3D Printing and Fabrication in Marine Science

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UNIVERSITY OF MIAMI

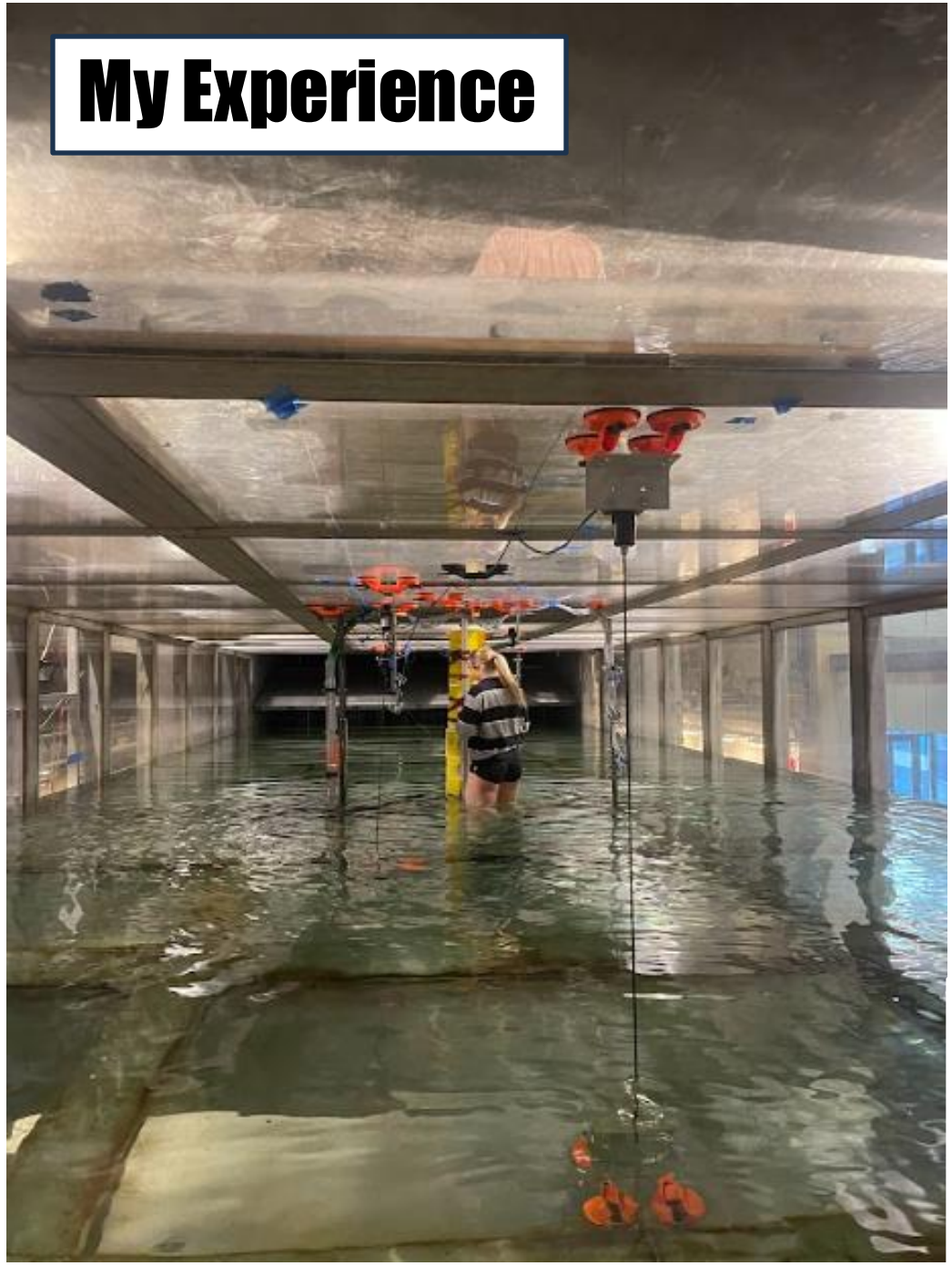
ROSENSTIEL SCHOOL of MARINE, ATMOSPHERIC & EARTH SCIENCE

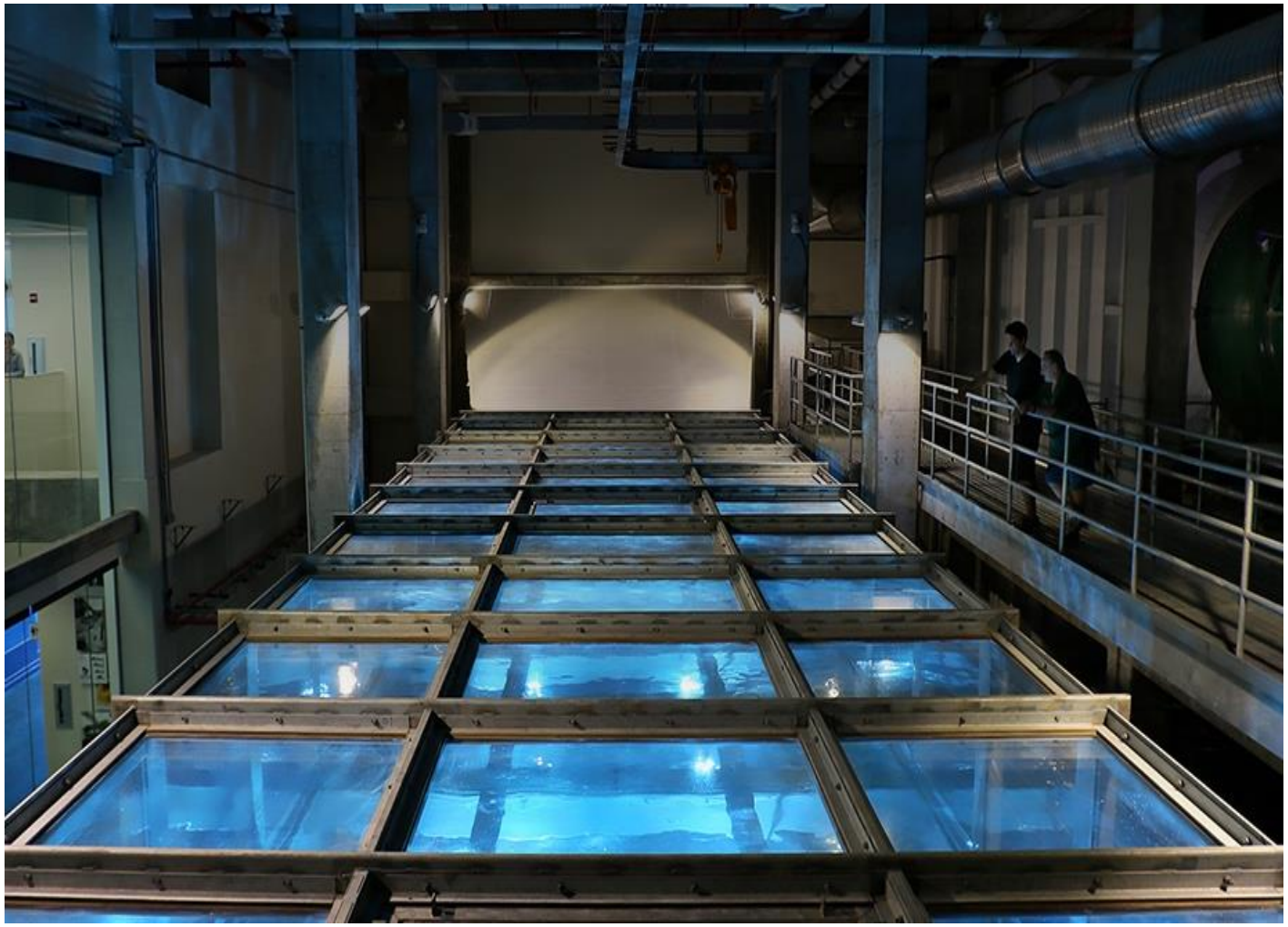
Overview

1. My experience
2. What is 3D printing and how does it work?
3. What are the different types of 3D printing?
4. How is 3D printing useful in marine science and working at sea?
5. Can 3D prints be used on CTD casts? My research
6. Demo!

My Experience

R/V F. G. Walton Smith

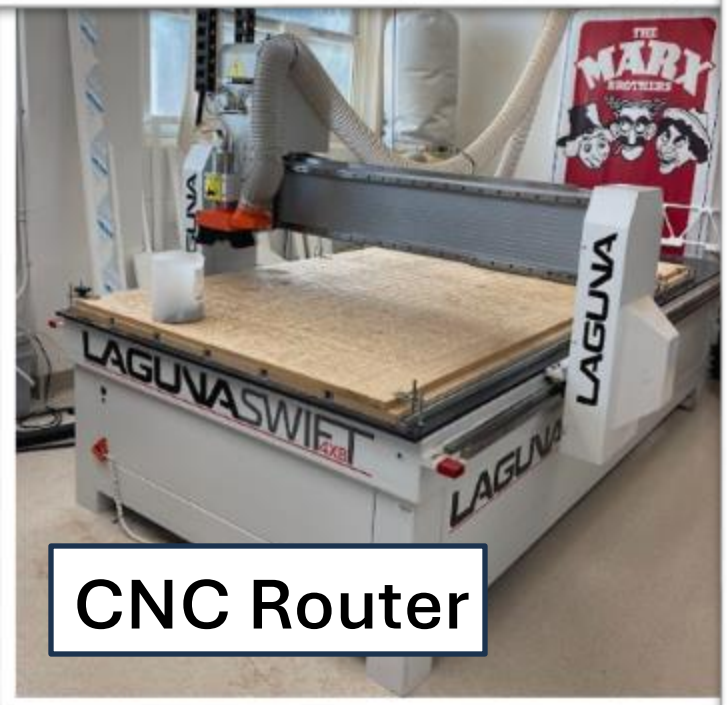




SUSTAIN Laboratory

My Experience

Laser Cutter



CNC Router

Makers Lab

3D Printers

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What is 3D Printing and How Does It Work?

What is 3D printing?

- 3D printing is additive manufacturing technology where material is layered to create a 3-dimensional object
- Produces less waste than subtractive manufacturing
- Includes a wide range of sizes, prices, and materials

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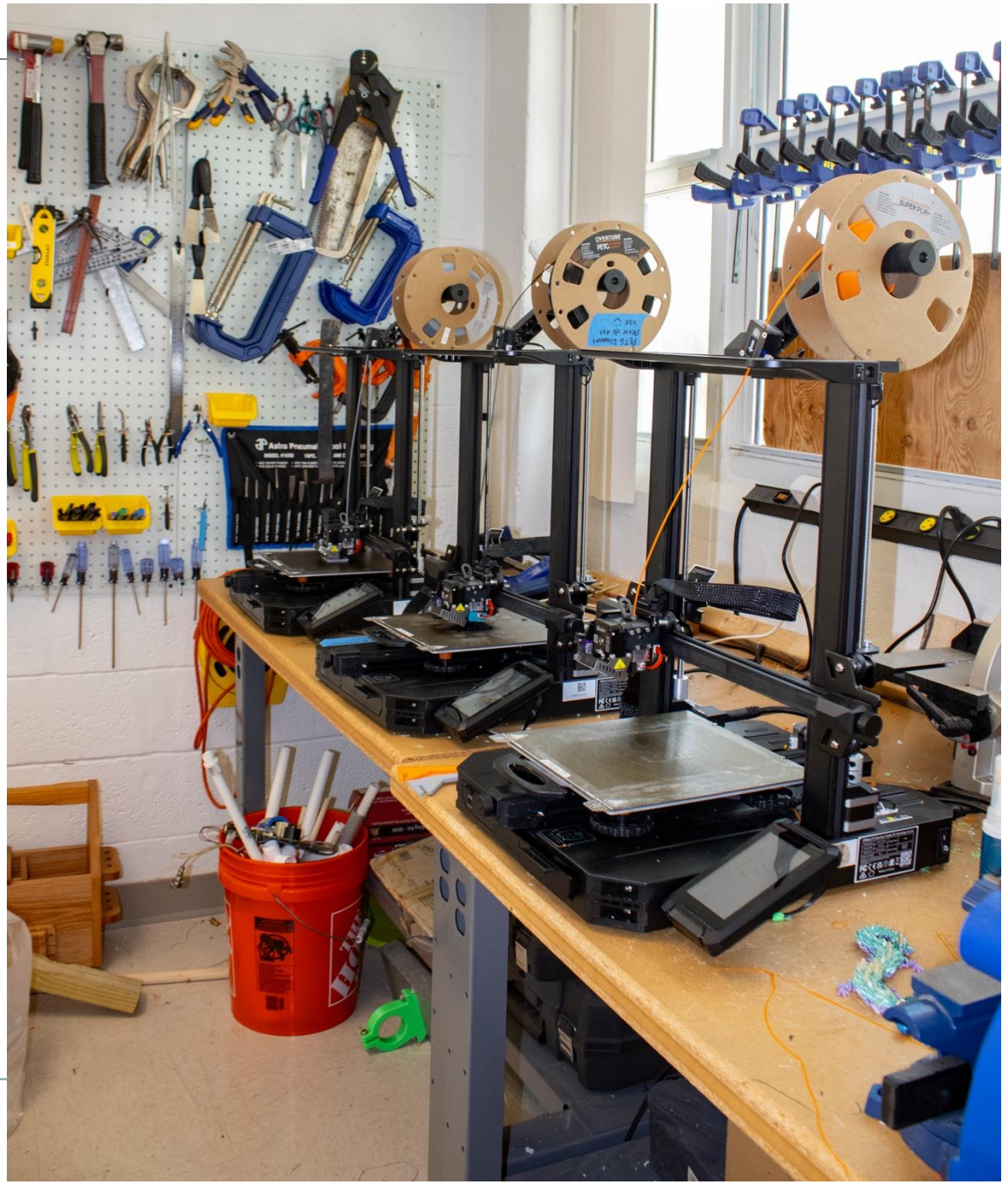

How expensive is 3D printing?

