2D – 2.5D Manufacturing

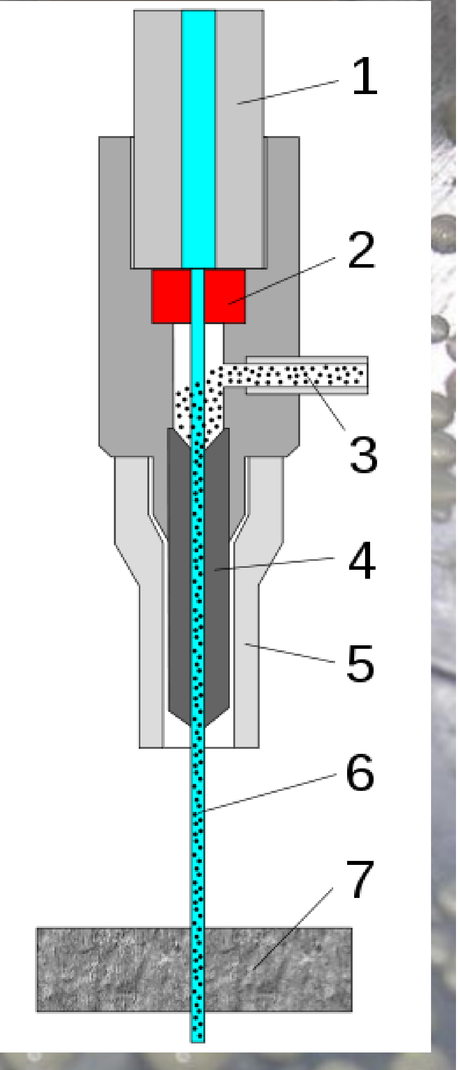
Milling


• High tolerance
• Moderate throughput
• Significant tooling costs / wear of tools

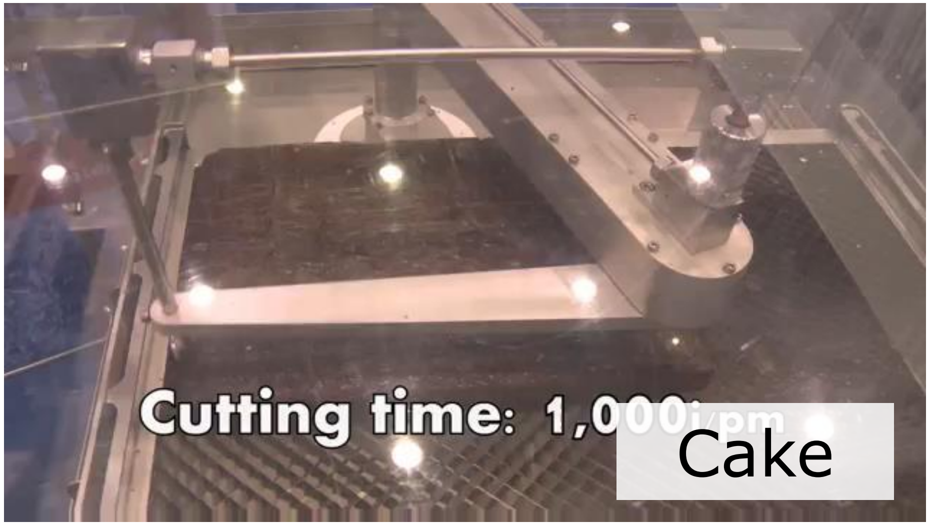
Milling

Water Jet Cutting

- Water + garnet abrasively cuts material with 60 ksi pressures
- Cold cutting of thick materials- no heat affected zone (HAZ) or discoloration
- No tooling costs
- Multi-axis control permits cut axes from normal



