NASSA FSD/FSE

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Presentation Overview

- **Technology overview and advantages**
- **Details of process & current state of development**
  - Conventional Friction Stir Deposition (C-FSD)
  - Bobin Friction Stir Deposition (B-FSD)
  - Friction Stir Extrusion
- **Ongoing work**
  - Rev 1 end effectors & continuous feed system PAR systems installation
  - Academic collaborations
- **Future work**
  - Parameter optimization
  - Allowables data
  - Larger scale builds

Technology Overview

- **NASA has developed Novel Advanced Solid-State Additive (NASSA) processes that allow the incorporation of Friction Stir Deposition (FSD) and Friction Stir Extrusion (FSE) processes into traditional FSW machinery.**

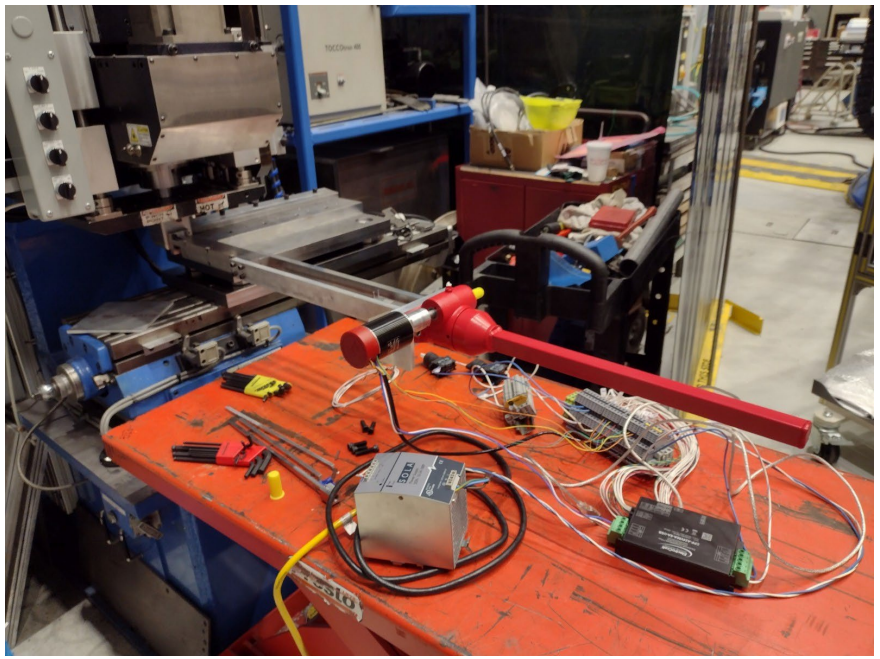
- **Three different end effectors that are enabled with one feeder/control mechanism**
  - Conventional Friction Stir Deposition (C-FSW)
  - Bobbin Friction Stir Deposition (B-FSD)
  - Friction Stir Extrusion (FSE)

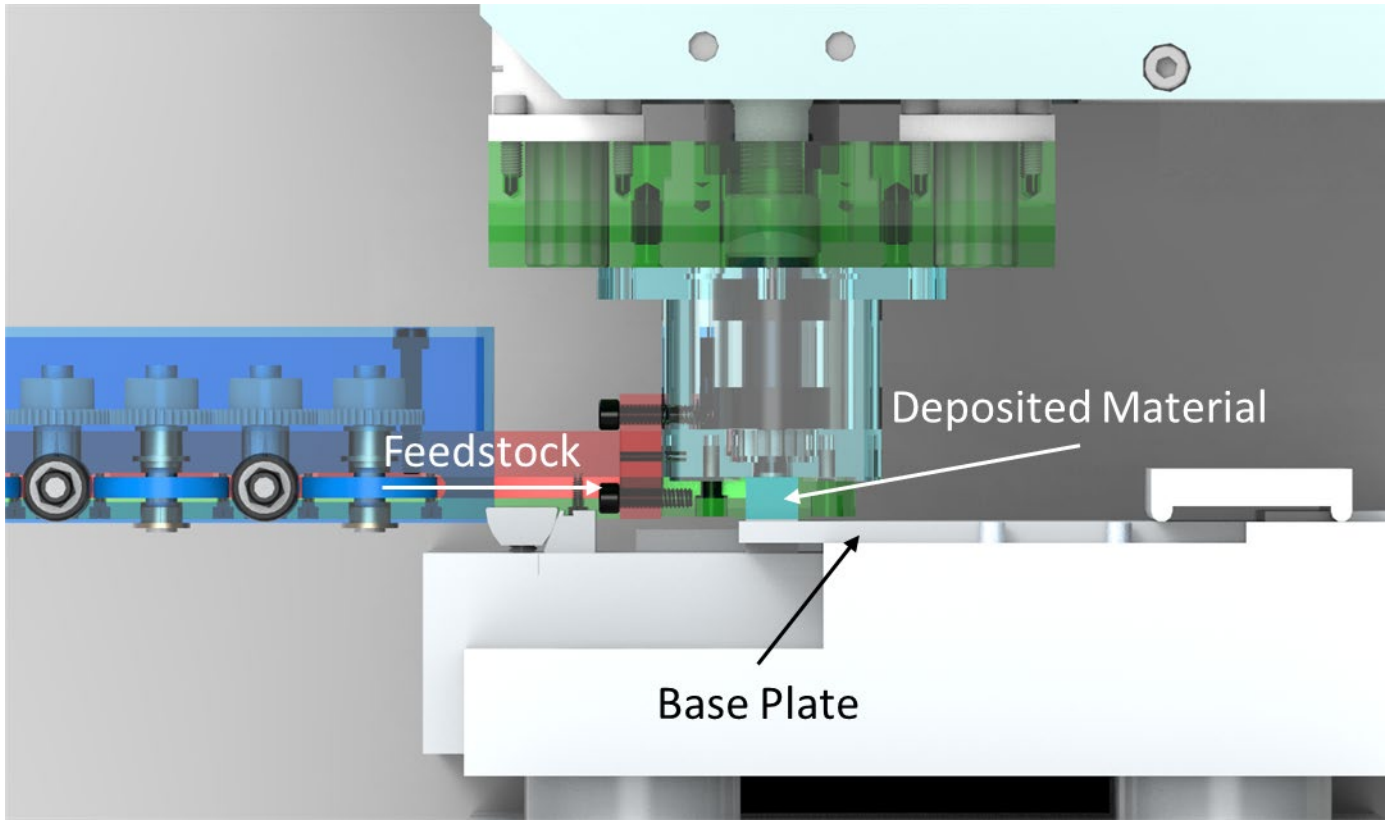
- **Advantages over traditional FSD technology**
  - The end effector model allows for rapid transition (minutes) from FSW to FSD/FSE and vice versa
  - Conversion of existing large scale FSW machinery into additive machinery via the purchase of an inexpensive end effector
  - Near-net shape additive manufacturing (smooth as-build surface quality)
  - Infinite Length Extrusions

C-FSD

C-FSD

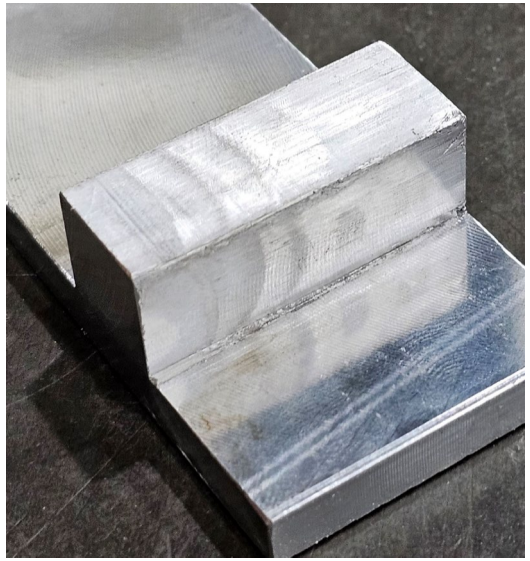
- Feedstock forced through side entrance hole
- Pin plastically deforms the metal and stirs it into the previous layer (or base material)
- Material deposited with an extruded surface finish

