FBMach – Scope of Operation

STEP-NC Super Model - 6th Industrial Review Board Meeting

January 29-30, 2003 - NASA JPL, Pasadena, CA

Bill Simons, *Honeywell Federal Manufacturing & Technology
Kansas City, Missouri

Operated for the United States Department of Energy under Contract No. DE-ACO4-01AL66850.

KANSAS CITY PLANT

Honeywell

FBMach Scope - Introduction

- System Overview
- Feature - Scope
- Stock Scope
- Process Planning – Scope
- Setup - Scope
- Tooling – Scope
- Interoperability Issues

FBMach Overview

- Feature Creation
- Stock Creation
- Feature Query
- Model-Based Tolerances
- In-Process Model / In-Process Features
- Process Plan Creation
- Work Instruction Text Generation

FBMach Scope – General Description

Scope Context: Process planning and in-process model generation.

- FBMach is designed to create process plans for:
  - Prismatic Milled Parts
  - Axis-symmetric turned parts
  - Combination Prismatic Milled and Axis-symmetric turned parts
- Parts that are outside of the scope of FBMach have:
  - Un-healable geometry
  - Milled Parts with Non-Planar Bottomed Features
  - Non-orthogonal blends
  - Tapered Walls
  - Spline Surfaces
  - Bottom fillet blends must have a constant blend radius.

Feature Scope - Context

Assumptions:

- Manual Feature Construction / Element Roles
- Tolerance Integration for Queries and Automation
- Stock – any shape (AP238 not fully tested with castings)
- Process Planning Support
- Work Instruction Text Generation Support

Focus:

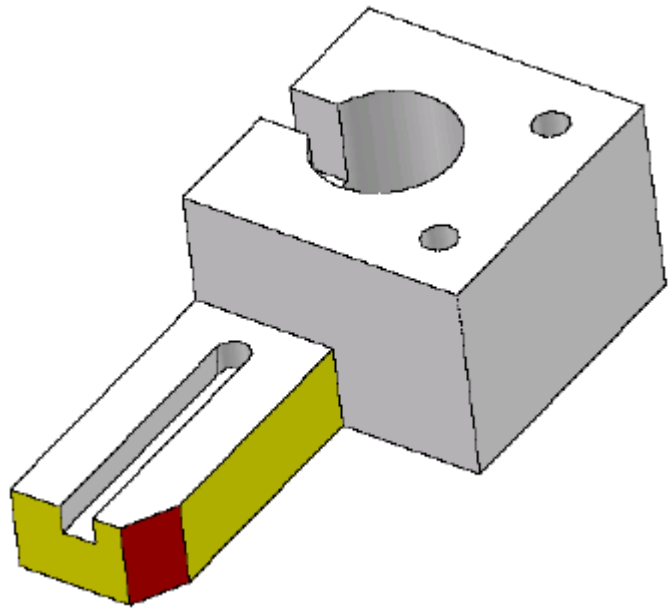
- Material Removal Features (Part Features)
- Automatic Feature Recognition
- Interactive Feature Recognition (with a hint)
- Queries
- AP238 Feature Export (Assume Process Plan Support)
- In-Process Feature Generation

Chamfer Feature

Auto Recognition	Interactive Recognition	Shape Queries	In-Process Feature	AP238 Export
X		X	(In-Process Model Only)	

Notes:

- Composite chamfers are currently handled with Generic features, a true feature is needed.

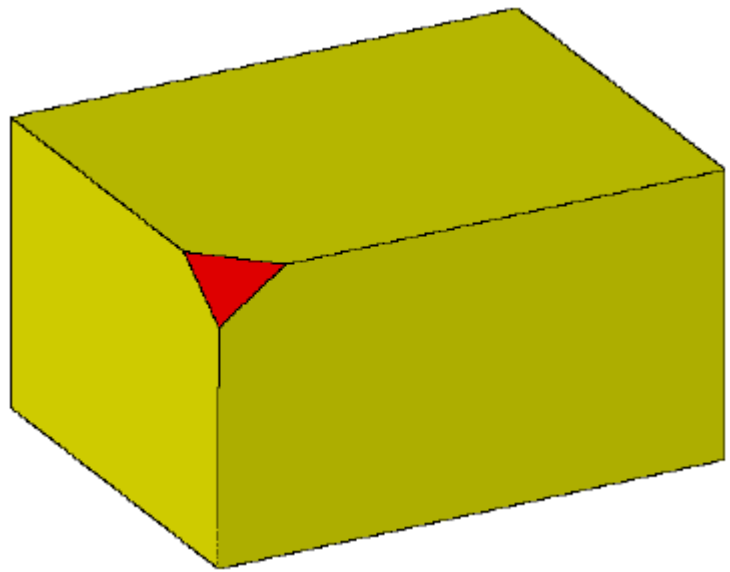


Corner Feature

Auto Recognition	Interactive Recognition	Shape Queries	In-Process Feature	AP238 Export

Notes:

- Can be handled by Planar Face

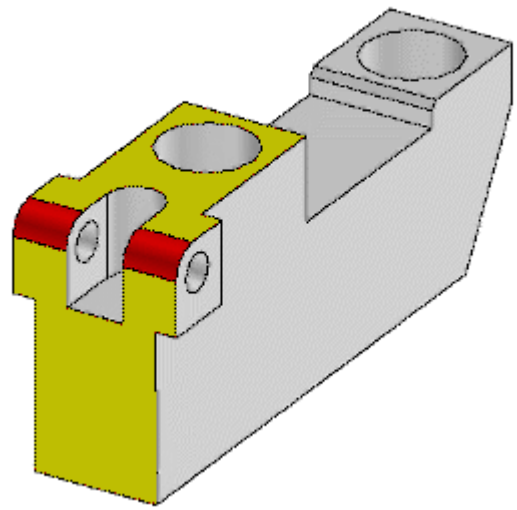


Corner Round Feature

Auto Recognition	Interactive Recognition	Shape Queries	In-Process Feature	AP238 Export
X			(In-Process Model Only)	

Notes:

- Composite corner rounds are currently handled with Generic features, a true feature is needed.
- Composite corner rounds should be added to AP238 Export because they are common.

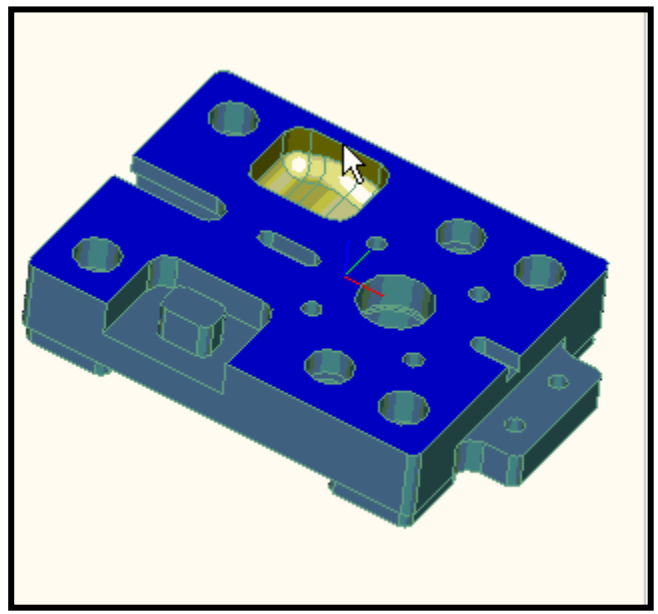


General Closed Depression Feature

Auto Recognition	Interactive Recognition	Shape Queries	In-Process Feature	AP238 Export
	X			X

Notes:

- Temporary Solution
- Only work for closed depression
- Need requirements for non-analytic surface support.

