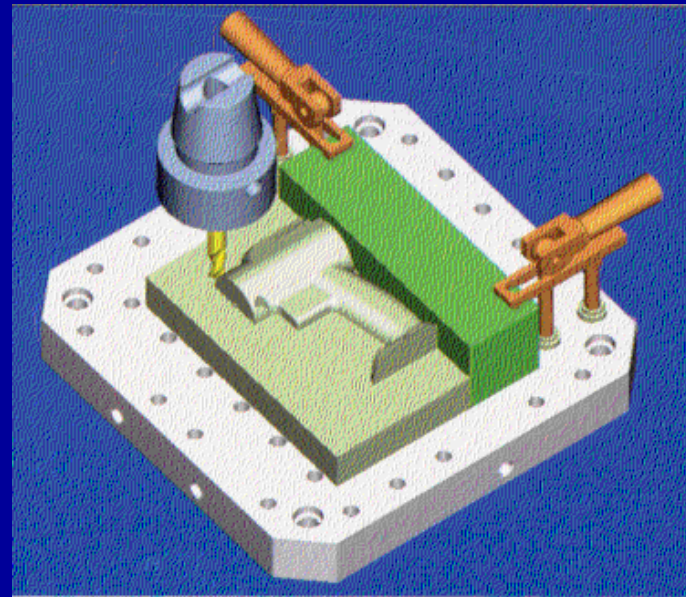
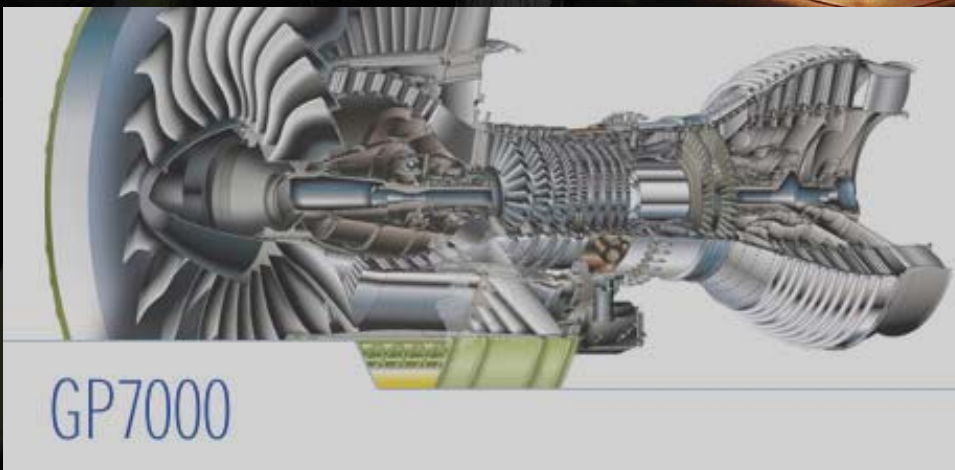


Computer Numerically Controlled (CNC) Machining and Tool Path Programming

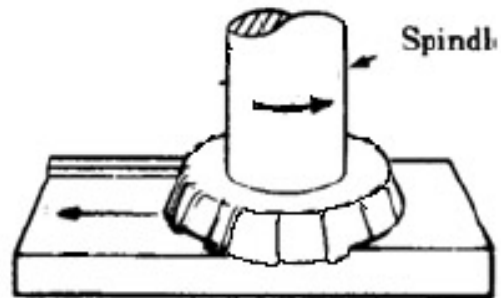


CNC Machining of Complex Surface Parts

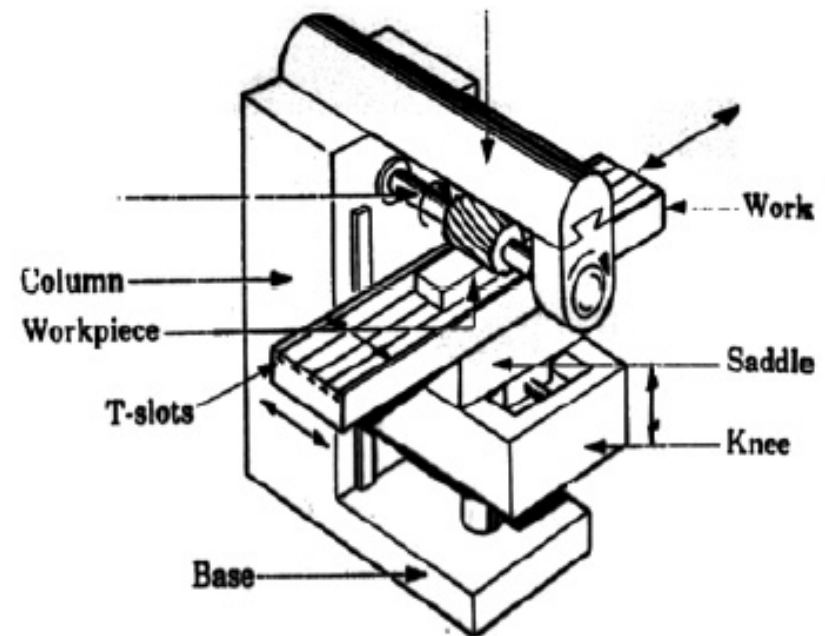
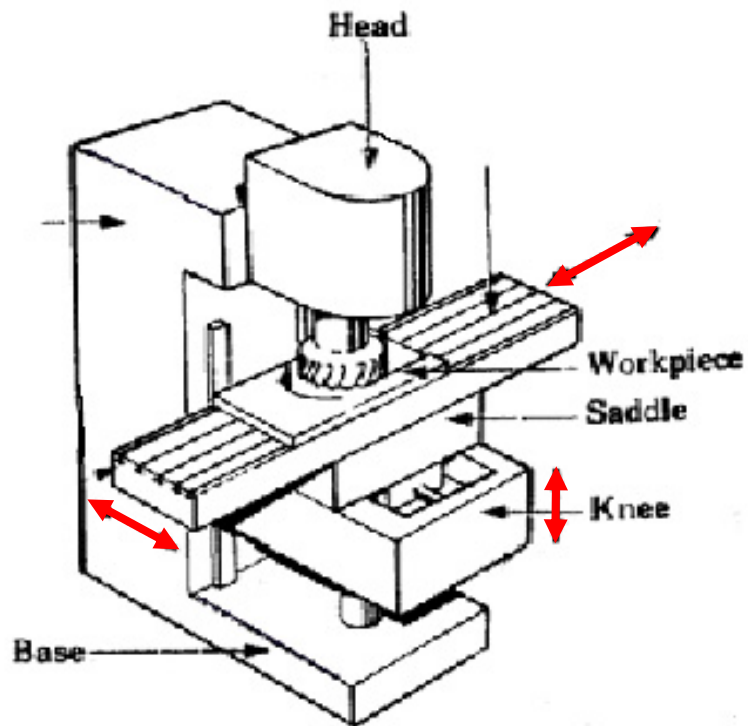
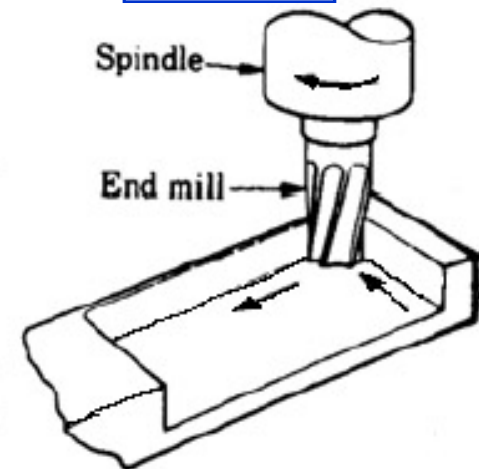


2 1/2 and 3 Axis Milling

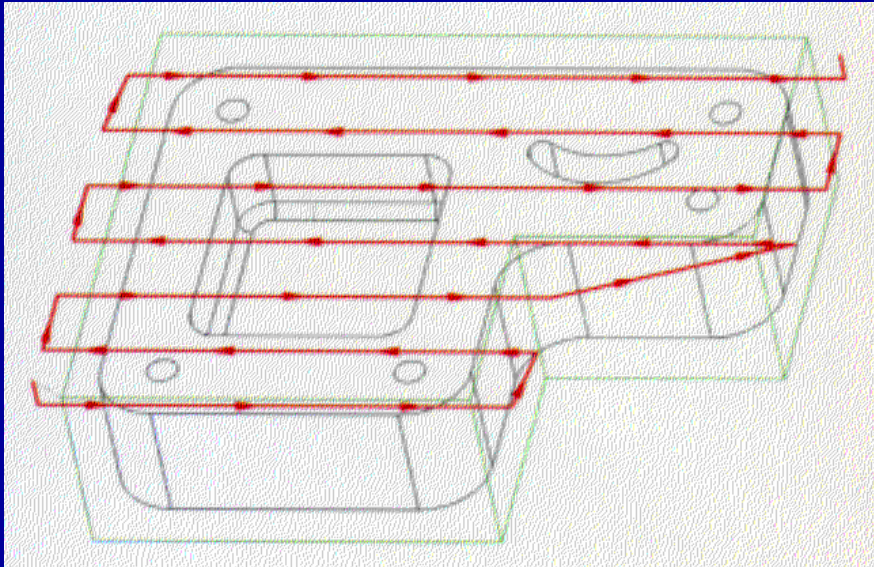
Face milling



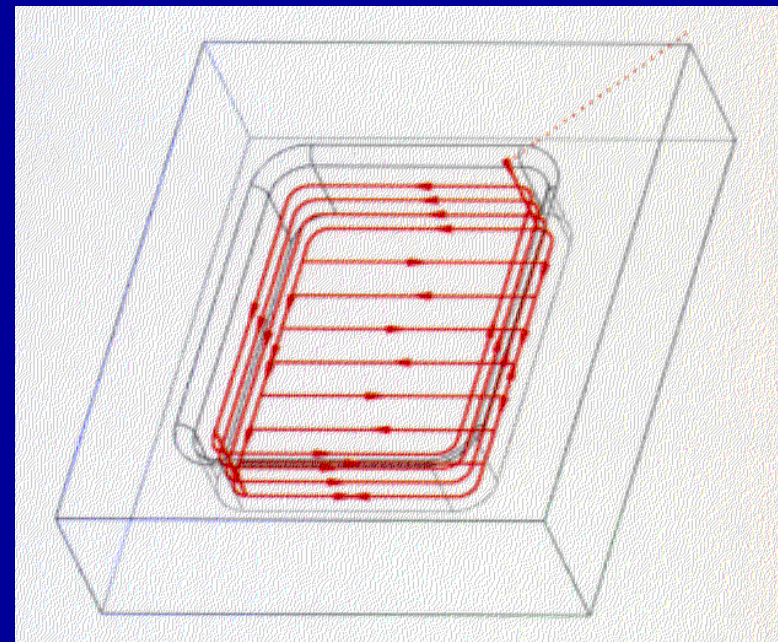
End milling



Face Milling



Pocketing



Three-Axis CNC Machines

- In 3-axis CNC vertical machine, the working table moves along x- and y-axis, and the tool along z-axis.
- In machining, tool orientation is fixed, either in vertical or horizontal direction.
- If all surfaces to be machined are accessible by the cutter in one setup, select a 3-axis CNC machine.