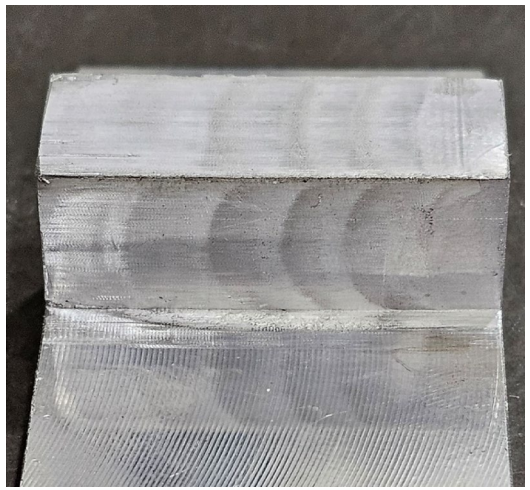


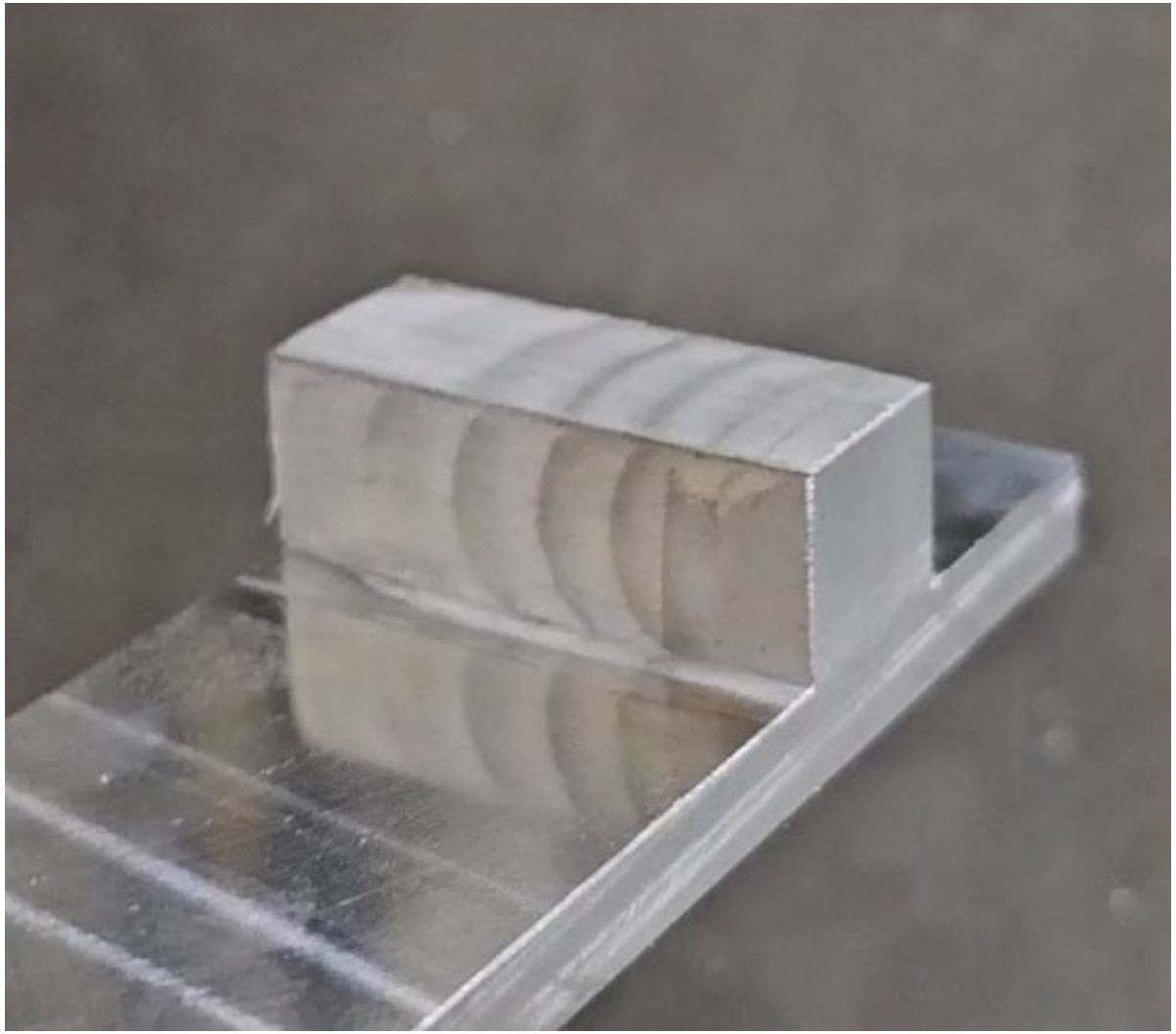


C-FSD

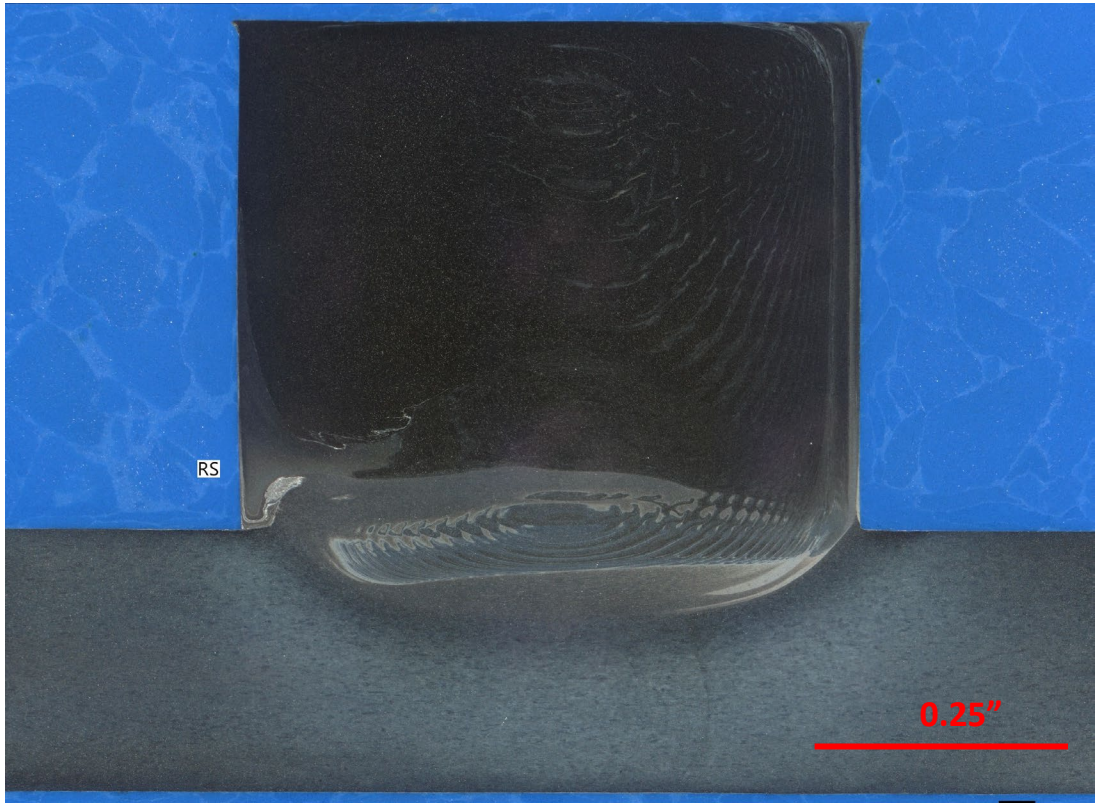
- **Advantages**
  - Modular design bolts on in minutes
  - Low-cost investment to upgrade existing infrastructure (sales to current users)
  - Additional capability for prospective customers
  - Extruded surface finish
  - Wide range of print geometries
  - Can print rib-stiffeners, walls, cubes, ect.



