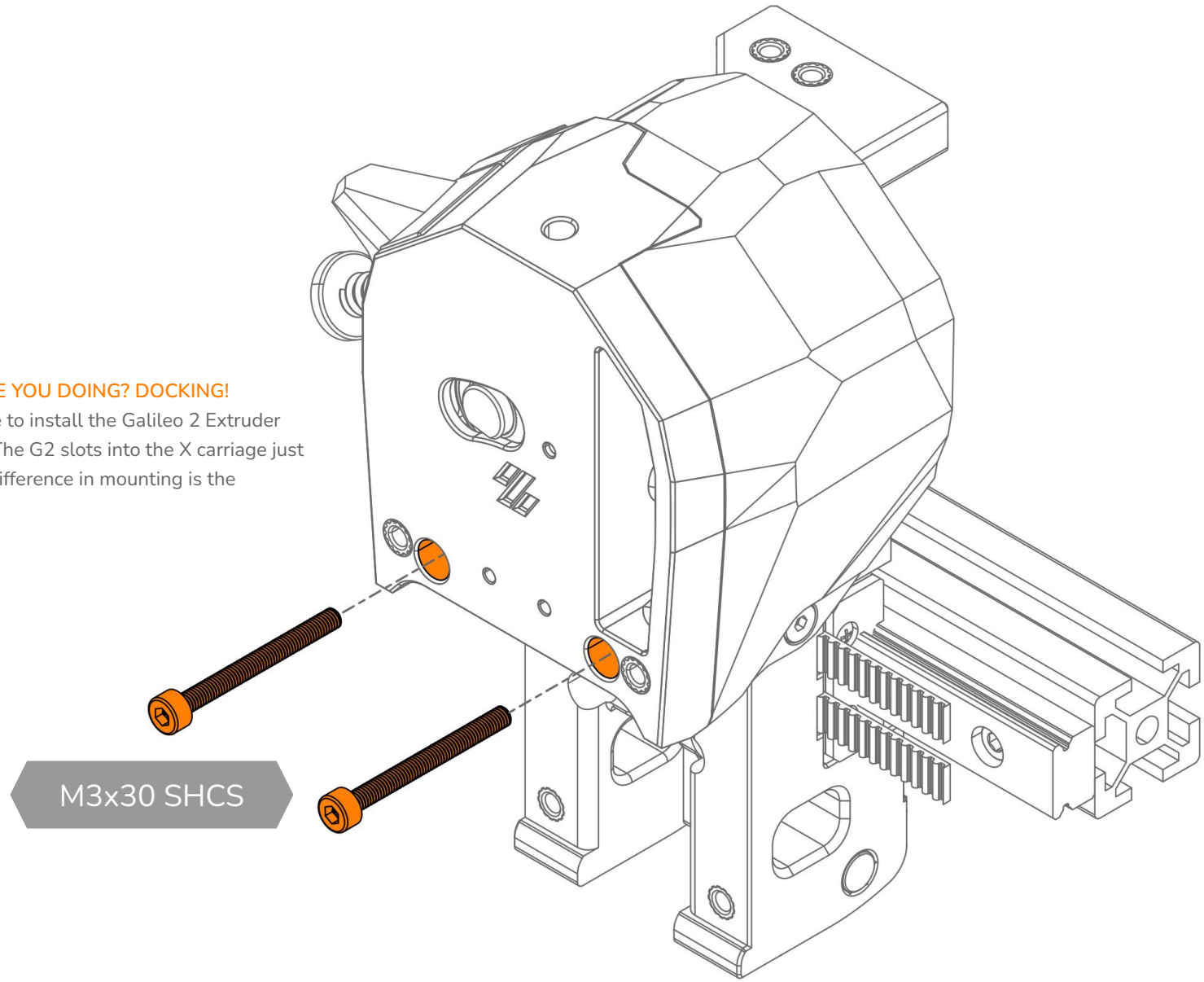
With the G2 Module fully installed, and G2E nearly complete, install the tension thumbscrew through the G2 Module and into the heatset in the Front Body.

NOTE: Due to the design nature of G2E, you will NOT need a lot of tension on this screw. Start with two (2) full turns IN from fully loose, then adjust while extruding as needed.