Water Jet Cutting

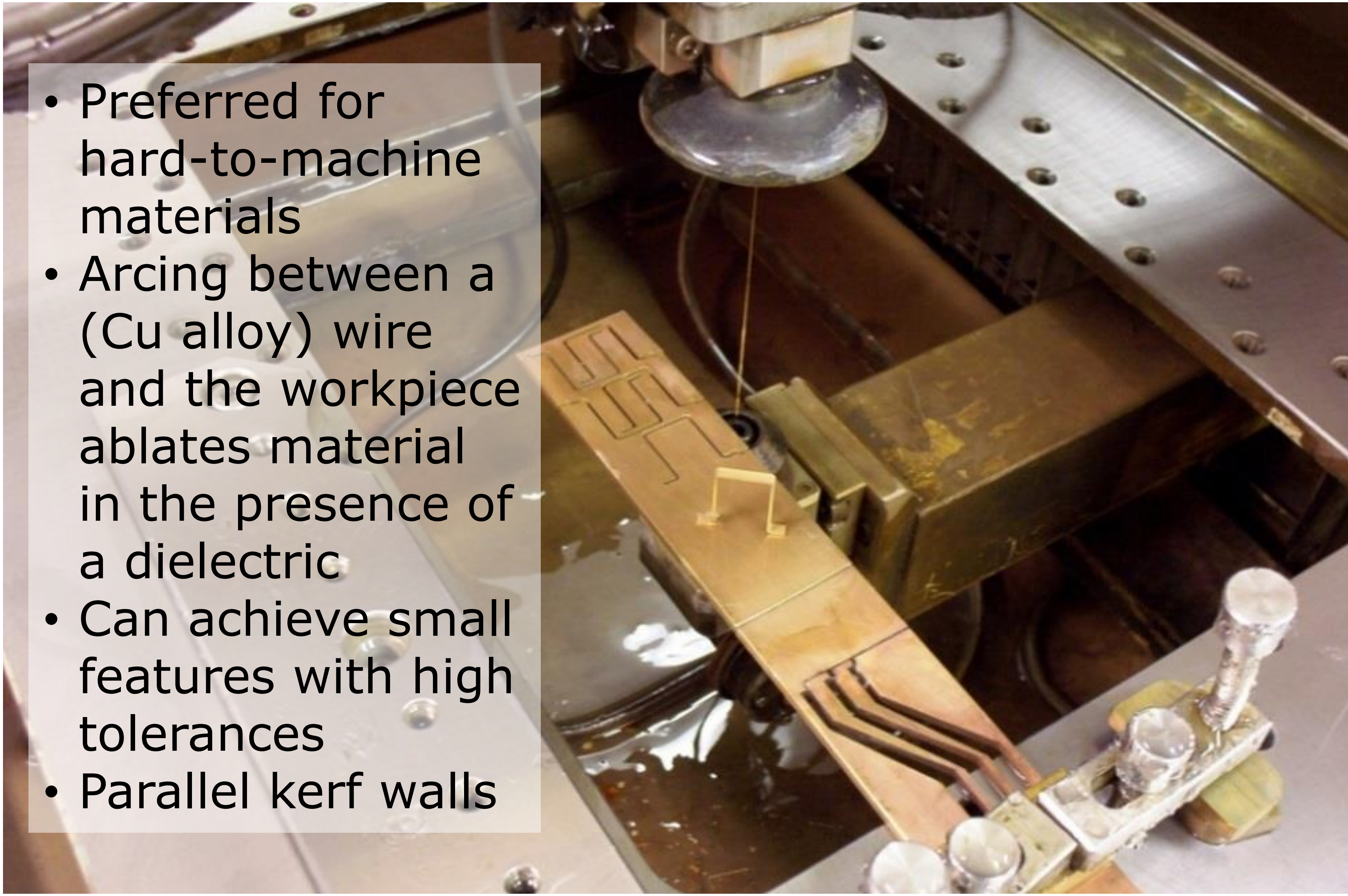


Cake


Steel

5 Axis Control

Electrical Discharge Machining (EDM)

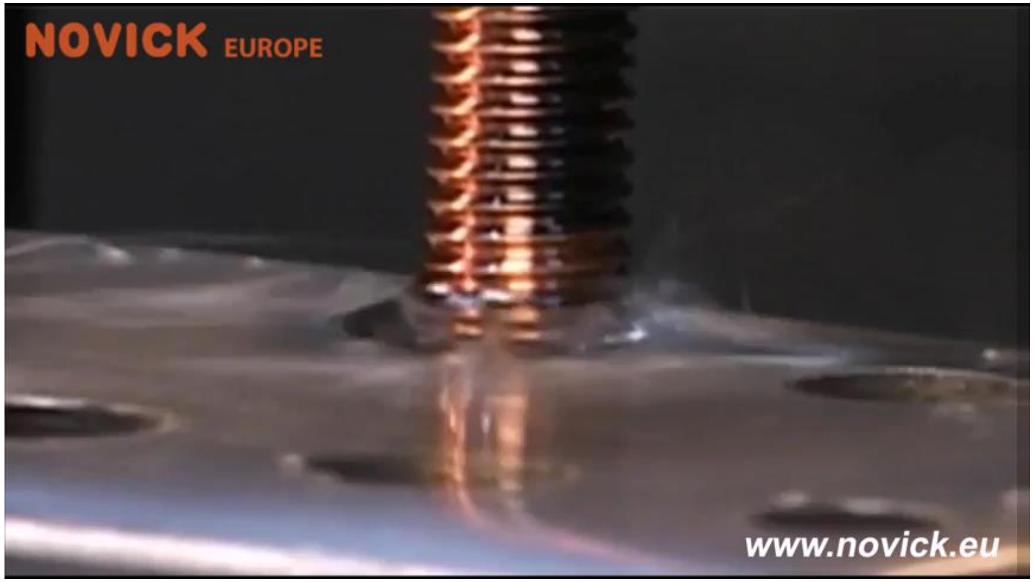


- Preferred for hard-to-machine materials
- Arcing between a (Cu alloy) wire and the workpiece ablates material in the presence of a dielectric
- Can achieve small features with high tolerances
- Parallel kerf walls

Electrical Discharge Machining (EDM)

Wire EDM

Electrical Discharge Machining (EDM)