Ender-3 S1 Plus 3D Printer

Print larger-size models, meet more printing needs.

★★★★★ 17 reviews

$289.00 ~~$479.00~~ Save $190.00

Earn 57 points.

Wide range of prices, dependent on the model of printer and filament used - **can be very inexpensive**

OVERTURE Super PLA+ Filament 1.75mm, Toughness Enhanced PLA Plus, Professional Toughness 3D Printer Filament 1kg (2.2lbs), High Precision +/- 0.02mm (Orange)

Visit the OVERTURE Store

4.5 ★★★★½ (7,068) |

Ask questions and search reviews

-21% $22.99 ($0.65 / ounce)

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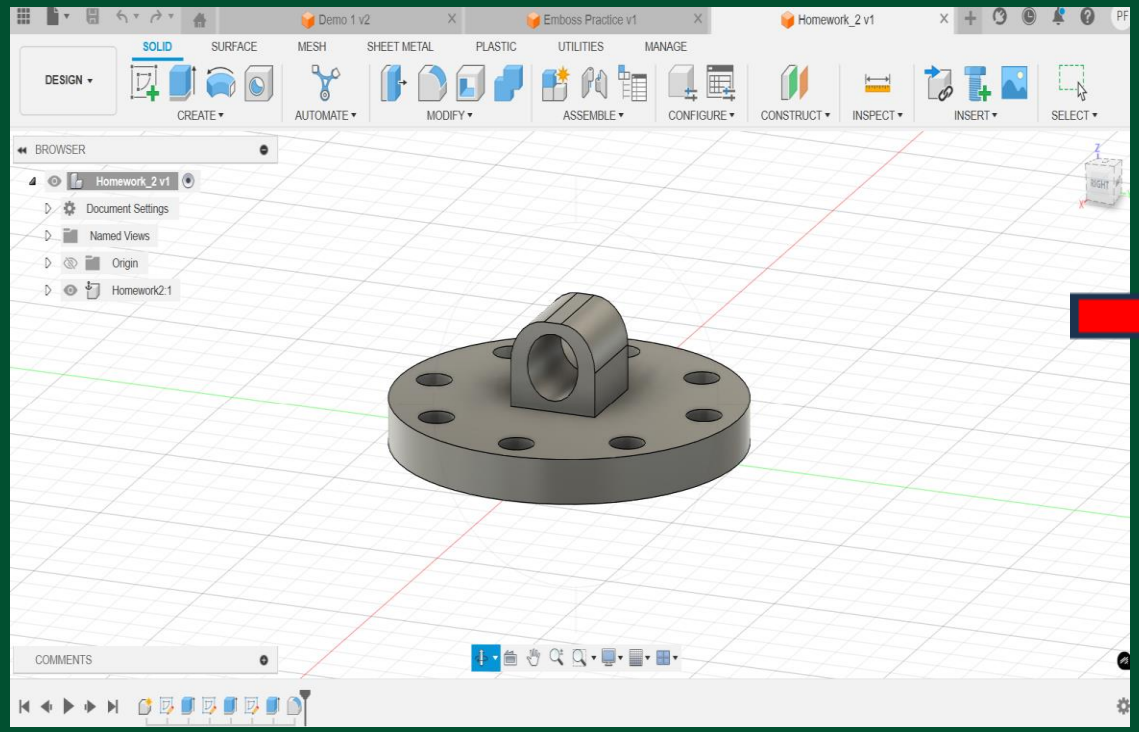
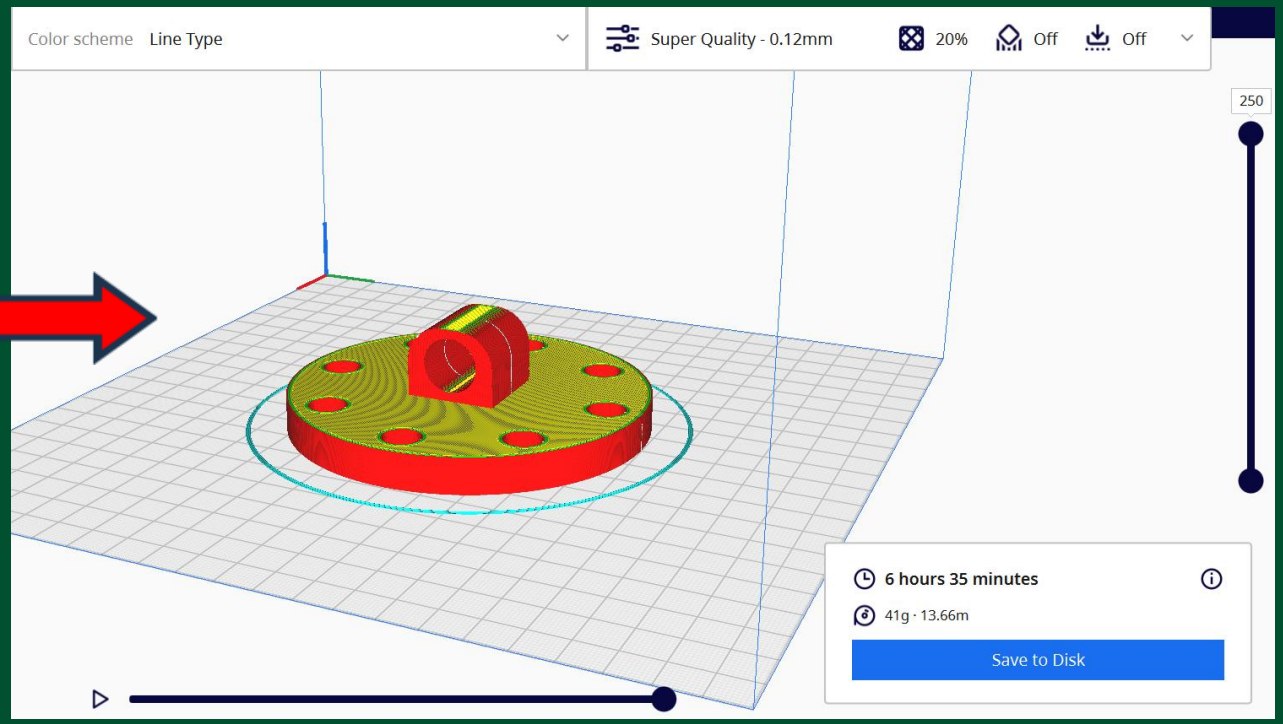
How does 3D Printing work?





1. 3D design software is used to sketch the object

2. 3D digital object is sent to a slicing software, converting the design to g-code

How does 3D printing work?

3. 3D printer reads g-code and deposits layers of material until the design is fully fabricated

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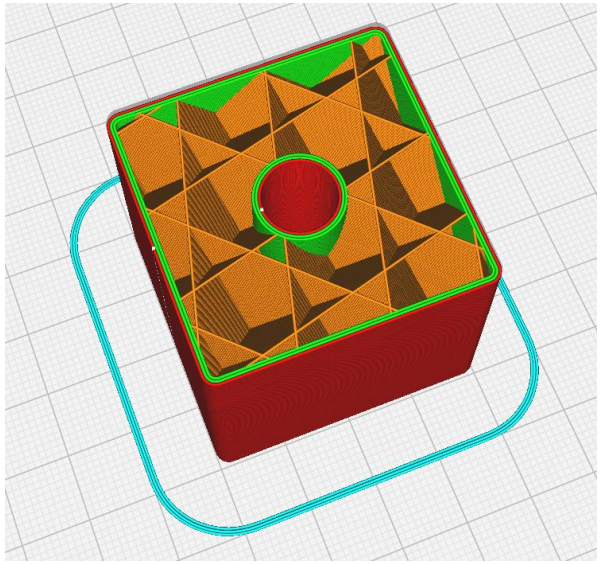
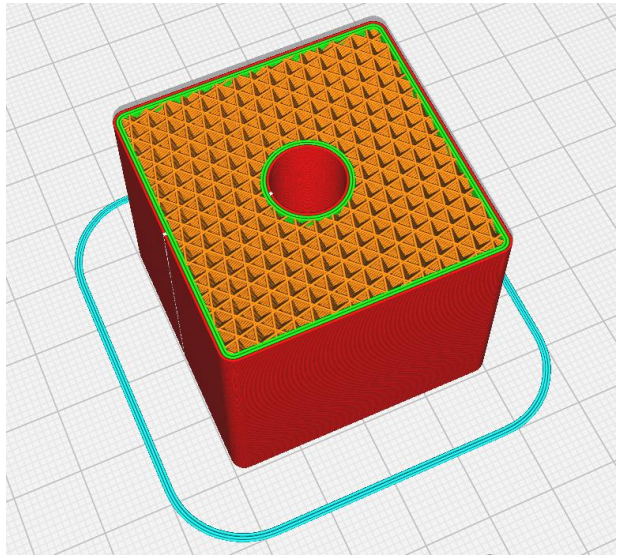
Printing Can Be Done at Different Infill Densities and Infill Patterns

