**Q: What does PRINT stand for?**

A: **P**rinting **R**eparatively with **IN**-situ **T**echnology

**Q: Why no 20% and 100% infill in analysis?**

A: 100% we could not vary the infill pattern. 20% was very clearly much weaker than the others after just a few tests

**Q: If there’s currently no research on in-situ 3D printed repairs, how is damage to airplane wings, rover wheels, etc, dealt with currently? Why are 3D printed repairs better? -- great thought**

A: Damage to a relatively small area can impact a much larger component. Rather than manufacturing an entire replacement, a small amount of material could repair it in much shorter time.

**Q: How did you decide the exact size/shape of damage? What are the actual dimensions of the damage area?**

A: Damage was selected for repeatability in a proof of concept. Add more

**Q: How did you decide on printer conditions?**

A: The nozzle and printer bed temperatures were chosen based on research and some initial experimentation. They’re pretty standard conditions for the Ender 3 Pro. Bed temp is typically 60-70 degrees and we went with the high end (70) to prevent warping

**Q: Why not print the whole piece and actually break off part to simulate damage?**

A: Part of future work - would require scanner and complex toolpathing. Also for repeatability of testing. We wanted to keep the damage consistent for each test in order to determine which repair is the most efficient.

**Q: What was your sampling rate for data collection?**

A: Sampling was done at roughly 0.2ms/sample or 5kHz (as fast the arduino could send it over serial)

**Q: Why do you think repair compression pieces were stronger than undamaged?**

A: Conformal layer helps w rigidity, infill patterns

**Q: Why did you choose to look at ABS too?**

A: To corroborate results between different materials - PLA and ABS are very commonly used. ABS is much more brittle, so we expected it to perform worse than PLA. Wanted to cross check results between more than one material

**Q: Why do you need conformal printing vs just going layer by layer like normal? Why not just fill in with putty?**

A: Less precision and the material that would be used to fill in (putty) would not have the same structural integrity. Putty is essentially 100% infill, and we found 100% not as strong as 60% for PLA.

**Q: Why didn’t we do the whole repair conformally?**

A: limitations to slicer. Couldn’t consistently print at different infill patterns using all conformal printing

**Q: This is a proof of concept with PLA and ABS, but is this applicable to metals and other materials considering the difference in chemical makeup.**

A: The process in which we test the strength of materials is applicable, although the results should not be directly translated over. For FFF printing (fused filament fabrication), these results could carry over, but should not be assumed. Further research should be conducted. This is actually something we wanted to test with Carbon Fiber PLA, however due we did not have the time to get around to this material. Jet Nylon

SLM printing can acheive near full-density during its prints, so infill percentage and pattern would not really be the focus for those applications. The concept of in-situ repairs would still apply and be useful, although the focus for SLM printing would be more of the scanning aspect, combined with print time efficiency.

**Q: Why can compression take so much more load than tension?**

A: adhesion is not going to be the point of failure for compression. For tension testing, the adhesion was found to be the weak point.

**Q: Why did you choose to use ASTM-D790 standards?**

A: These standards aligned most closely with our testing plans and procedures due to our choice of material and to use 3 point bending

**Q: Why is 60% stronger than 80%?**

A: 60% has more space to expand. 60%, lines of infill are not touching. When lines are touching (80%) you have high stress concentrations

### **After Presentation NOTES:**

***Dr. Lloyd:***

Graphs:

* Figure 21
* Take out significant figures (9.23 is too much, lessen to either 9.2 or 9)
* Add in the materials used for the

Content:

* Look at cyclic loading
* There are possible ways to look at points of failure before actually reaching it just by looking at the ways the materials looks after printing.
* 60 degree C is not extreme environment
* Brittle materials almost always fail at tension
* Nylon is better, if we take it to outer space then the materials we use are not exactly applicable since they are degradable in those extreme environments

Dr. Fuge

* Very reasonable
* Asked how might be directly extended

***Dr. Becnel:***

* Did well given the circumstances
* Milk the Covid reason as far and as much as you can

Results:

* Why did a certain print pattern give unexpected results?
  + Added rigidity by adding more directions to the layers
  + The fibers are aligned directly with the stress tension
* No citations on repairing damage
  + Think about adjacent areas when doing research
    - Carbon fiber composite repair work
      * Could have help a lot of our analysis
* Surface preparation
  + Since they’re thermo plastics, heating up and preparing the surface could have increased the bond strength
    - Want chain entanglement
    - More melt interaction