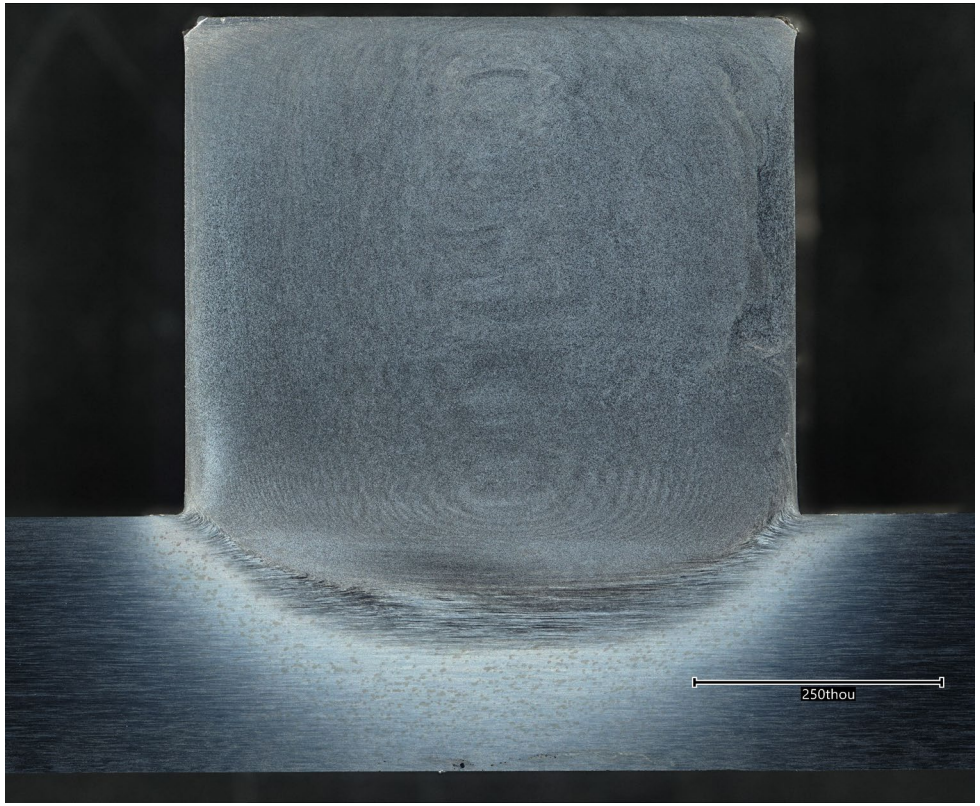




C-FSD Macros



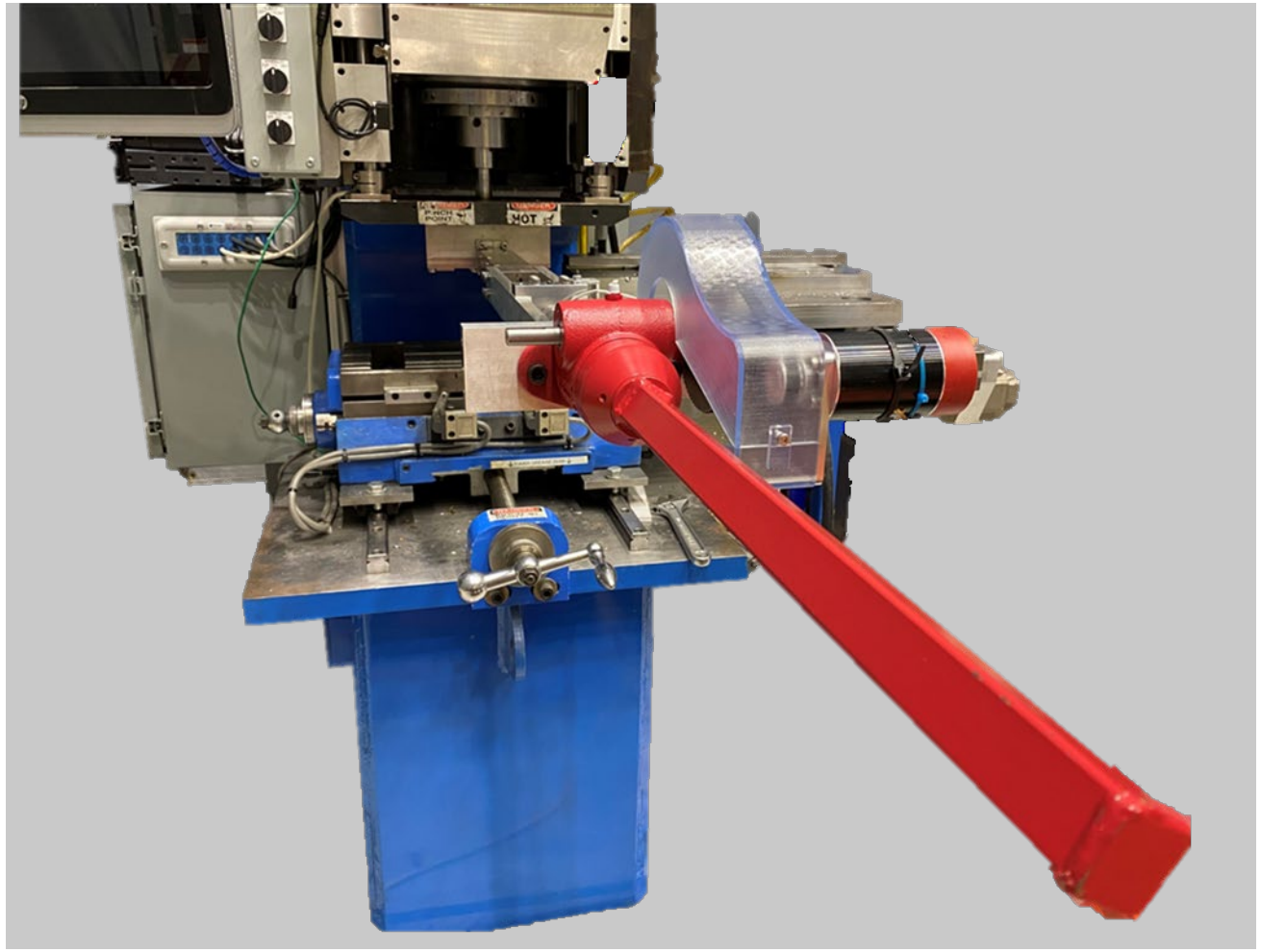
6061 C-FSD with Carbon Coated Feed-Rods



2195 C-FSD with No Carbon

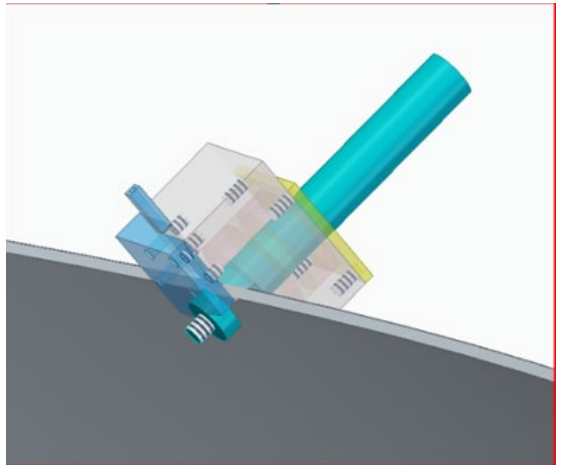
B-FSD

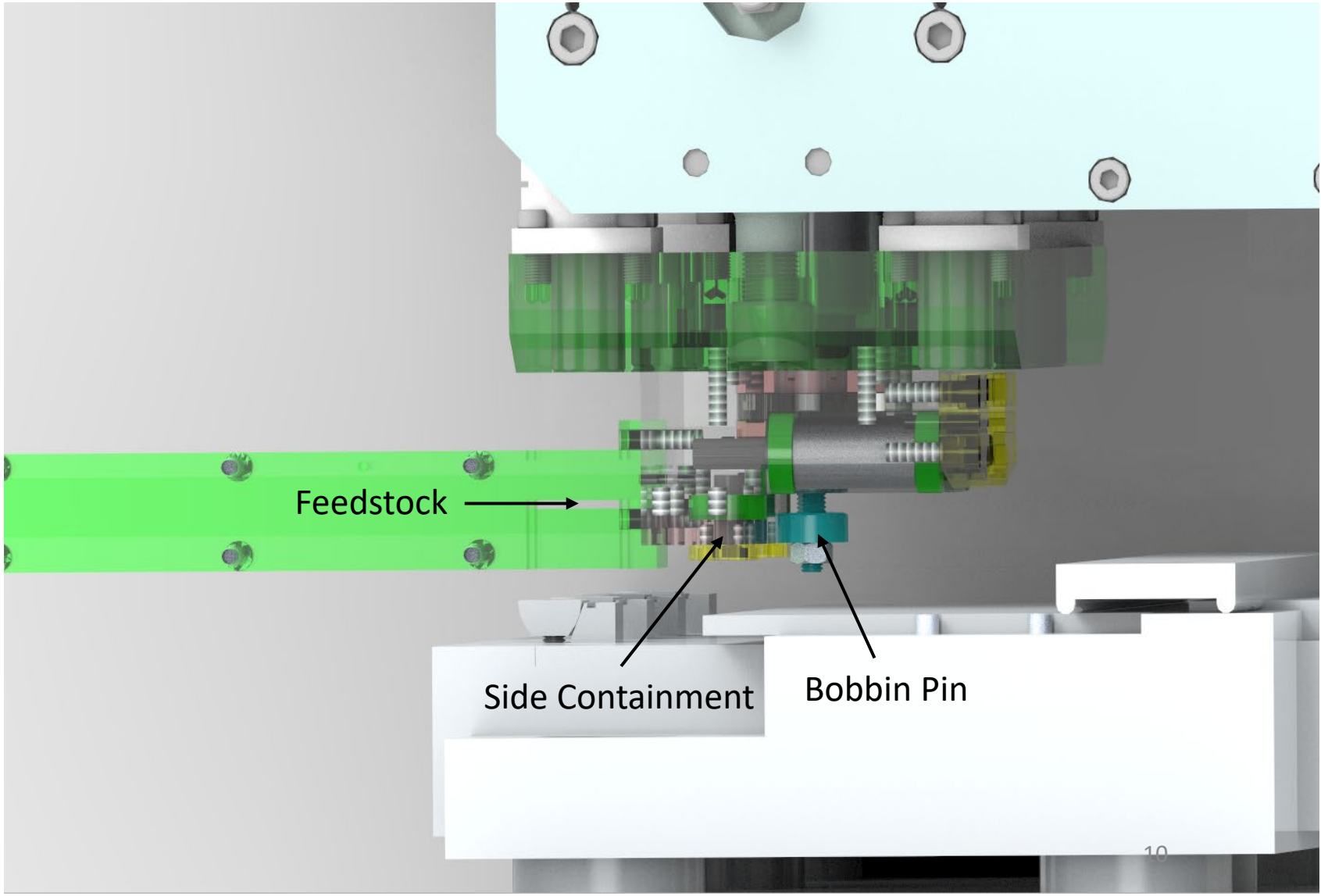
B-FSD



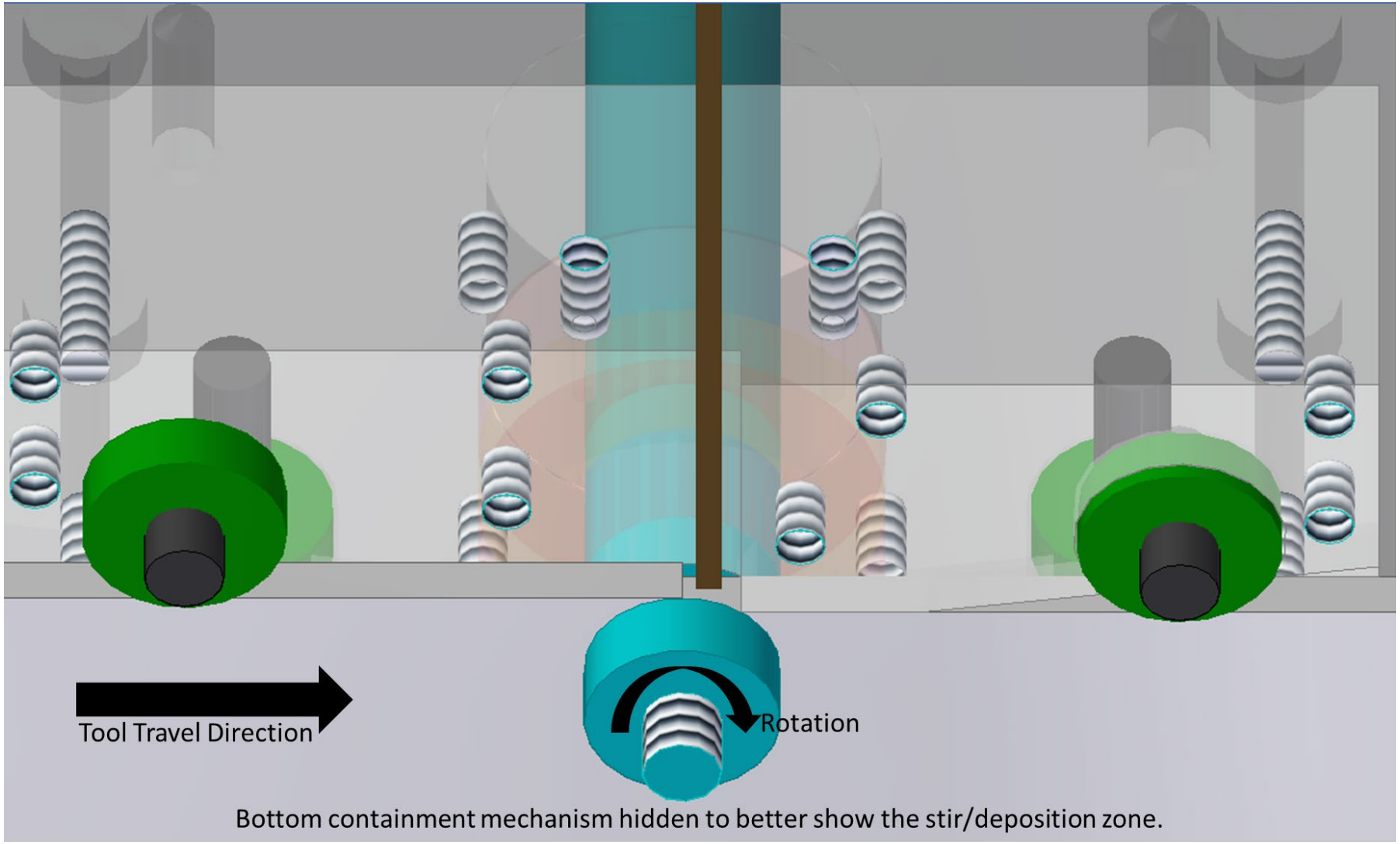
B-FSW

- **How it Works**
  - Filler is fed into the side of the stir zone