Die Sinking EDM

Laser Cutting

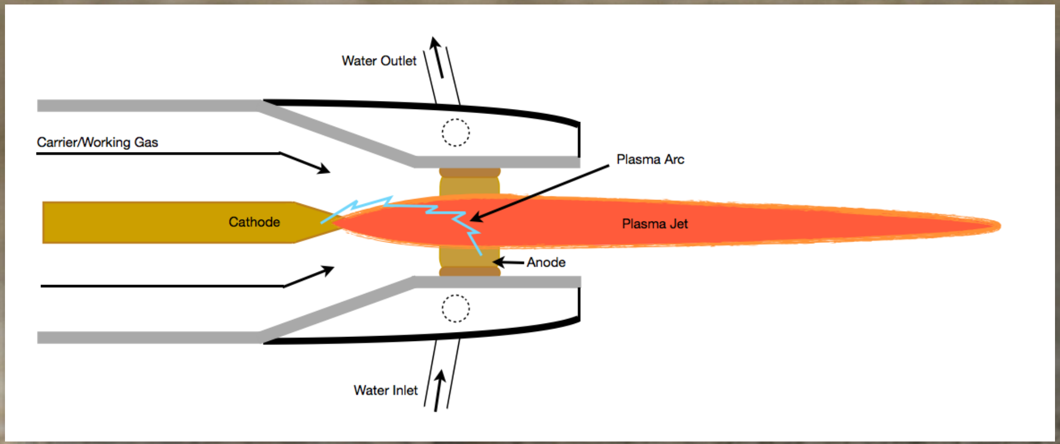
- Can be used in low to high volume applications
- No tooling costs
- Reduced part stresses and minimal to moderate heating

Laser Cutting

Laser Cutting

Plasma Cutting

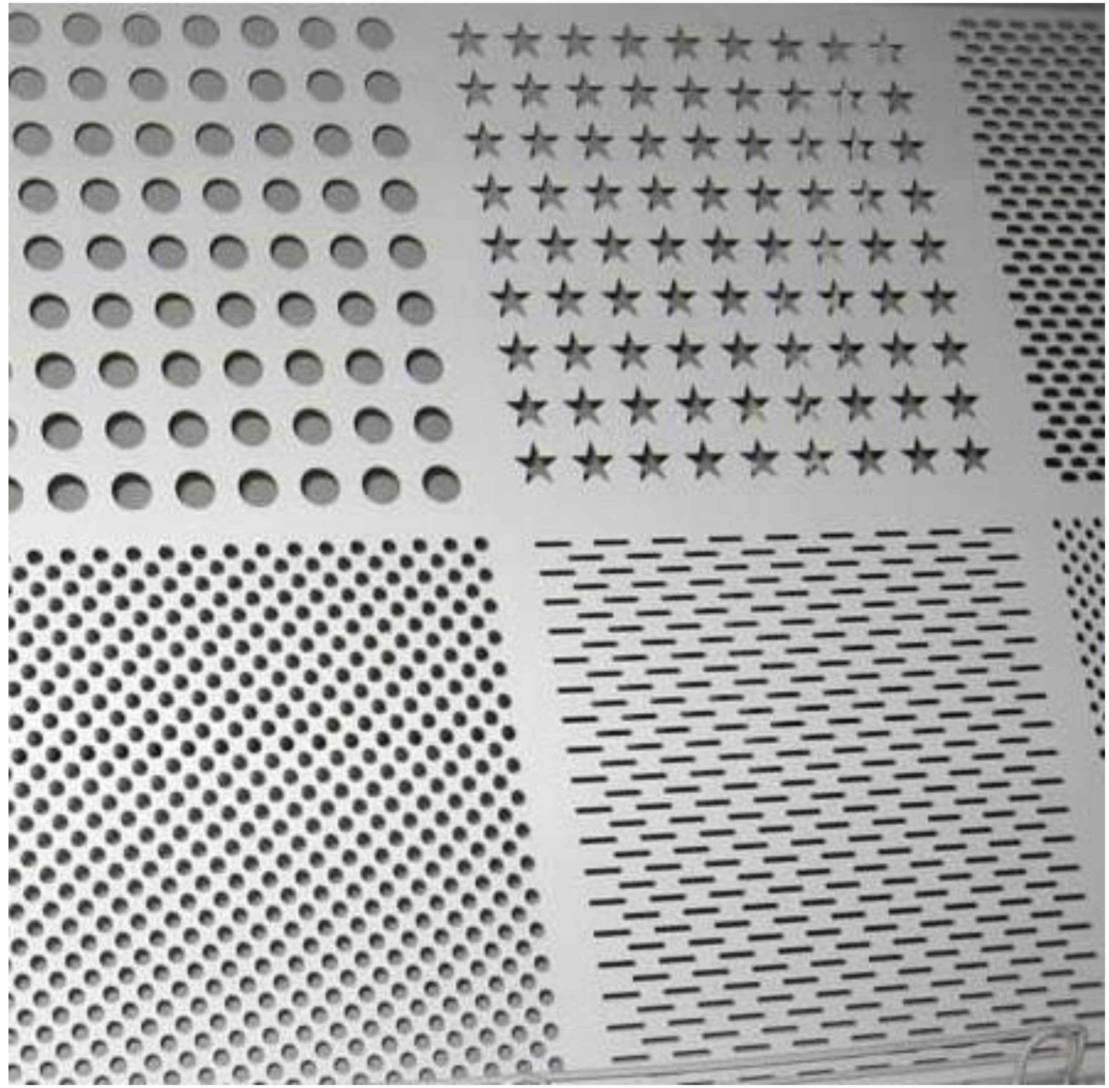
- Inert gas blown from nozzle excited to plasma state via applied bias
- Cutting is achieved via melting – thus a HAZ is expected
- Rough finish unless optimized or thin