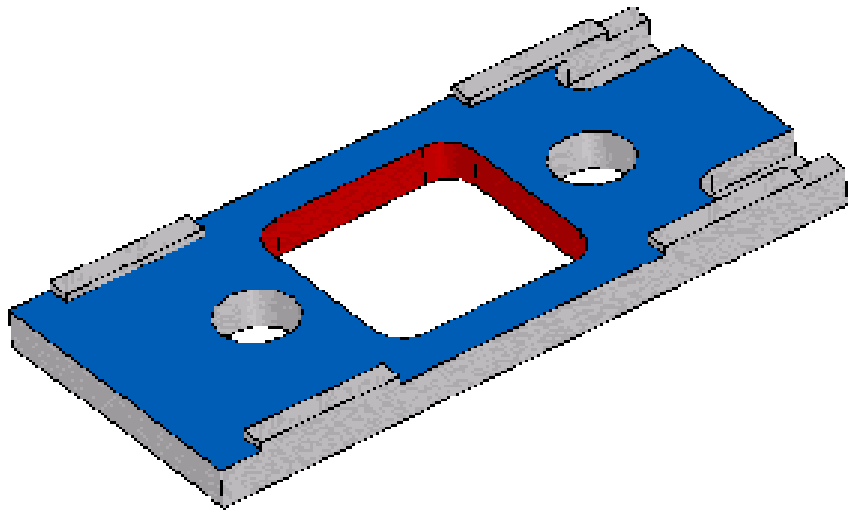


General Cutout Feature

Auto Recognition	Interactive Recognition	Shape Queries	In-Process Feature	AP238 Export
X	X	X	X	X

Notes:

- Internal cutout loop must exist on top or bottom adjacent face.
- Typically correspond with Pocket type in-process features

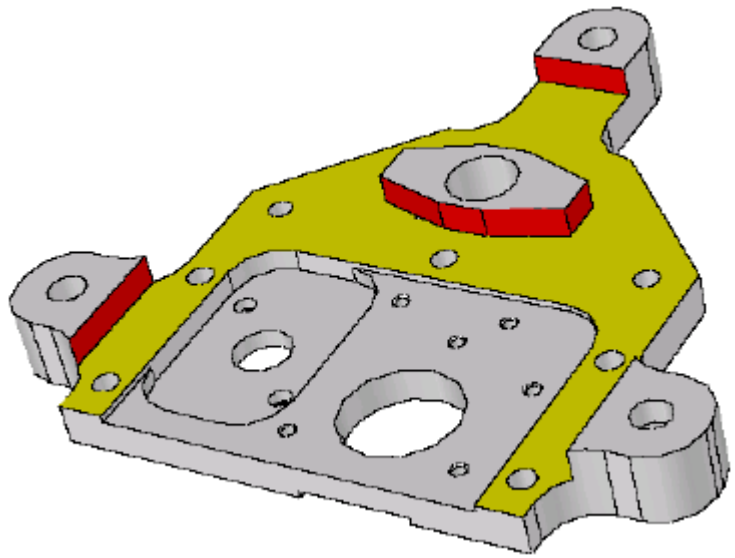


General Removal Feature

Auto Recognition	Interactive Recognition	Shape Queries	In-Process Feature	AP238 Export
X	X	X	X	X

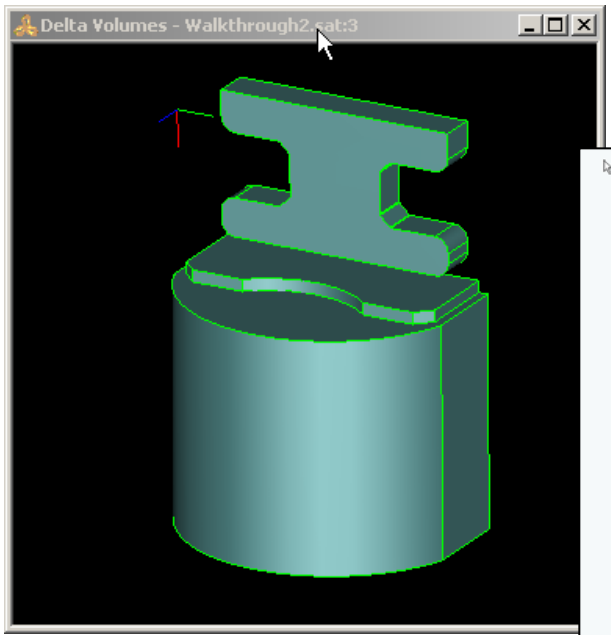
Notes:

- Does not currently handle tapered sides
- Used for 3 AP238 Features:
  - *Removal Volume*
  - *Flat Face with Boss*
  - *Open Pocket*
- Bottom Fillet Blends are supported, but continue to be a challenge.

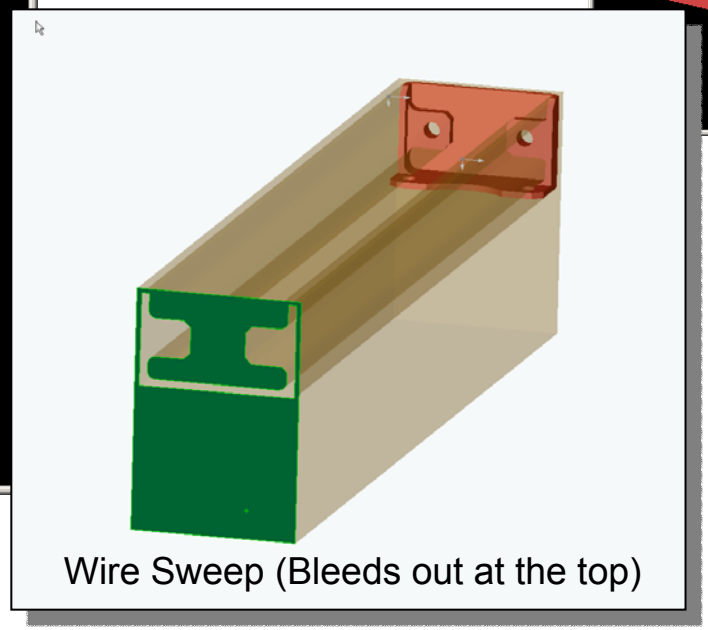


General Removal Limitations

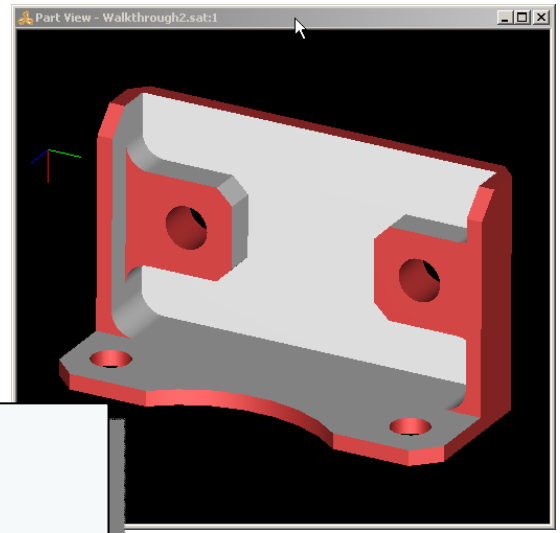
- Clipping Spaces need intelligent constraints:



Resulting Delta Volume



Wire Sweep (Bleeds out at the top)



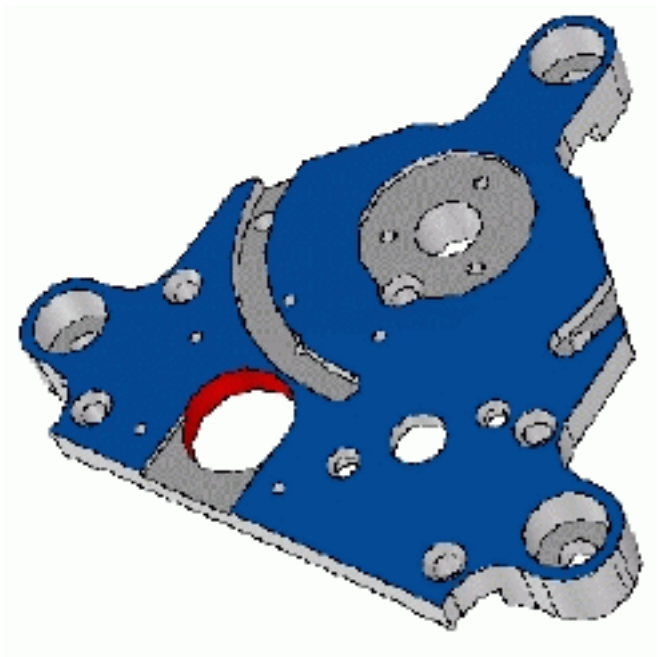
General Material Removal Feature

Hole Feature

Auto Recognition	Interactive Recognition	Shape Queries	In-Process Feature	AP238 Export
X	X	X	X	X

Notes:

- Auto-feature recognition does not recognize spherical bottomed holes.
- In-process feature automation does not handle top-adjacent faces that are non-planar.
- Non-chamfer – tapered holes are not supported by Automatic and Interactive feature recognition.