  - Each deposited layer is stirred with multiple prior layers or the base plate (excellent interlayer bonding)
  - Bobbin tool provides containment of the material on the top and bottom, while a non-rotating side plate contains the side





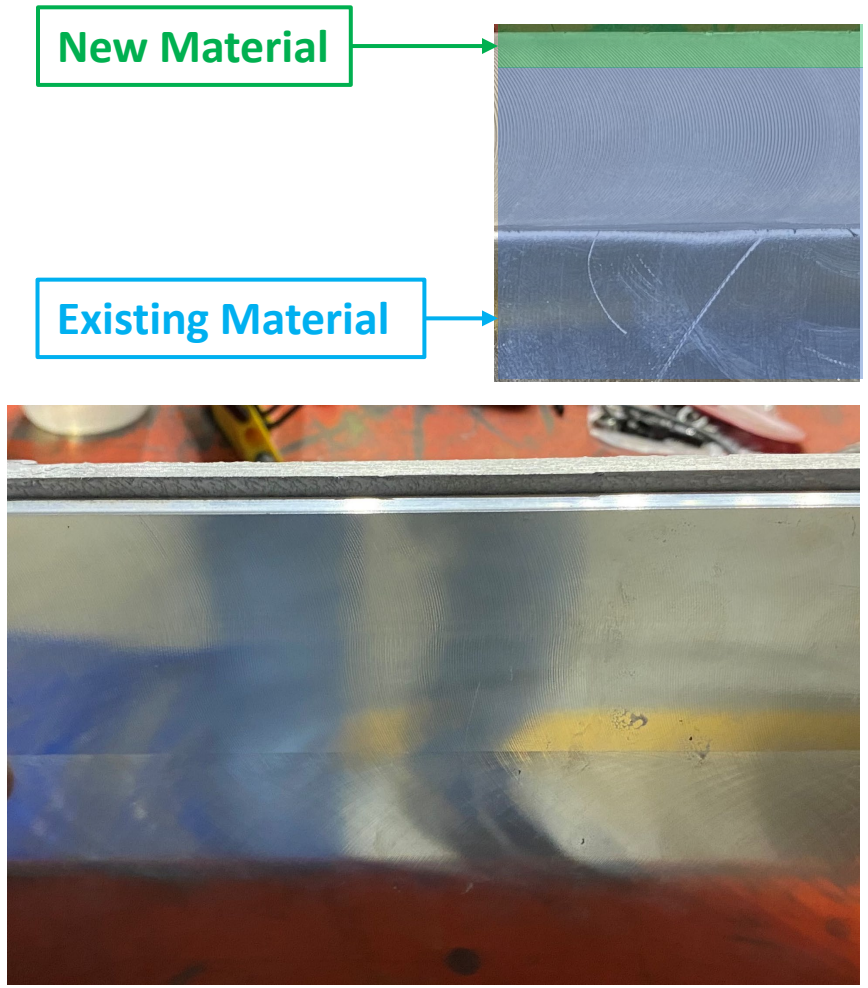
B-FSD Overview



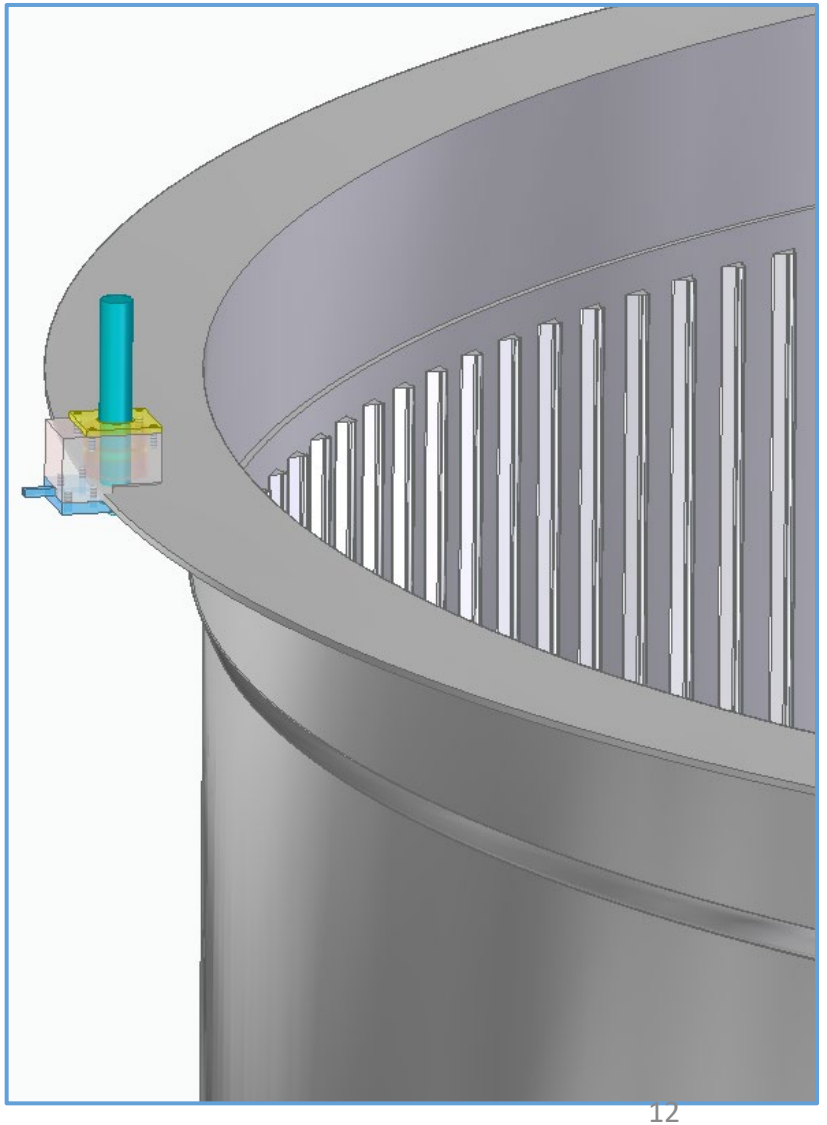
Bottom containment mechanism hidden to better show the stir/deposition zone.

