

PTC[®] Live Global

PART 200 - Be Ready to Produce Production Parts Prior to New CNC Machine Delivery

Jim Huddy
National Sales Manager

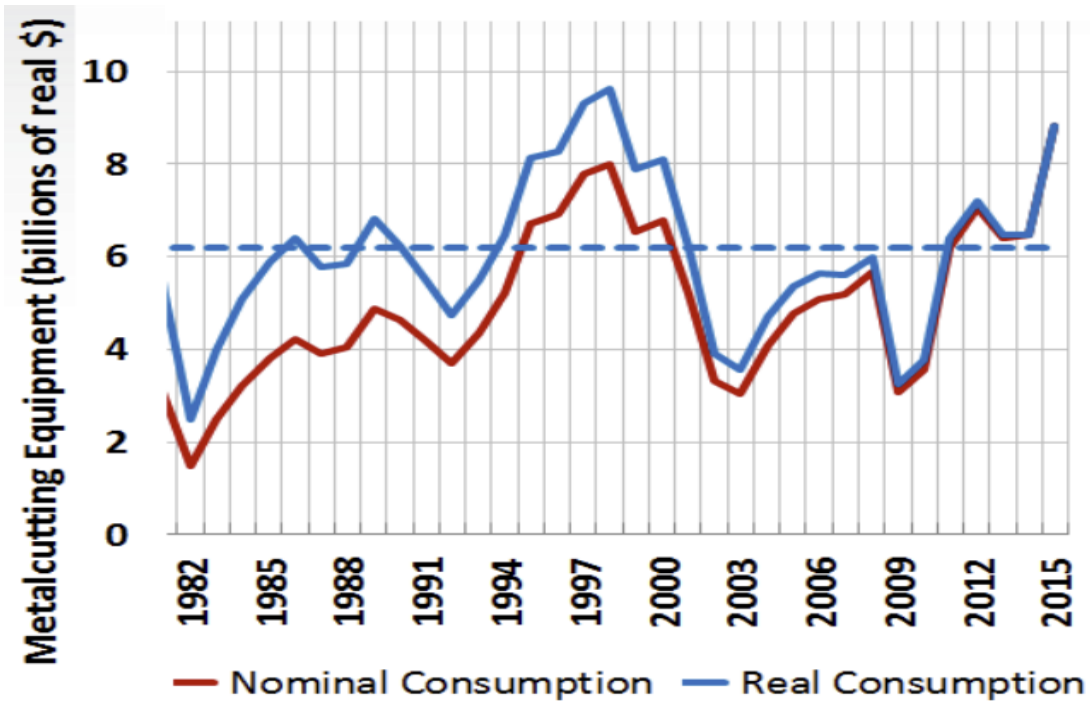
June 9, 2015

CGTECH
VERICUT



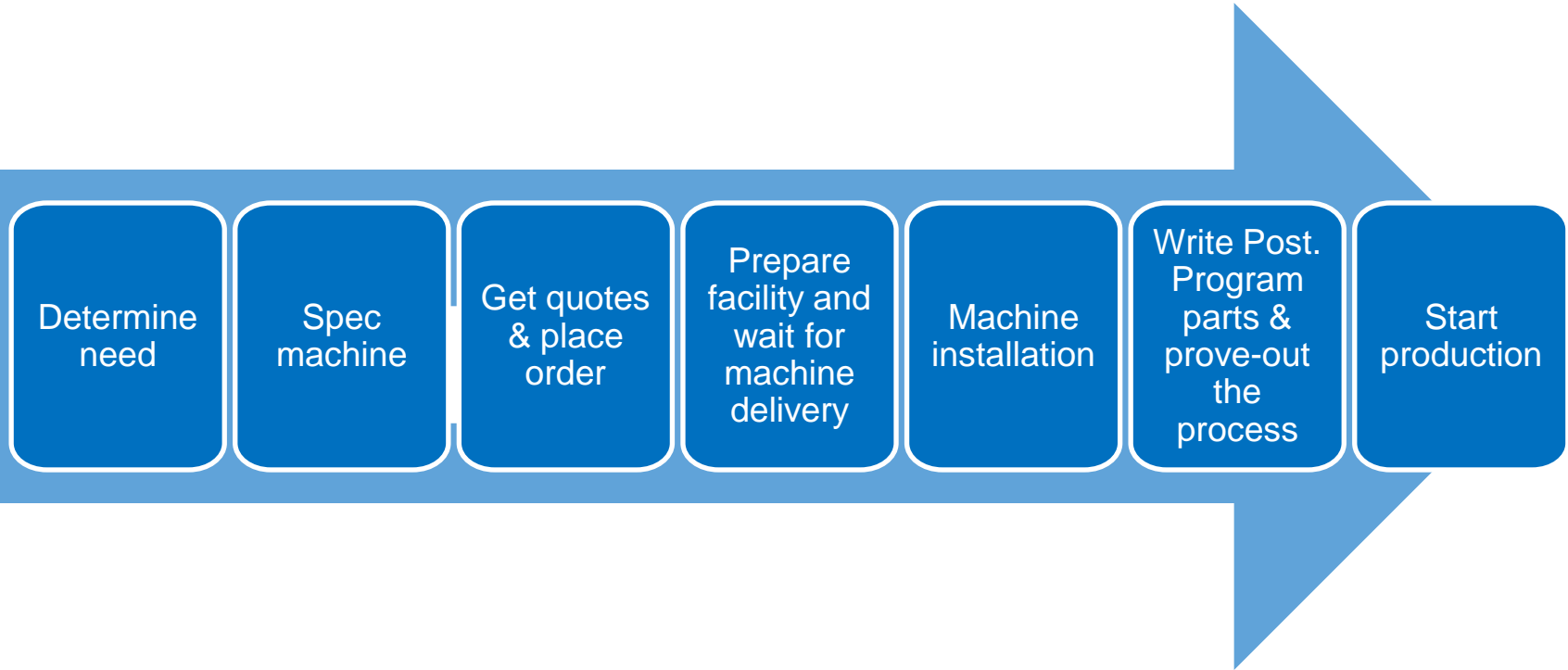
- G-code driven NC simulation software can help prove out parts before a new machine has been delivered
- Must determine what features are important to simulate with a new complex multi-axis machine tool