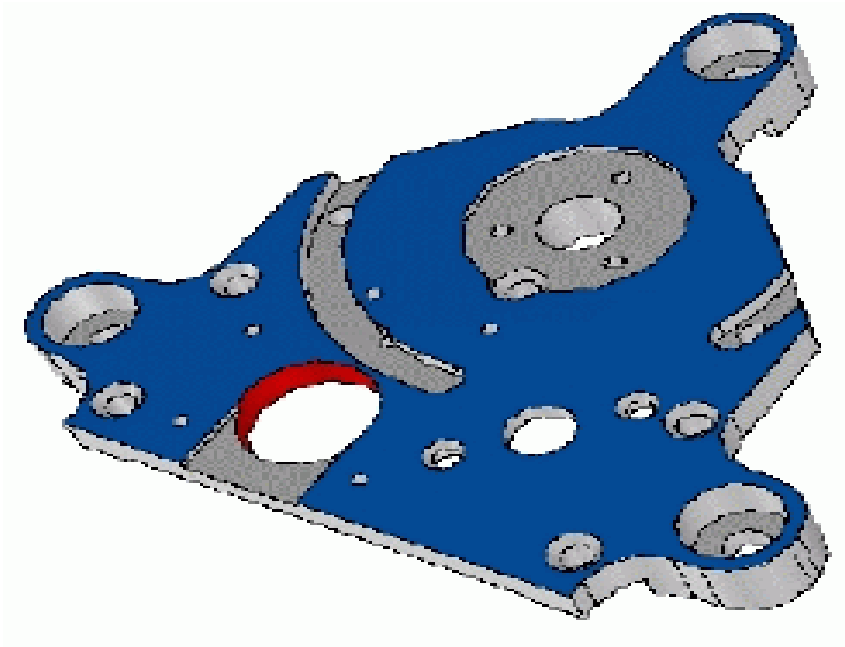


Threaded Hole Feature

Auto Recognition	Interactive Recognition	Shape Queries	In-Process Feature	AP238 Export
X	X	X	X	X (no threads)

Notes:

- The system recognizes a threaded hole if a thread has been previously assigned to a side element of the hole.

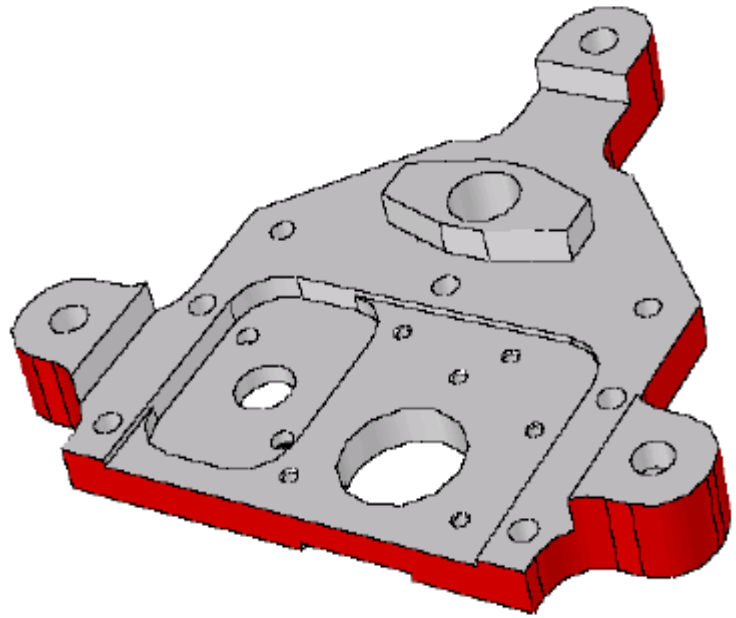


Periphery Feature

Auto Recognition	Interactive Recognition	Shape Queries	In-Process Feature	AP238 Export
X	X	X	X	X

Notes:

- Does not currently handle tapered sides
- Automatic and Interactive recognition does not handle:
  - blind peripheries
- Automatic feature recognition does not handle sharp cornered peripheries.
- Clipping space algorithms do not add extra material in corners where tool is larger than the part radius.

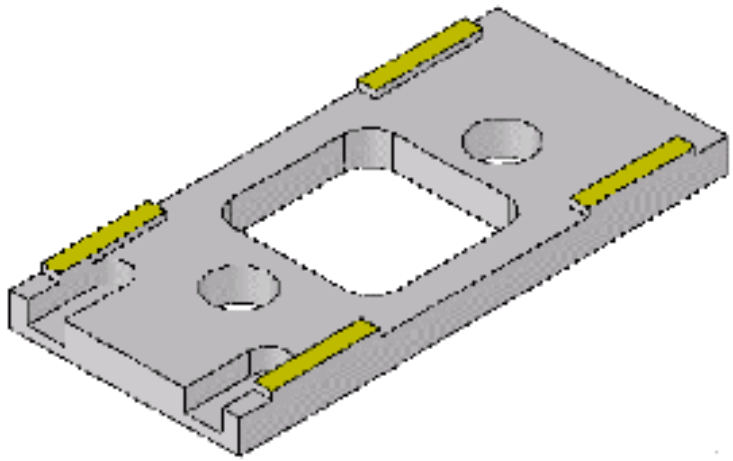


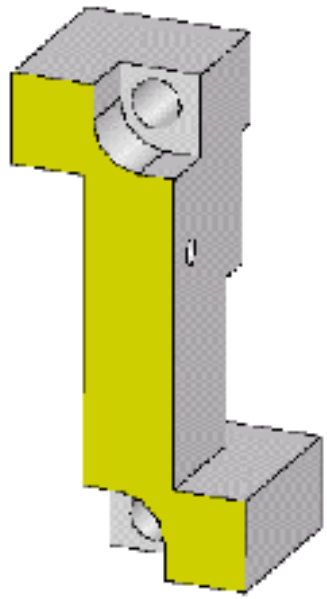
Planar Face Feature

Auto Recognition	Interactive Recognition	Shape Queries	In-Process Feature	AP238 Export
X	X	X	X	X

Notes:

- Planar faces translate to flat-face.
- Planar faces are designed only for exterior planar faces and therefore do not translate to flat-face with boss.