B-FSD

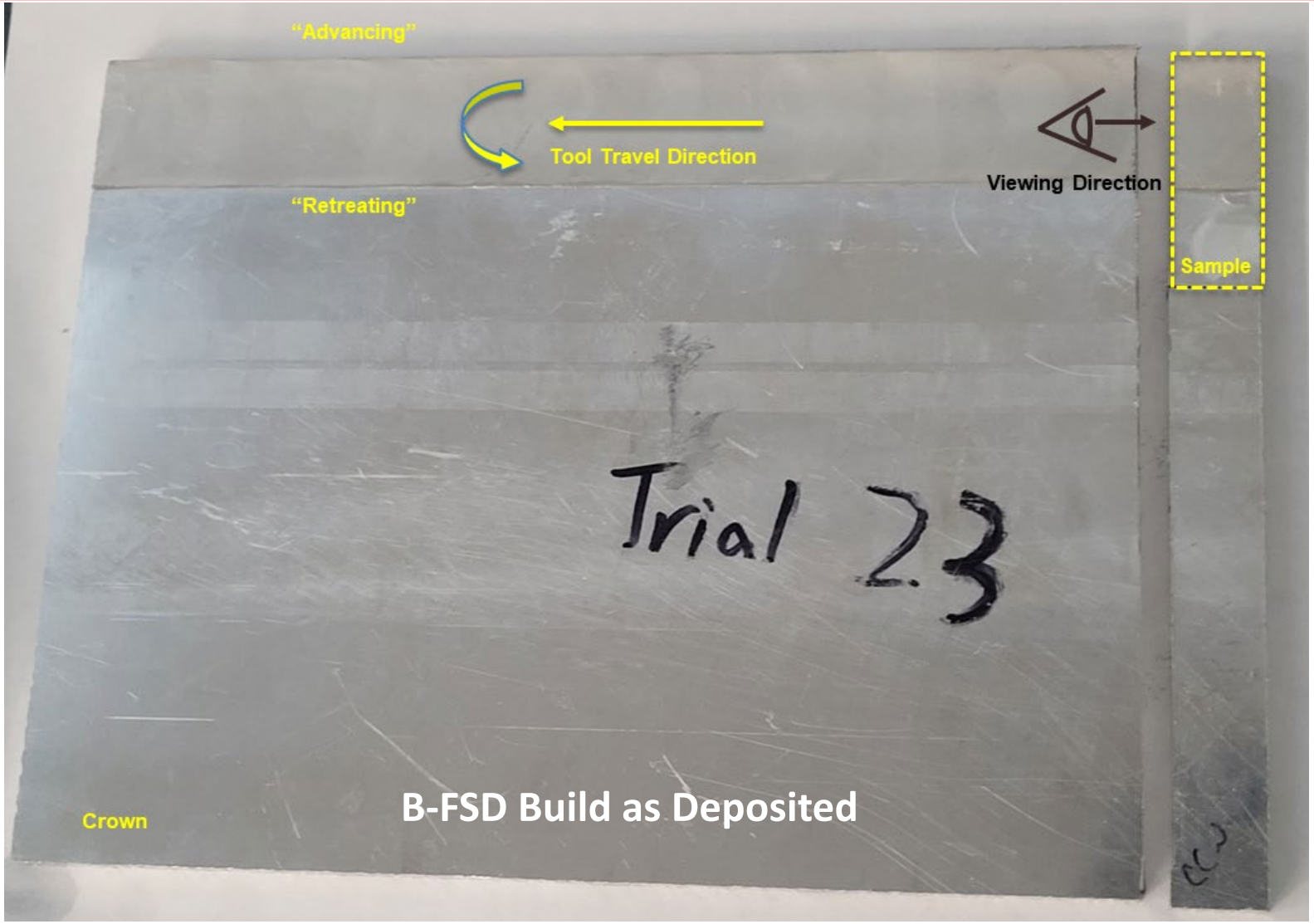
- **Advantages**
  - Modular design bolts on in minutes
  - Low-cost investment to upgrade existing infrastructure (sales to current users)
  - Same feeder as C-FSD
  - Additional capability for prospective customers
  - SR-FSW surface finish
  - Wide range of print geometries
  - Can print walls, domes, cylinders, etc.