Infill Densities

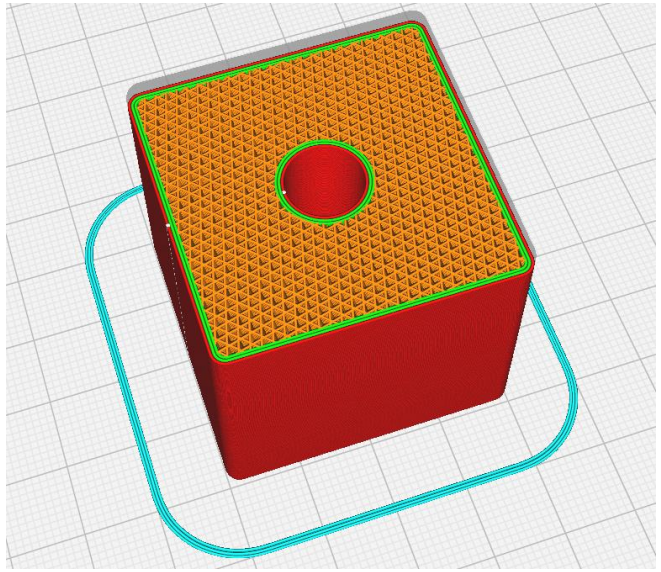
10% Infill



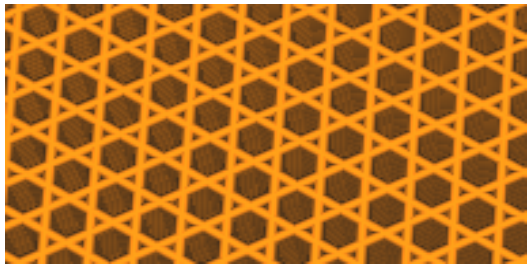
50% Infill



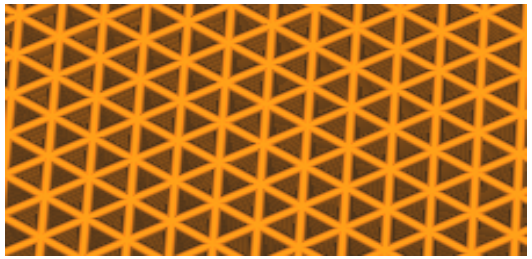
90% Infill



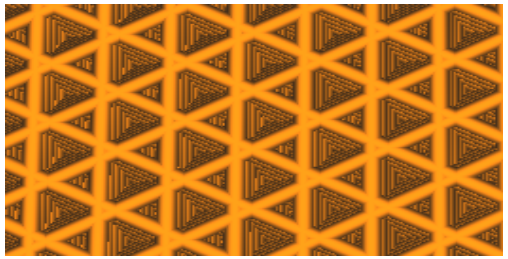
Infill Patterns



Tri-Hexagonal



Triangles



Cubic

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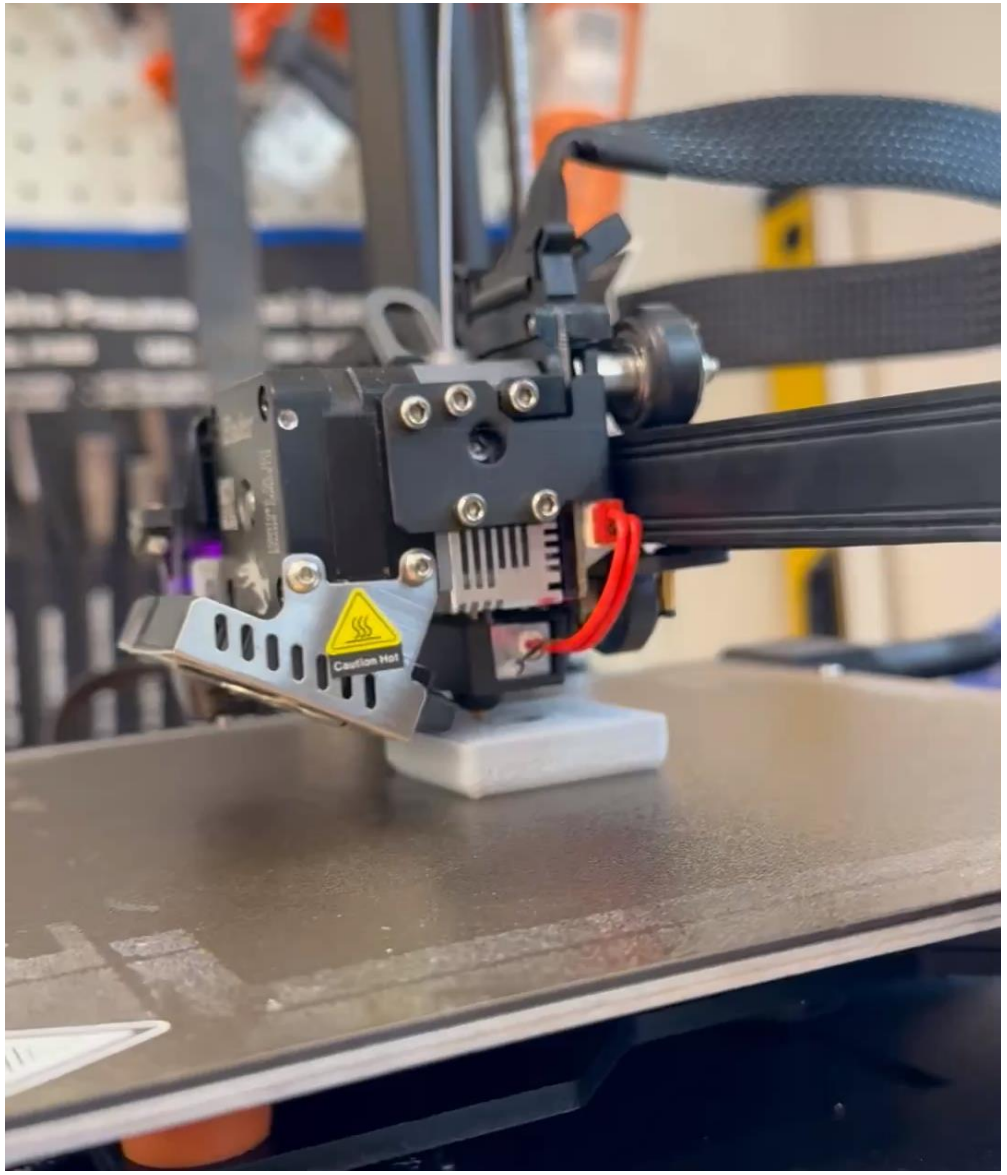
What are the Different Types of 3D Printing? 3 Examples



Fused Deposition Modeling (FDM)

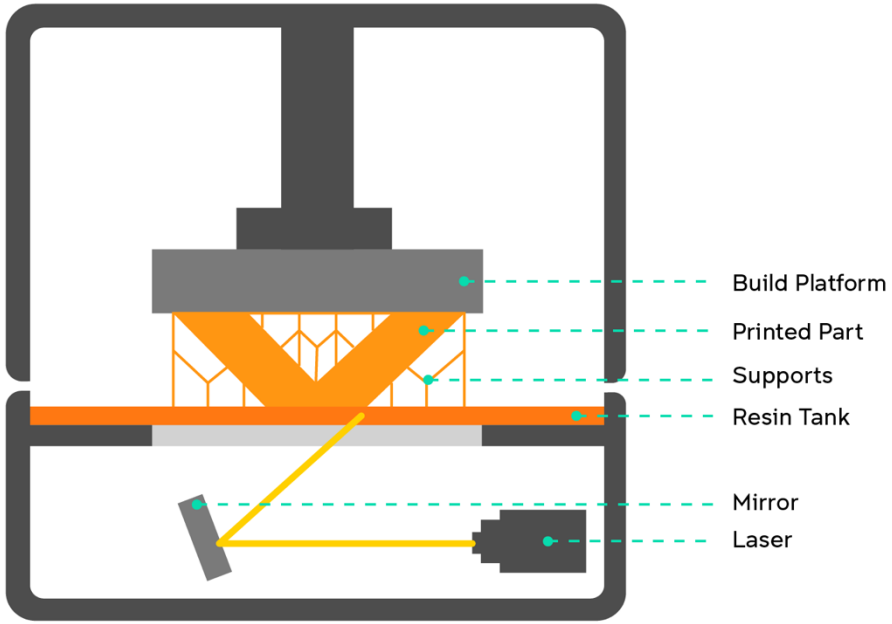
Builds objects layer by layer by extruding molten plastic or composite material through a nozzle

Stereolithography (SLA) 3D Printing

A UV laser cures liquid photopolymer resin into hardened plastic

Key Feature: liquid resin bath

Produces high-resolution results



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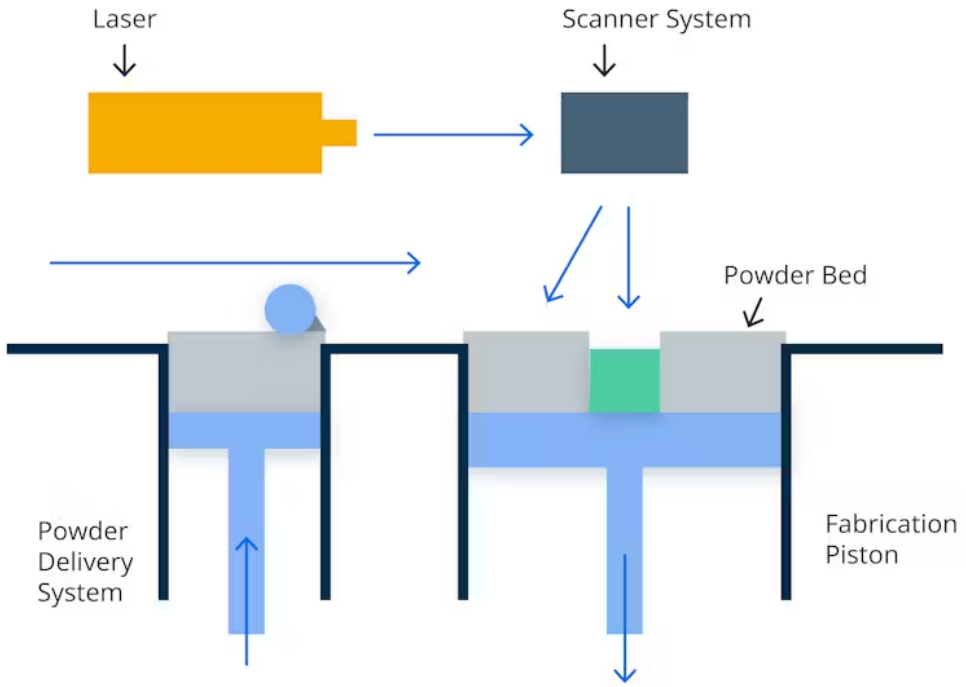
Selective Laser Sintering (SLS)

uses a high-power laser to sinter small particles of polymer powder into a solid structure



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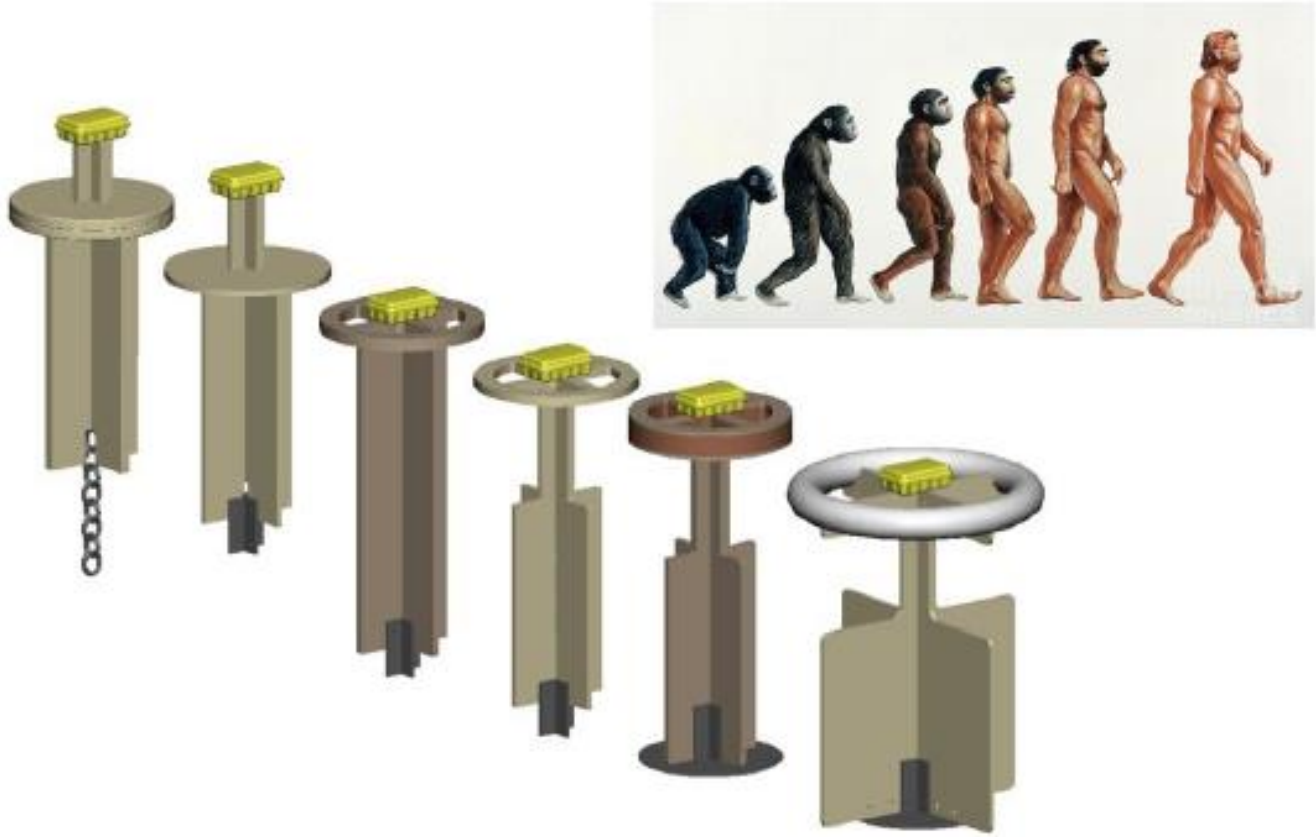
How is 3D Printing Applied in Marine Science?

Prototyping

- Speed and price of 3D printers allows for rapid prototyping in both a field and laboratory setting

- Flaws in an instrument's design can be discovered without a long manufacturing process

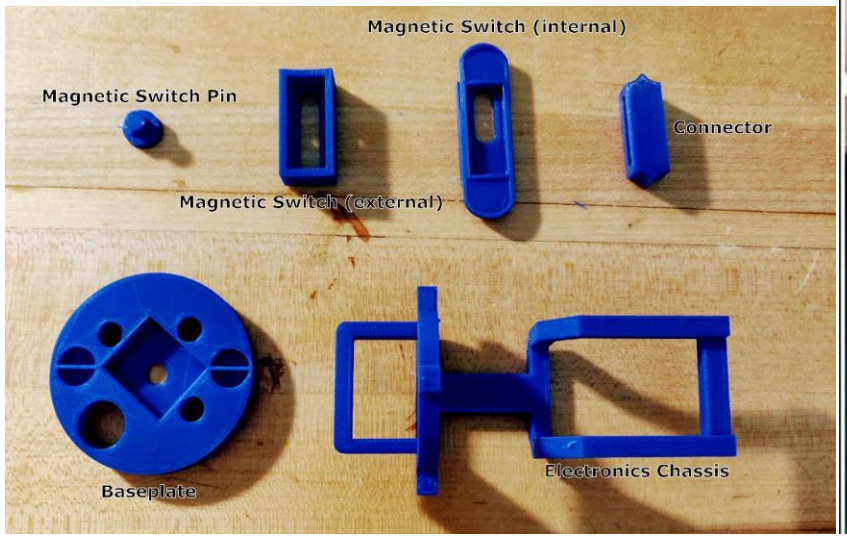


Tamay Özgökmen, Ocean Engg Survey, ***2025***

Tamay Özgökmen,
Ocean Engg Survey, 2025

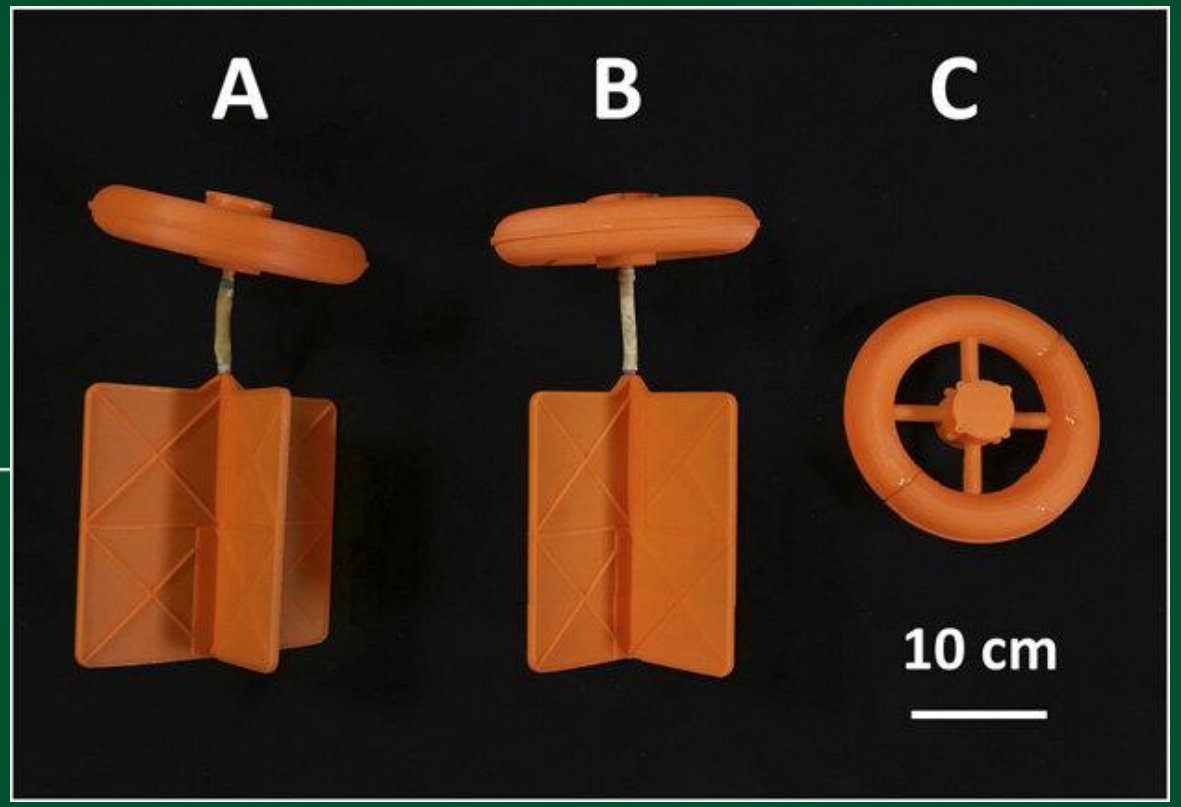
How Can 3D printing Help in Experimentation?