Synchronized Motions in 3 Axis



Five-Axis CNC Machines

- X-, Y-, and Z- Axis Motions and A- and B- axis Rotations (**Simultaneously**)
- Tool orientation can be changed simultaneously during machining.
- If some surface patches to be machined are not accessible by the cutter in one setup, consider to use a 5-axis CNC machine.



Five-Axis CNC Machines



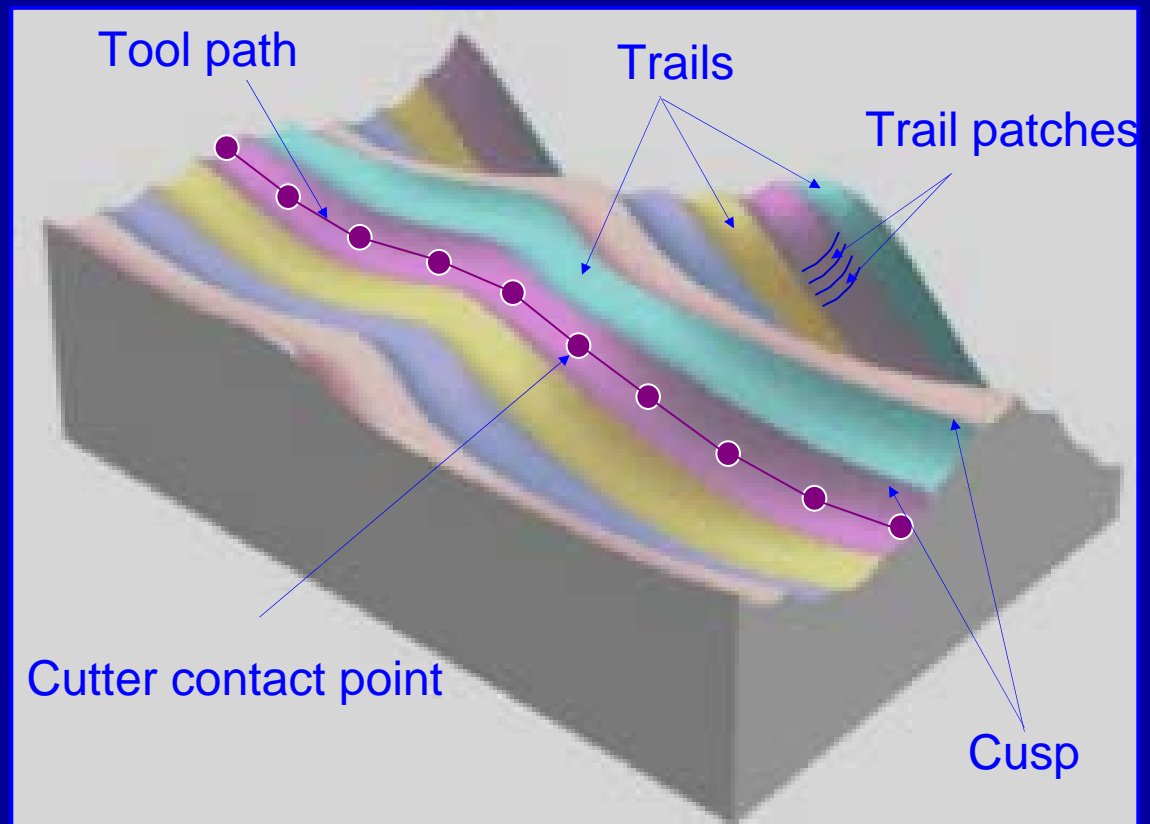
Five-Axis CNC Machining



Cincinnati V5-2000 5-Axis
CNC Machining Center

Machined Surface

- CAD Model of the Surface
- Tool Path Generation
- Simulation of Cutting
- Accuracy of the Machined Surface
- Over-cut and Over Cut Detection



Computer-Aided Manufacturing (CAM)

CNC Tool Path Programming

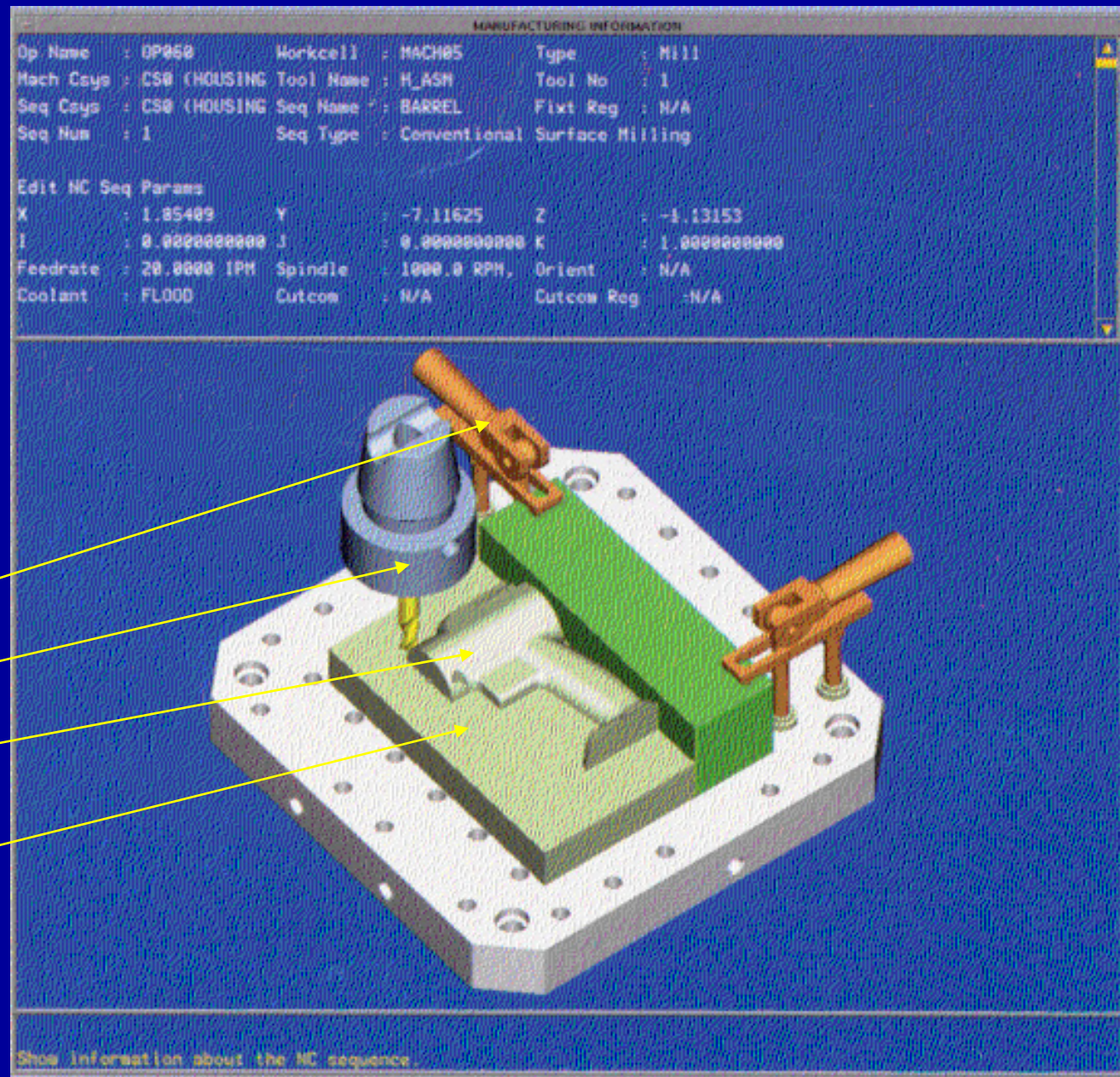
- ...
- Automatic **Tool Paths** Generation for CNC Machining from CAD Models
- Tool Path **Verification** and Graphical **Simulation** of CNC Machining
- CNC Post-Processor for Machine Dependant **G-code** Generation

Tool Path Generation, Machining Simulation

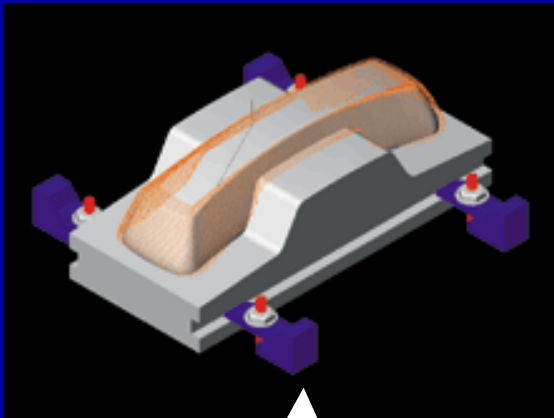
3-Axis Milling

- Fixture
- Cutter
- Part
- Workpiece

NC Sequence

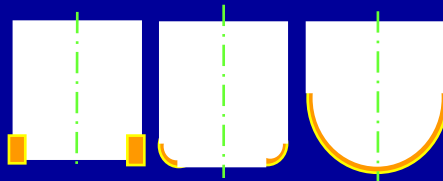


Tool Path Generation and Machining Simulation

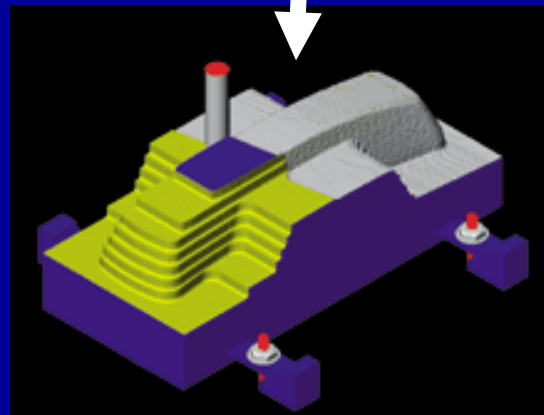


Generate 3-axis
CNC tool paths
for the mold of a
phone handset

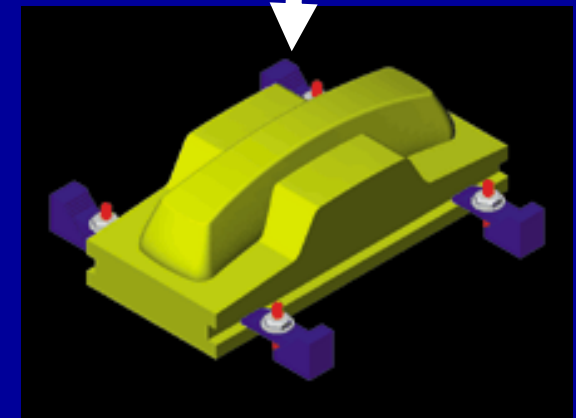
**Flat, Torus and
Ball End Mill**



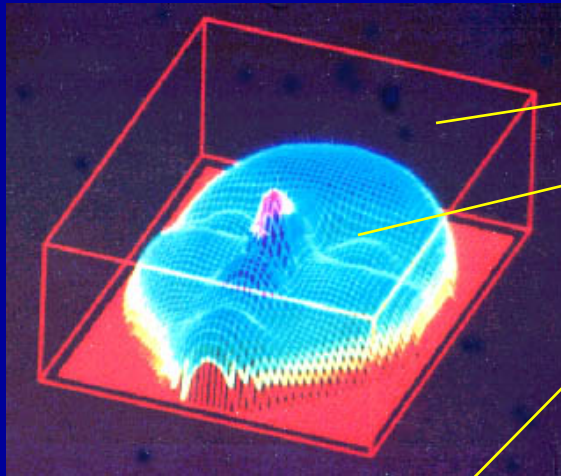
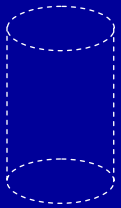
Verify the tool
paths and
simulate the
milling process



