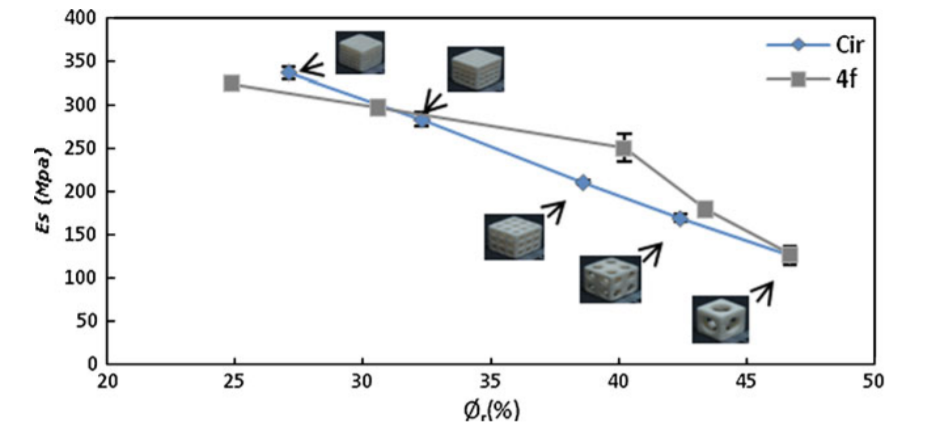
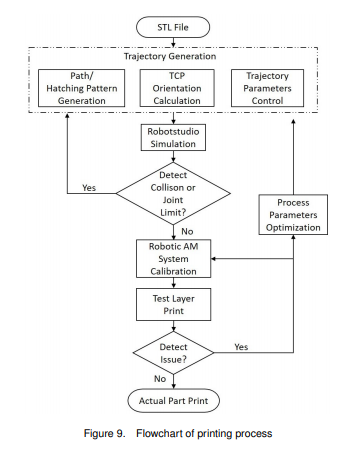
Composite Conformal Printing Literature Review