B-FSD Single Layer vs Starting Plate

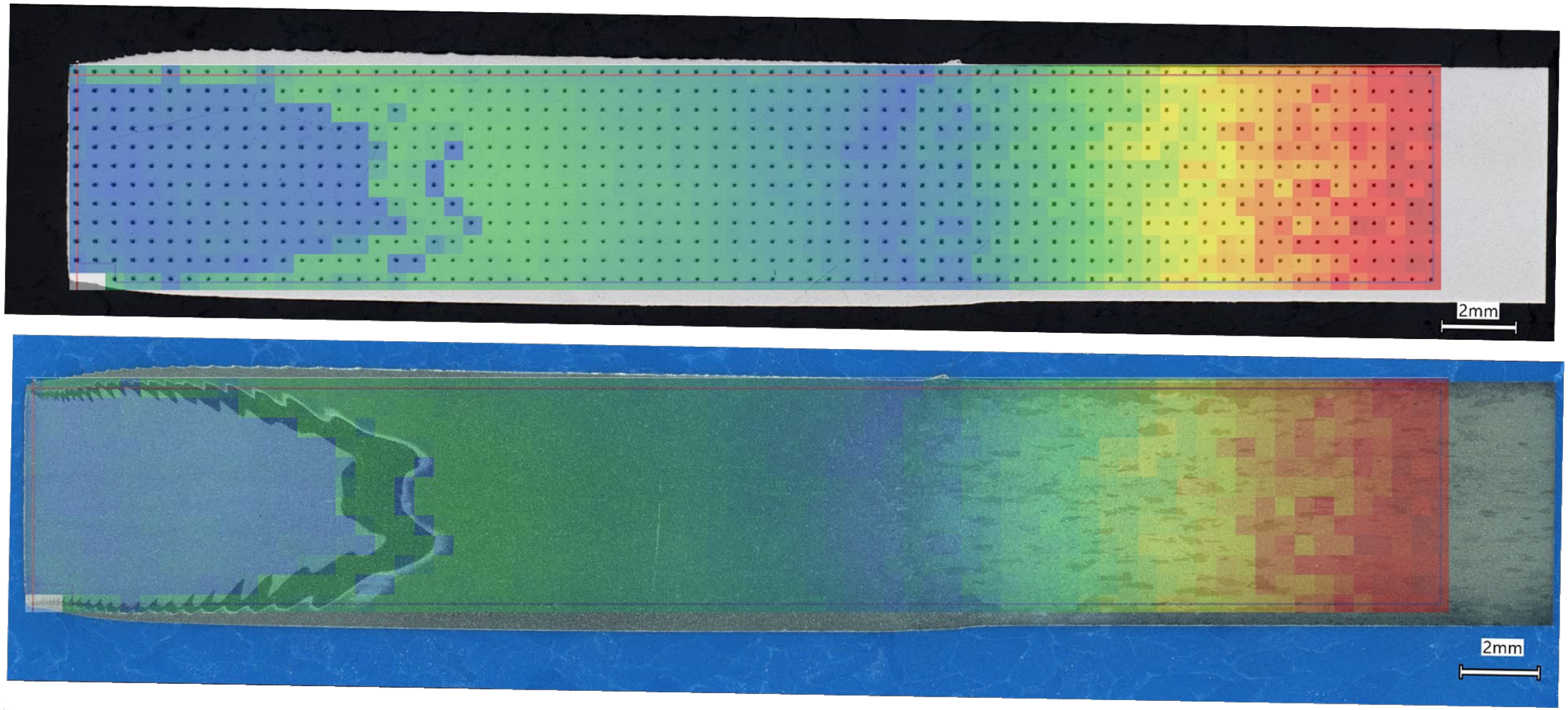


B-FSD Build Comparison



B-FSD Trial 23 Macro

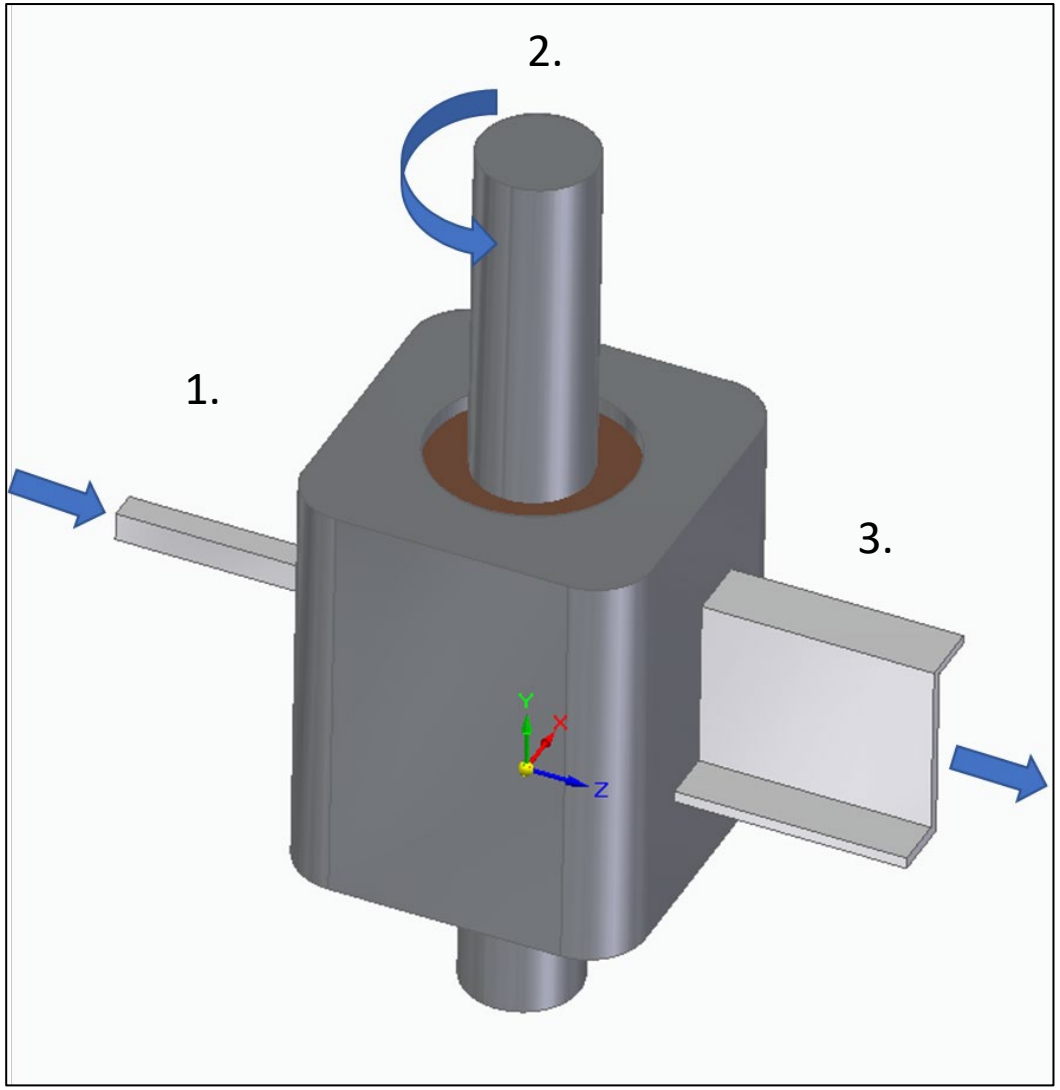
B-FSD Trail 23 Hardness Overlays

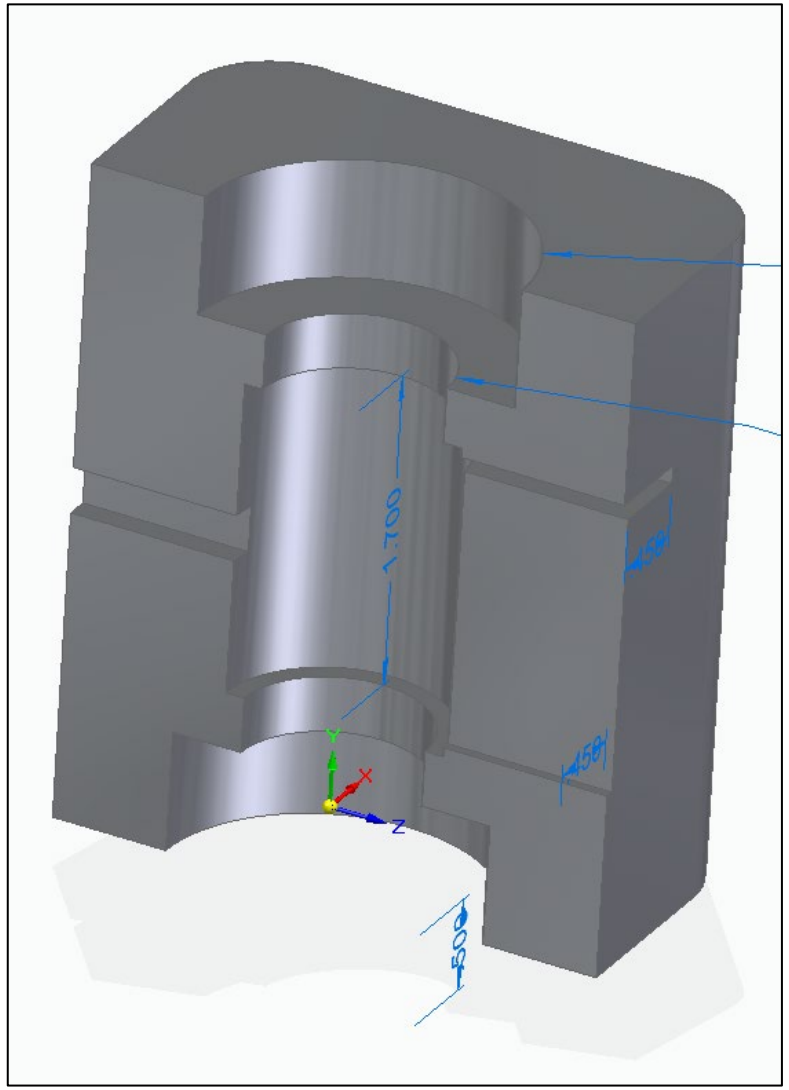


FSE

Friction Stir Extrusion

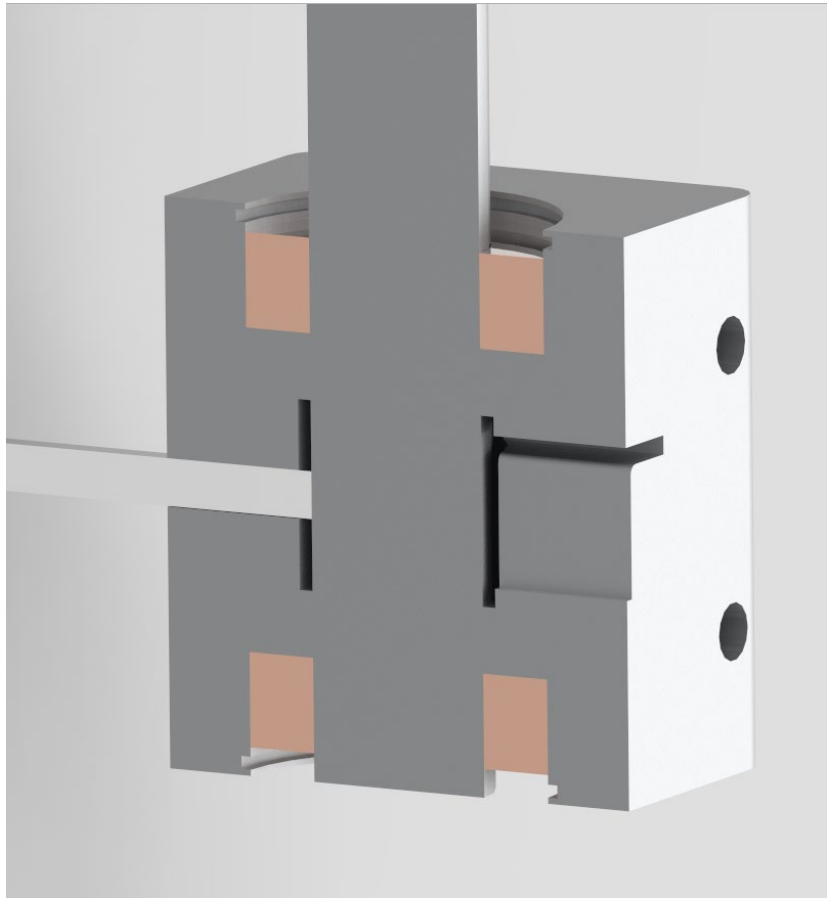
- **How It Works**
  - Feedstock fed in by the same bar feeder as the C-FSD & B-FSW (could also use a different one)
  - Feedstock is deformed by the rotating pin (heat & material flow)
  - Material is forced through extrusion profile by pressure generated by the bar feeder
  - Essentially C-FSW with a steel plate on the bottom