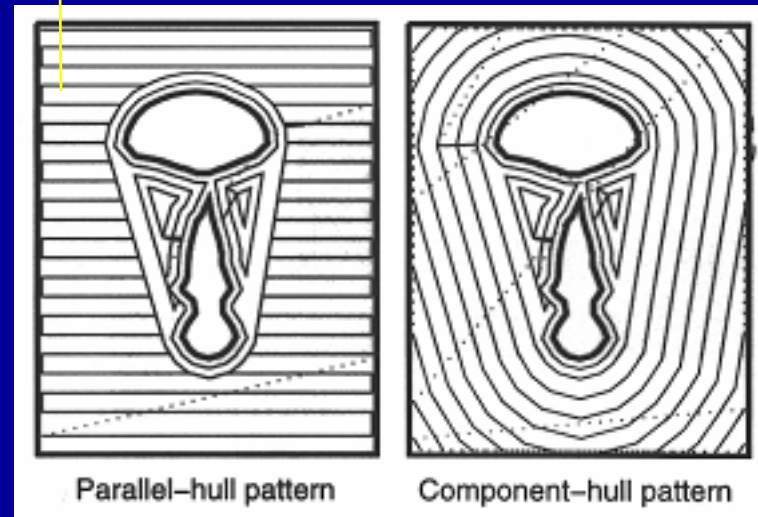
The digital result
of the virtual
CNC machining



2 1/2 Axis Rough Machining

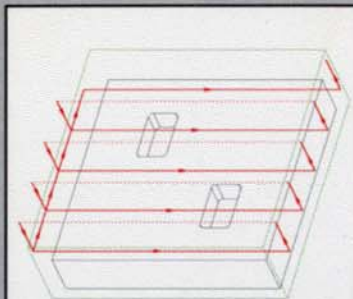
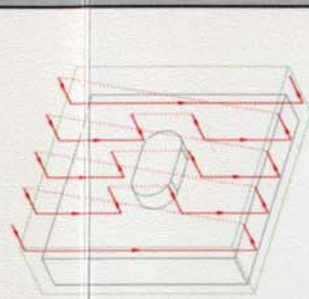
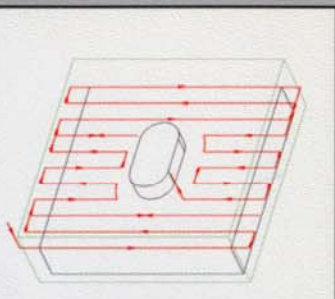
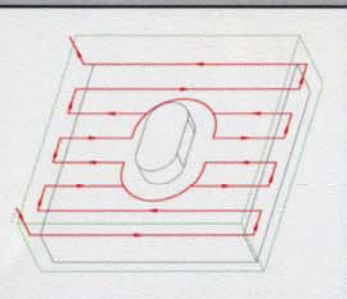
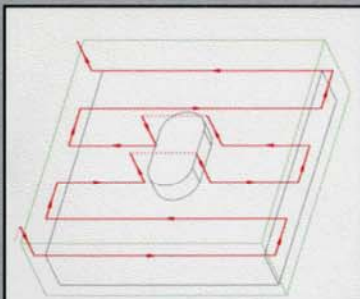


- Stock (or Workpiece in Pro/Mfg)
- Mechanical Part
- 2D Contours for Layered Machining
- Tool Path for Example 2D Layers

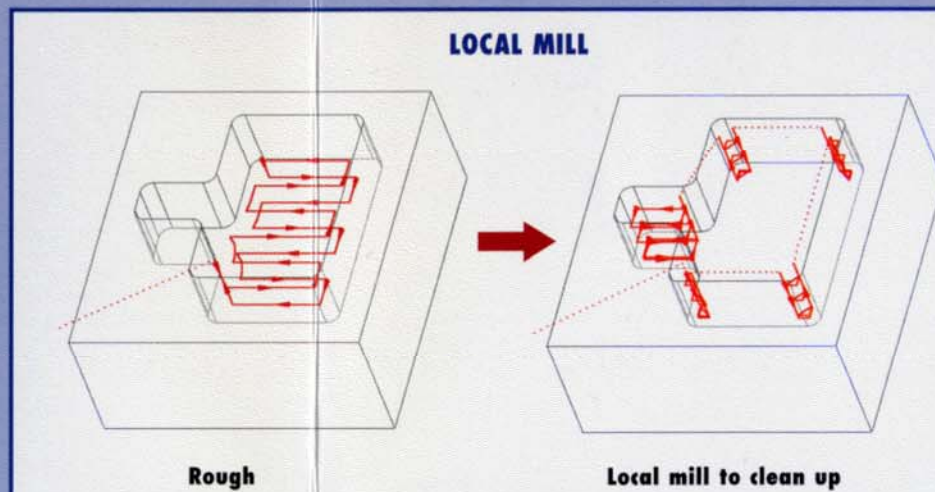
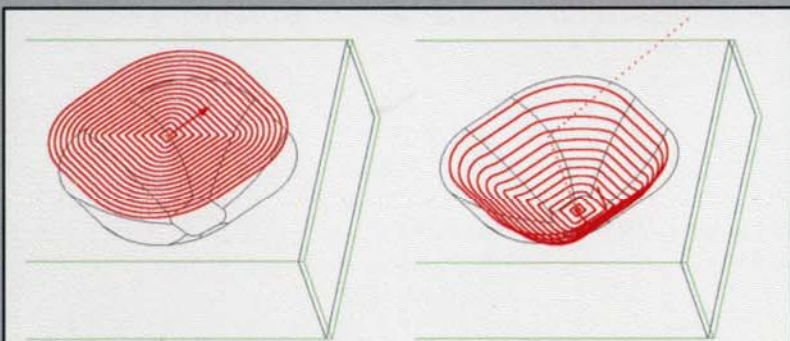
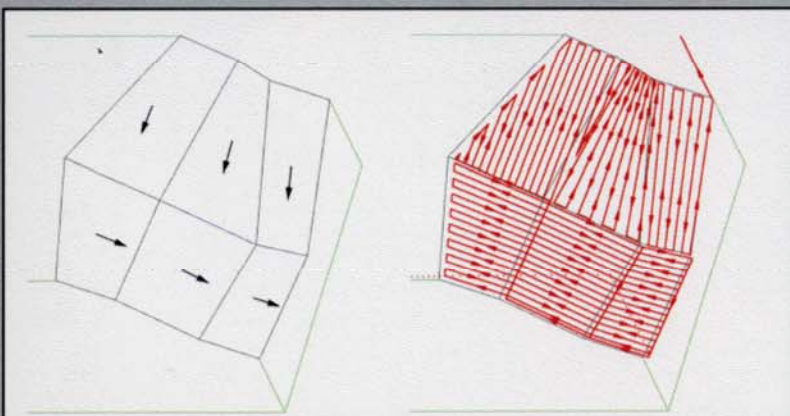