Unexpected problems are expected!



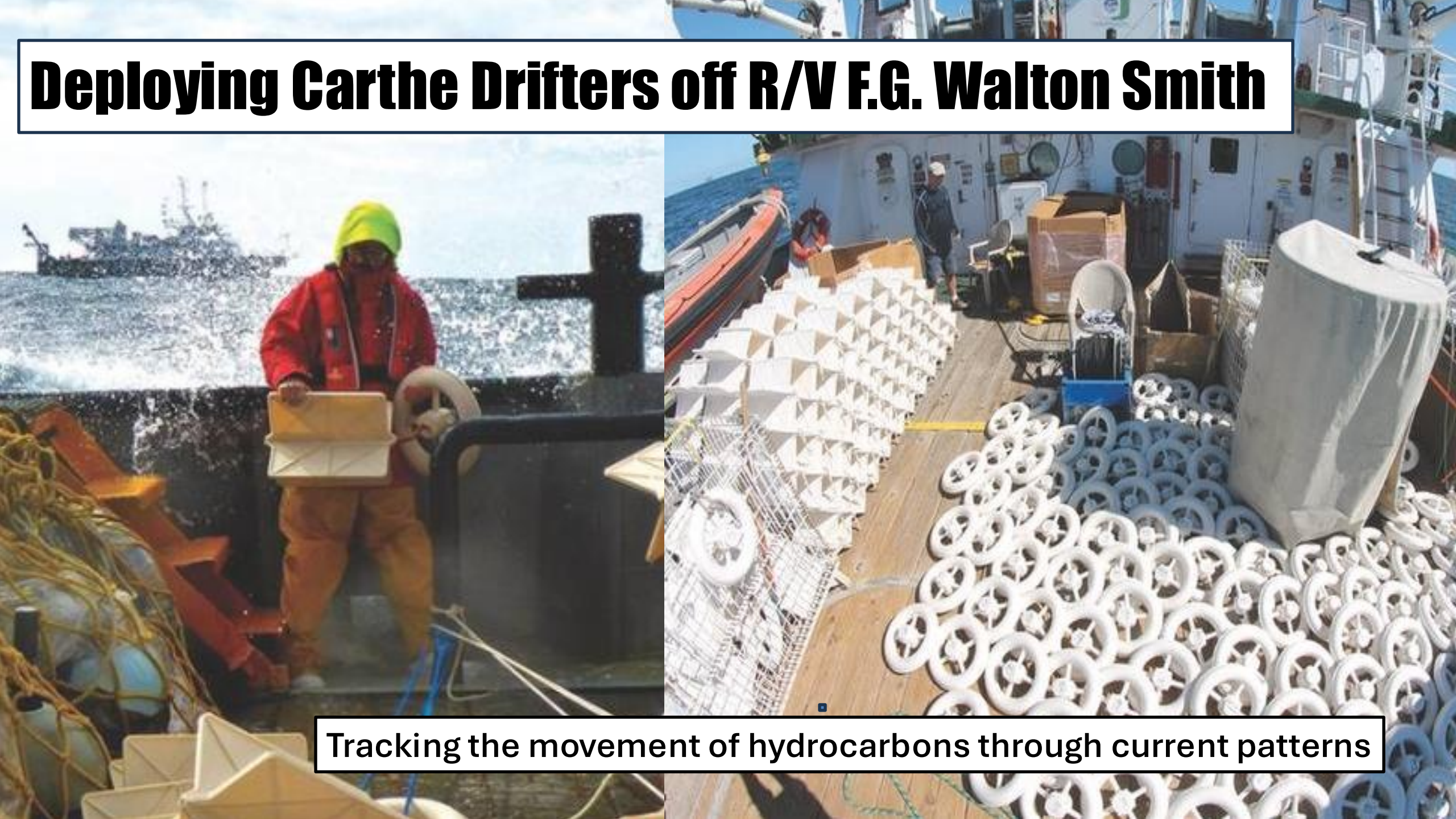
Examples of how this applies to 3D printing: Auxiliary Instruments (Electronics Holders, Electronic board organizers, switch components)

Prototyping the Carthe Drifter



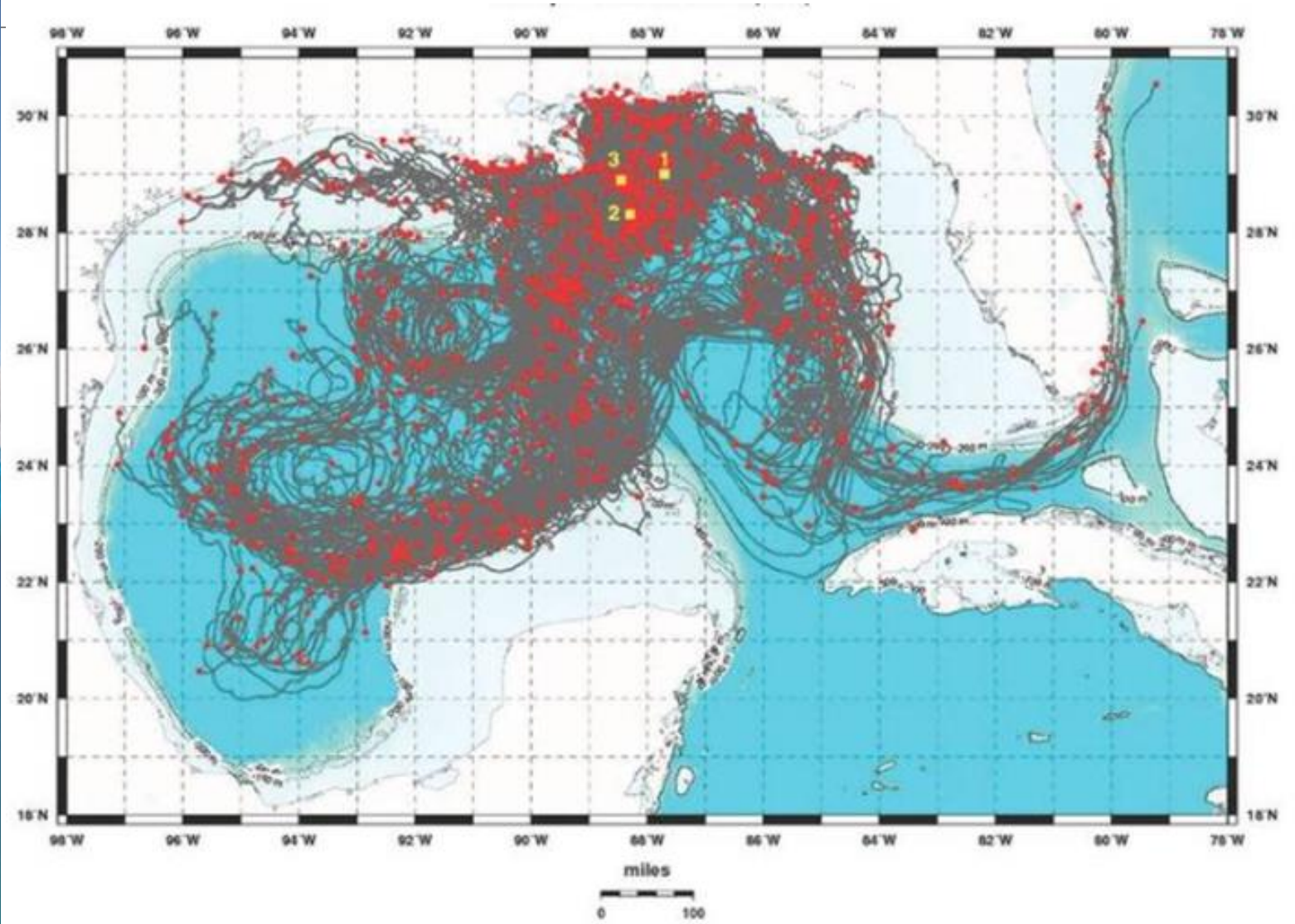
Designed with 3-D printable
PHA biodegradable plastic

Deploying Carthe Drifters off R/V F.G. Walton Smith



Tracking the movement of hydrocarbons through current patterns

Data Collected

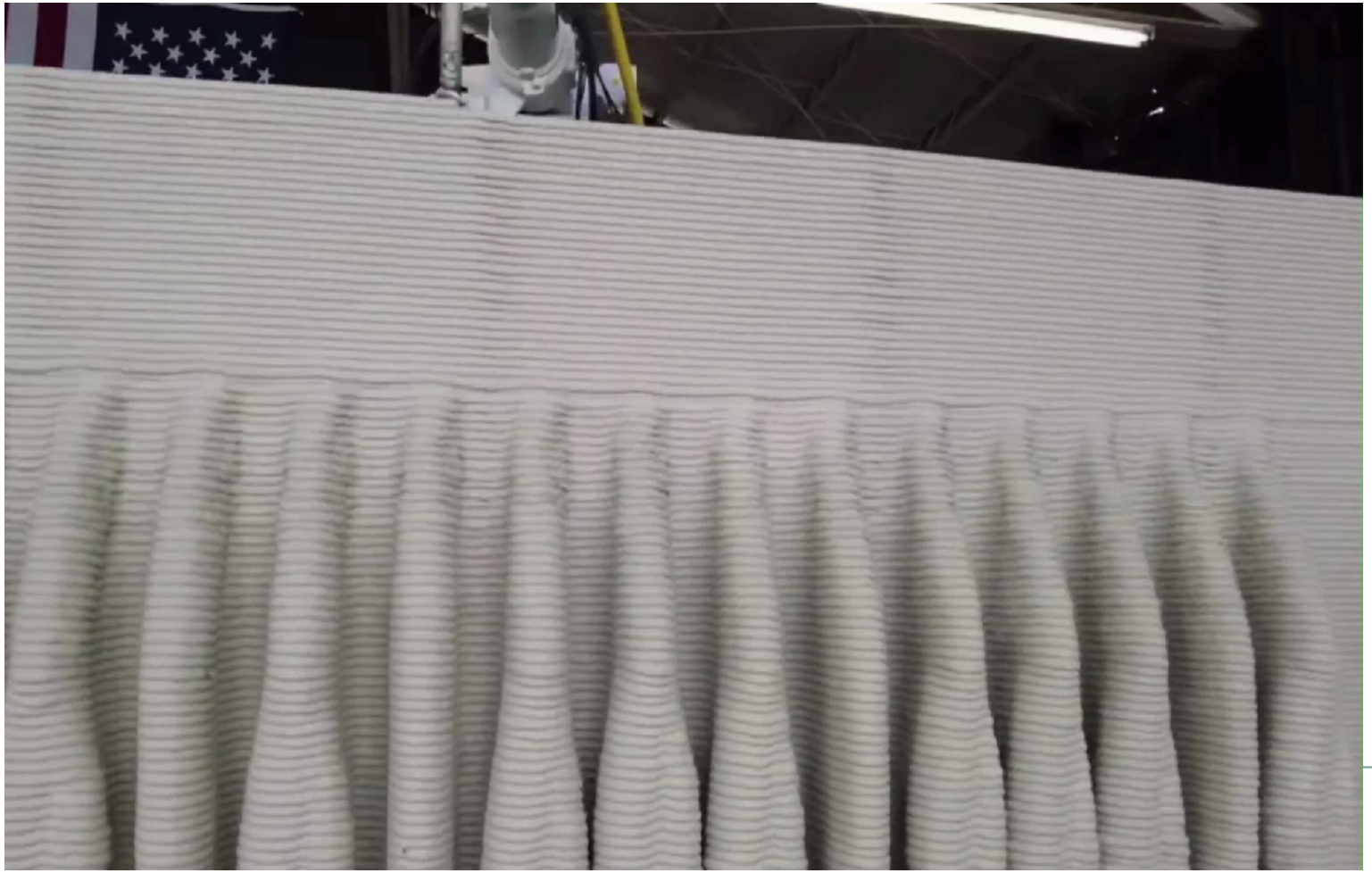


Three-month long trajectories of 1000 drifter units from the LASER field experiment. (Image: GreenWave Instruments LLC)

Printing and Prototyping the Cyclonic Sampler

3D Printed Concrete Seawalls

3D printing can also be useful in final production. These are seawalls created by KindDesigns to mitigate coastal erosion



Testing in the wave tank

Listed in TIME magazine as one of the best inventions of 2025, dissipates wave energy by deflecting it in multiple directions