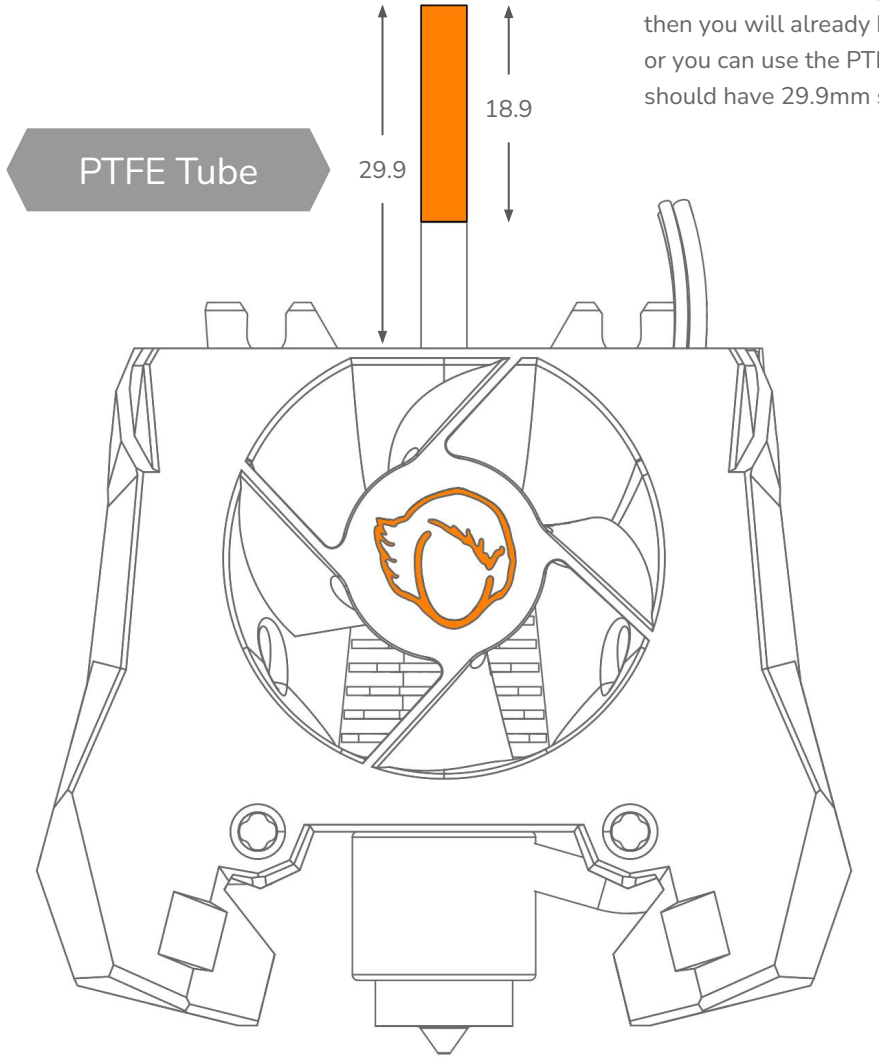
COOPER WHAT ARE YOU DOING? DOCKING!

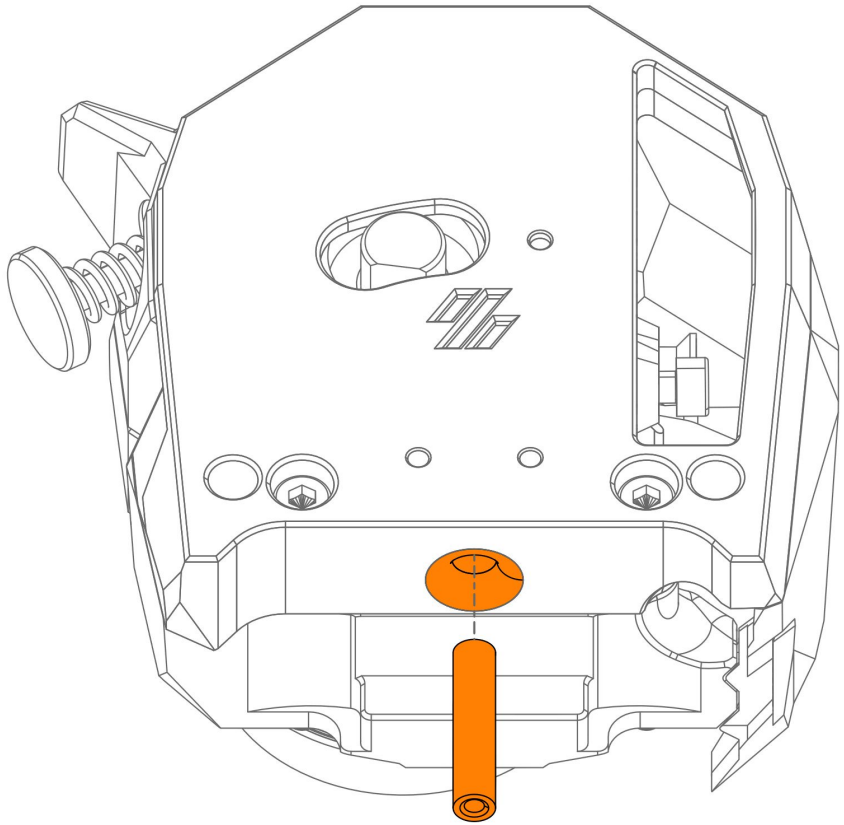
At this point it is time to install the Galileo 2 Extruder onto the X carriage. The G2 slots into the X carriage just like CW2. The only difference in mounting is the hardware used.