Parallel-hull pattern

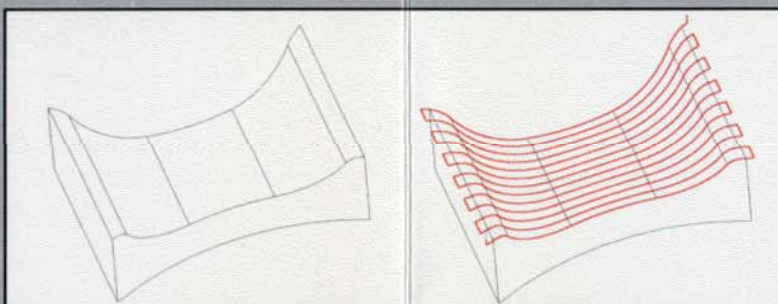
Component-hull pattern



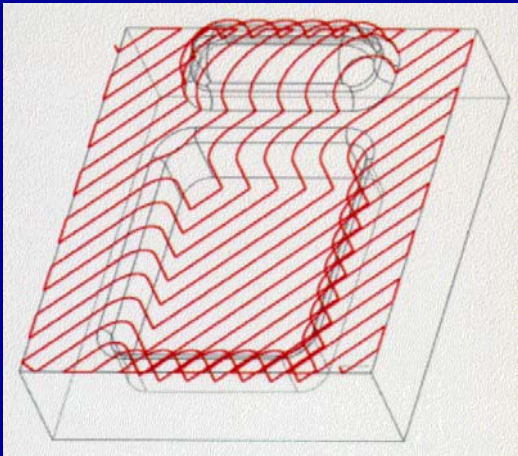
CONTOUR TYPES



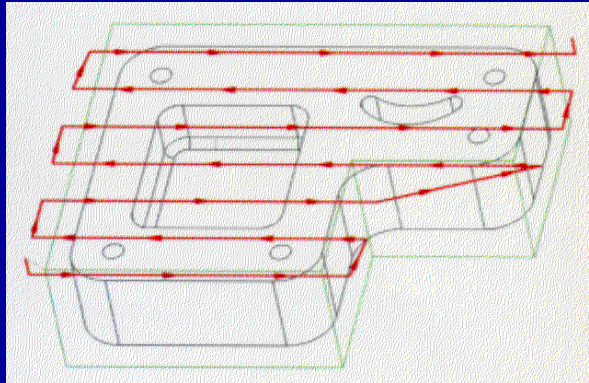
Different Tool Path Patterns



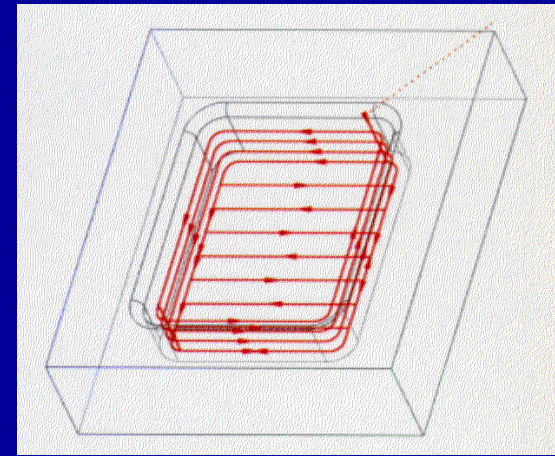
Conventional Surface



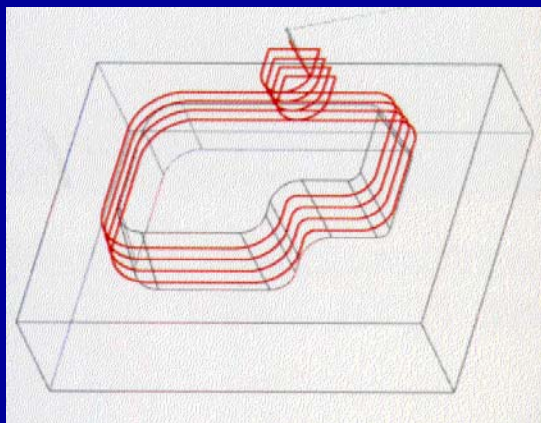
Face



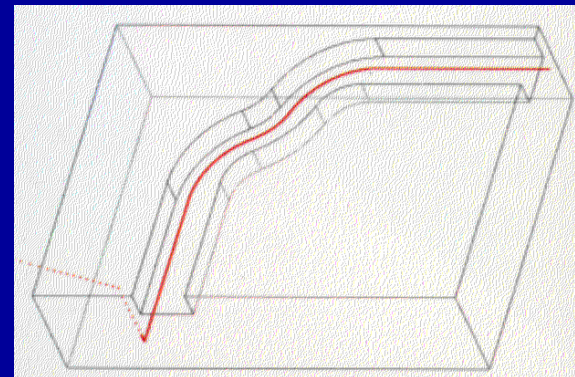
Pocket



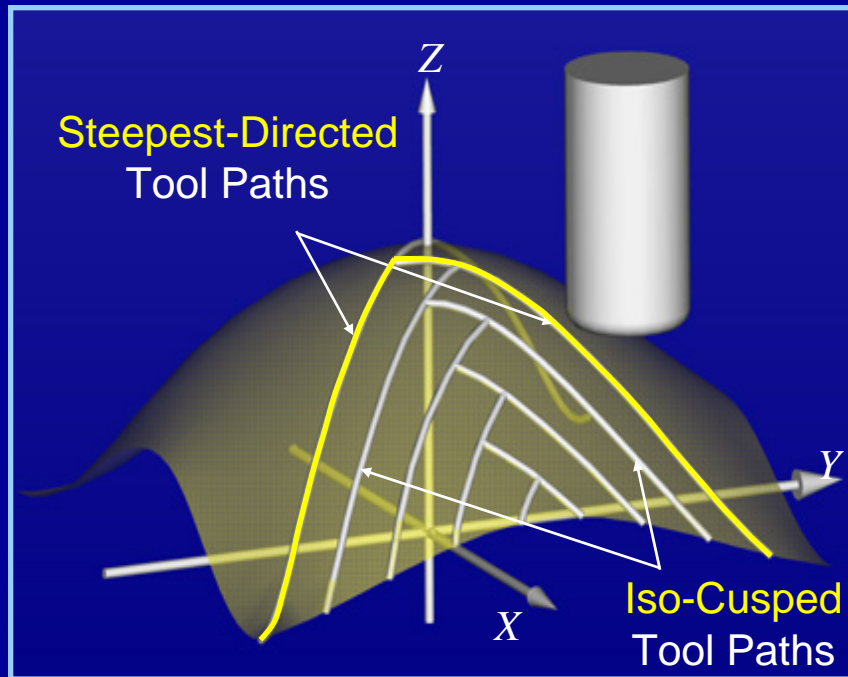
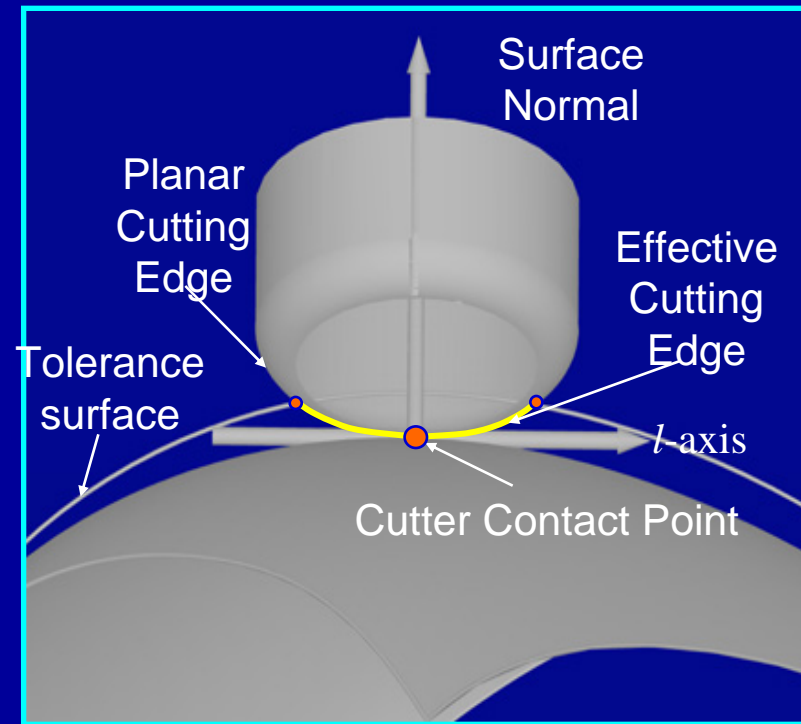
Profile



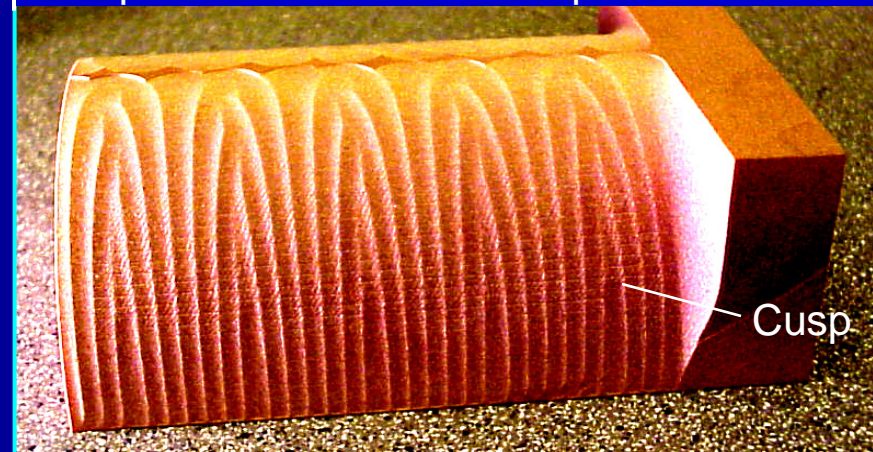
Trajectory



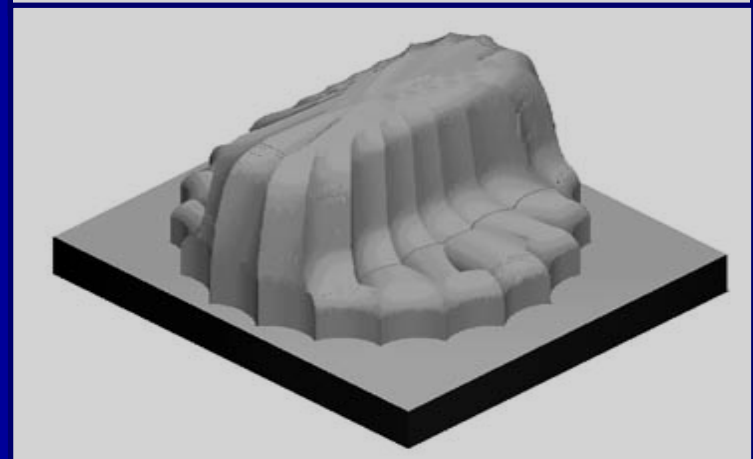
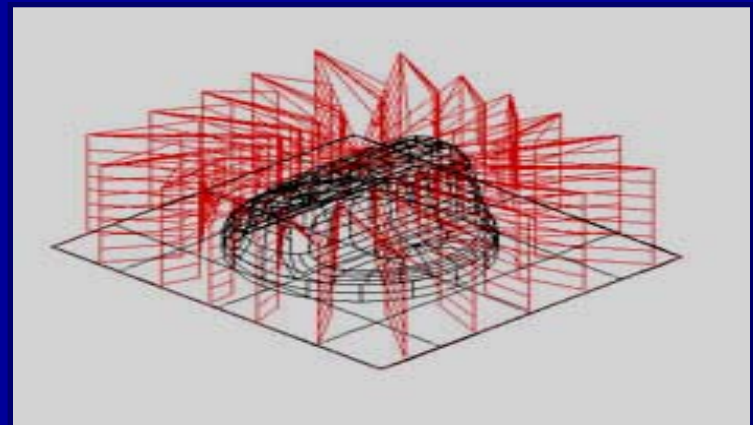
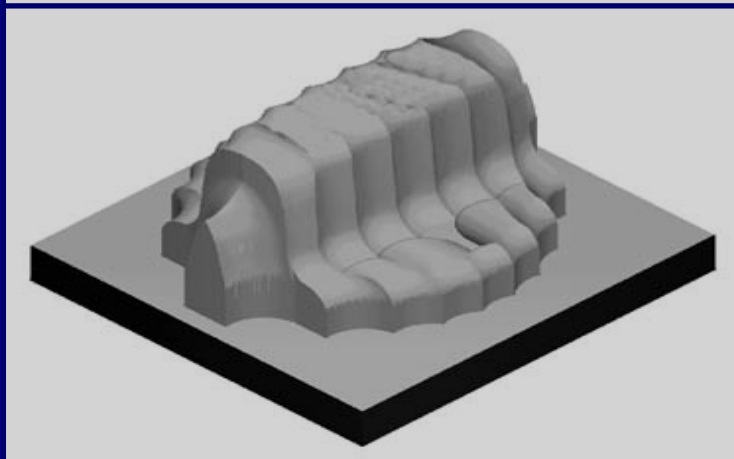
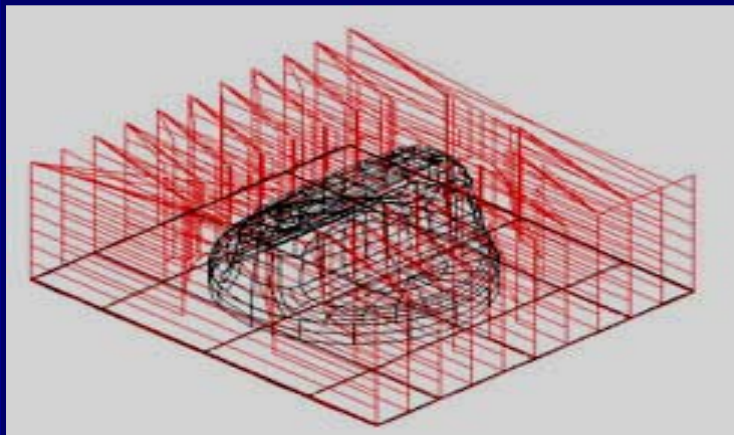
Cutter, Part Surface, Surface Normal, Tolerance Surface, Tool Path, Cusp