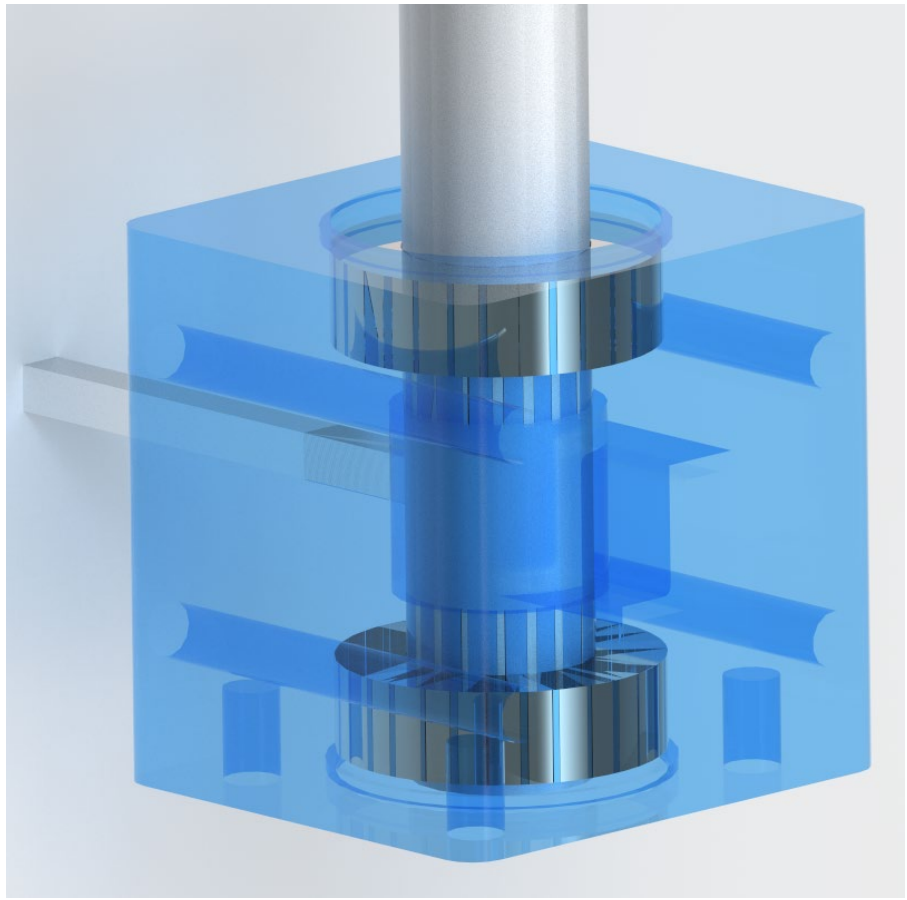




Friction Stir Extrusion

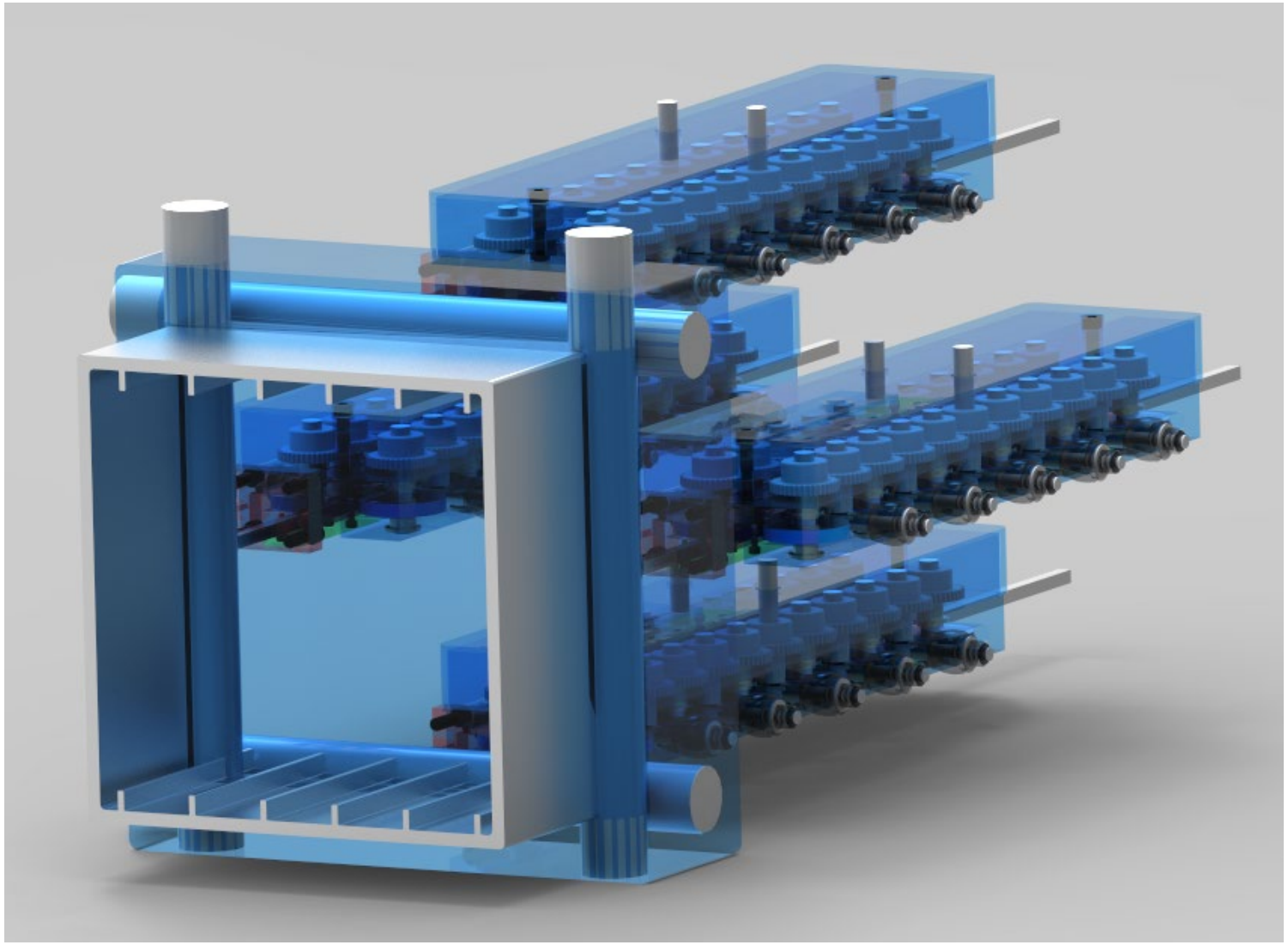
- **Advantages**
  - Modular design bolts on in minutes
  - Low-cost investment
  - Can use the same feeder as C-FSD & B-FSD
  - Change in extrusion shape only requires bolting on a new face (low cost)
  - Infinite length extrusions
  - Can stack multiple extrusions to make cylinders or other closed body structures on a large scale (1’ to +30’ diameters)
  - Only need a motor and feed mechanism (no FSW machine technically needed)
  - More equiaxed properties than a typical extrusion





