# Additively Manufactured Fasteners

*Amber Dressler[1,2], William Scharnberg[1], Anthony Abousleiman[1], Samantha Harris[1], Phil New [2]*

*[1] The University of Texas at Austin, [2] Sandia National Laboratories*

## BACKGROUND

- Additive manufacturing (AM) enables production of complex, high resolution, custom parts from robust materials without the restrictions of conventional/ traditional manufacturing methods.
- The project sponsor, Sandia, already benefits from this rapid, inexpensive prototyping in their broad array of research projects.
- Selective laser sintering (SLS) machines are available at UT-Austin for prototyping .
- AM removes existing design constraints, allowing for innovation in fastener designs.
- AM design freedom allows focus to shift from how a part will be made to how a part needs to function.
- However, variability in part properties limits functional capabilities and usage confidence.
- **Primary project aim: develop fasteners that could be integrated into AM parts to alleviate the need for traditional fasteners.**
- **Secondary aim: explore build-to-build variability in SLS.**

## CONCEPT GENERATION

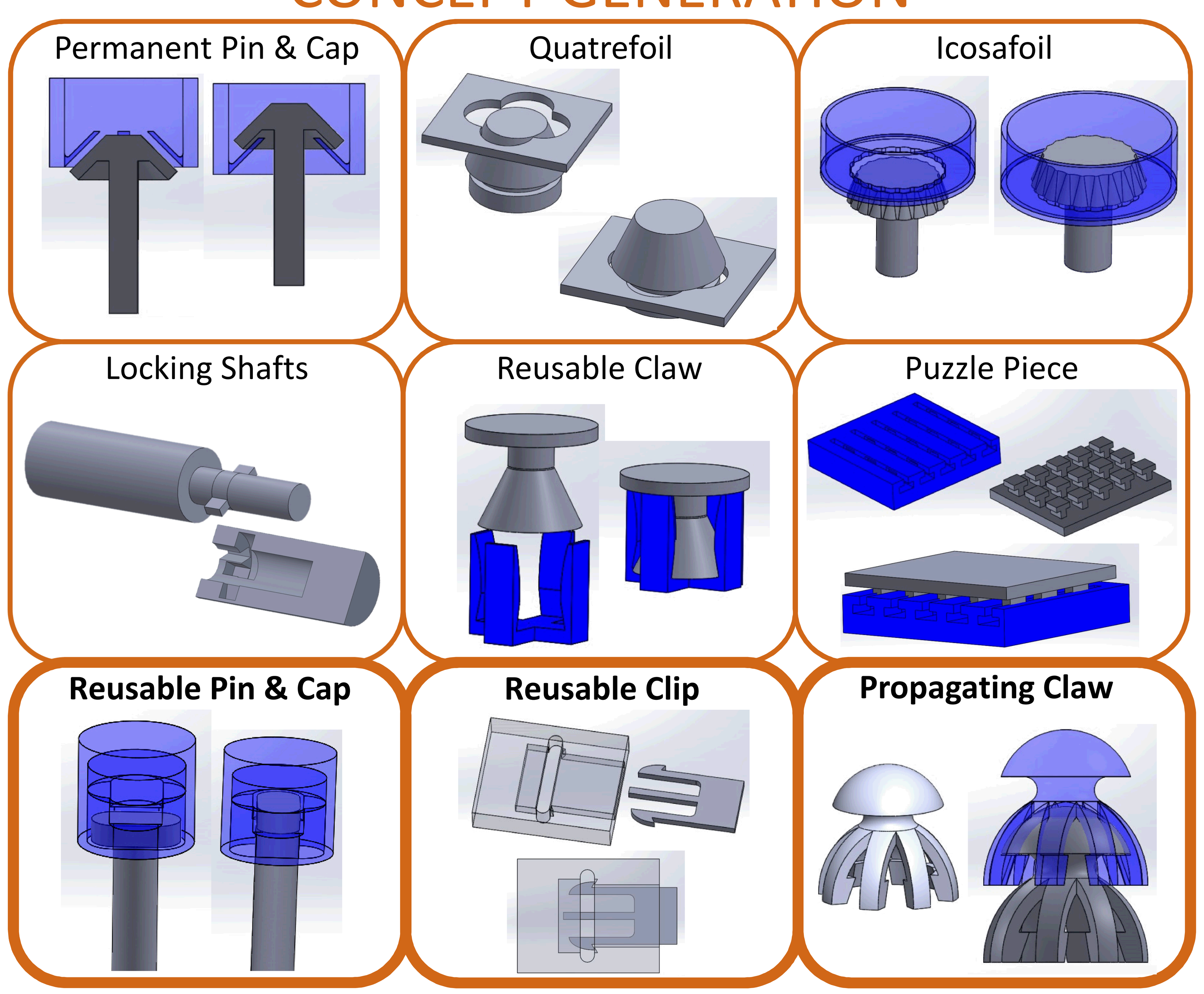



*Figure 1: Various fastener designs created during concept generation (concepts chosen for variability testing in bold).*

## METHODOLOGY

- Nine concepts (Figure 1) were prototyped using SLS in nylon 12 at UT Austin (Figure 2).
- Three designs did not function as designed, another two were too weak.

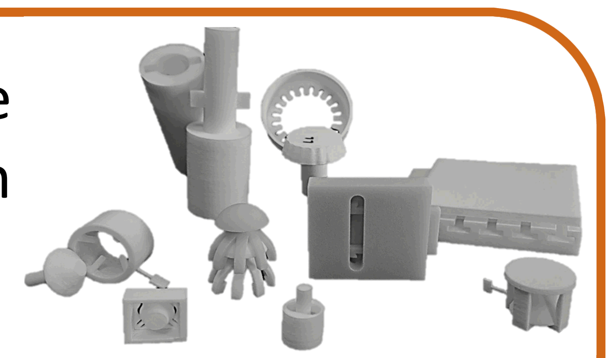


*Figure 2: Prototype fasteners.*

- From the remaining four designs, the **reusable pin and cap**, **reusable clip**, and **propagating claw** were chosen for strength and variability testing.
- Stress analyses modeled in SolidWorks to ensure the sections did not create stress concentrations (Figure 3).

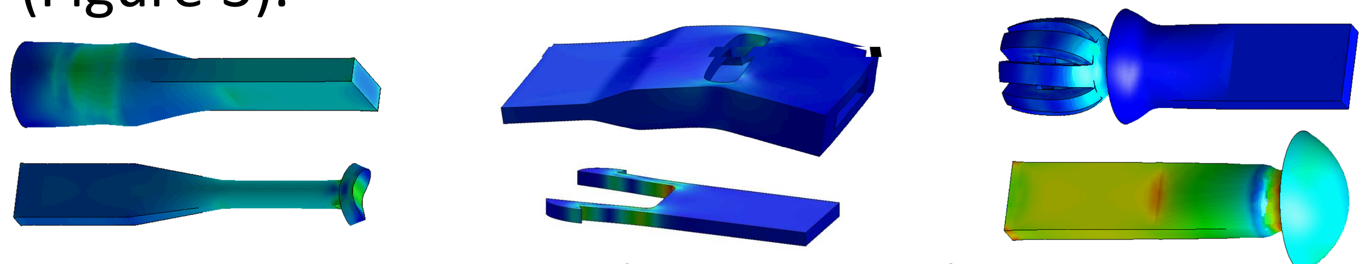


*Figure 3: Sample FEA stress analyses.*

- Variability testing separated into two categories: location-to-location and day-to-day.
- All prototypes built on a single machine at Stratasys Direct Manufacturing using glass-filled nylon 12
  - Location variation: each fastener was built in nine locations on the build platform (Figure 4).
  - Day variation: location variation test repeated over three days.