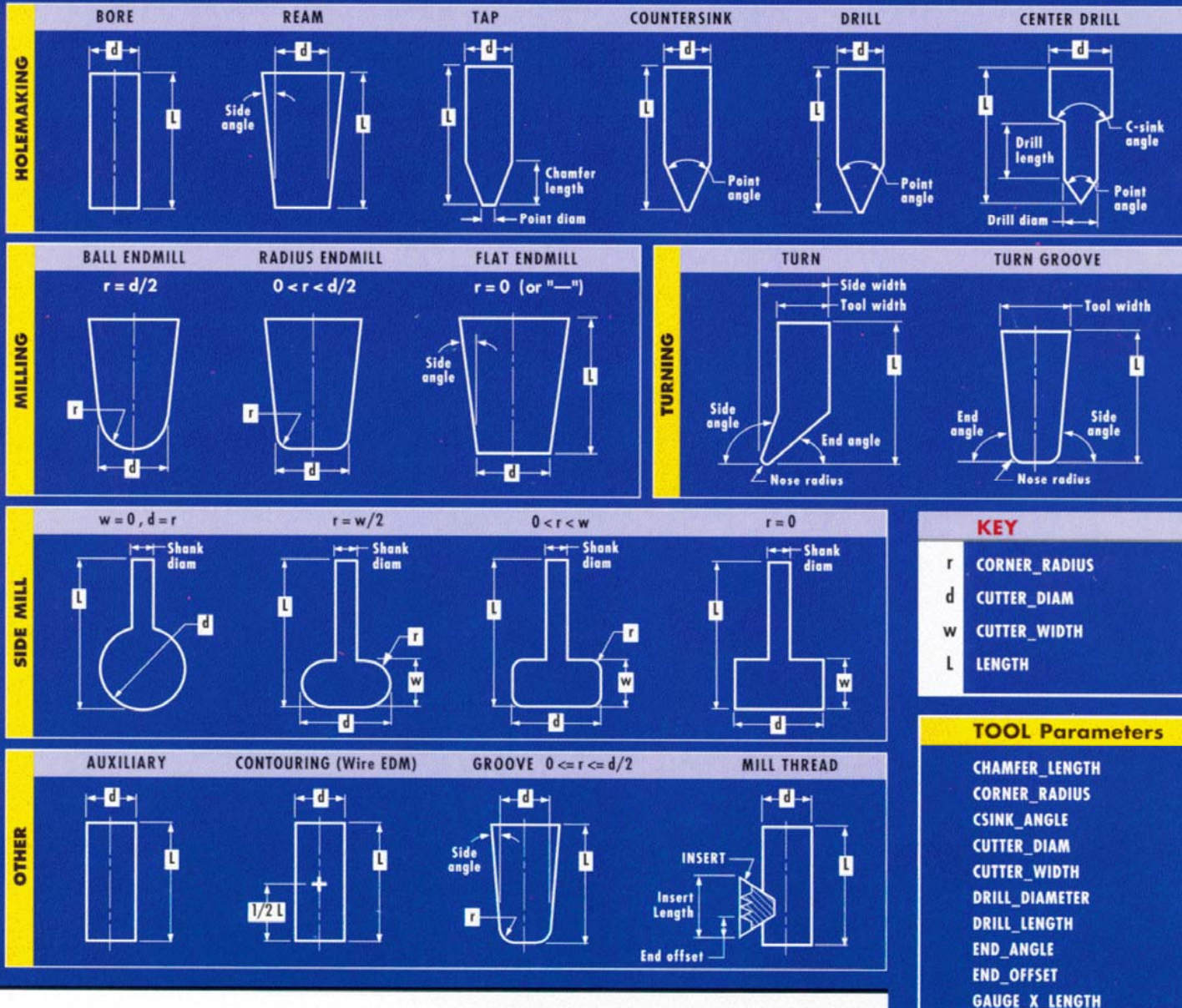
Steepest-Directed & Iso-Cusped Tool Paths



Parallel-Plane-Guided and Radial Tool Paths



Setting Up Tools



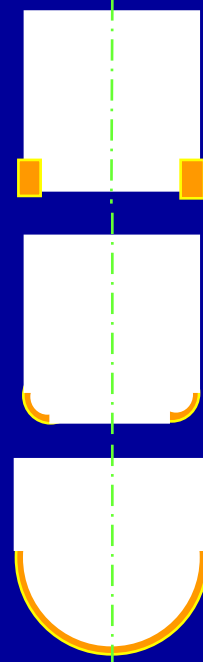
KEY

| | |
|---|---------------|
| r | CORNER_RADIUS |
| d | CUTTER_DIAM |
| w | CUTTER_WIDTH |
| L | LENGTH |

TOOL Parameters

CHAMFER_LENGTH
CORNER_RADIUS
CSINK_ANGLE
CUTTER_DIAM
CUTTER_WIDTH
DRILL_DIAMETER
DRILL_LENGTH
END_ANGLE
END_OFFSET
GAUGE_X_LENGTH

GAUGE_Z_LENGTH
HOLDER_TYPE
INSERT_LENGTH
LENGTH
LENGTH_UNITS
NOSE_RADIUS
NUM_OF_TEETH
POINT_ANGLE
SHANK_DIAMETER
SIDE_ANGLE
SIDE_WIDTH
TOOL_COMMENT
TOOL_LID
TOOL_MATERIAL
TOOL_TYPE



Setting Up Machining Parameters

Goto Point

Specify Tool Motion Parameters:

Feed... FEEDRT / 20.000, IPM

Spindle... SPINDL / RPM, 1000.000, CM

Coolant... COOLNT / OFF

Cutcom... CUTCOM / OFF

Specify Target Goto Point: Specify Offset Values:

Specify Point ... Specify Offset ...

Specify Axes Tool Moves Along:

☒ Simultaneous ☐ X Axis ☐ Y Axis ☐ Z Axis

☒ Z First

☒ Z Last

Define Tool Axis at Target Point:

☒ Along Z axis

☒ Use Previous

☒ Specify New Axis Specify Axis ...

OK Preview Cancel

Sets speed and machine parameters.

Defines location to move tool.

Controls axes of motion.

Defines tool axis orientation for the motion.

Accepts/Previews/Cancel tool motion.

Pro/Mfg Menu System

MFG MDL

- Assemble
- Create
- Redefine
- Delete
- Replace
- Simplfd Rep
- Done/Return

MFG SETUP

- Workcell
- Tooling
- Fixture
- Operation
- Param Setup
- CL Setup
- Mfg Geometry
- PProcessor
- Done/Return

MACHINING

- Operation
- NC Sequence
- Matrl Remove
- CL Data
- Output Order
- Synchronize
- CL Command
- Mfg Setup
- Utilities
- Done/Return

CL DATA

- Input
- Output
- Edit
- Post Process
- NC Check
- Done/Return

PARAM SETUP

- Site
- Mach DB
- Peck Table
- Register

CL SETUP

- Tool Table
- PPRINT
- Feed Color
- NC Alias

MFG GEOMETRY

- Mill Volume
- Mill Surface
- Drill Group
- Datum Feats

MACH AUX

- Machining
- Auxiliary
- Volume
- Local Mill
- Conventl Srf
- Contour Srf
- Face
- Profile
- Pocketing
- Trajectory
- Holemaking
- Thread
- Grooving
- 3 Axis
- 4 Axis
- 5 Axis
- Done
- Quit

MILLING *2 1/2 to 5-axis machining performed on a mill type machining center.*

- 2 1/2 axis roughing.
- Removes leftover material from a previous toolpath.
- Surface machining which follows planar slices across the part.
- Follows specified contours of type SURF, CUTLINE, or PROJECTED.
- 2 1/2 axis surface roughing.
- Machines near-vertical surfaces with side of tool.
- Machines walls & bottom surfaces. Used to clean up after volume milli
- Drives tool along edge or user-specified curve.
- Drilling, boring, tapping, etc.
- 3-axis helical milling.
- 3 to 5-axis milling, with the tool moving along a GROOVE cosmetic fea

MACH AUX

- Machining
- Auxiliary
- Area
- Profile
- Groove
- Trajectory
- Thread
- Holemaking
- Outside
- Inside
- Face
- HEAD 1
- HEAD 2
- Done
- Quit

TURNING *Generally used on stock which is symmetric about the Z axis (i.e. stock with circular cross-sections throughout).*

- Used for rough-cut turning.
- Follows a profile defined by surfaces of the part, datum curves, or by si
- Uses a peck-type motion to turn narrow grooves.
- Defines the trajectory of the tool control point by sketching.
- Machines the outside surfaces of the workpiece.
- Machines the inside surfaces of the cored workpiece.
- Machines the workpiece surfaces perpendicular to the lathe axis.
- Uses HEAD 1 turret (default for 2-axis workcell; optional for 4-axis).
- Uses HEAD2 turret (only applies to 4-axis workcell).