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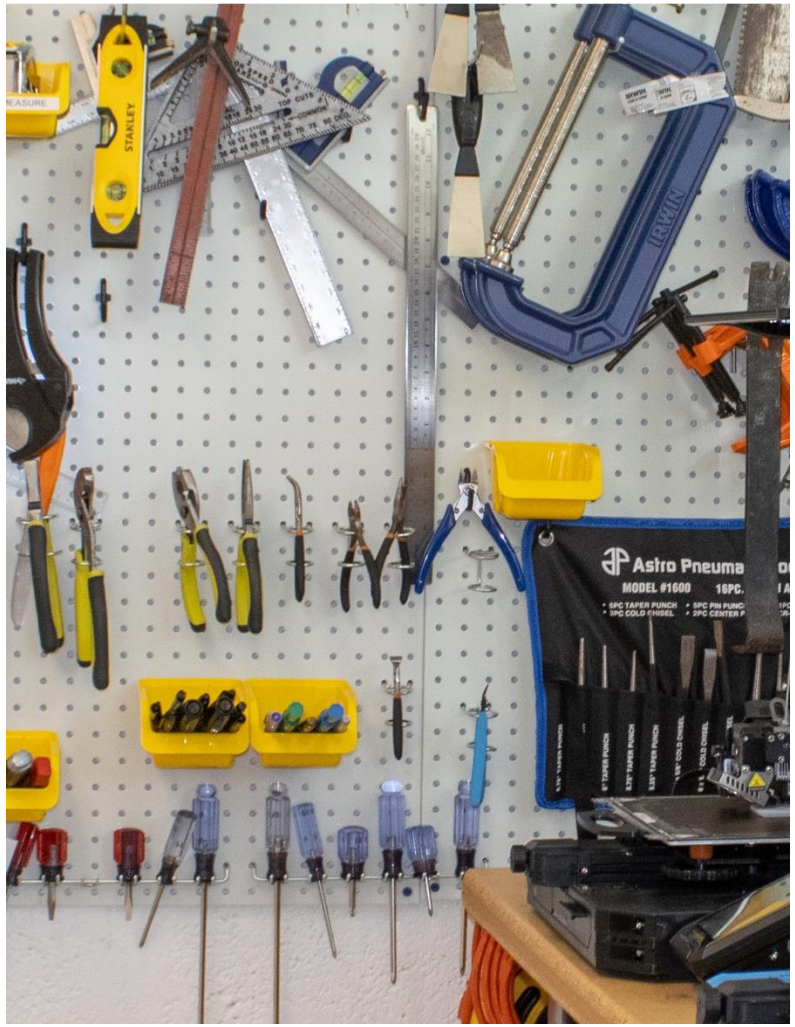
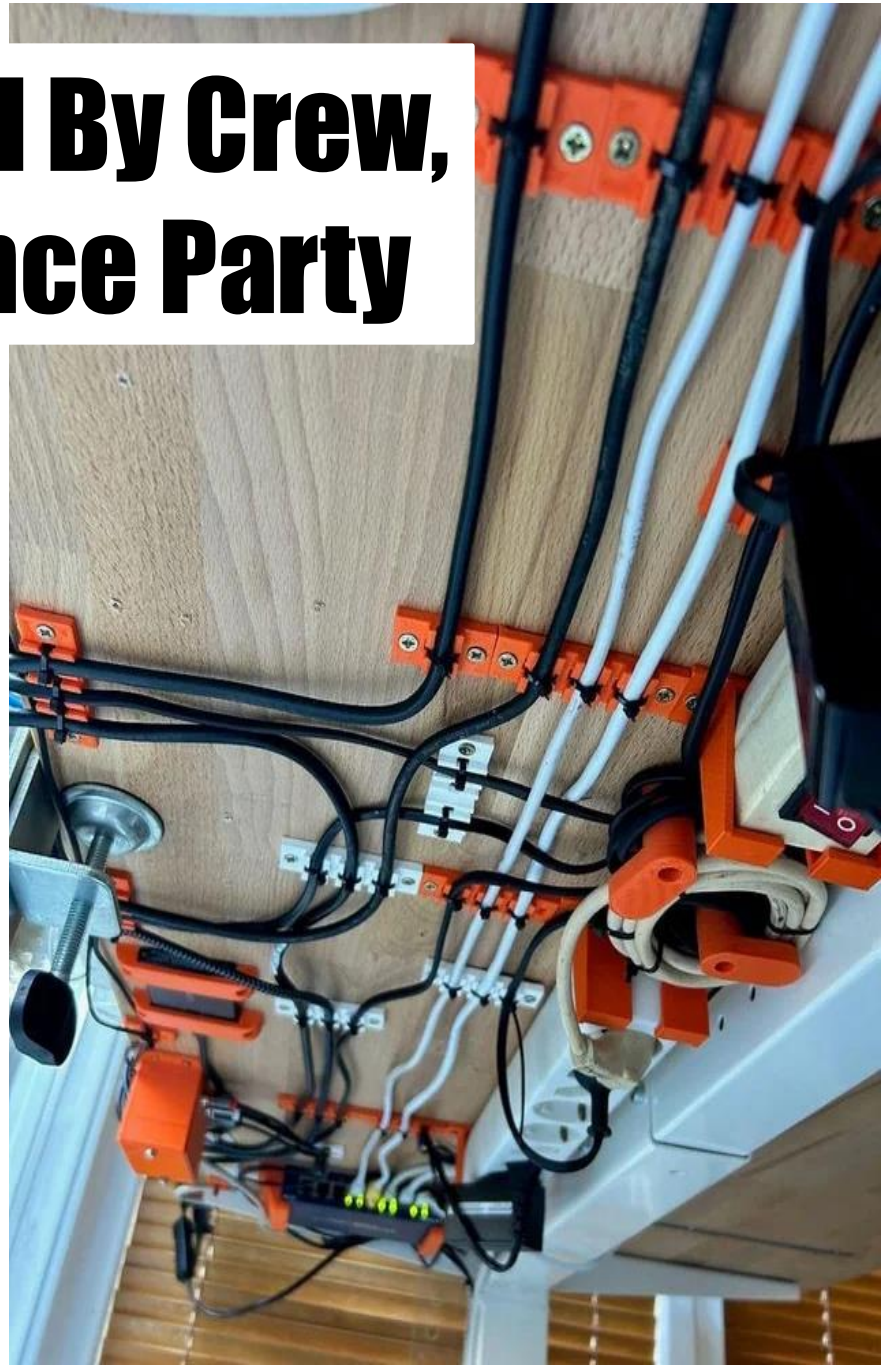
Can 3D Printing Be Done at Sea?

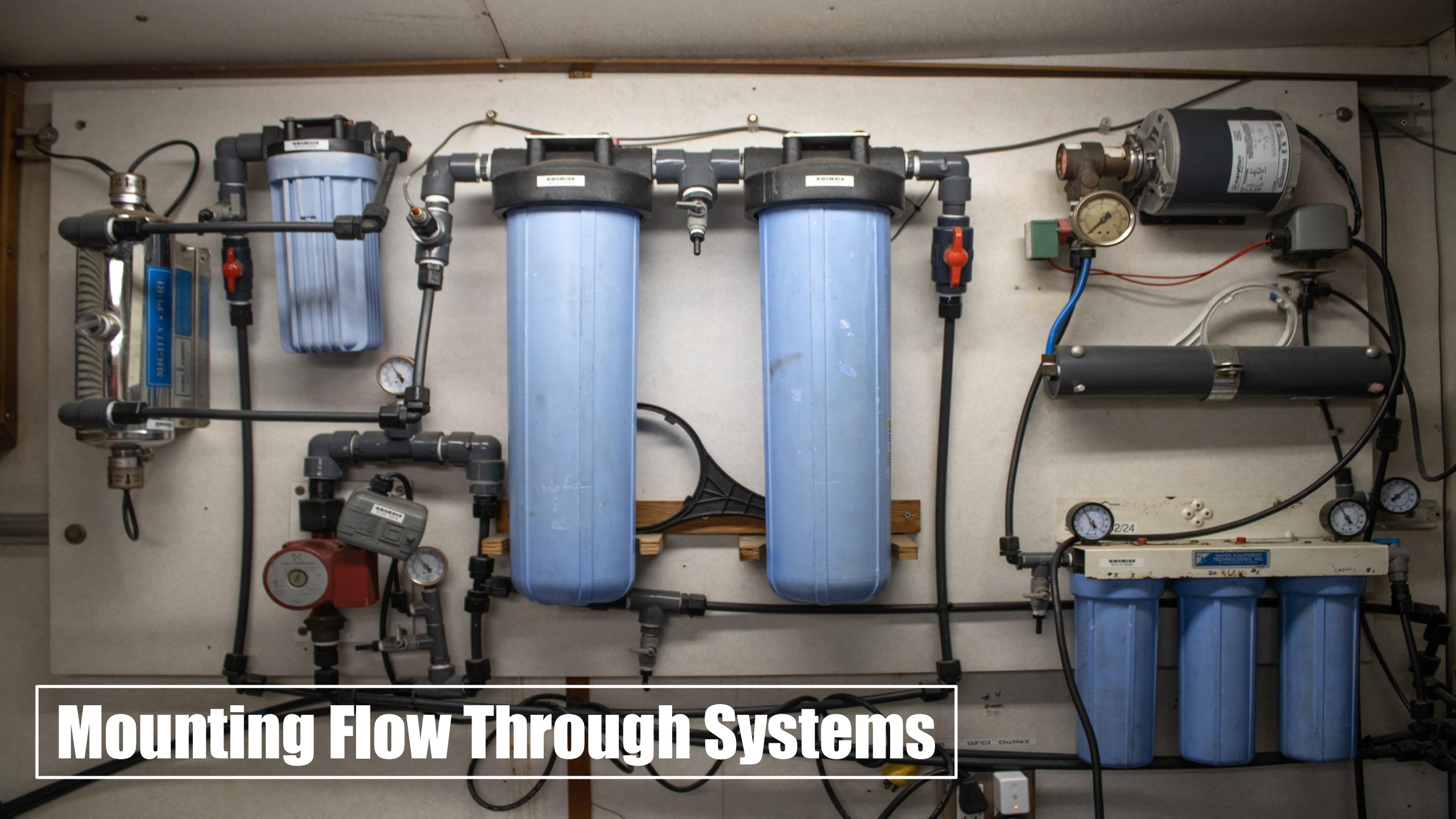
3D Printing Can Be Done at Sea

FDM printing is possible at sea because the nozzle arm and build plate remain parallel, moving together with the rocking movement of the ship

3D Printers Can Be Used By Crew, Technicians, and Science Party






Mounting Flow Through Systems

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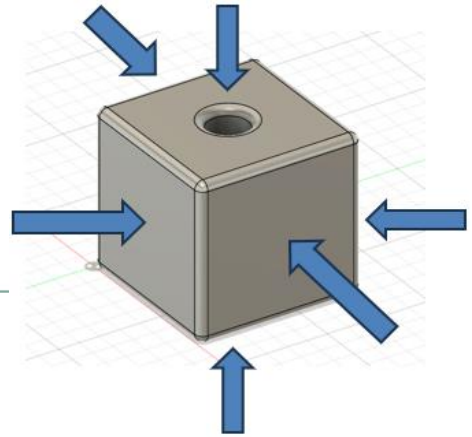
Can Inexpensive 3D Prints Be Used on CTD Casts? My Research

Hypothesis: FDM 3D Prints Will Retain Structural Integrity with CTD Cast Submergence

As hydrostatic pressure increases with depth, water will infiltrate the porous cavities of the 3D print, preventing deformation and preserving the structural integrity of the print



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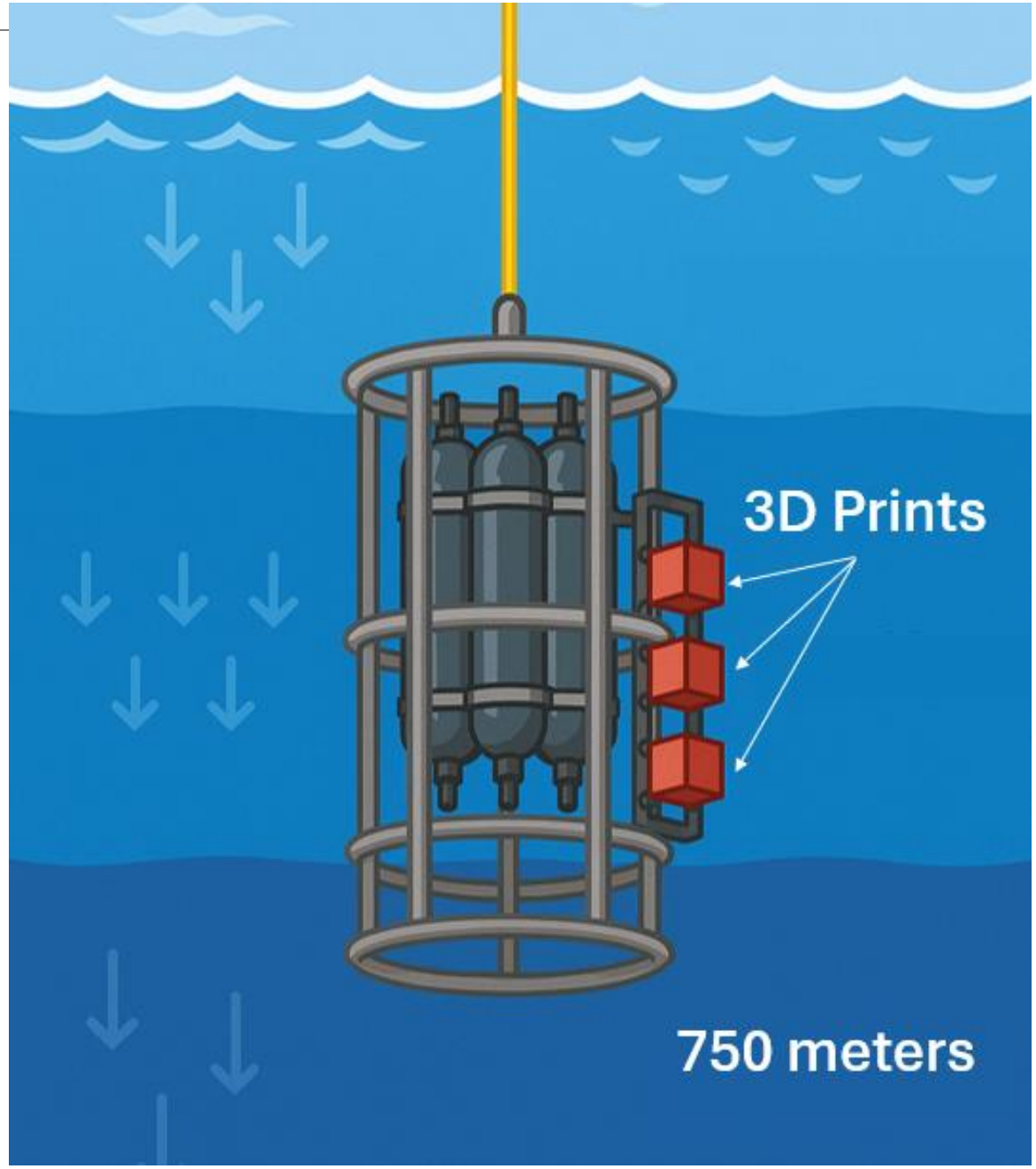


General Plan

Phase I: Can 3D printed cubes withstand submergence on a CTD cast?