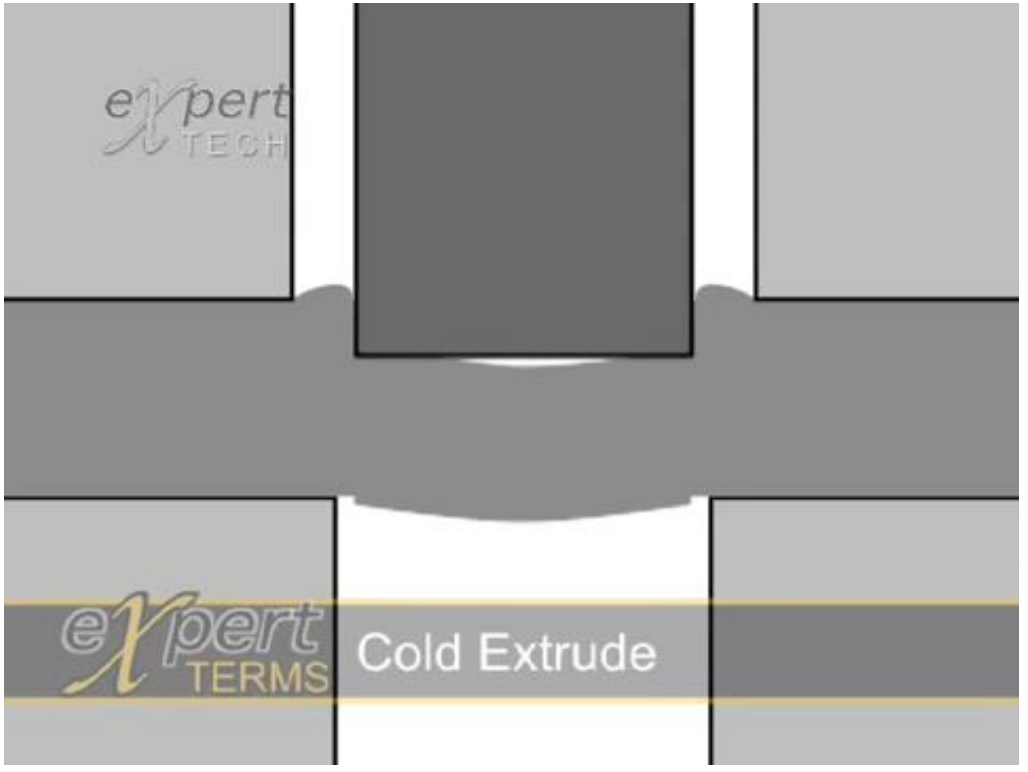
Plasma Cutting

Stamping / Die Cutting

- High throughput, parallel process
- High tooling costs and tool wear
- Higher quality edge finish (may) require secondary finishing to remove burrs / roughness