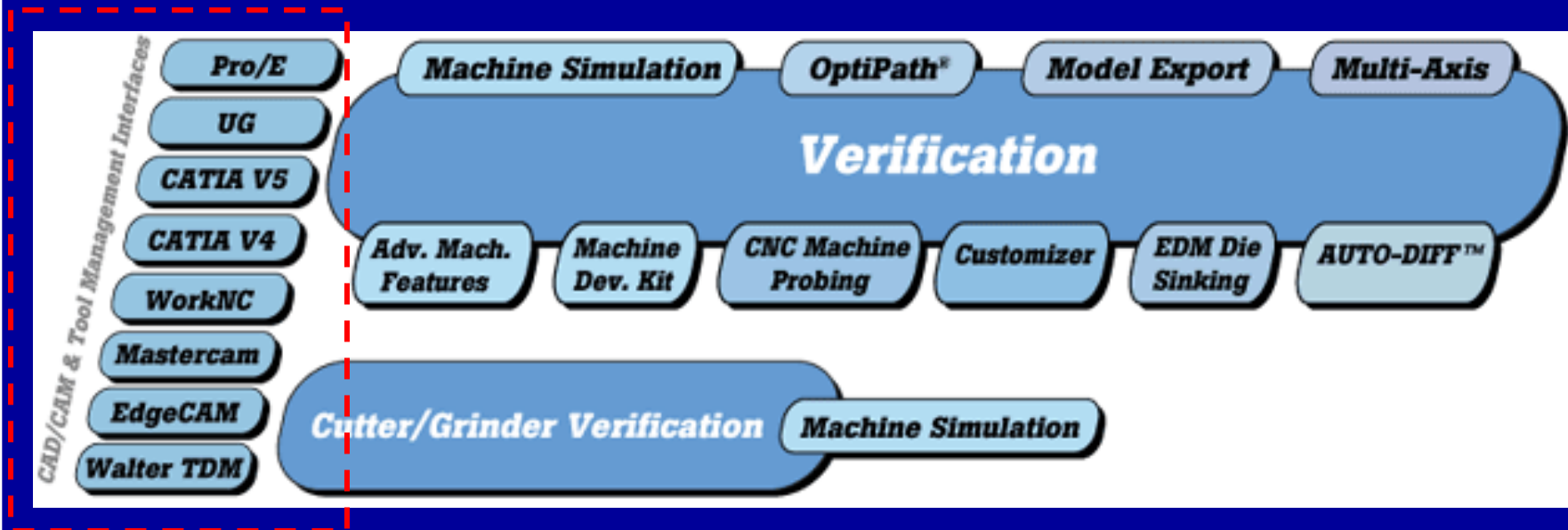
MACH AUX

- Machining
- Auxiliary
- Contouring
- No Core
- Taper Angle
- XY-UV Type
- 4 Axis
- 2 Axis
- Done
- Quit

WIRE EDM *Used for any type of 2-axis contouring, including wire EDM, flame cut, waterjet, and laser.*

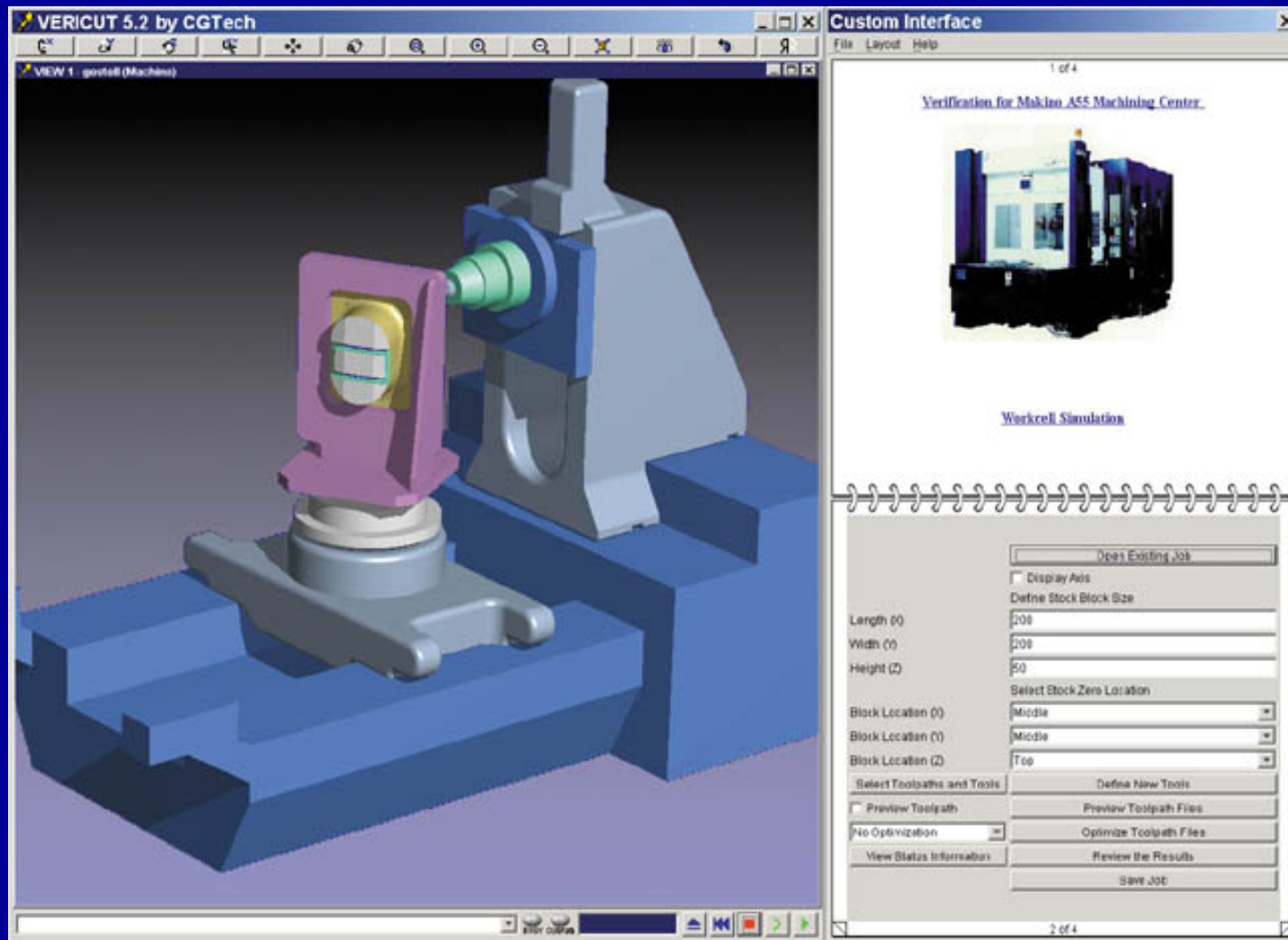
- Causes the WEDM tool to follow a specified trajectory.
- Removes all material within a specified contour.
- CL Data output on XYZ/UV format.
- CL Data output on HEAD1/HEAD2 format.

VERICUT Interface to Major CAD/CAM Systems

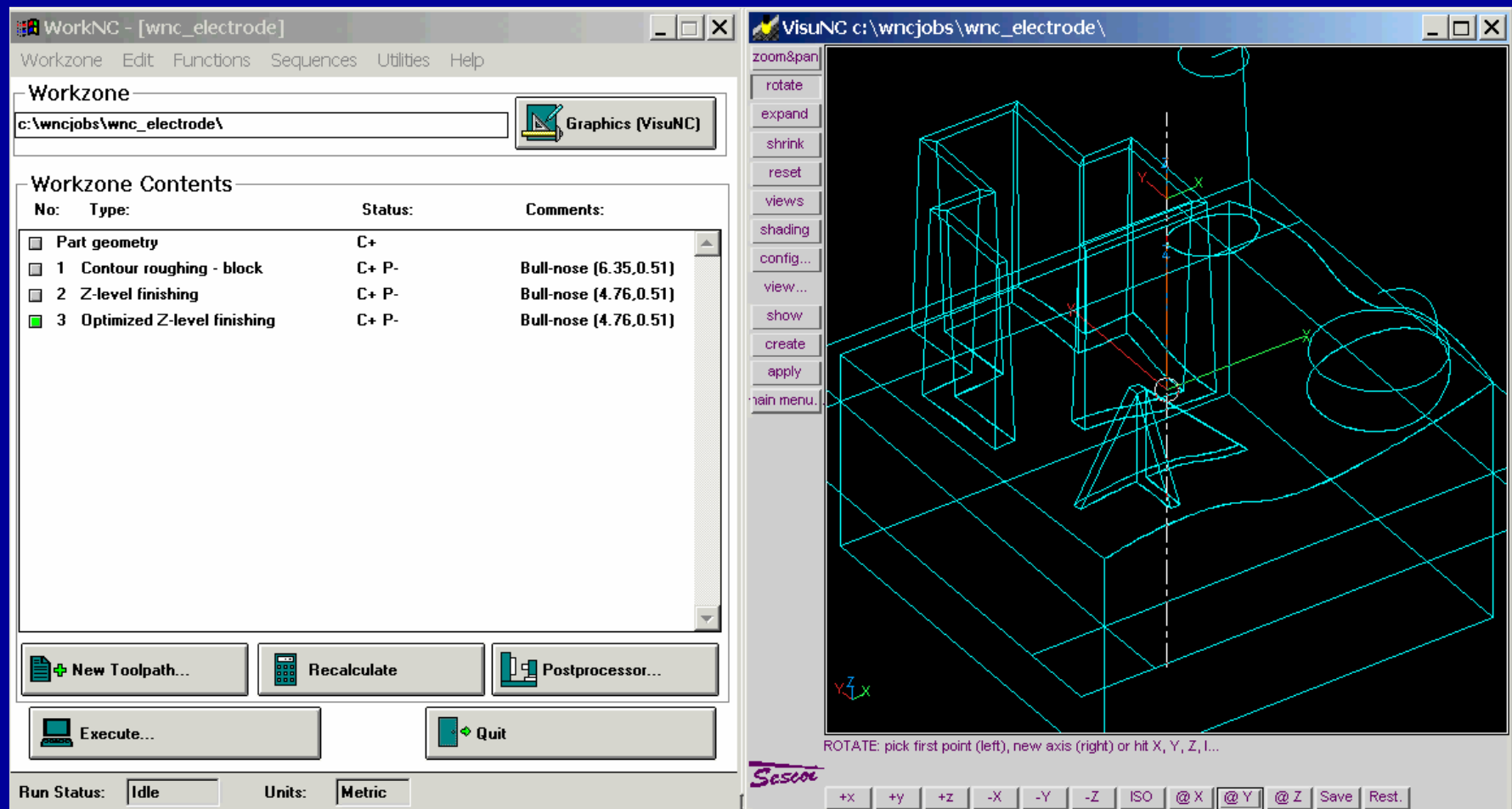


**Pro/E has licensed a CNC simulation module
from VERICUT
– with no machine tool modeling capability**

Simulation of CNC Machining (VERICUT)