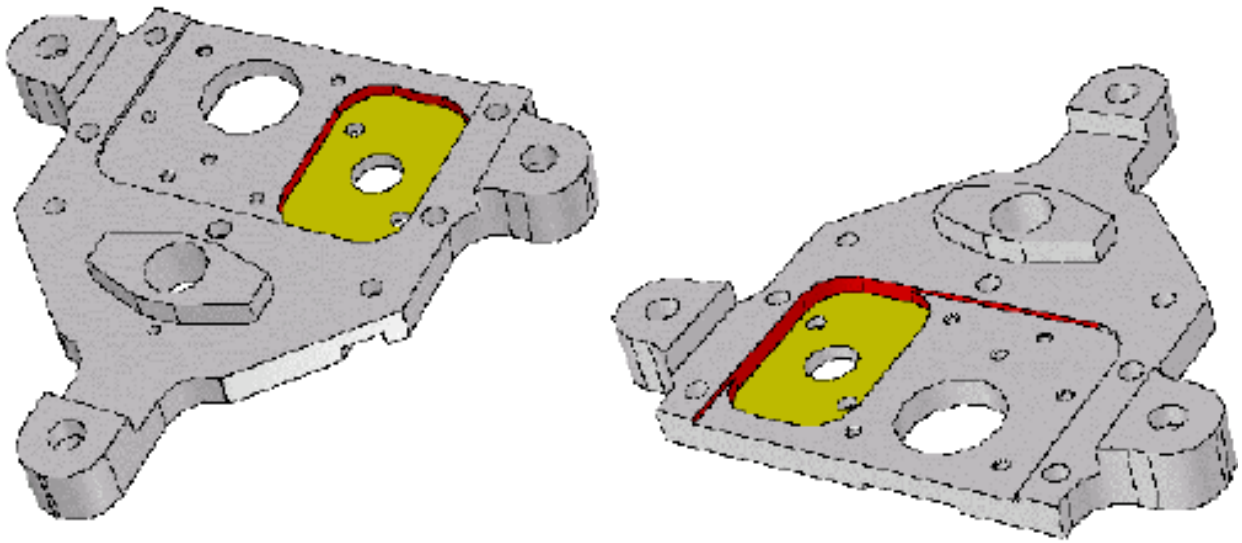


Pocket Feature

Auto Recognition	Interactive Recognition	Shape Queries	In-Process Feature	AP238 Export
X	X	X	X	X

Notes:

- Does not currently handle tapered sides
- All side faces must be closed; therefore, “open pocket” does not correspond with FBMach pockets.
- Bottom Fillet Blends are supported, but continue to be a challenge. (geometric anomalies)

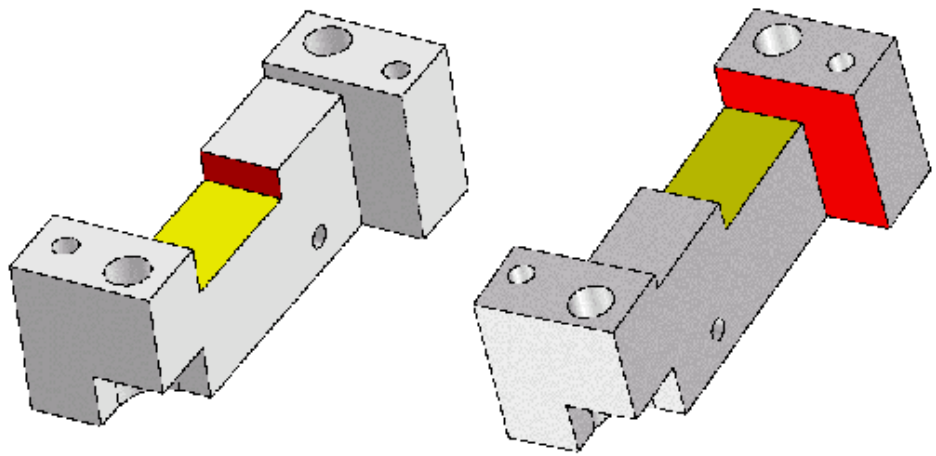


Slot Feature

Auto Recognition	Interactive Recognition	Shape Queries	In-Process Feature	AP238 Export
X	X	X	X	X

Notes:

- Scoped for non-tapered linear slots
- Bottom blends and closed ends are supported.

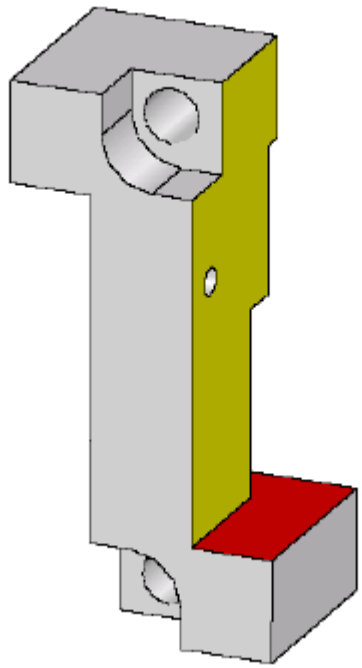


Step Feature

Auto Recognition	Interactive Recognition	Shape Queries	In-Process Feature	AP238 Export
X	X	X	X	X

Notes:

- No concave corners on the sides
- Does not currently handle tapered sides
- Bottom blends are supported.

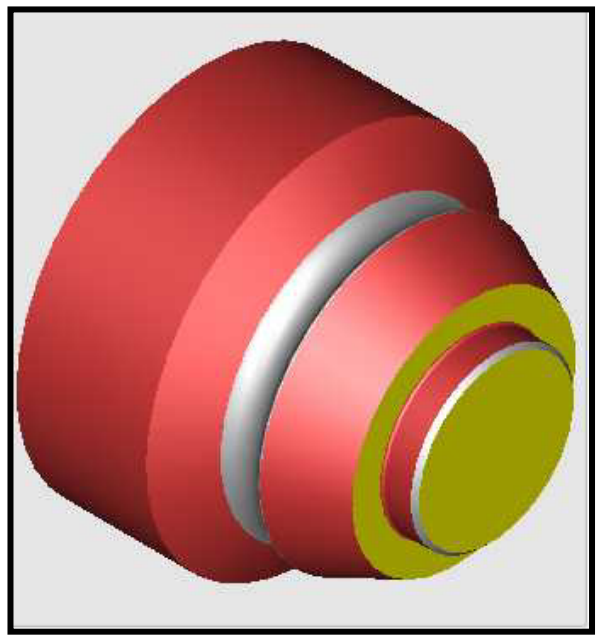


General Revolution Feature

Auto Recognition	Interactive Recognition	Shape Queries	In-Process Feature	AP238 Export
	X		(In Process Model Only)	

Notes:

- Coaxial faces
- Current development focused on generating in-process models
- Designed to support feature interactions

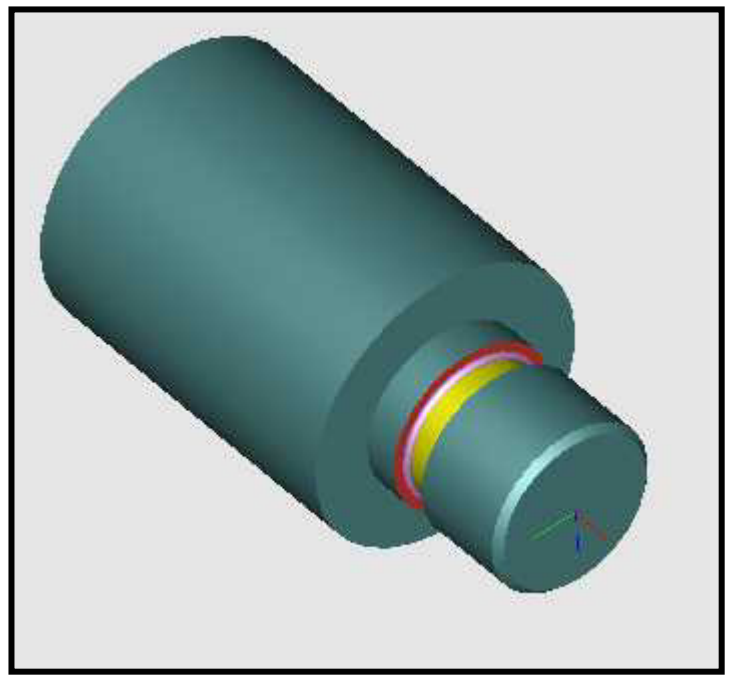


Groove Feature

Auto Recognition	Interactive Recognition	Shape Queries	In-Process Feature	AP238 Export
	X		(In Process Model Only)	

Notes:

- Coaxial faces
- Current development focused on generating in-process models
- Designed to support feature interactions