Stamping / Die Cutting

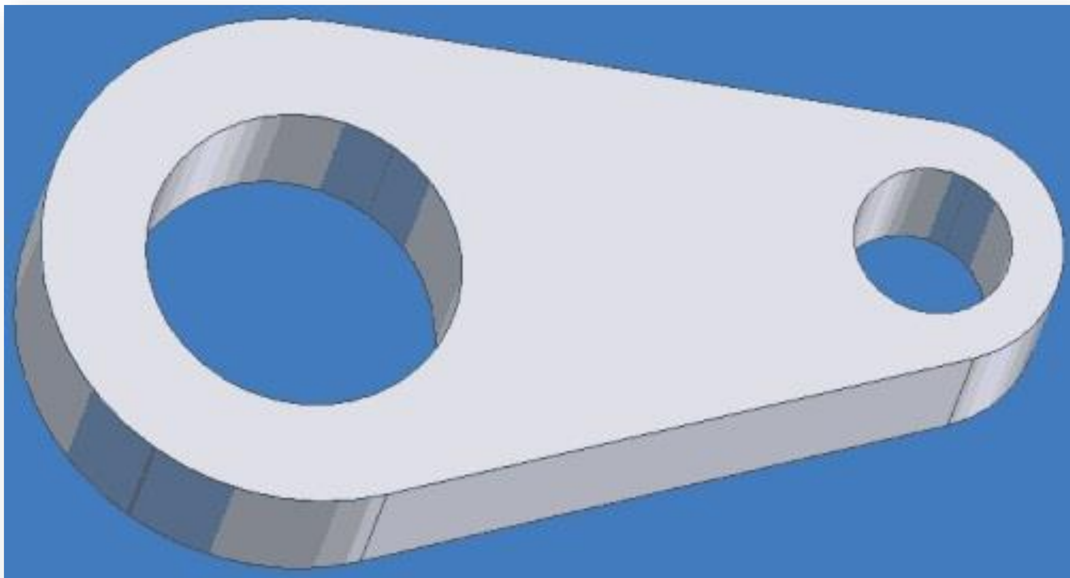


Summary

Method	Materials	Kerf (in. x 0.001)	Tolerance (in. x 0.001)	Throughput	Direction of forces
CNC Milling	Most materials	Tool diameter	1	Moderate	XYZ
Stamping	Thin metals and plastics	n/a	10	High	Z
EDM	Conducive materials	4 - 14	0.2	Low	Minimal
Laser	Plastics, woods, metals (non flammable)	6	2	Moderate	Minimal
Water Jet	Most materials	20	1 - 8	Moderate	Z