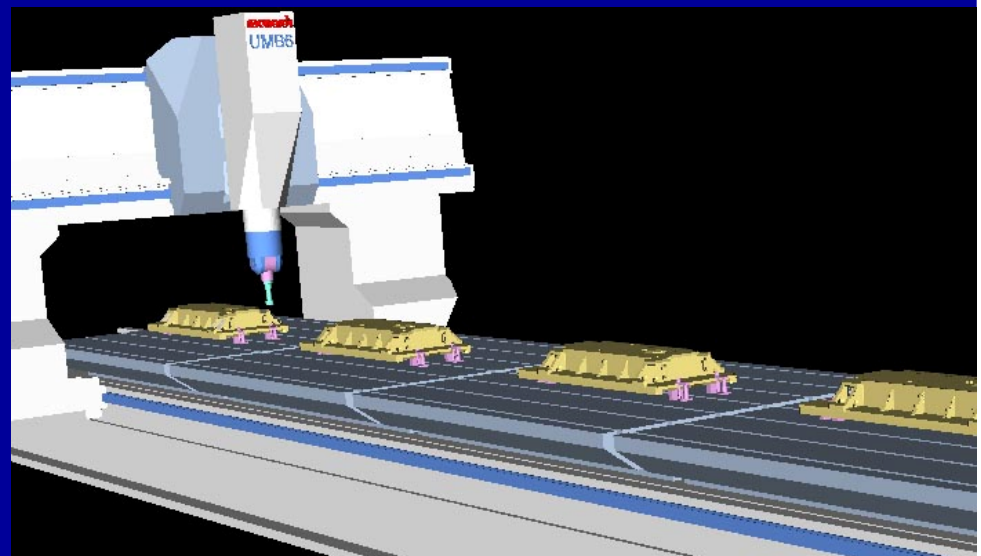
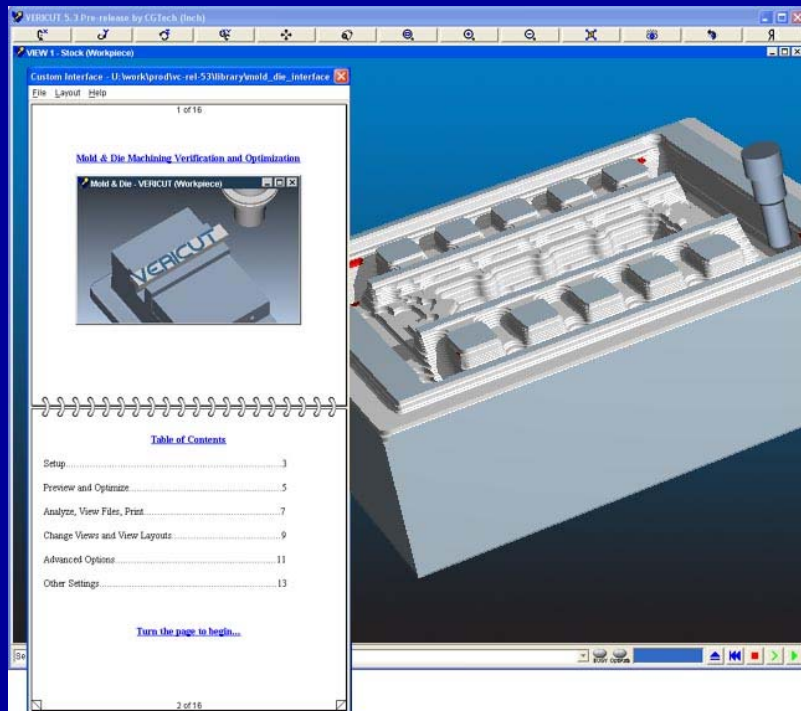
Machining Simulation and Tool Path Verification



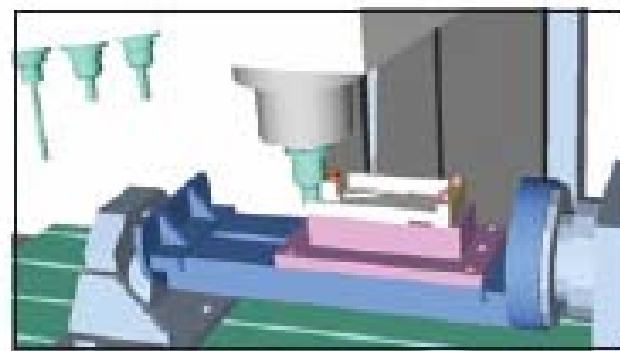
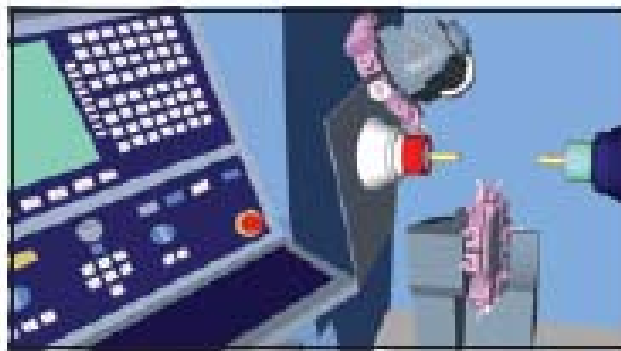
**5-Axis CNC
Milling Based
on a CAD
Model of Boat
Design**