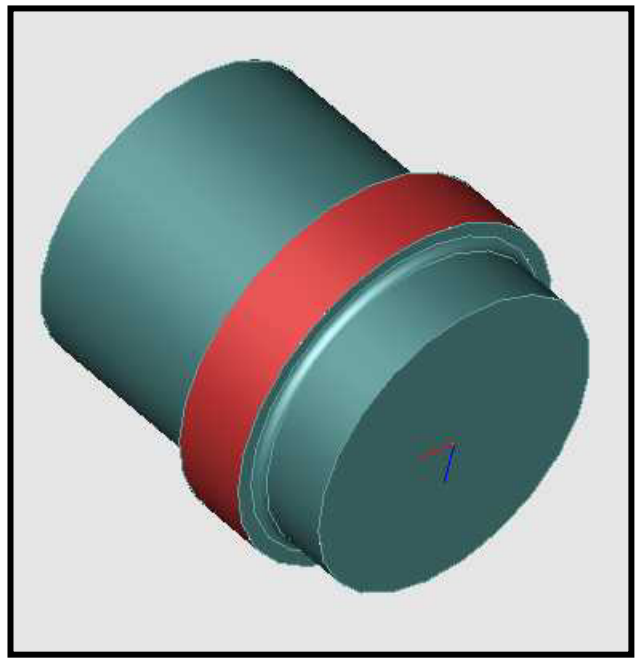


Outer Round Feature

Auto Recognition	Interactive Recognition	Shape Queries	In-Process Feature	AP238 Export
	X		(In Process Model Only)	

Notes:

- Coaxial faces
- Current development focused on generating in-process models
- Designed to support feature interactions

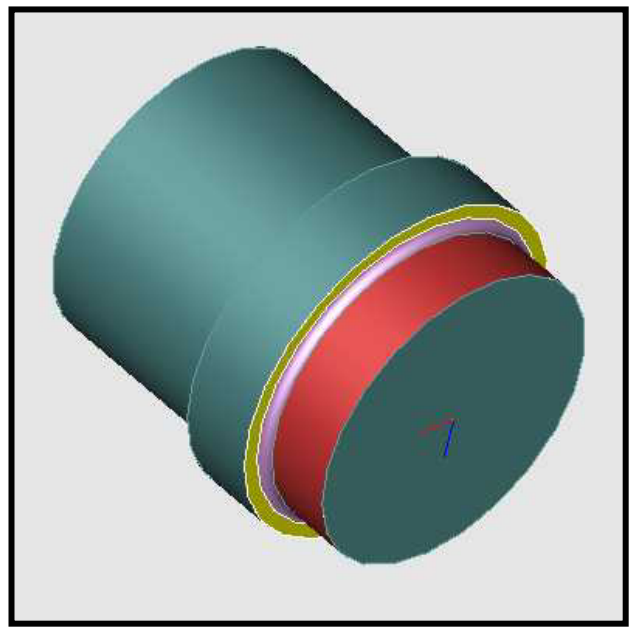


Outer Round To Diameter Feature

Auto Recognition	Interactive Recognition	Shape Queries	In-Process Feature	AP238 Export
	X		(In Process Model Only)	

Notes:

- Coaxial faces
- Current development focused on generating in-process models
- Designed to support feature interactions



Automatic Process Plan Generation - Scope

- Prototypical capability generates:
  - One Sequenced Operation
  - Tool Usage Group containing cuts to be machined by one common cutting tool
  - Cutting Tool Requirements for each tool usage group
- Prototype uses the following information for input
  - Feature Type
  - Feature Shape
  - Tolerances
- Following inputs are currently out of scope
  - Part Material
  - Feature Orientation
  - Setup Information
  - Fixture Information

Setup Scope

The following capabilities currently exist:

- Fixture Constraints – Interactive tools to constrain a given set of cuts
- Interactive Orientation – Interface includes tools for complete control of part and stock orientation

The following capabilities are planned:

- Automatic Orientation
- Fixture import

The following capabilities are currently out of scope:

- Multiple Part Setup

Interoperability Issues

- Gaps
- Split Surfaces
- Non-analytic Surfaces
- Tiny Edges
- Tiny Faces
- Units

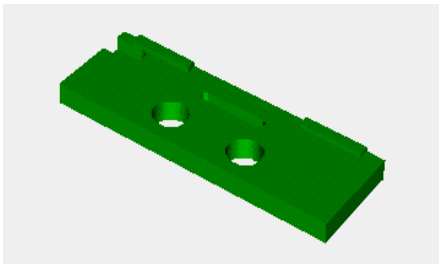
Cutting Tool Scope

Tool Type	Currently Supported	April 2003	October 2003
Bore	X		
Counter Bore	X		
Corner Round End Mill	X		
Counter Sink	X		
Center Drill	X		
Drill	X		
End Mill	X		
Reamer	X		
Shell Mill	X		

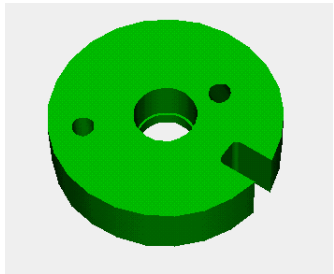
Cutting Tool Support

Tool Type	Currently Supported	April 2003	October 2003
Extended Cutting Tool Body Parameters		X	
General Insert Support		X	
Face Turn		X	
OD Threading		X	
Grooving		X	
Cutting Tool Assemblies			X
Extensions			X
Collets			X
Extended Holder Support			X