## BUILD-TO-BUILD TESTING RESULTS

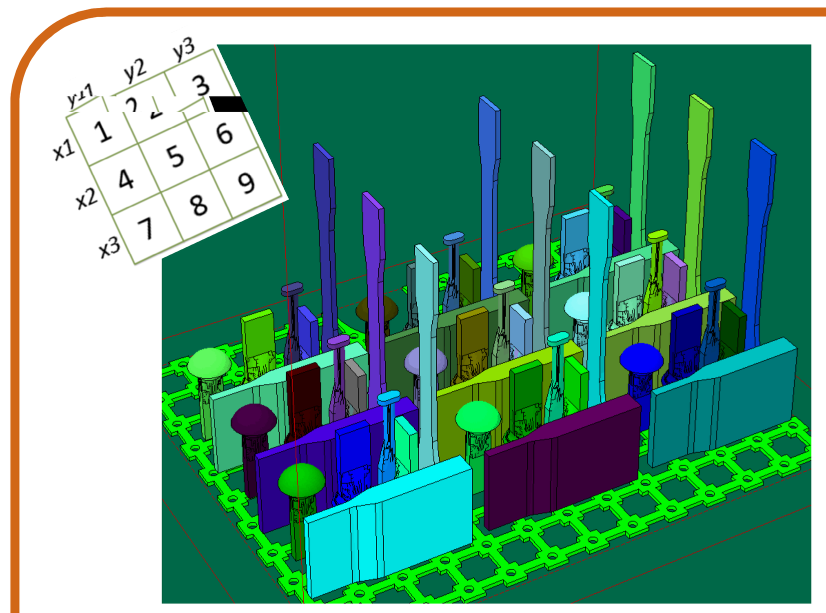
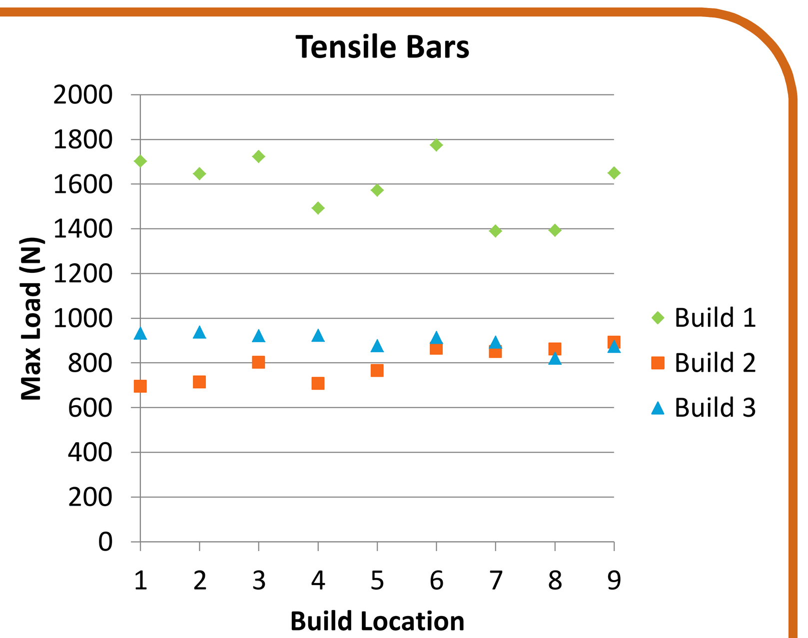
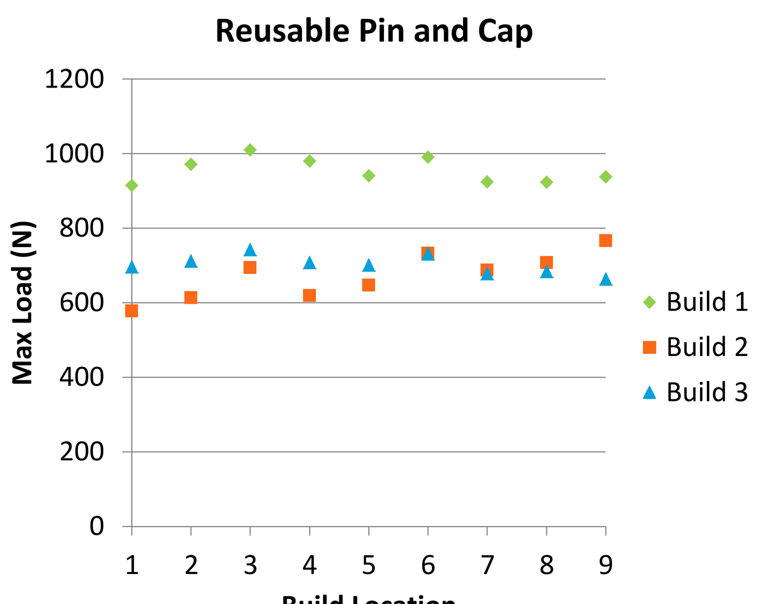
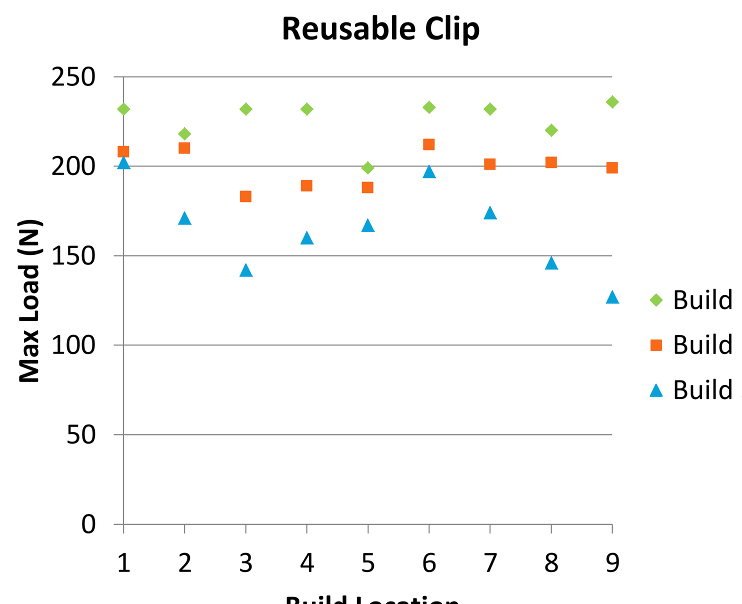