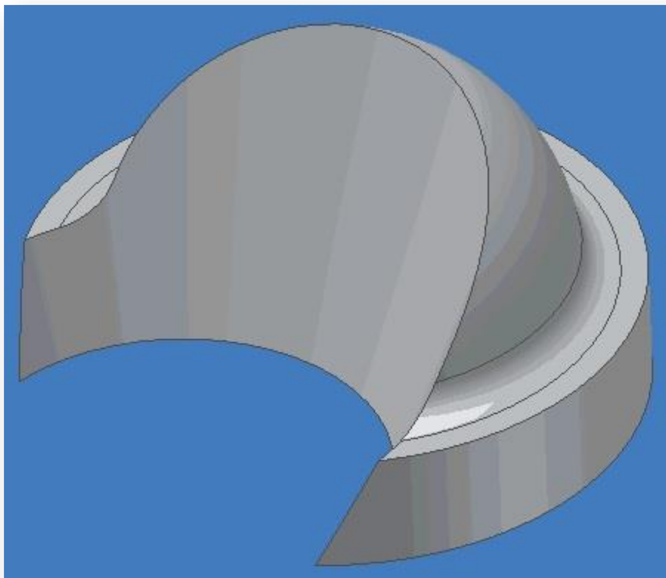
2.5D to 3D

2.5 D



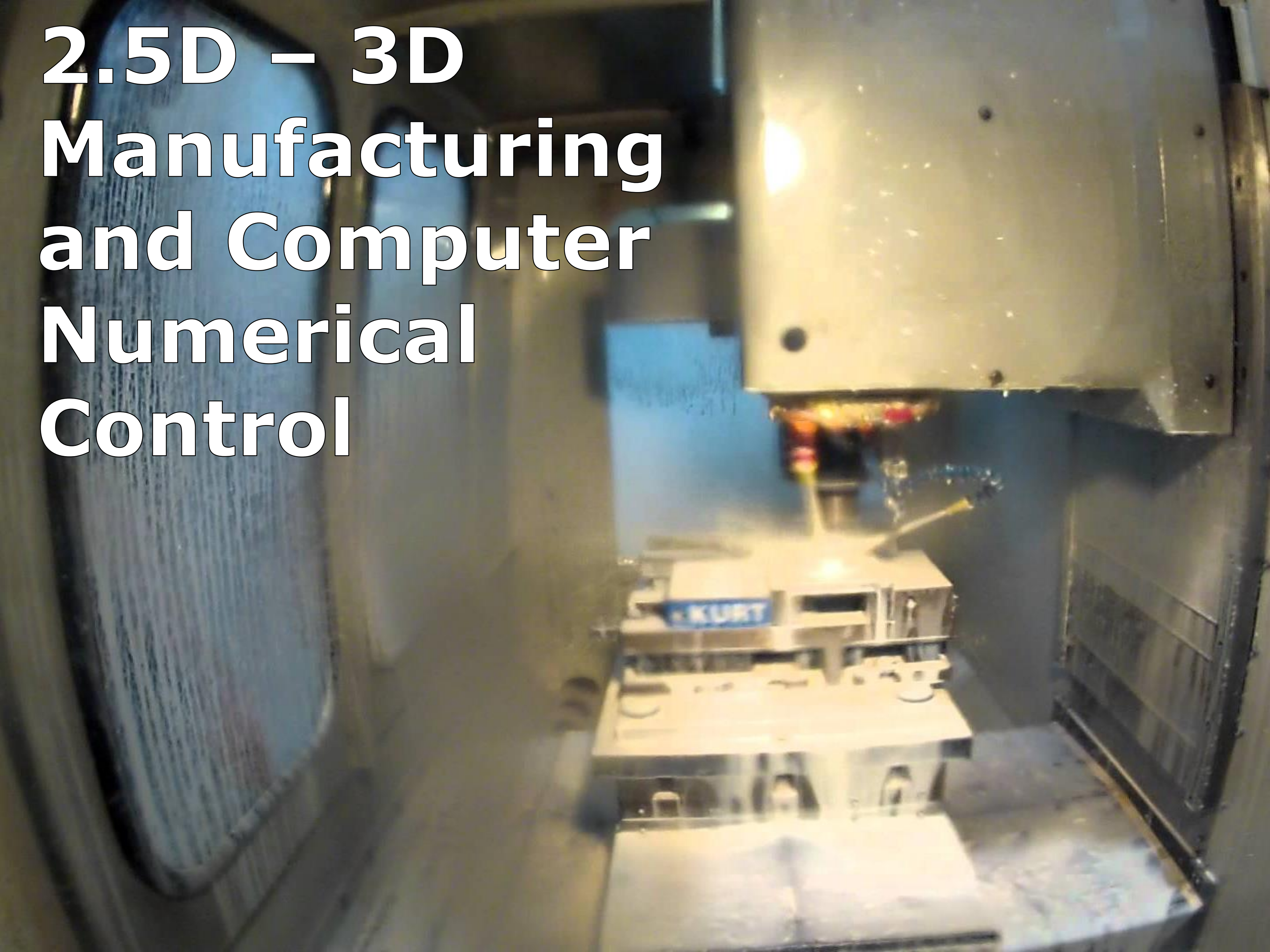
Computerized control over x/y axes

3D

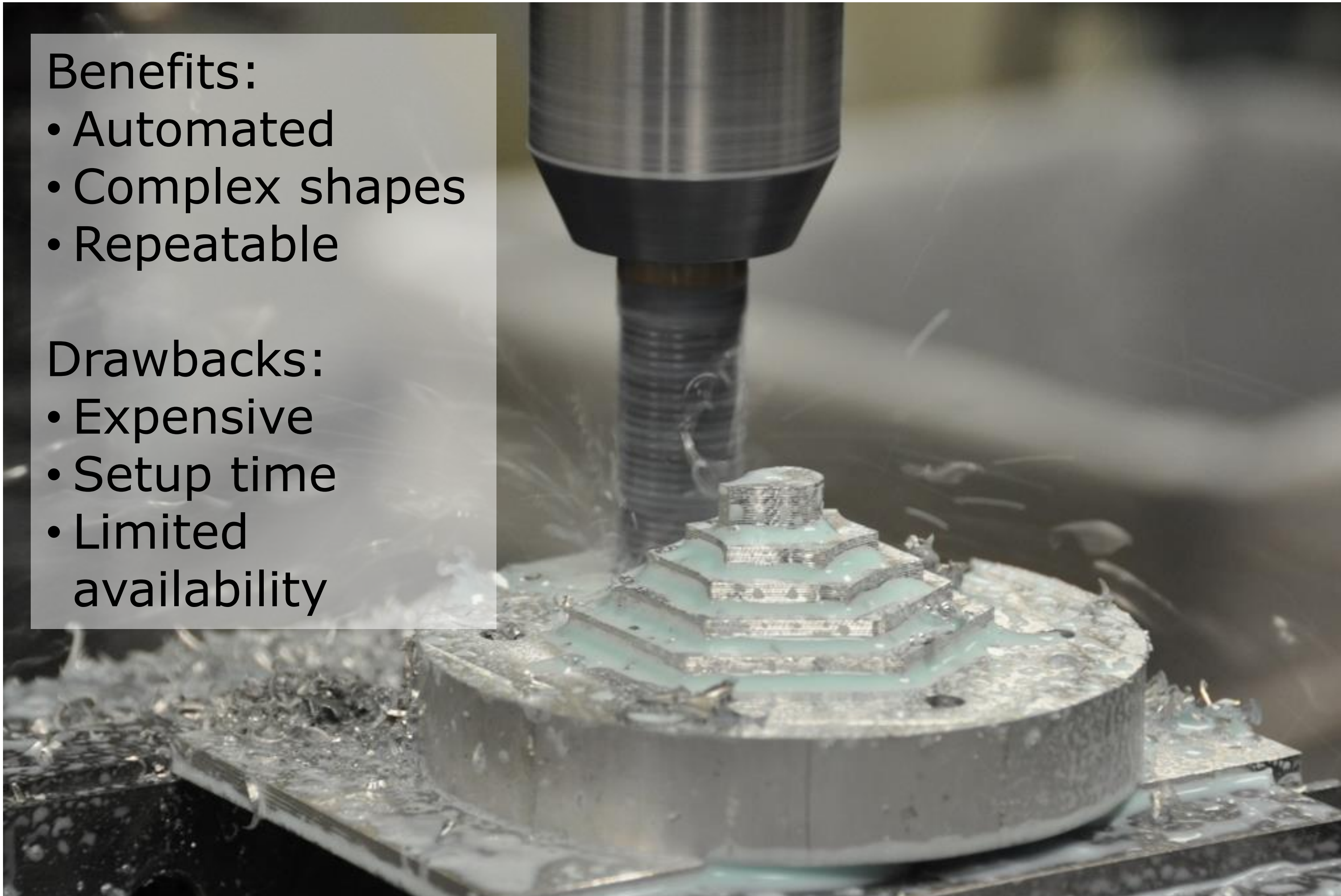


Multi-axis programming

2.5D – 3D Manufacturing and Computer Numerical Control



CNC Machining



Benefits:
- Automated
- Complex shapes
- Repeatable

Drawbacks:
- Expensive
- Setup time
- Limited availability

CNC at UPenn

Machining Center

ProtoTRAK (retrofit mill)