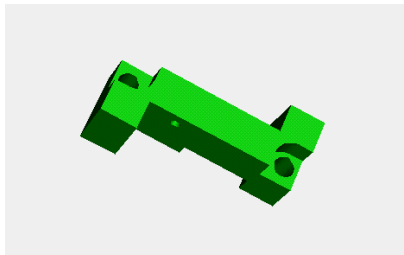
Milling Test Parts



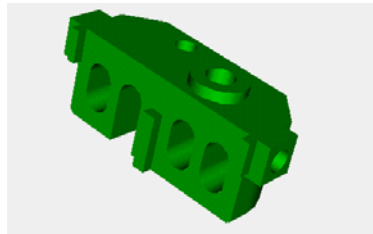
Edge Retainer
3999092



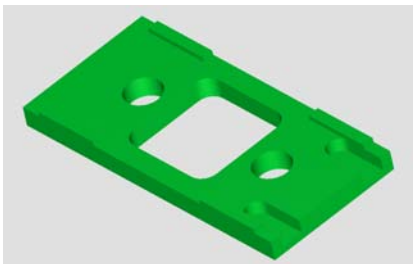
Puck



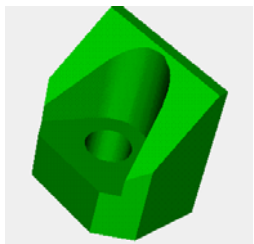
Bracket 399166



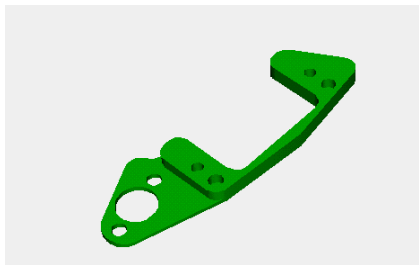
Spinner 399093



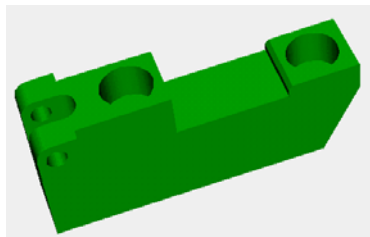
Center Retainer
399091



Short Block
249433-00

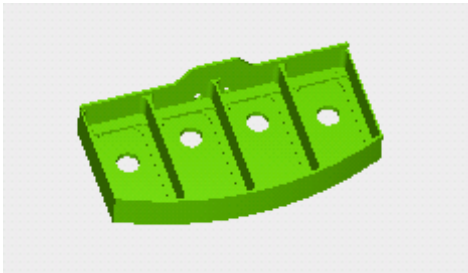


Bracket 390131

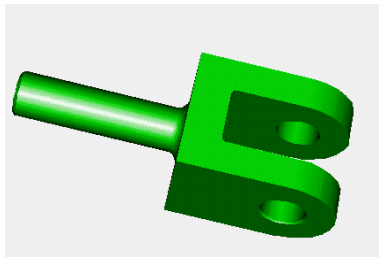


SwitchArm 297942

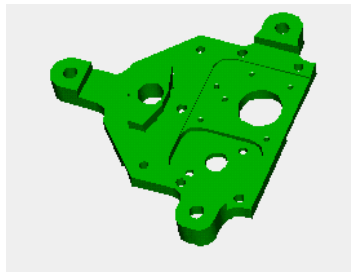
Milling Test Parts



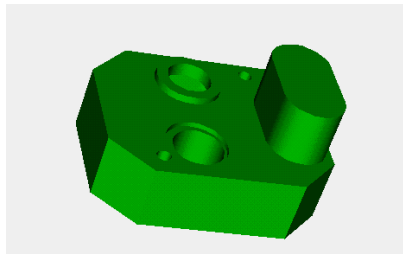
Boeing Part



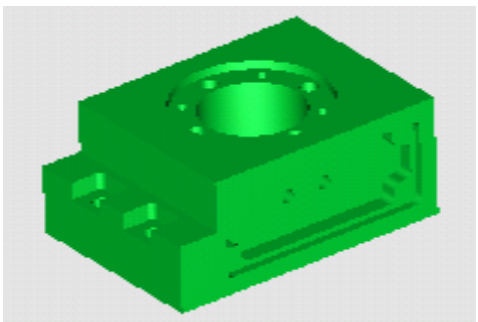
Clevis



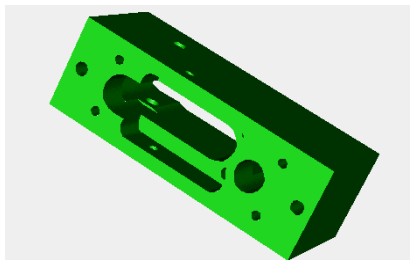