*Figure 4: Sample build layout.*




## CONCLUSIONS

- Highest maximum load average (776 N) - Reusable pin and cap.
- The strength of the reusable clip could be improved with a redesign to have larger contact area between its abutment surfaces.
- Due to tolerance issues, the propagating claw fasteners from builds 2 and 3 did not fasten properly so they could not be tested.
- Variations in part strength from location-to-location and day-to-day exist.
- A potential cause of variation in test results was that the SLS machine underwent maintenance due to a failed build between builds 1 and 2.

## FUTURE WORK

- Iterate on fastener designs and prototyped to improve strength and functionality.
- Explore feasibility and advantages of additional materials to increase the impact of these fasteners on AM design.

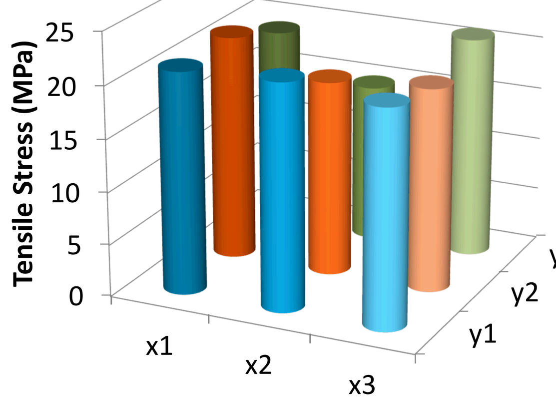



*Figure 5: AM property map.*

- Increase sample size of prototypes to better understand build variability and develop more complete property map based on part bed build location (Figure 5).
- 3-D variation data is needed to take advantage of the entire build volume for part production.

## ACKNOWLEDGEMENTS

We wish to acknowledge Sandia National Laboratories for sponsoring this research, with many thanks extended to their technical staff who offered assistance and guidance; in particular, Earl Conway, Phil New, Tommy Woodall, and Lindsay Klennert. Special thanks are given to Dr. Carolyn Seepersad, for her expert insight, mentorship, and generosity of time. SLS prototyping at UT Austin was facilitated by Mark Phillips. Lastly, we would like to thank Brad Pagano of Stratasys Direct Manufacturing, who worked closely with us to ensure our builds were completed to the required specifications.