Large-Scale Extrusion

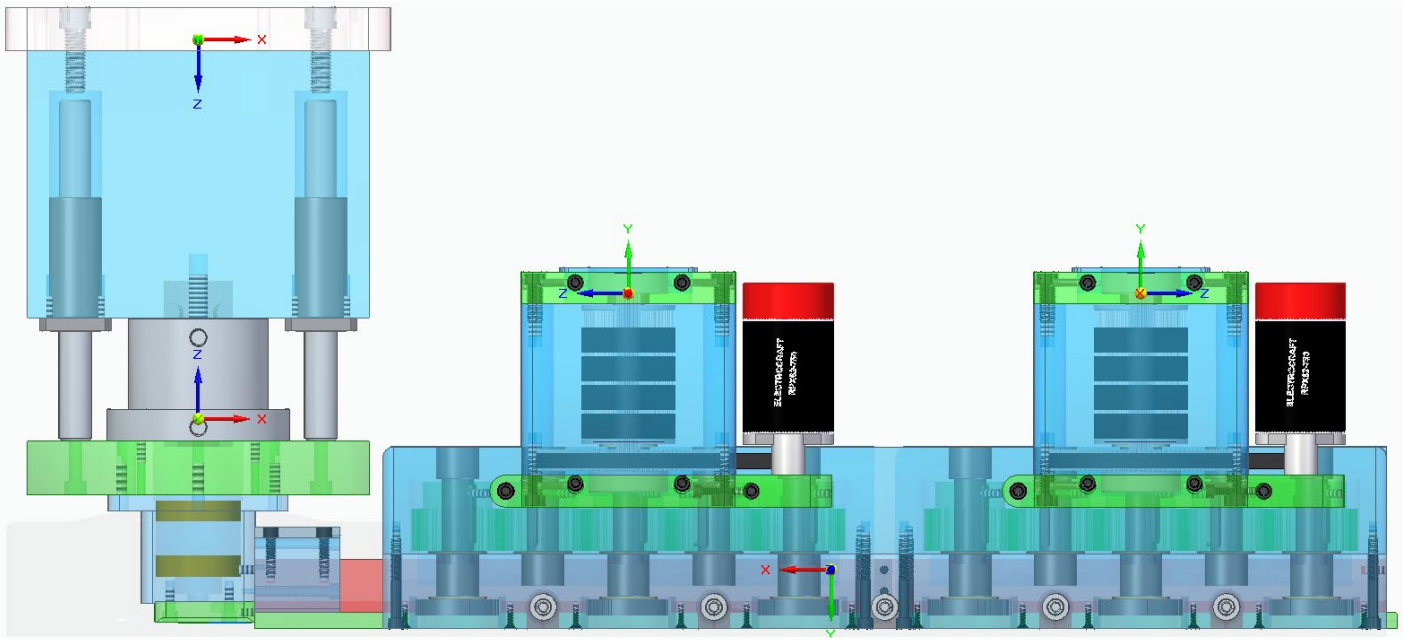
- **Advantages**
  - Can extrude massive parts very quickly
  - Low-cost investment
  - Can use the same feeder as C-FSD & B-FSD
  - Change in extrusion shape requires a new die face (relatively low cost)
  - Infinite length extrusions
  - Only need a motor and feed mechanism (no FSW machine technically needed)
  - More equiaxed properties than a typical extrusion
  - Can make domes, rings, and other circular extrusions

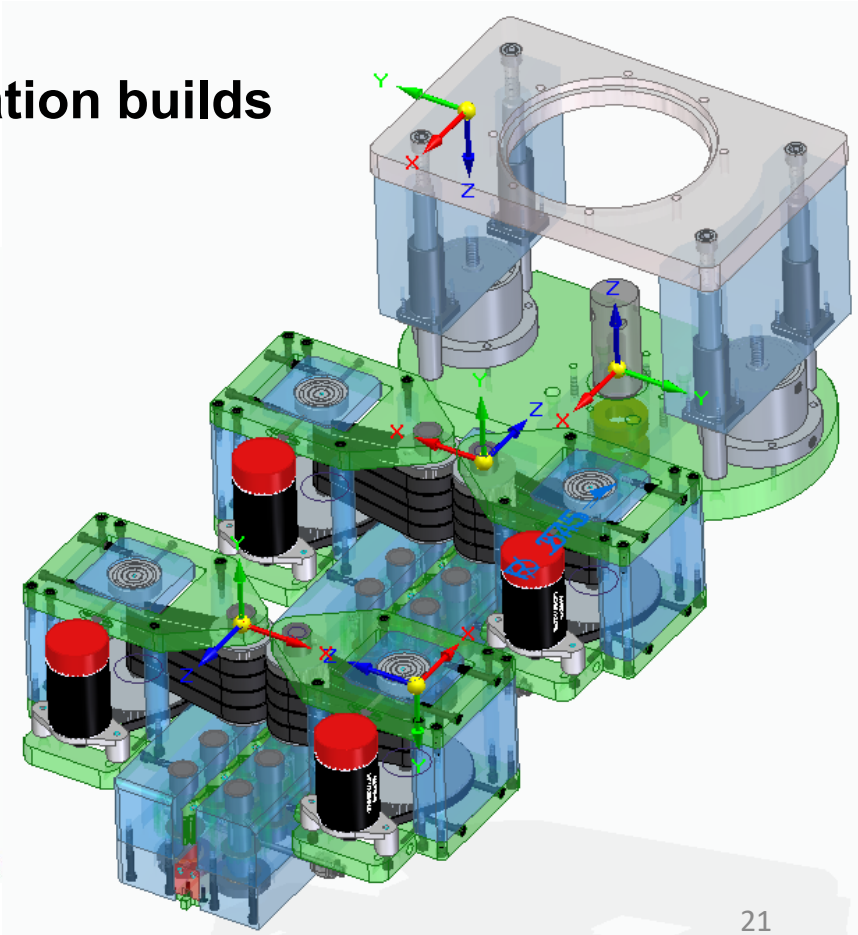


Next Steps

Continuous Feed System & PDS Integration

- **Continuous feed system to be integrated into the week of PDS November 18th 2024**
  - Allow for continuous feed
  - Deposition rate: targeting +50 lbs/hr
  - Multi-wall builds
- **Begin developing design allowables & initial qualification builds**





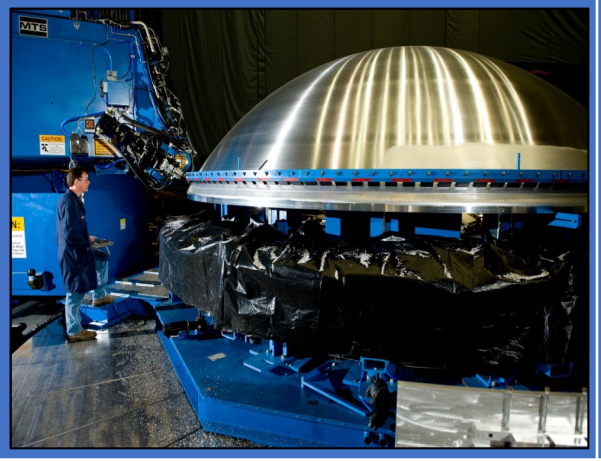
Questions

Novel Advanced Solid-State Additive (NASSA)

Build Size: NASSA Processes are an end-effector based technology suite that utilizes existing MSFC FSW infrastructure (30’ Diameter, 15’ Build Height)

Where it will be utilized: Terrestrially, and in-space

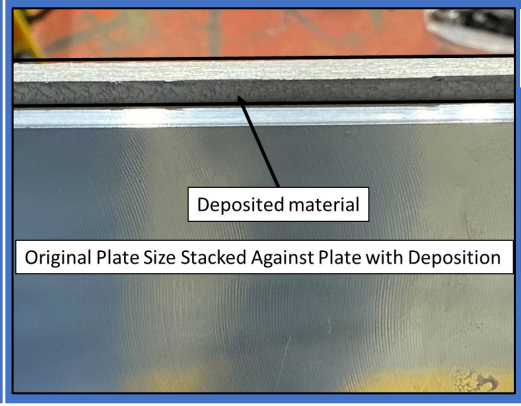
NASSA Advantages: Can utilize existing FSW infrastructure, extremely high deposition rates, smooth surface finish as deposited (no machining needed), in-space applications can test all relevant parameter on earth

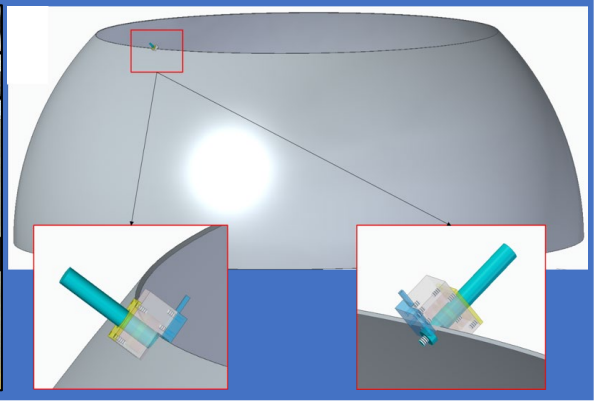


Bobbin Friction Stir Deposition (B-FSD)

Where it will be utilized: Terrestrially, and in-space.

What it can build: Domes, Barrels, varying thickness print

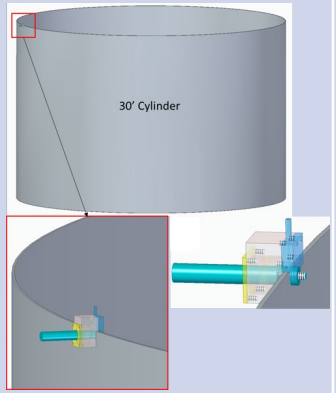




Conventional Friction Stir Deposition (C-FSD)

Where it will be utilized: Terrestrially, and in-space.

What it can build: Stiffeners, Domes, Barrels



Friction Stir Extrusion

Where it will be utilized: Terrestrially, and in-space.

What it can Extrude: Wire, Angles, Closed Structures, Domes, Barrels