1797609in



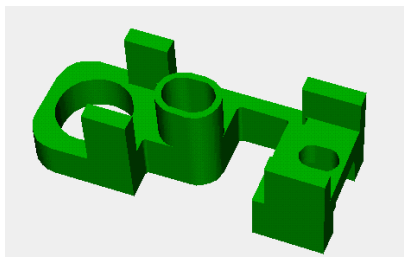
Part06



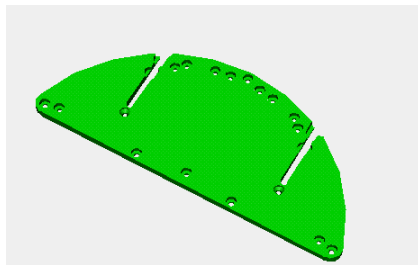
Demo04



KAMI

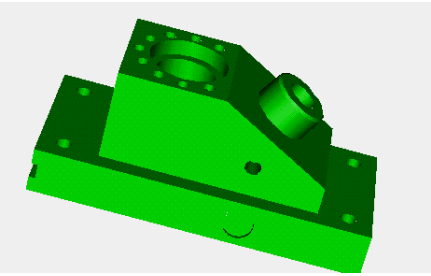


Kim2

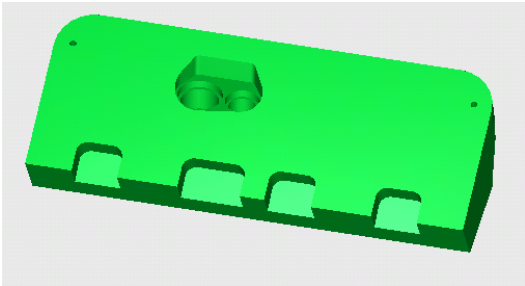


Baseplate 322107

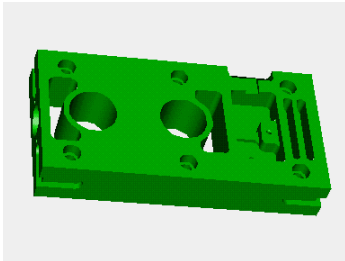
Milling Test Parts



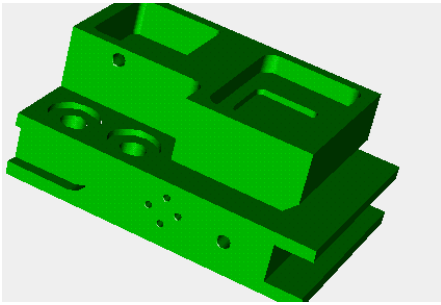
ANC101



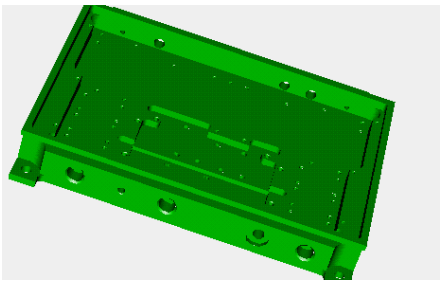
Limited V8 Head



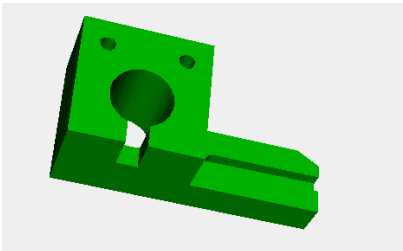
TEAM Plate7



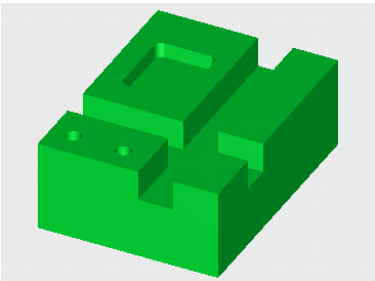
IAMS



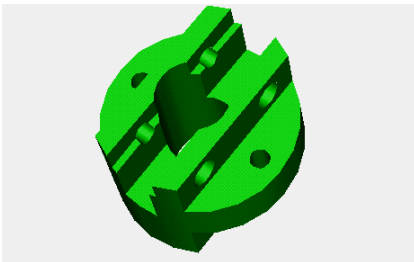
2827056



Sqrkey102

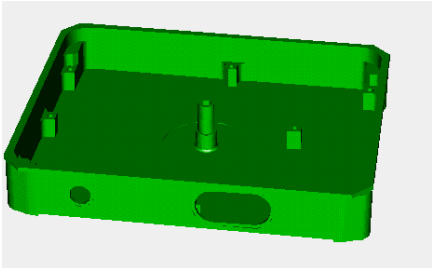


Criscrs

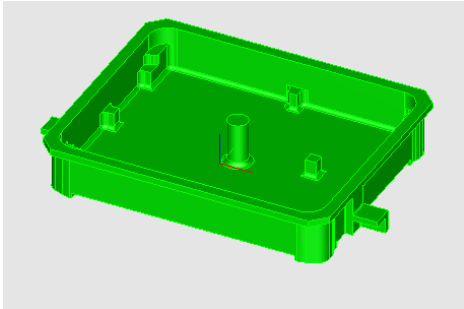


Socket

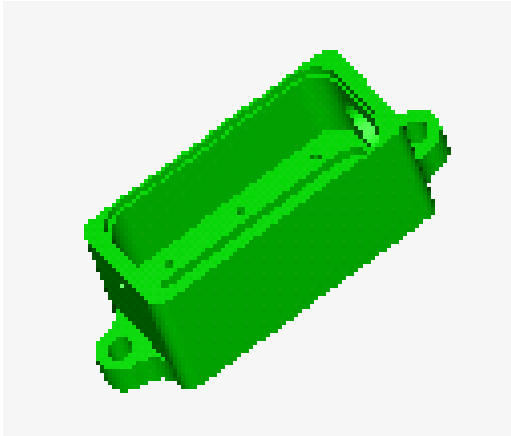