Submerge two sets of 3D printed cubes at varying infill densities and lengths of exposure

Phase II: Will different printing material affect these results? Are the results from the previous experiment consistent?

Submerge three sets of 3D printed cubes at varying infill densities and lengths of exposure

Phase III: Will 3D printed cubes be as structurally sound after submergence? (testing expected December 2025)

Print identical sets of 3D prints and test all sets, both submerged and unsubmerged, under a hydraulic press

Research Methods (Time to 3D Print!)

I first designed my test instrument, a cube, on Autodesk Fusion 360 software, sliced in Ultimaker Cura software, and printed on a Creality Ender Plus model 3D printer

Price List:

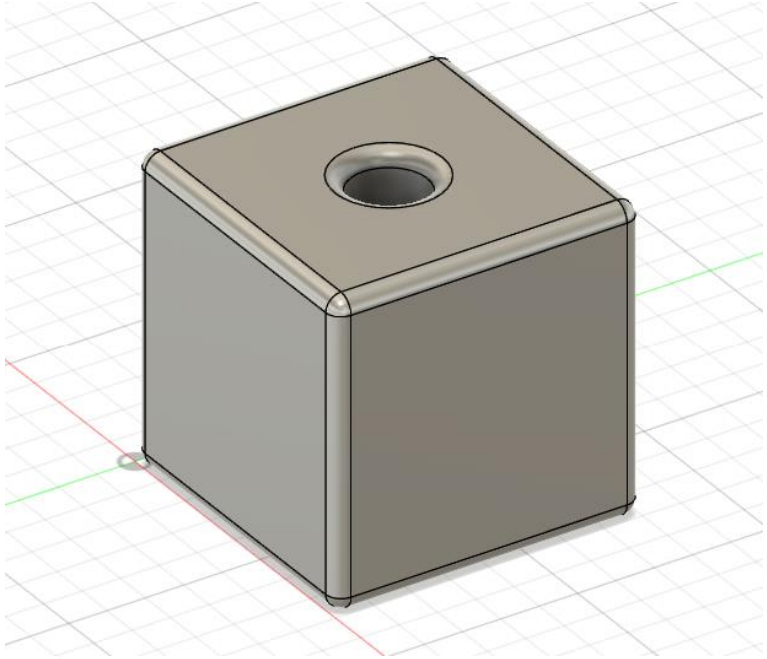
Autodesk Fusion Software: $86 monthly

Ultimaker cura software: Free

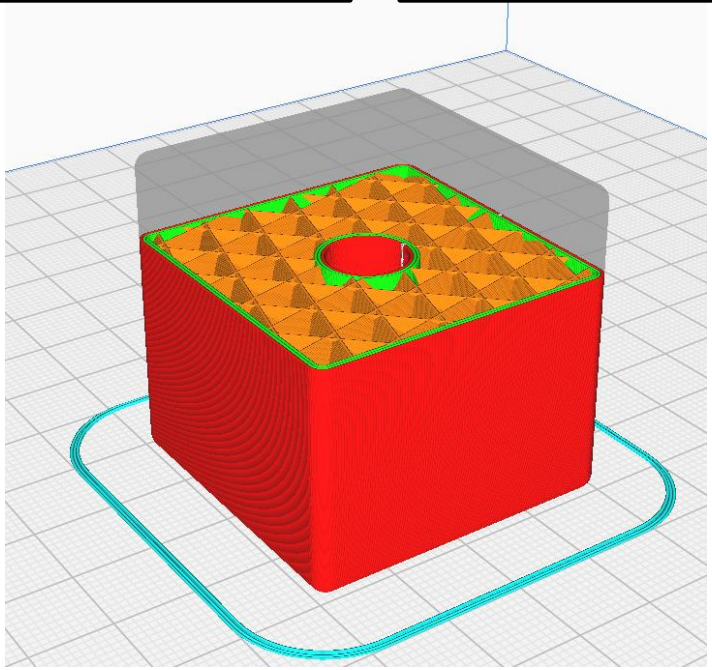
Cost of Printer: $289.00

Cost of Printed Cube: $0.70 to $1.84

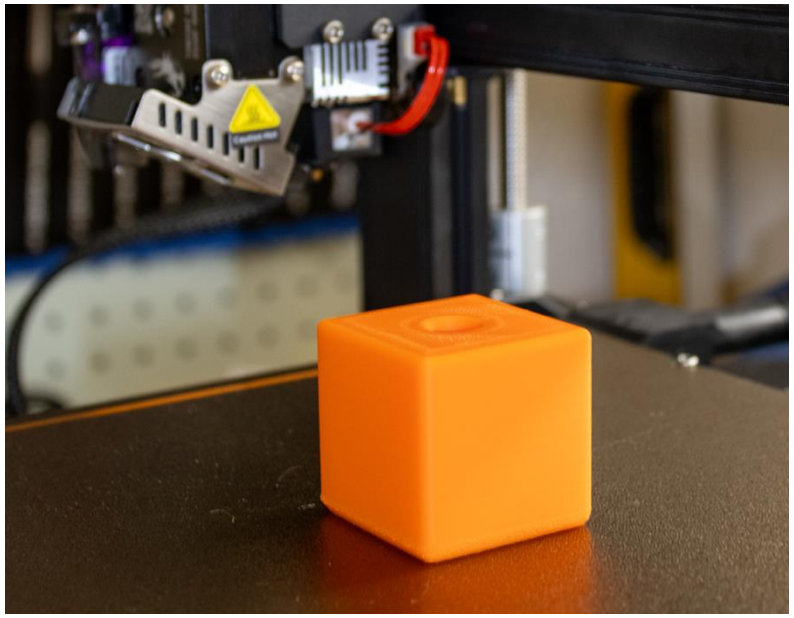
Cost of PLA and PETG is very similar



4 cm x 4 cm x 4 cm

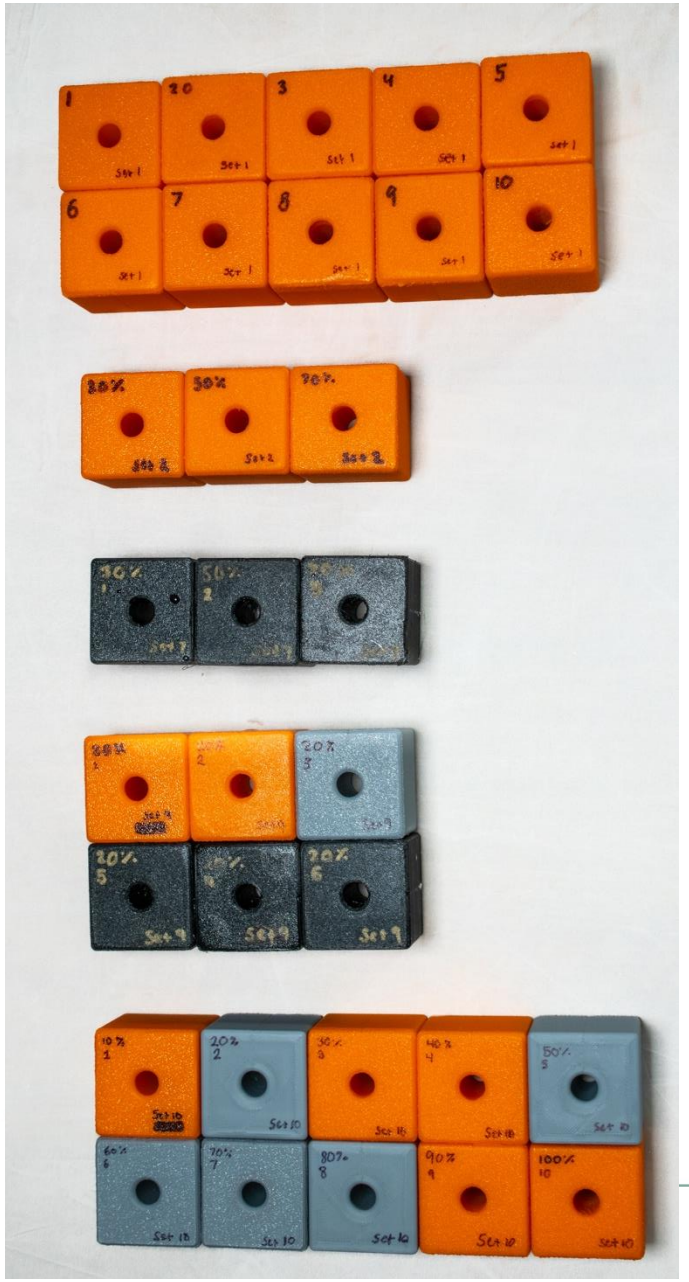


Cubic infill pattern



Printed Cube

5 Sets of 3D Cubes Printed



Set One: 10 PLA cubes, infill densities at increments of 10% ranging from 10% infill to 100% infill
Exposure: 1 single CTD cast to 750 m

Set Two: 3 PLA cubes at densities of 30%, 50%, and 70%
Exposure: 8 CTD casts, deepest cast to 750 m

Set Three: 3 PETG cubes, infill densities at 30%, 50%, and 70%
Exposure: 8 CTD casts, deepest cast to 750 m

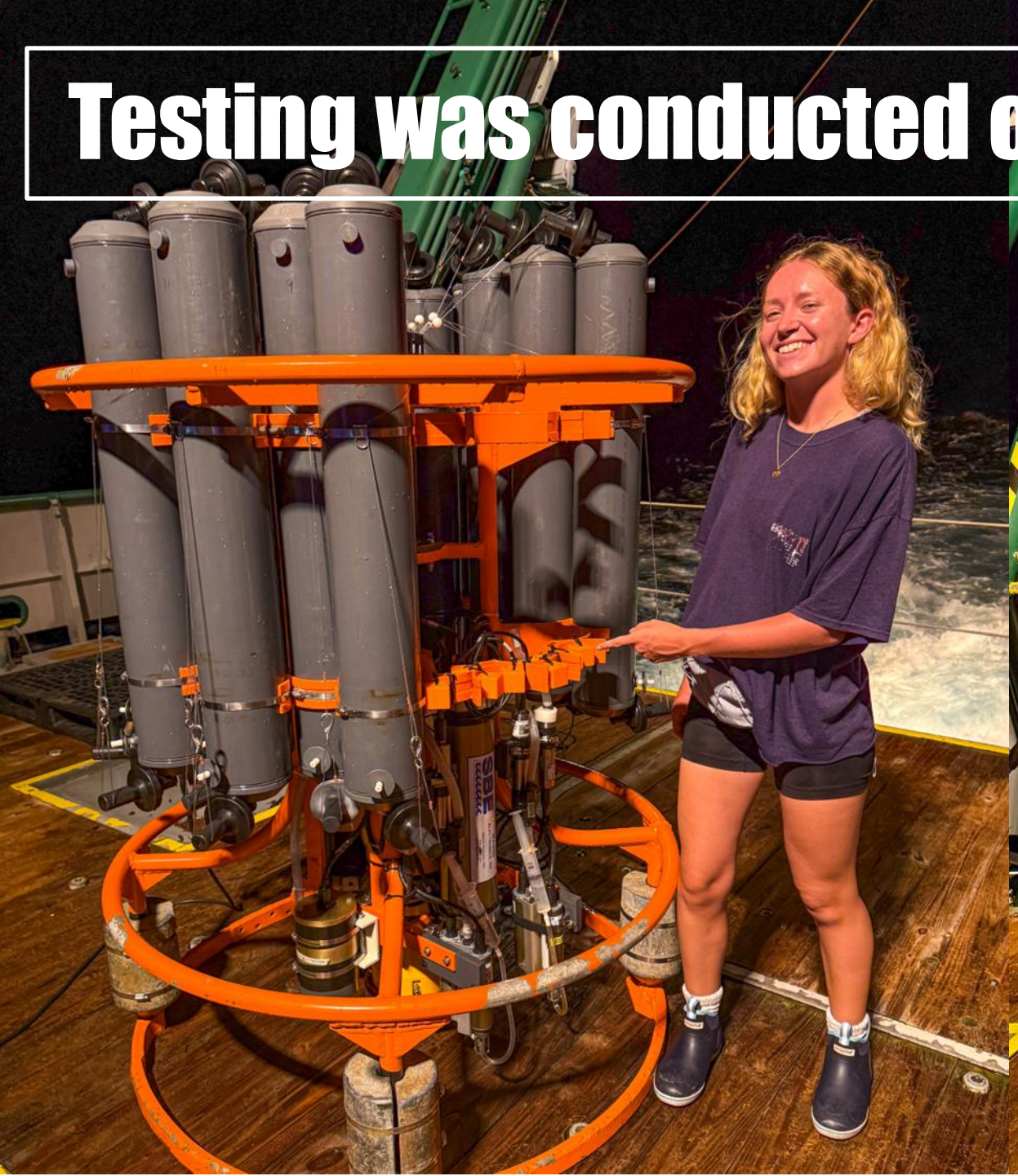
Set Four: 3 PLA cubes and 3 PETG cubes, all at 20% infill density
Exposure: 1 single CTD cast to 750 m