# Overview

# Literature Review

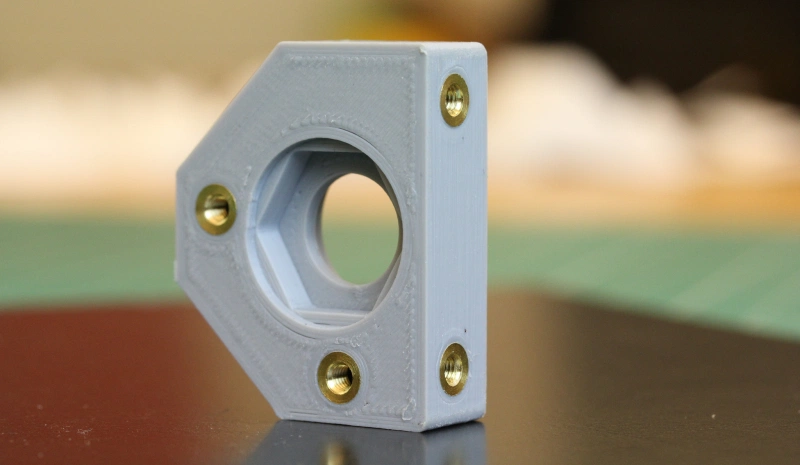
## Current Work

* Integrating real-time multi-resolution scanning and machine learning for Conformal Robotic 3D Printing in Architecture
  + They’re using two robots, one that 3D scans and one that 3D prints
  + Uses PETG pellets
  + Scanning produced a point cloud → Neural network prediction for stresses and deformation → branching pattern reinforcement pattern from network prediction
* Additive manufacturing methods for repairs
  + Direct energy deposition
    - Often mentioned as an effective potential way to repair damaged metal parts
    - Process involves using a high power laser to heat up a melt pool on the surface of damaged area. Powdered metal is sprayed onto surface which is melted and resolidifies layer by layer
    - Internal cracks can be repaired by first digging out a void to the depth of the crack and filling void back in
    - Failure stresses of repaired areas lower than yield stress of bulk material
    - Rapid thermal contracting often causes small defects that impact overall strength
    - Quality of print can be unpredictable largely due to thermal stresses
  + Cold spray
    - Doesn’t use a heat source, so a lot of the problems associated with DED are gone
    - Metal powder is sprayed at high enough velocity that particles fuse with the surface metal
    - Cold spray deposits have very common defects due to poor particle bonding
    - Mechanical properties often poor but can be improved by increasing velocity or heat treatment after deposition
    - Most deposits require machining and/or milling before (if surface is not smooth) and after
    - Print angle needs to be 90 degrees or else significant decrease in quality
    - Materials with high hardness or strength more difficult to use
  + Have not found any examples of FDM used for repairs
* Honeycomb structures
  + Provides optimal strength to weight ratio
    - May be hard to replicate, would have to use in lit review and probably go with trusses
  + Uses minimal material while providing strength in tension
* Truss structures
  + Probably easier to print for basic tests
* Tissue-engineered bone repair scaffolds
  + Researchers investigated the structural integrity of small 3D printed cubes by varying the size of frequency of circular holes in the cube. Relates to our project because we’re looking at being able to repair a structure using the least amount of material while maintaining structural integrity
* 
* Rohith’s stuff ([pdf](https://watermark-silverchair-com.proxy-um.researchport.umd.edu/v01at02a026-detc2018-85975.pdf?token=AQECAHi208BE49Ooan9kkhW_Ercy7Dm3ZL_9Cf3qfKAc485ysgAABDIwggQuBgkqhkiG9w0BBwagggQfMIIEGwIBADCCBBQGCSqGSIb3DQEHATAeBglghkgBZQMEAS4wEQQMOd9_cc7nRYMJkHbsAgEQgIID5SoGIL3faEfoloh3rdRFHAdmOb_b1embInDgNzlUN9vs11e_bXIboodxKM8jrJ93shPnzhHjeZFBOYC5ahNmTMMb2xTnsz7h7XdpY_7Ve3ZWmmVDnkQH2jOEfs7pTwYgu6f5p1vuabQ6zVaDPk11MITahJ7e1B5UitaAv5jC9xj998EXs6FZVCKAbtEXGQg44qMsxhmQ8Xg_kWana2IukGtTrCClGMnIYDlaW8MiqdeHvhxRsXr8fCvmtXXnTekVbXmL0PxjrOTDqeZWkScO6unyFZ6unhKW3Yx1zCQwYgkMmJ6osUyklvn0yW0ru4mzYeqEL4TNwqiC78-5QxDJEfApQDzX4iaffEIFAlvFAP16aCucljVEtXsCBuZ3_iUkGO-_E0-e6TcOZljfHl12G2tDHaxNBf-zfRuG9NN4ciRF3sNu5V7sb-AXH9P6qh102nKUX1Ln5ONKdh21qvzkjYtgU3Y19-XtY87bKM7cqIKPFwXvihzi7bmQPehqphME84i0nFr8v1Ns_kLfORjY05wbbmywSbQDx9PI5CW_gjy8ldAaENLzhh1HZpAc1ePS68Y0sWVHOVJ9krR4LC3CkQvvRQpjSaaPMHYTZwAoq7a7Q_qwRarpgsAiYPAGPE58wV1VZFYpIAmd8zfw6Fm86I8tQSB21zf1Jc_wpR3YlZc9HaB01ezaFmLYaxY7hY4H6DZRFNwdZN3LOgSzw-ynVMwSGuhgURGBgRIqXOroqTRplt0C_5hACVQCYQ9GKsVwy6yZ_MHaYOzY5LPMvzMPuTd-l-8AZ65TLWjszW3YWhjqKO9A41qWYNTPDnuiQ5xGsWULg7e5H3gKNJNihdXkJ3a9QL6yOGrbb4deu31UpugvV7fLK4nTD-W6Rr0pmWznaxpvo0ttl4GIoLw3PvupAT0Pu8Q-ki2rgZoeLQRMlsWfU_PPg-QNPQuRggo4s-_ZEJn8DeiDnIsV2z2UmiymrZE0BrG1AZm0okdEdzOSsQ0ZYWBlbVhebU6R-Ivh2VMFBxISGF5c4YJL3YdDFudXCFDCe2VzMHg5z_y6bFlJyiVRaA2JPo2X3MjNebwJn_CduYsQT5DTAGEpztslKfKqMJWmxBlawyqtPH1IBkG2rBldNAwYPJP8ejeOq4cY_Kn0lrhDBqvCnCBtz3atmMjBLNga8BSkBWSNxxS53v_ascp2PiLQTUgpTMXZ2WLE68ApQdes56OB1EhC__UsIAl31jhAVrCVcC6j3HFsgwnr1tY-YP7w8fQz9JHFOsV6WdW_prPYI5L8dWYUYASaL5DTtj1ZtQJLpPbvPryTI0jeArOCv1a3Igs)) - Nonplanar 3D printing
  + Researchers from the University of South Carolina used an extruder on a robotic arm for nonplanar 3D printing. Their solution for collisions between the nonplanar print and the printhead was to multiply the printing angle by an adjustment factor. Part of their research was testing multiple of these adjustment factors to see which resulted in the smoothest print. When printing on curves both convex and concave, the speed of the extrusion was both increased and decreased to keep uniform layer thickness. This ensured that layers would even and material would not build up.
  + 
  + Researchers from the University of Hamburg created an approach for toolpath generation and nonplanar slicing for 3D printing. This approach allows for the printhead of the printer to travel vertically while printing. The researchers used this approach to a smoother surface than traditional 3D printing. To solve the issue of the printhead colliding with higher printed layers, they created an algorithm that detects collisions. When collisions were detected, the printhead would rise above the layers and continue planar printing. To create a nonplanar toolpath, potential non planar regions are identified and then their top layers are moved upward to the highest possible printing point. The projection of these planar layers is then used to create the nonplanar toolpath on the top surface of the 3D printed structure.
  + <https://www.researchgate.net/publication/335542750_3D_Printing_of_Nonplanar_Layers_for_Smooth_Surface_Generation>