Milling Test Parts



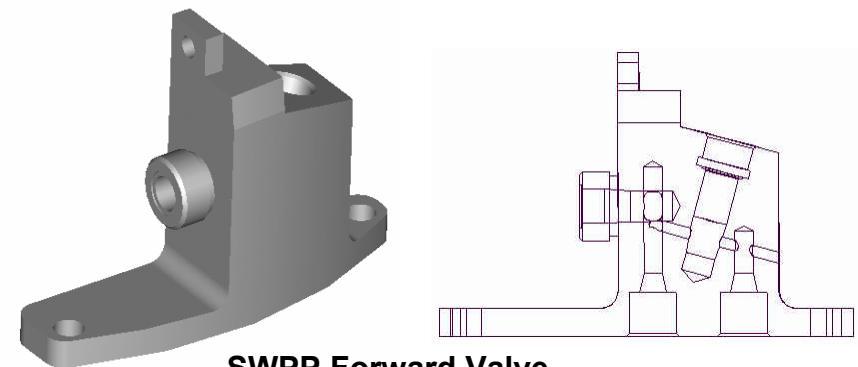
Housing 390027



Housing 390027 - Casting

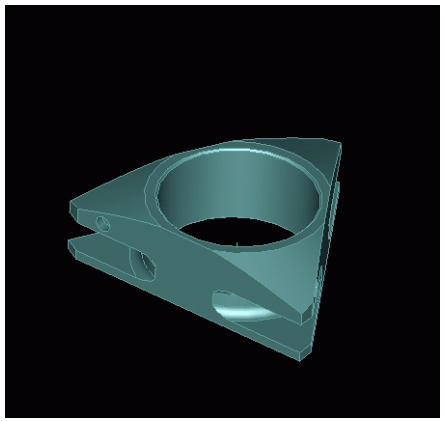


B61-MERX

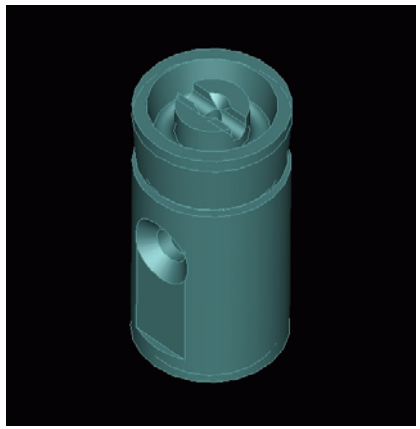


SWPP Forward Valve

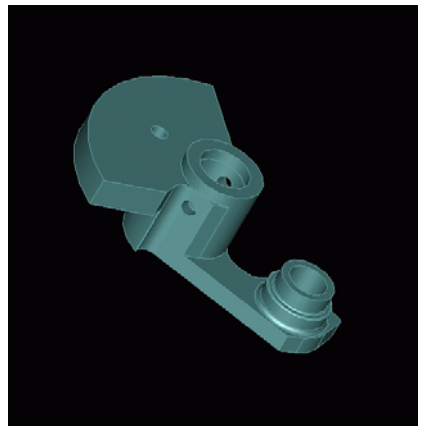
Milling Test Parts



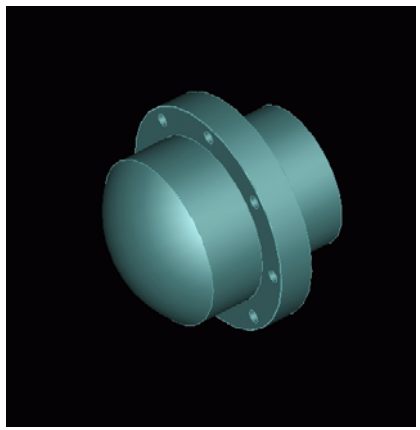
IAMS 7111



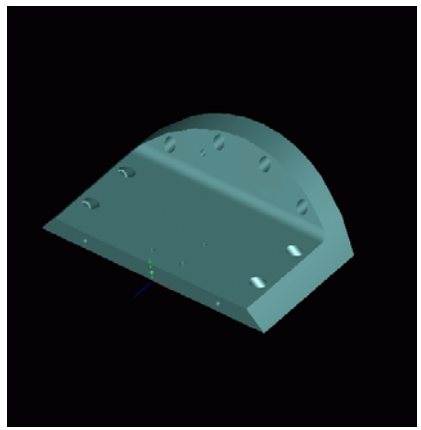
RB082498



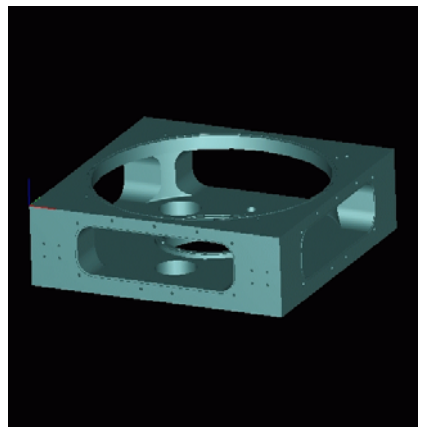
702367



LANL 7968

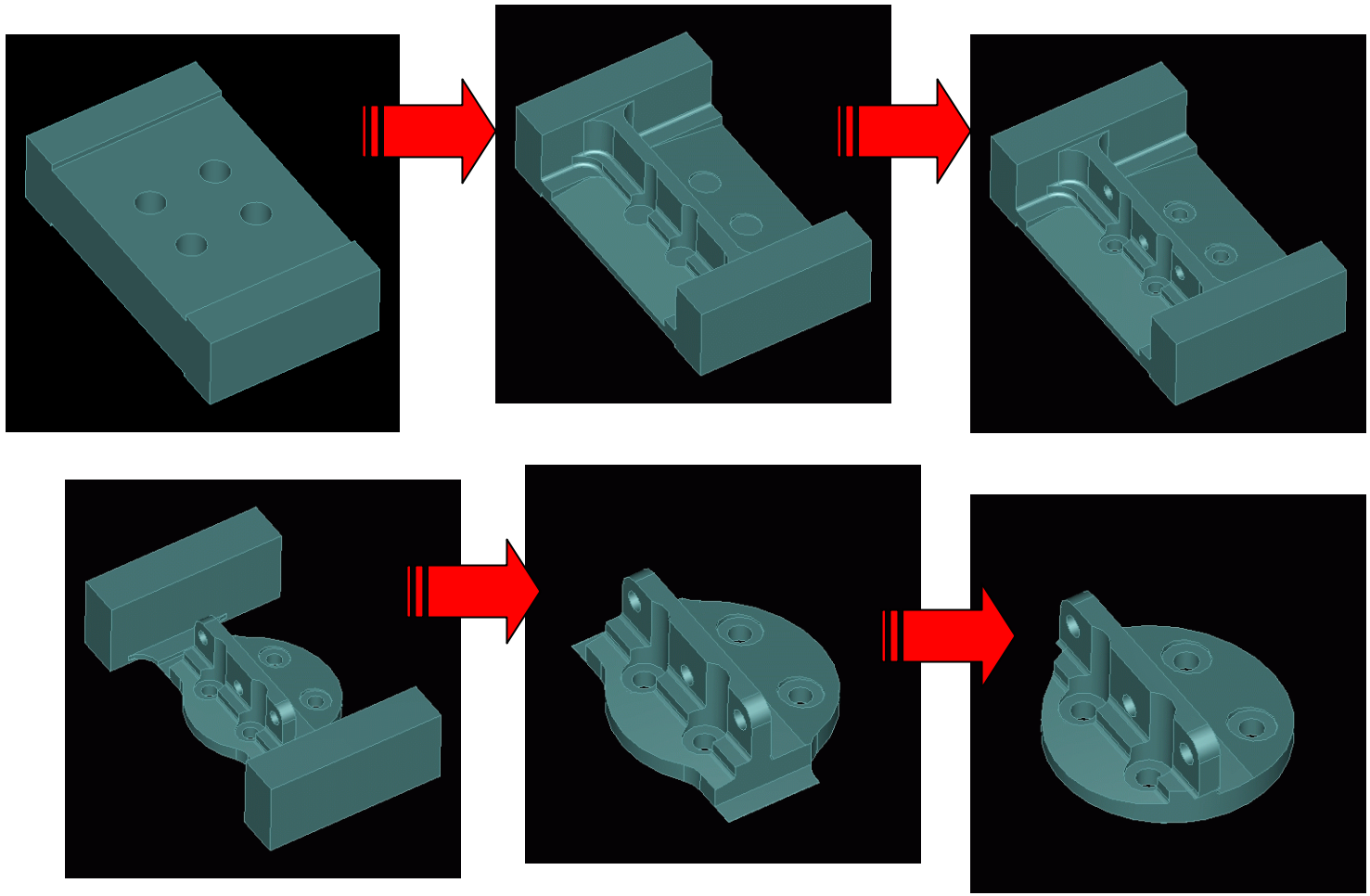


LANL 7971

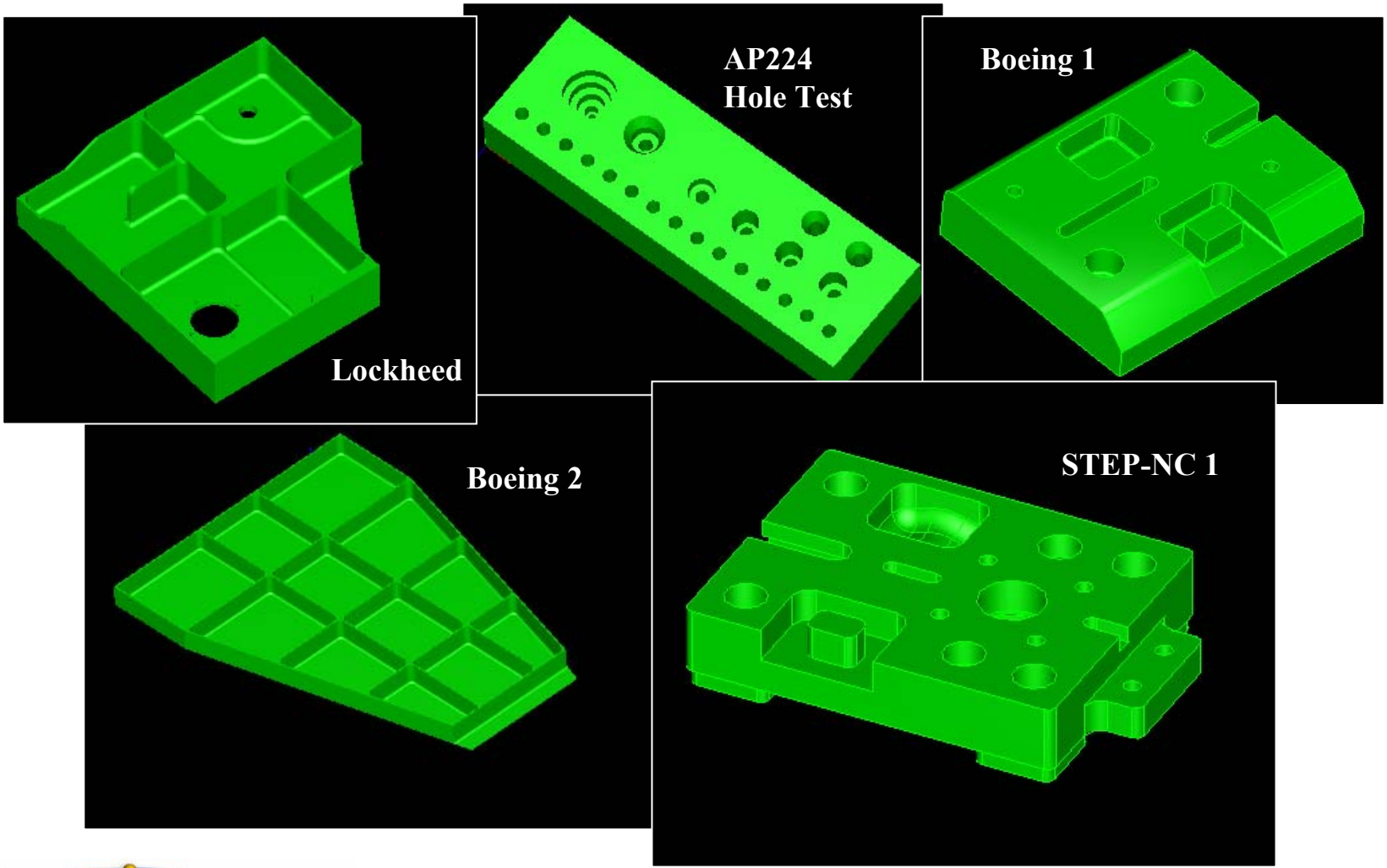


Maine Machine

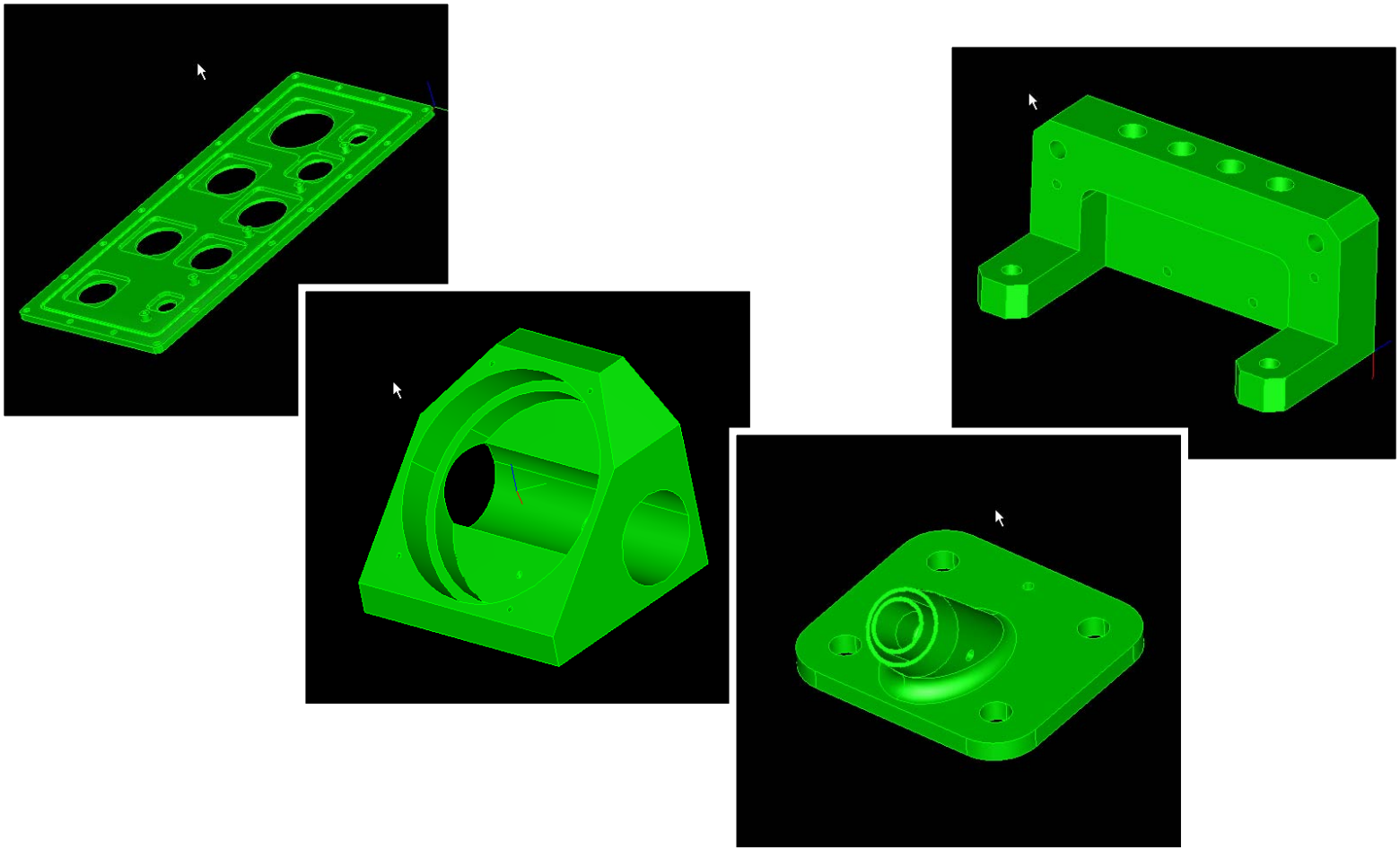
704353 In Process Models



STEP-NC Test Parts



STEP-NC Test Parts



Turning Test Parts