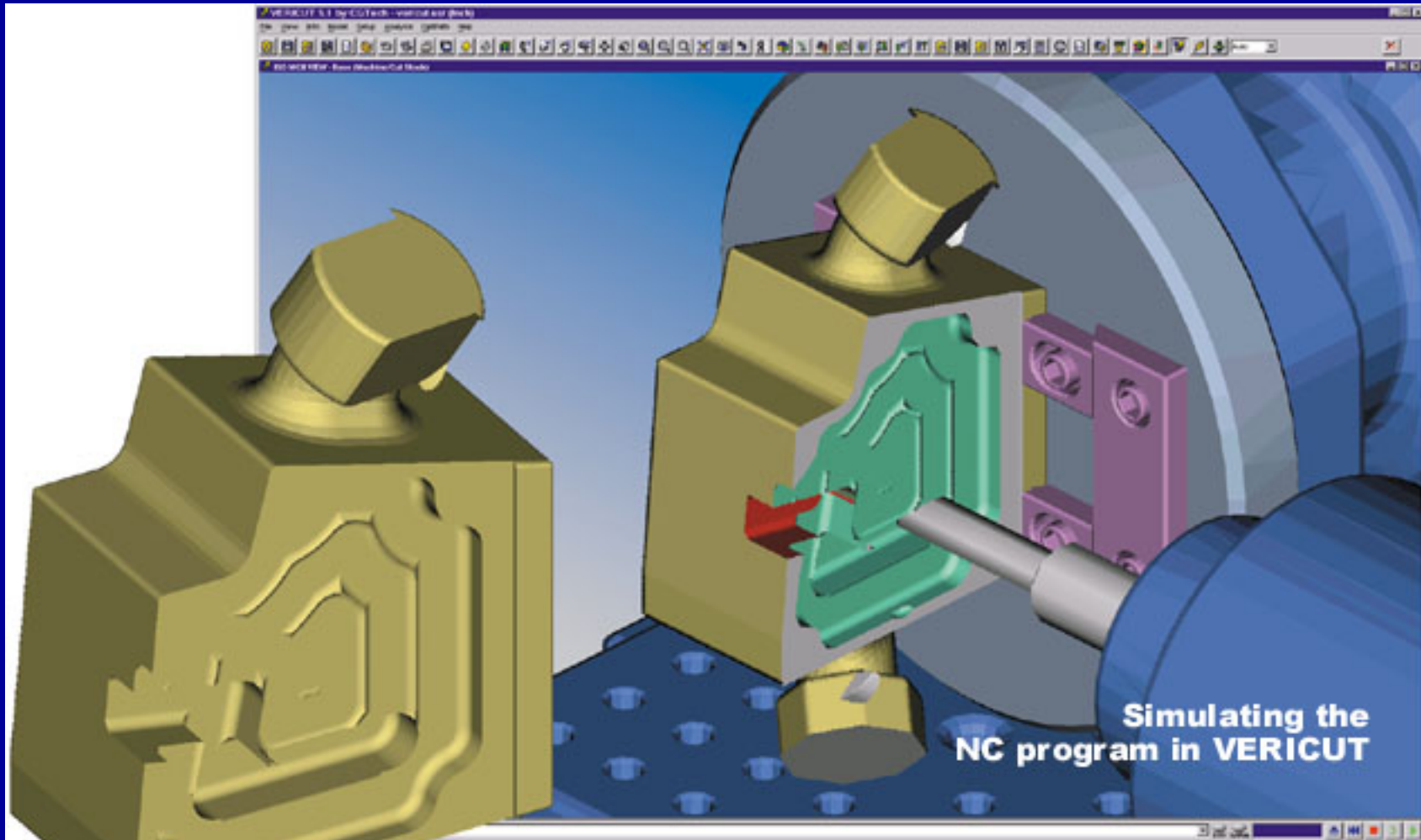


Different CNC Machines & Tasks



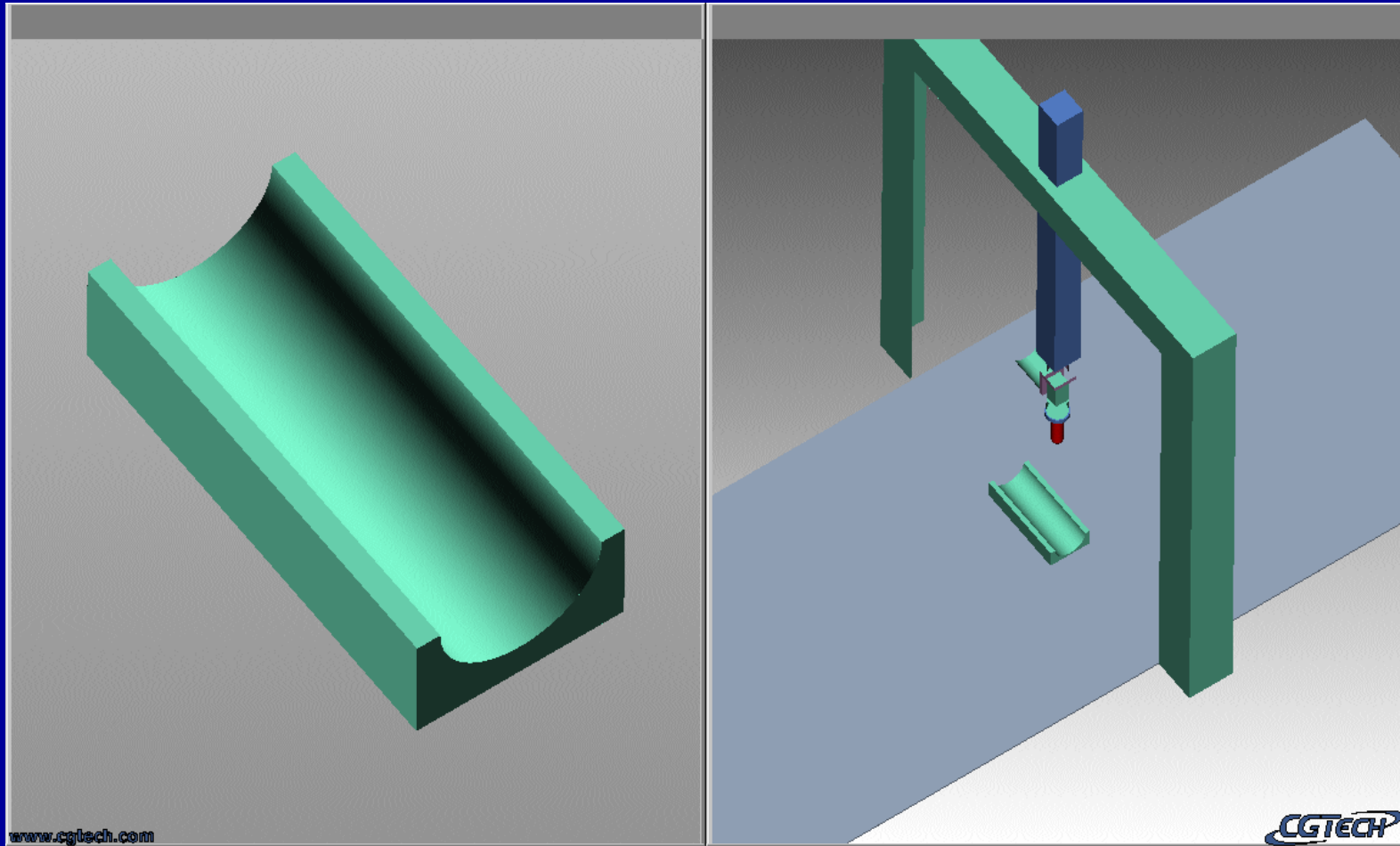
VERICUT CNC Machine Simulation



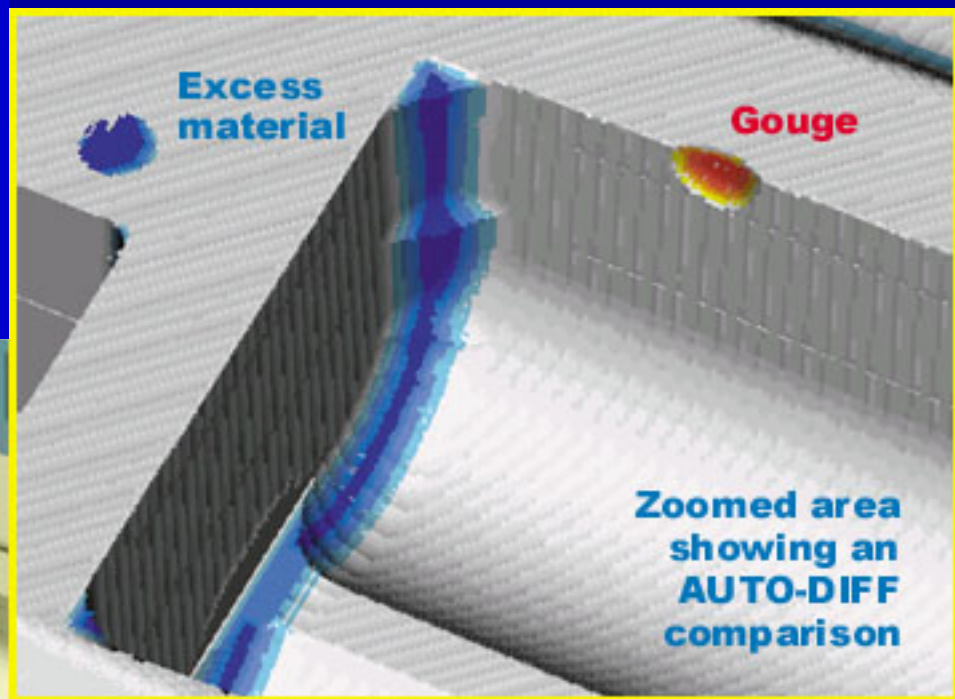


"As-cut" CAD-compatible model

CNC Milling Simulation - CUSP



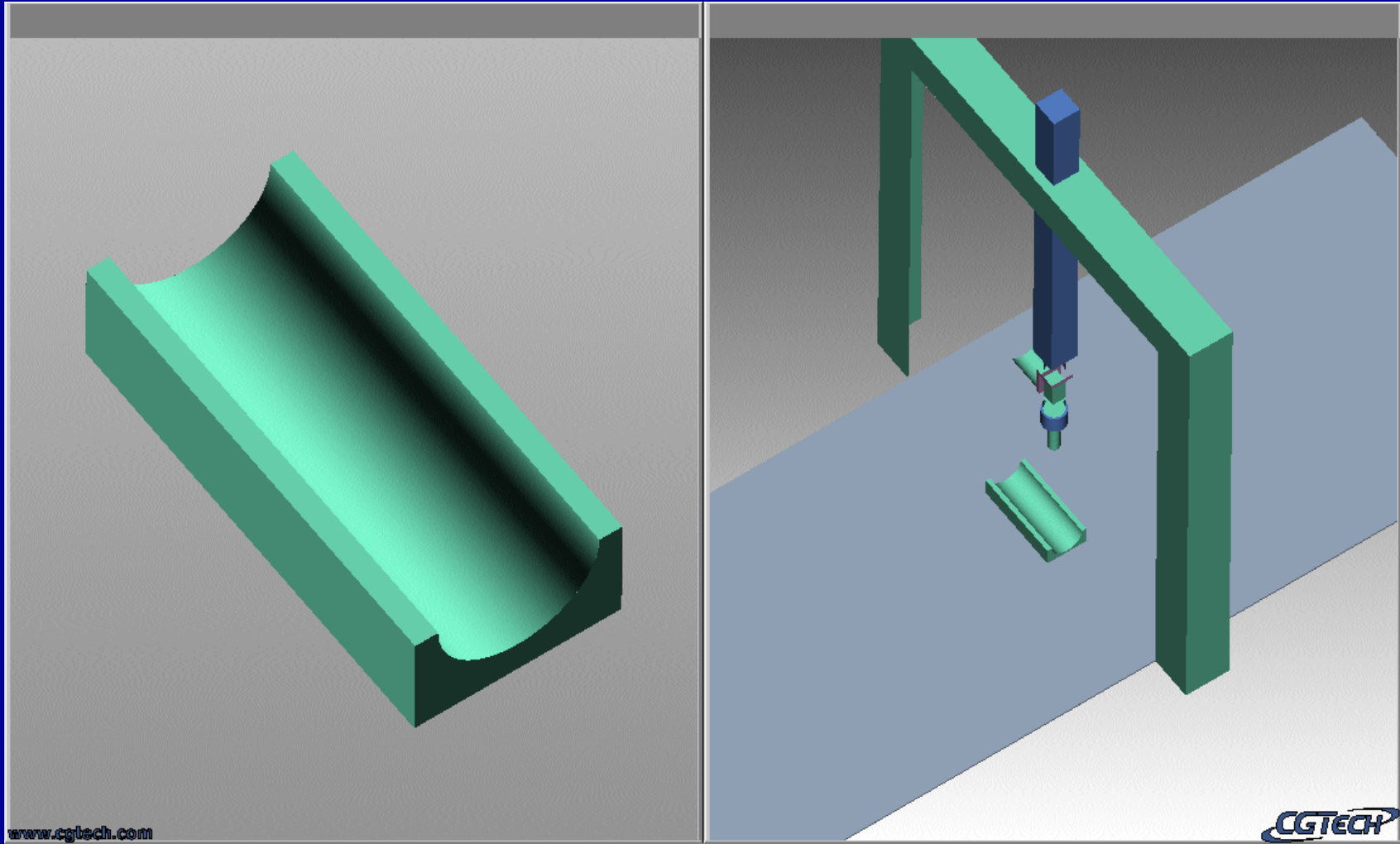
Gouge Detection



Part cut in VERICUT
from the NC program...

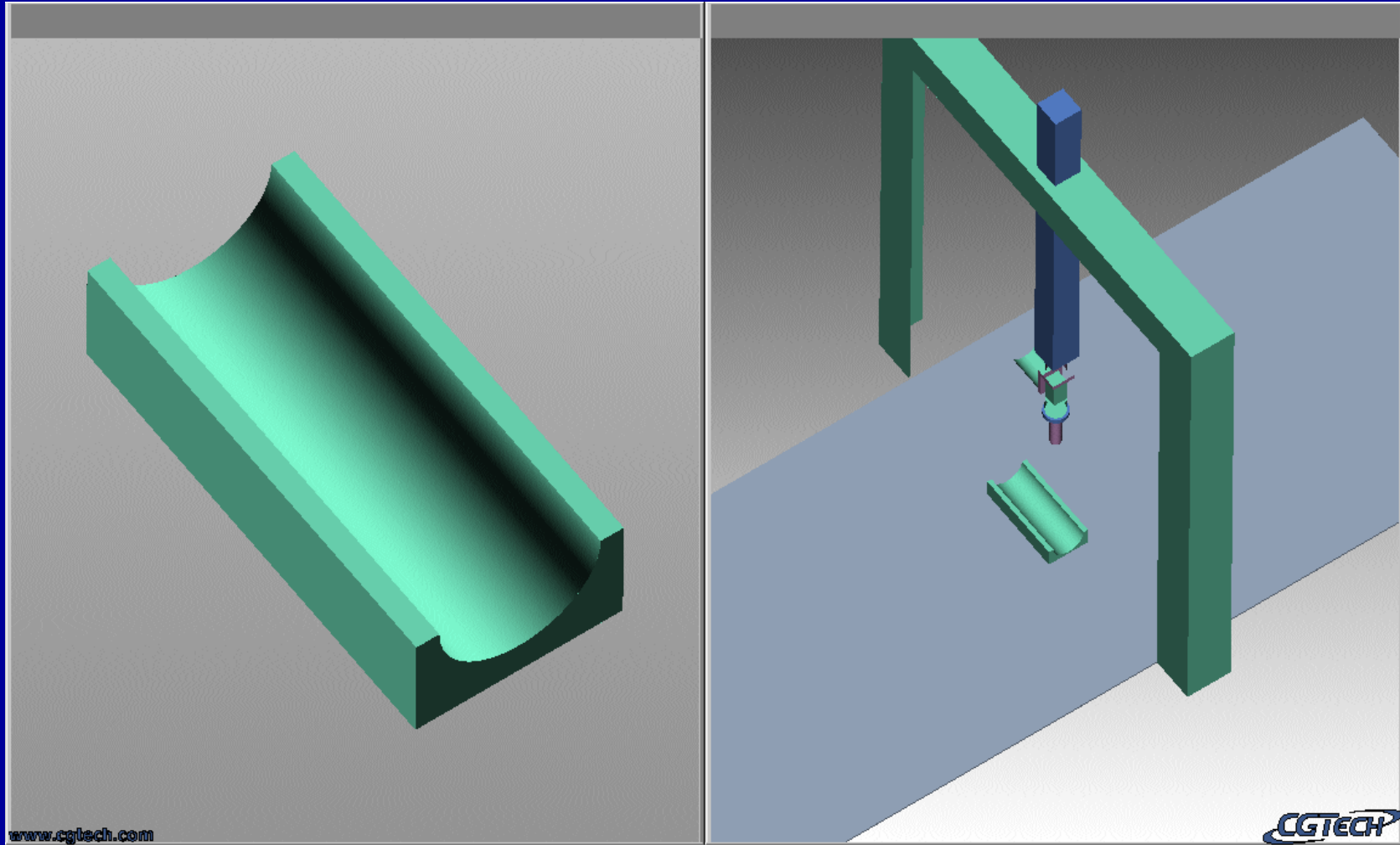
Collision and Gouge Detection

- Flat End Mill



Collision and Gouge Detection

- Torus End Mill



EDM CNC Simulation