Set Five: 10 PLA cubes, infill densities at increments of 10% ranging from 10% infill to 100% infill
Exposure: 1 single CTD cast to 750 m

Research Methods

Test cubes attached via zip tie to the CTD cage

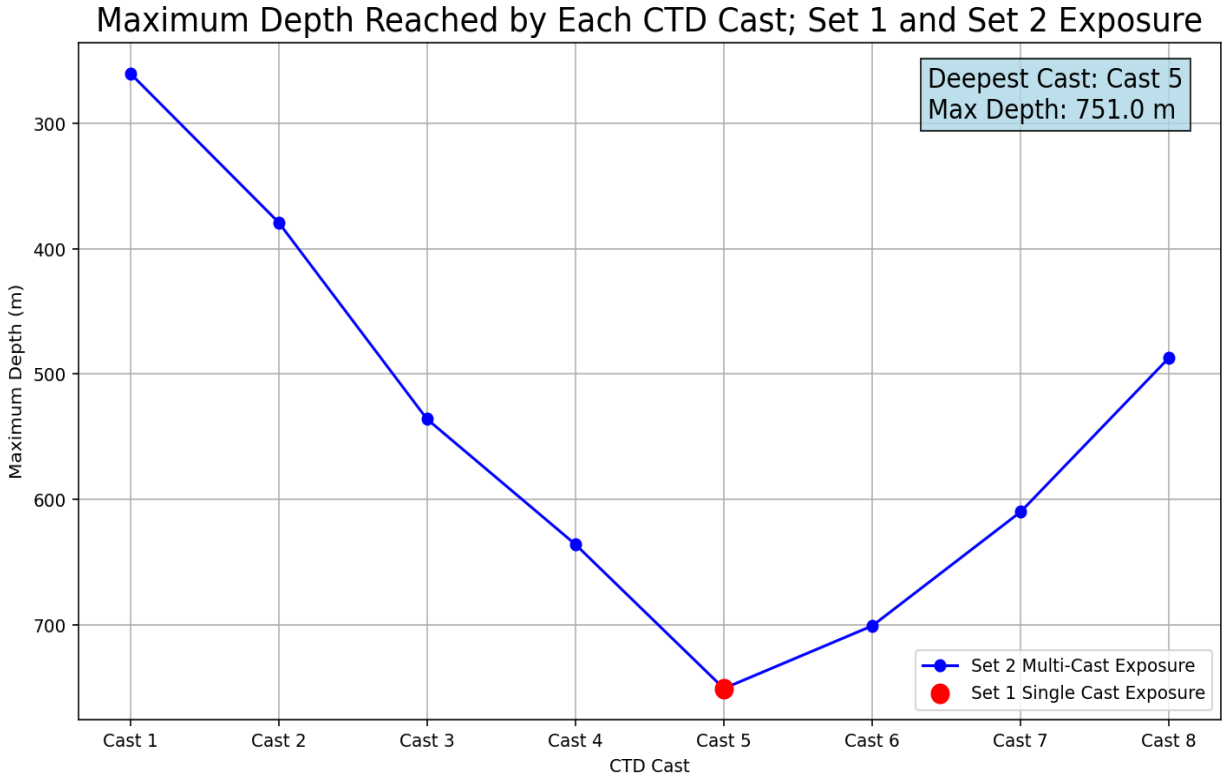
Testing was conducted over two research cruises



Onboard R/V F.G. Walton Smith

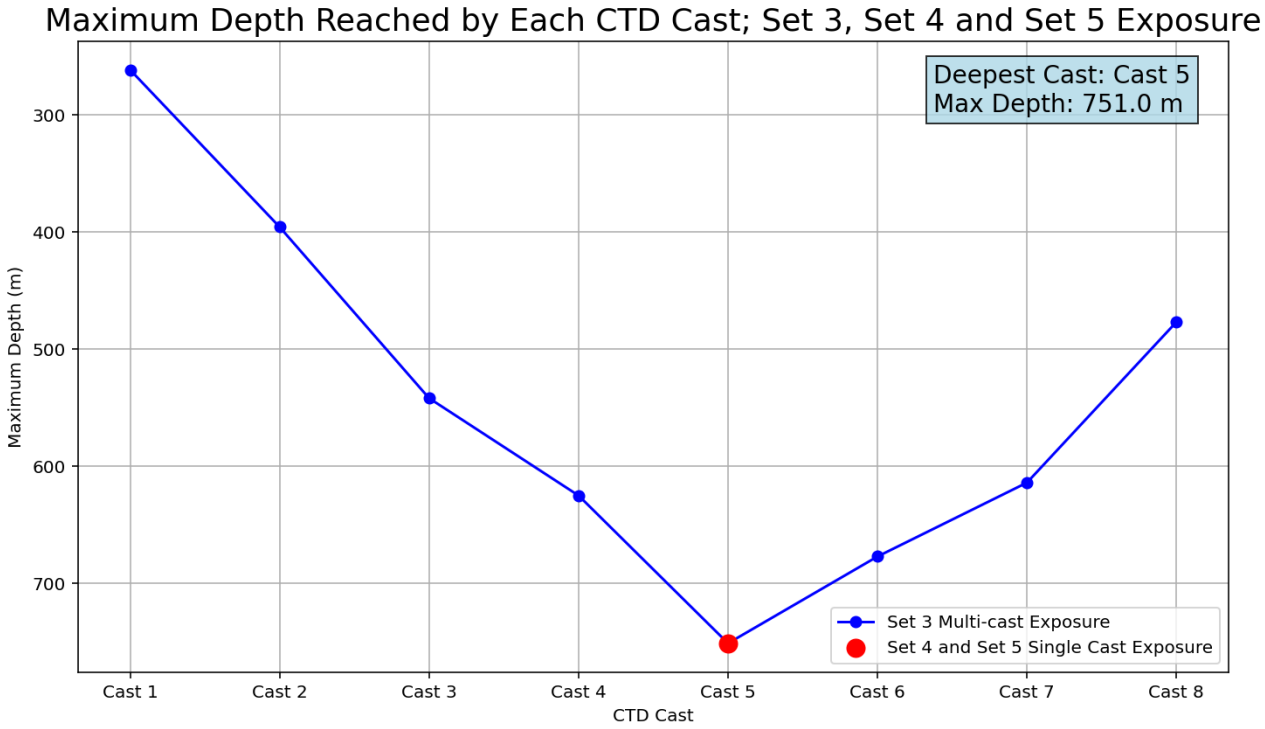
Recorded Exposure

Phase I: *Can 3D printed cubes withstand submergence on a CTD cast?*



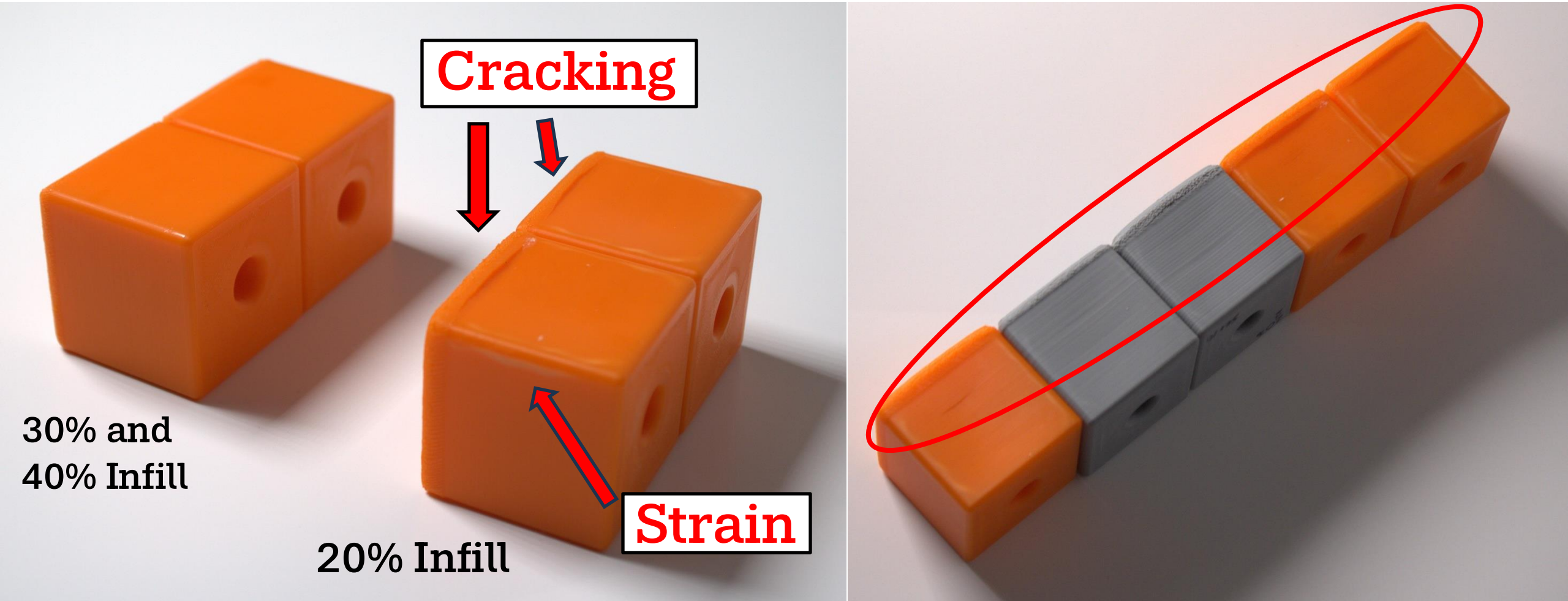
Set 1 and **Set 2**

Phase II: *Will different printing material affect these results? Are the results from the previous experiment consistent?*