ProtoTRAK


ON
OFF
SAFETY INSTRUCTIONS
TRAK DPM2
WITH
PROGRAM
SPINDLE CONTROL
PROTO TRAK SMX

ProtoTRAK

Utility

- 3 axis digital readout
- Jog
- Power feed
- Cut arbitrary features in the x/y plane

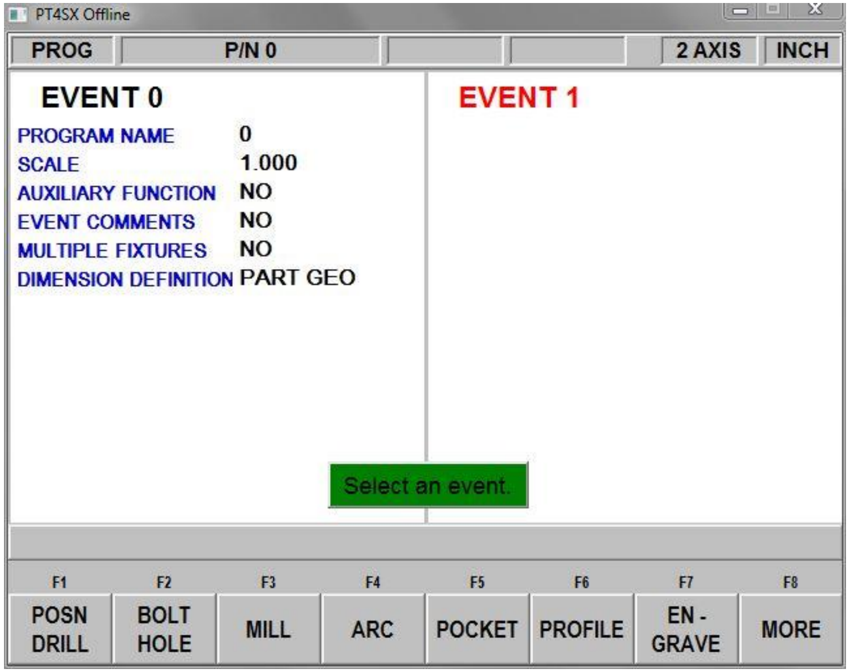
ProtoTRAK Controller
(DRO mode)

Conversational Programming

You have experienced dxf conversion / importing into the ProtoTRAK software

- Simple geometries can also be programmed conversationally on the controller
- The basic procedure is:
  1) Enter header info
  2) Program “events”
  3) Execute

Conversational Programming



Mill: Straight line profiles (with connective radii)

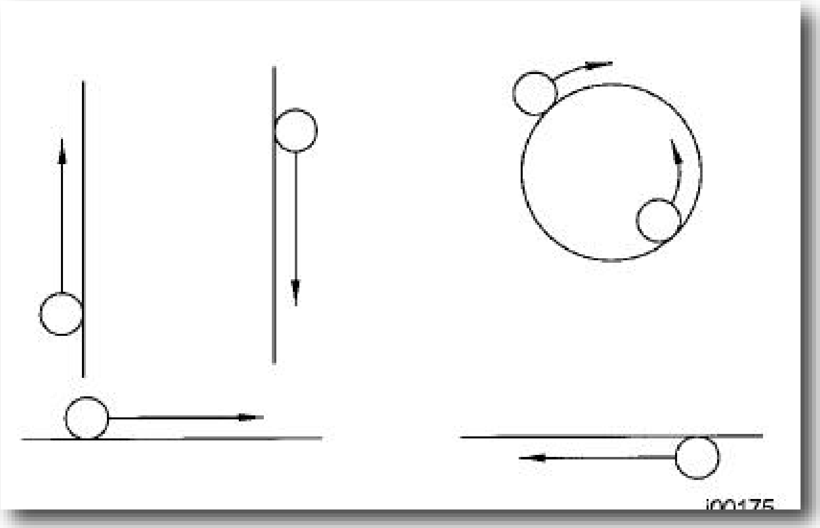
Arc: Specify beginning, end, and center of arc