Strength of 3D Prints

## Common Types of Damage

### Generalizations and Definitions for Our Use

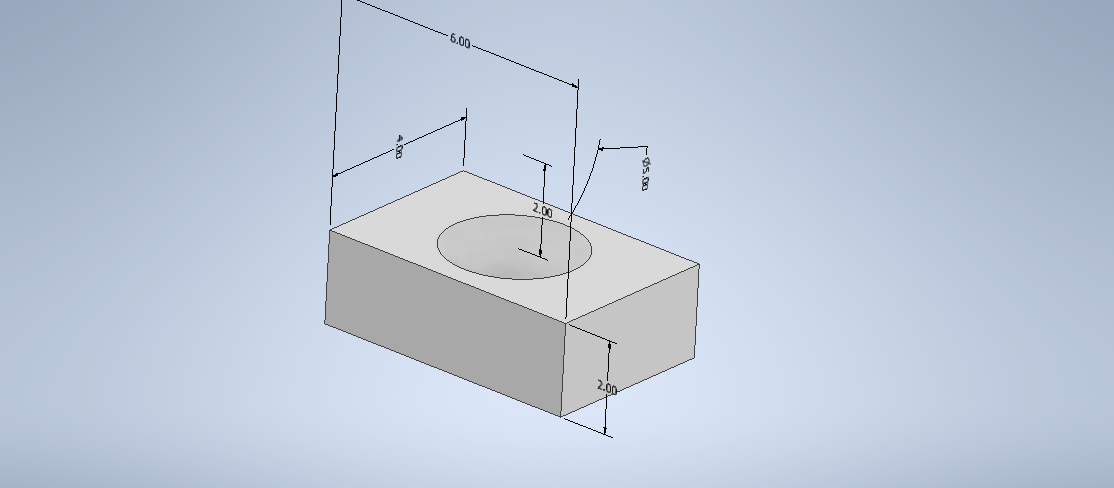
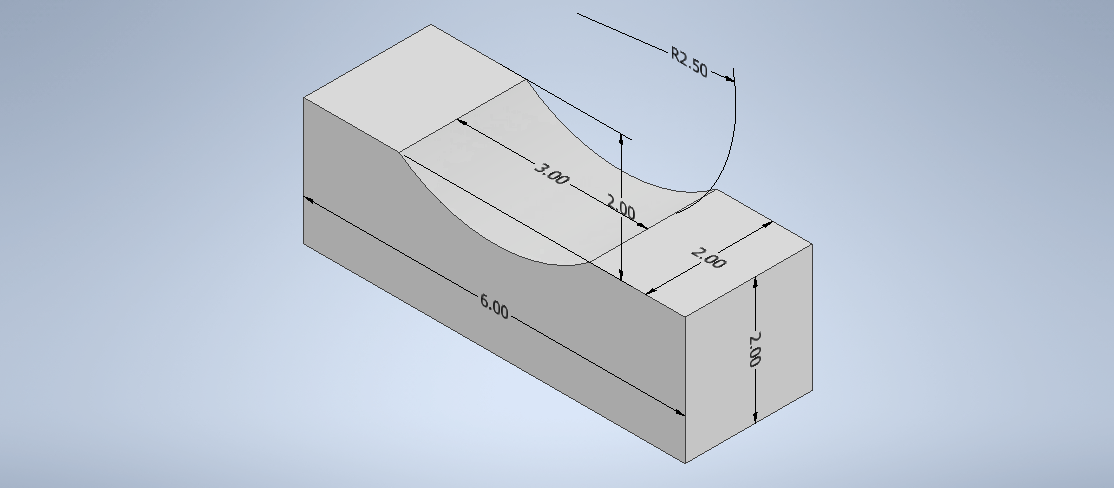
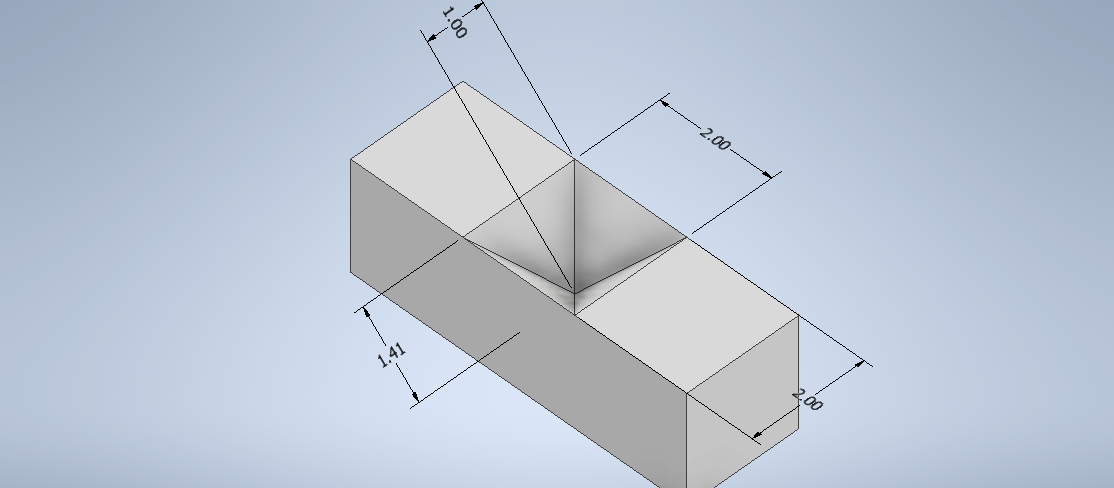
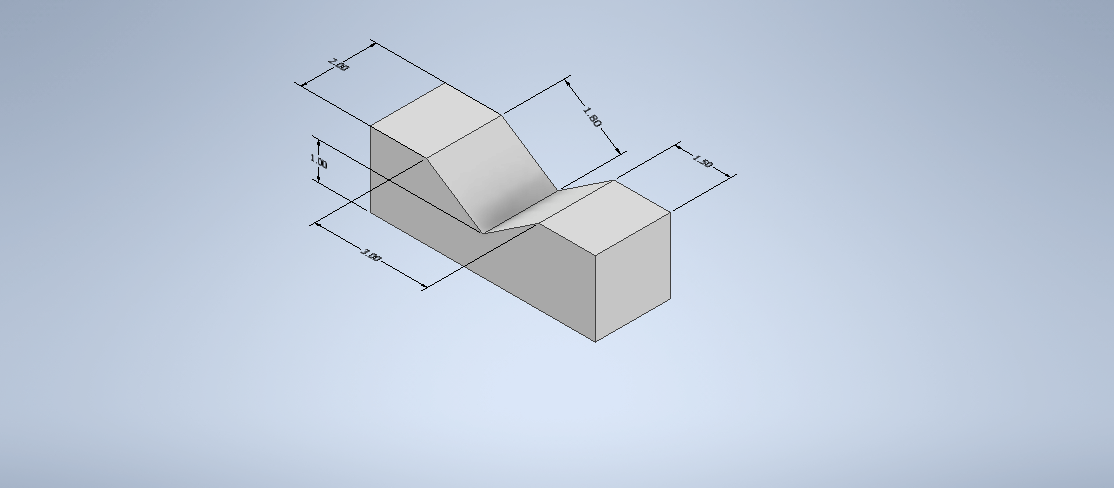
* Two companies have already required multi-material printing (hybrid manufacturing workflow) in printing whole houses. This paper argues for conformal printing composites in architecture. Conformal printing does not necessarily have to be for repair, so any surface/structure can be supported within this framework.
  + <https://journals-sagepub-com.proxy-um.researchport.umd.edu/doi/pdf/10.1177/1478077120948203>
* Reinforce or repair stripped inserts
  + 

### Alternatives (Pros/Cons)

# Methodology

### Testing 3D Parts for Failure

A useful experiment would be to print common mechanical parts (gears, inserts, etc.) and test for failure. The corresponding failure type and shape will be a test case.  
  
 Buy plastic sheets and smacc it, corresponding to divots and cracks in an airplane wing. Repairing cracks can be done preflight to reduce fuel consumption.

<timeline>  
  
 

## What’s next

Tuesday 15, September 2020

* Decide on printer

## 3D Printer Requirements

* New Research Questions
  + What 3d prints are used commonly?
    - How do they fail?
  + How do we repair 3d printed parts?
    - Vs subtractive manufacturing?
* How are we testing?
  + What equipment?
  + What data are we collecting?
  + What hypotheses?
* What printer are we using?
  + How will a normal printer print on a concave surface?
  + What software does it use?
  + Who’s going to keep it?
  + What’s our budget?
  + Fail cases?