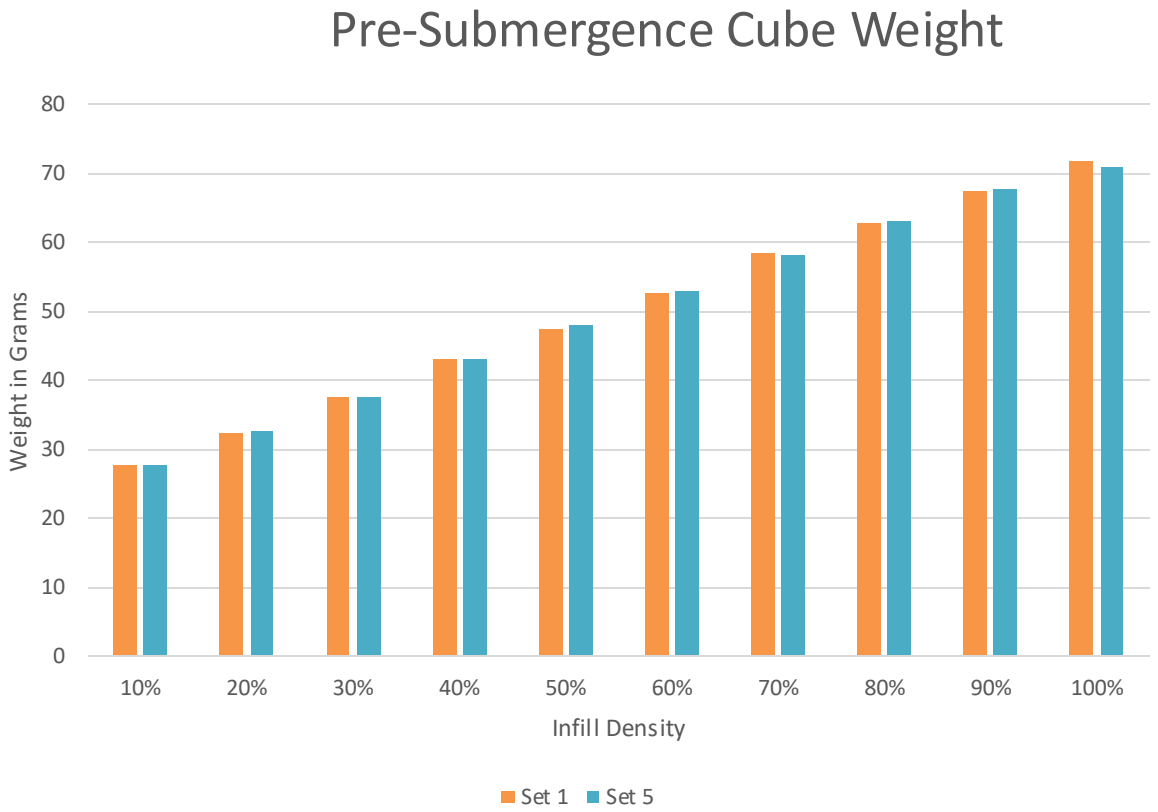
Set 3, **Set 4**, and **Set 5**

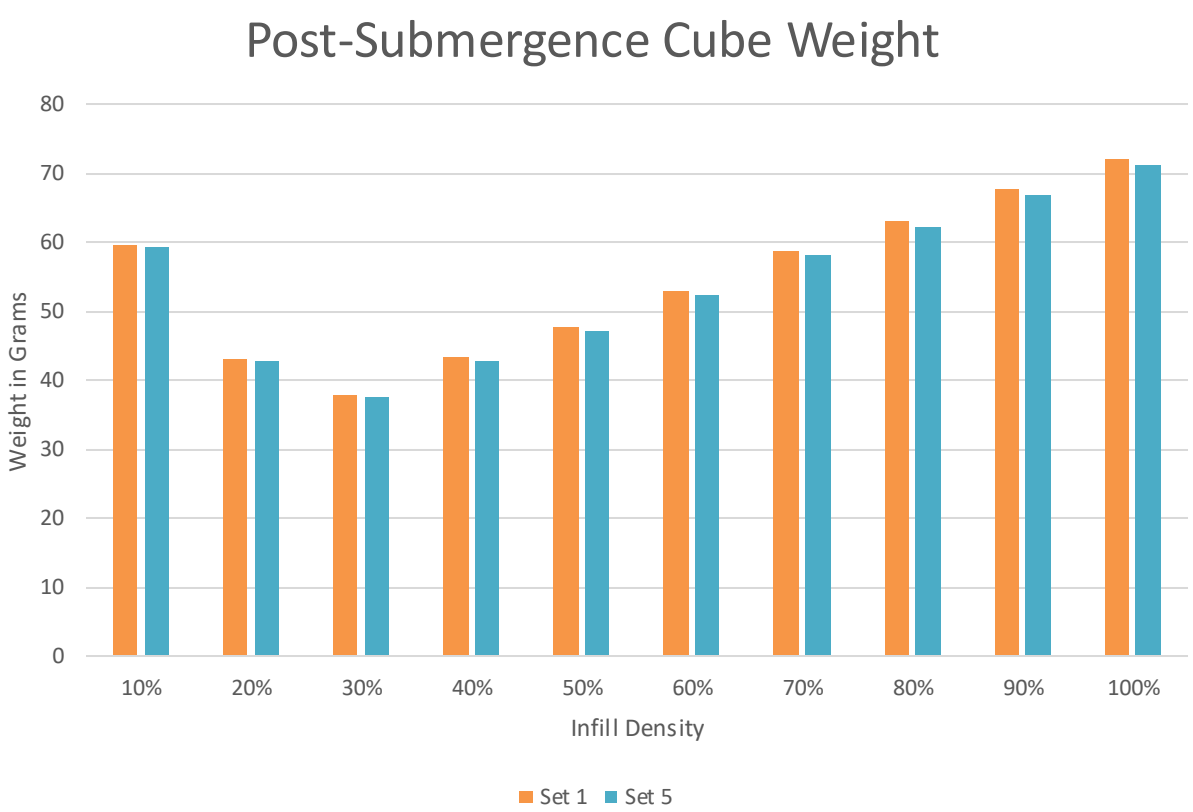
Findings: Consistent Cracking and Strain of 20% Cubic Infill Densities with PLA material



Findings: Cubes With Infills Higher than 20% and PETG Material of Any Infill Density Did Not Deform

Findings: Consistent Changes in Post Submergence Weight





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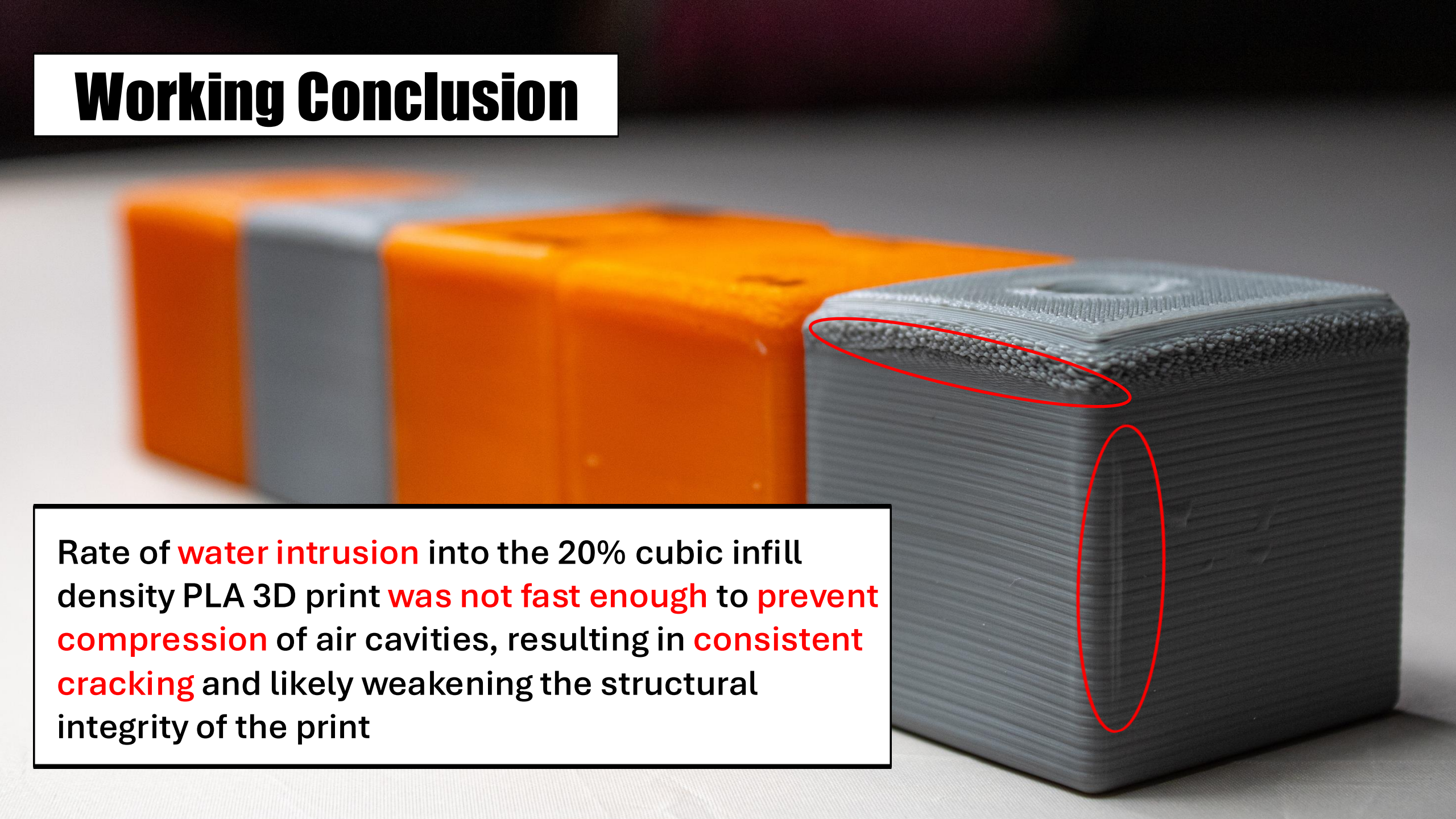
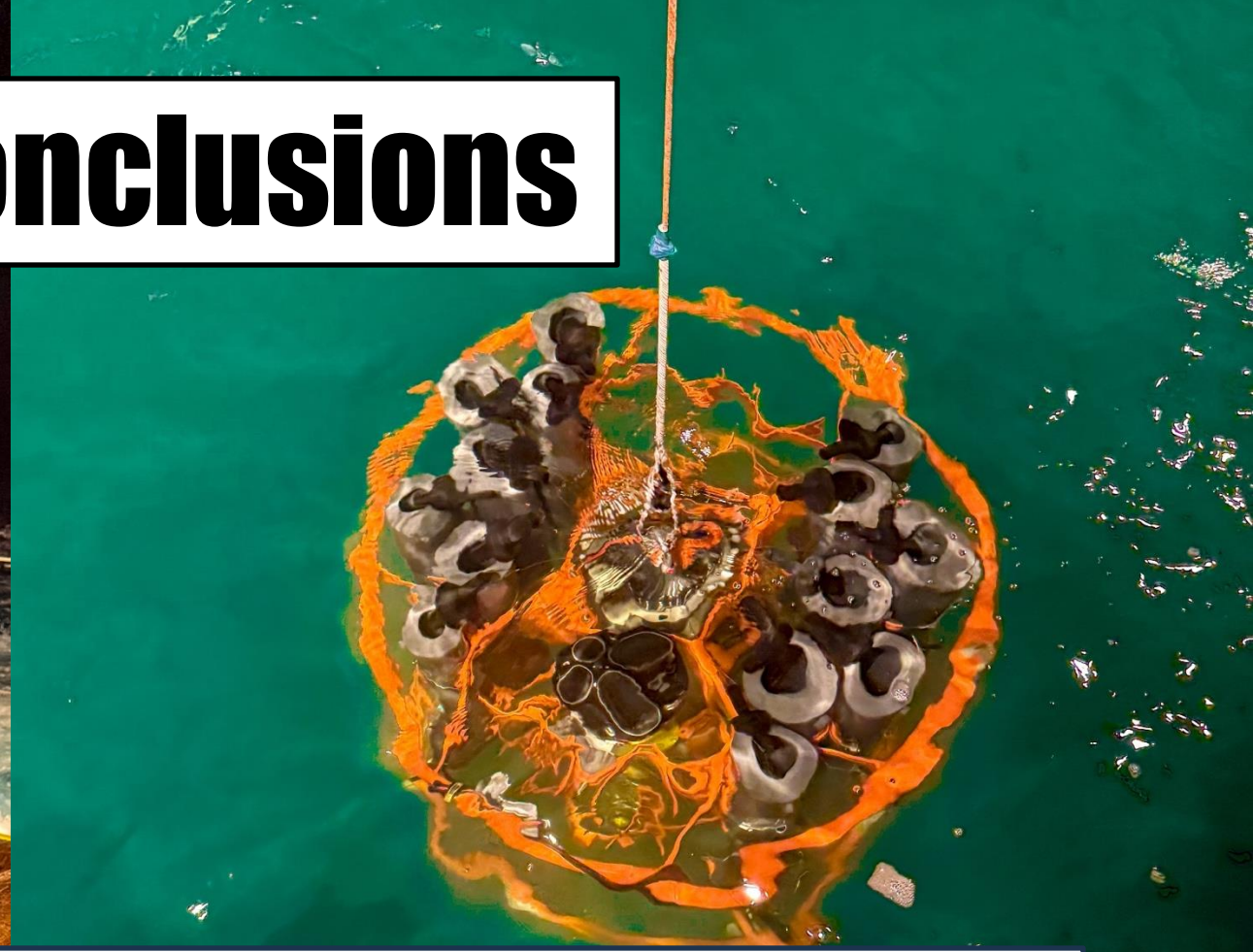
Set 1 and Set 10: Identical sets of PLA prints, tested under the same conditions

Working Conclusion



Rate of water intrusion into the 20% cubic infill density PLA 3D print was not fast enough to prevent compression of air cavities, resulting in consistent cracking and likely weakening the structural integrity of the print

Working Conclusions



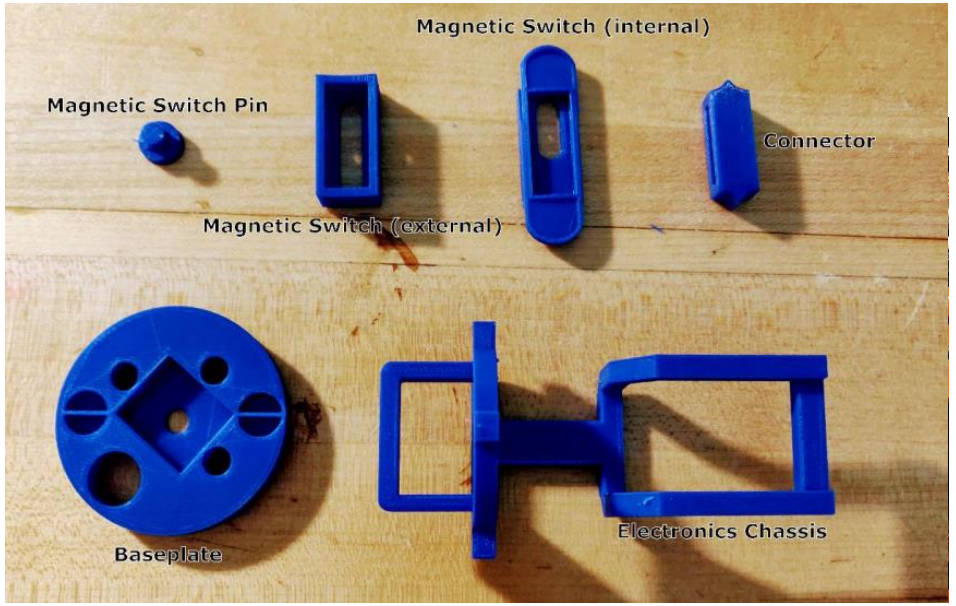
Inexpensive 3D printers and inexpensive filaments can be utilized by the research fleet with many applications, including CTD data collection

Recommendations for Incorporating 3D Prints on CTD casts

Use infill densities of 30% or higher

Favor PETG filament over PLA

Note of caution: Protect PLA parts from heat and UV



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Hamilton, L. H. (2023). Cost Effective Soft Material Conductivity, Temperature, and Depth (CTD) Sensors.

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Demo!

Questions?