Pocket: Interior circular, rectangular, or irregular pocket

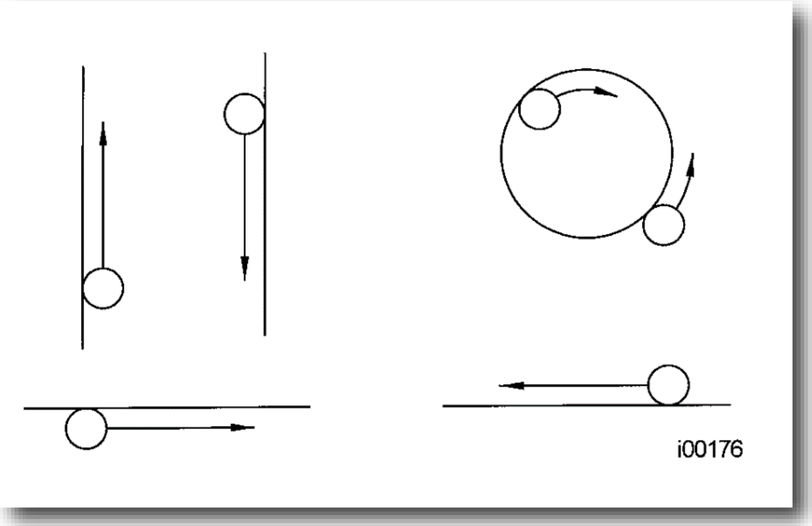
Profile: Exterior circular, rectangular, or irregular profile

Milling Side

Left



Right



ProtoTRAK Tips / Warnings

Always check Z!!!

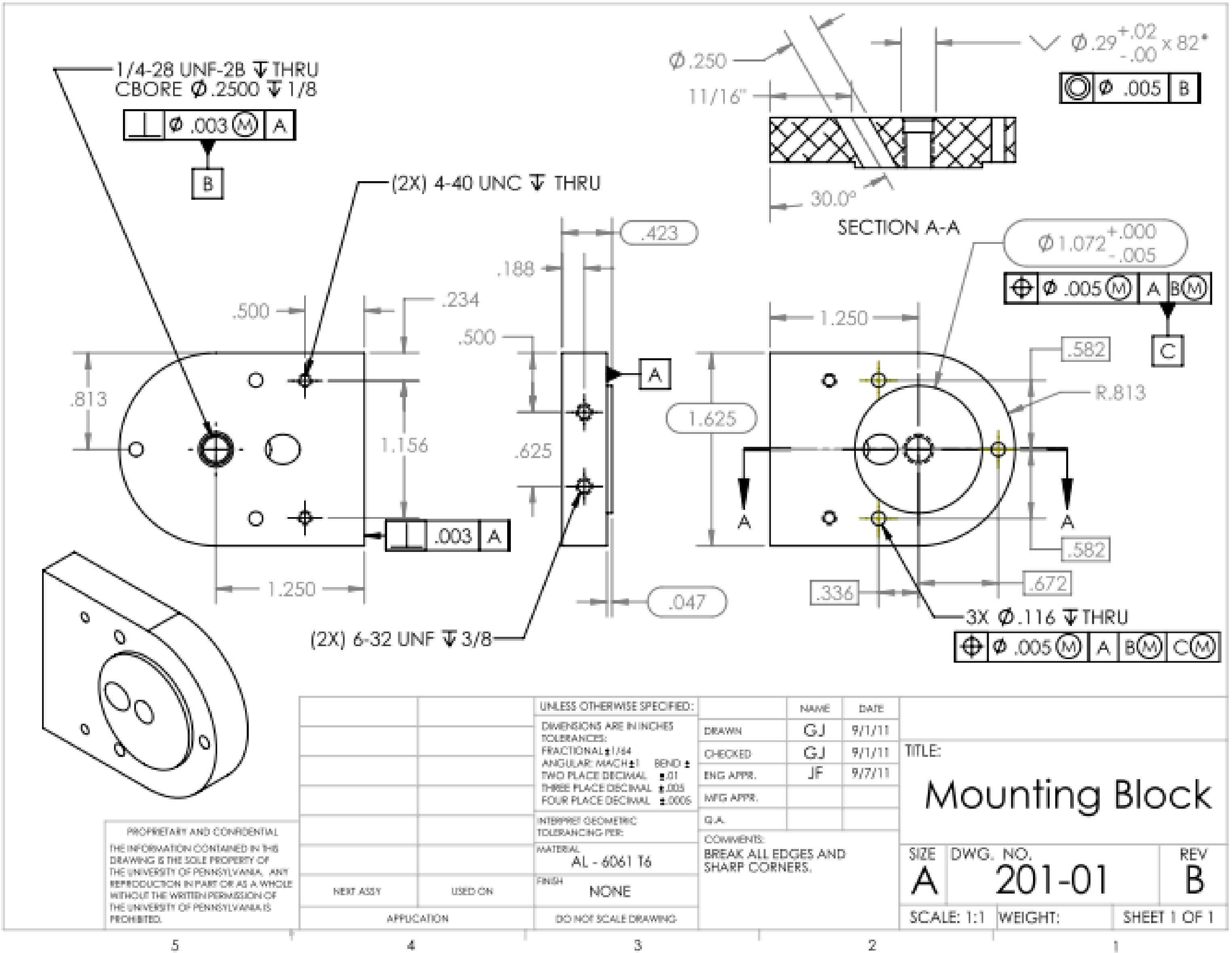
- Not doing so can cause flying metal, tool damage, machine damage, human damage
- Check Z whenever you start a milling event or move to a new milling event

Perform a test pass offset in Z from your part

- Do not perform a “trial run” as this can damage the machine

Oversize your tool (in the tool table) to allow for a finish pass

Milling the Mounting Block



Milling the Piston Flange