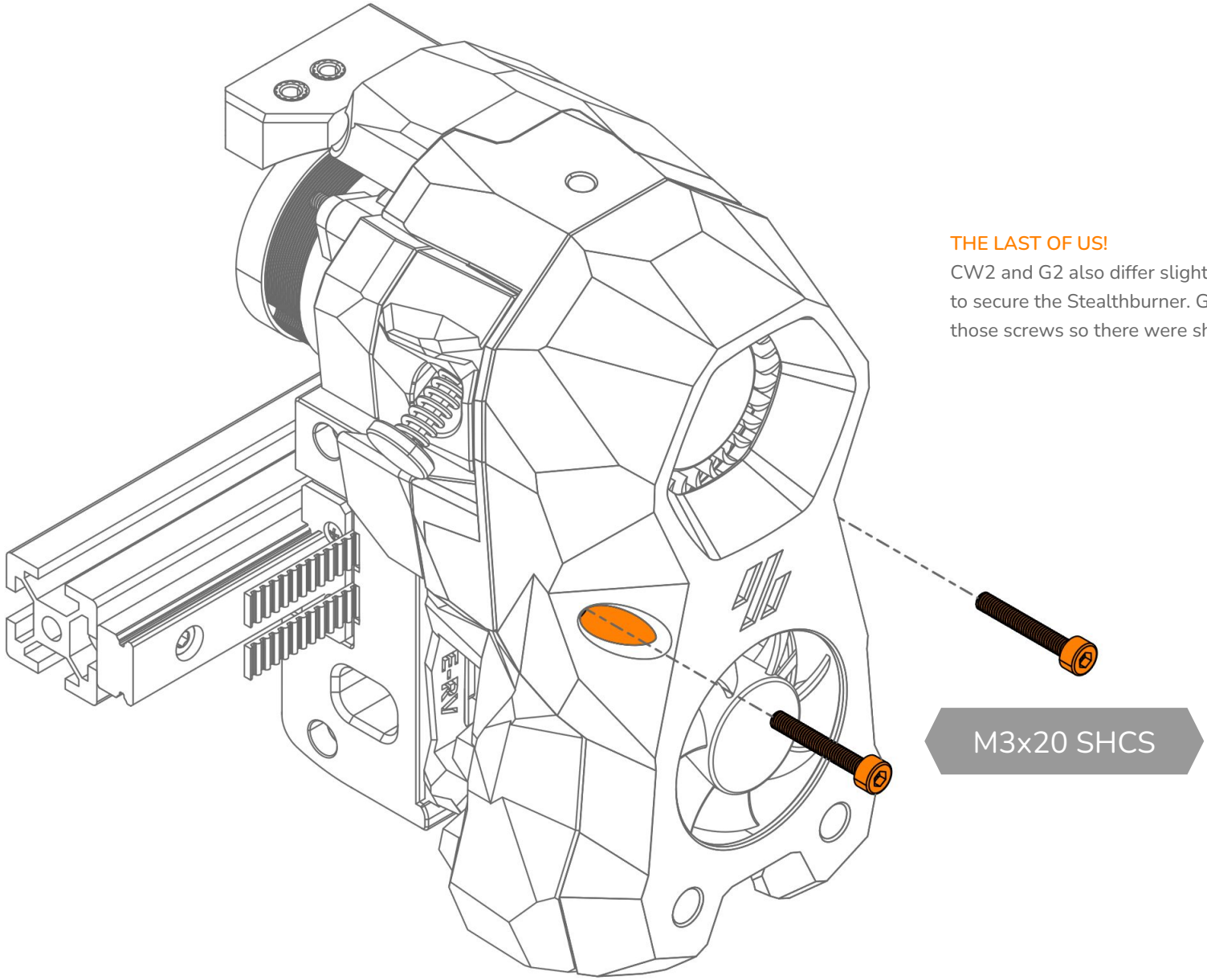


INTO THE WORMHOLE

There are 2 methods you can use to setup the PTFE tube. If you are swapping from CW2 then you will already have a PTFE tube you can just add to that with a new 18.9mm piece or you can use the PTFE cutting jig in the G2 repo and cut a new piece. The new new piece should have 29.9mm sticking out the top of the hotend mount.







THE LAST OF US!

CW2 and G2 also differ slightly in the top 2 screws to secure the Stealthburner. G2 has less space for those screws so there were shortened


GALILEO 2