U.S. machine tool consumption is expected to increase from 2014. PTC[®] Live Global

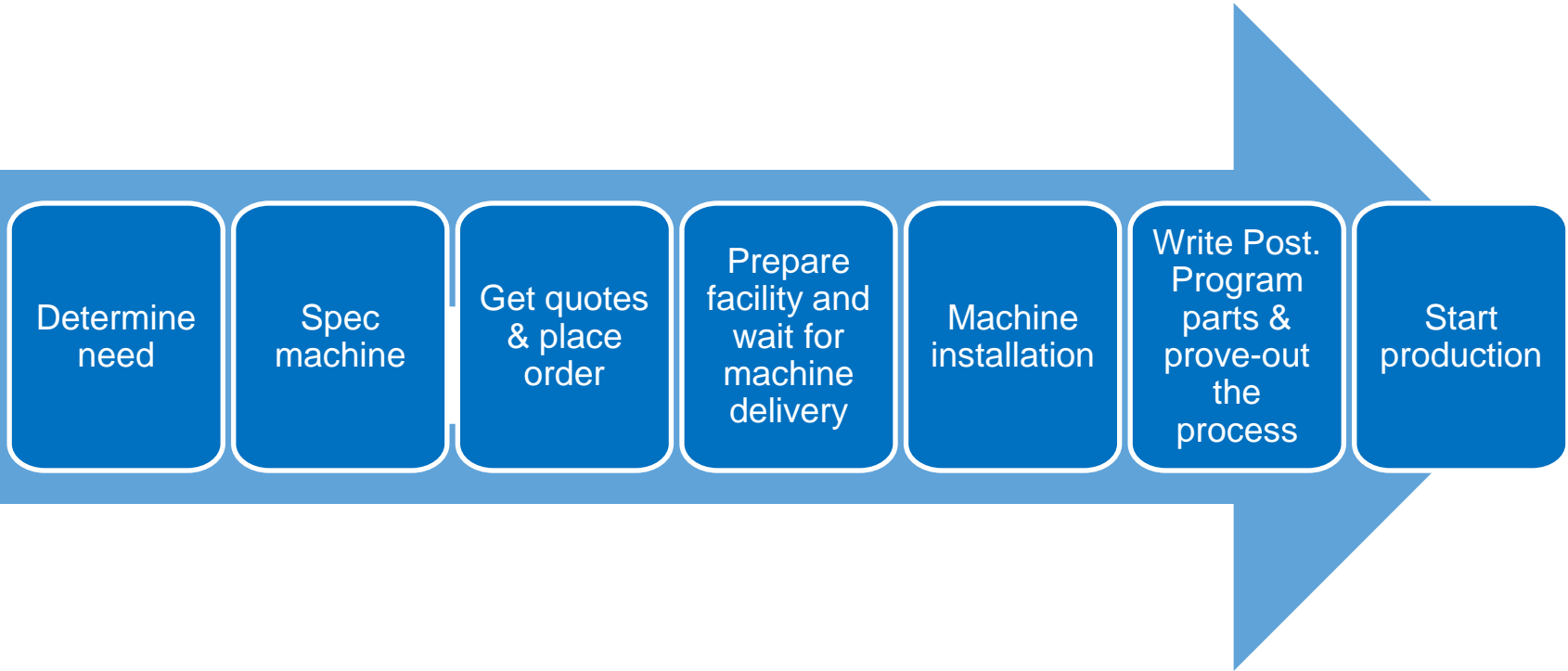


Source: 2015 Metalworking Capital Spending Survey and Forecast, Gardner Business Media

The typical machine buying process is long.



The buying process can be shortened with simulation.



- Large machined parts, sub-assemblies and assemblies
- Ultra-high-speed mills, high-speed mills and gantries producing (up to 70 feet)
- Complex 5-axis parts with small tolerances

- AMG Huntington Beach orders new DST Ecospeed F-2060 in 2014
- 787-9 wing ribs for GKN Aerospace



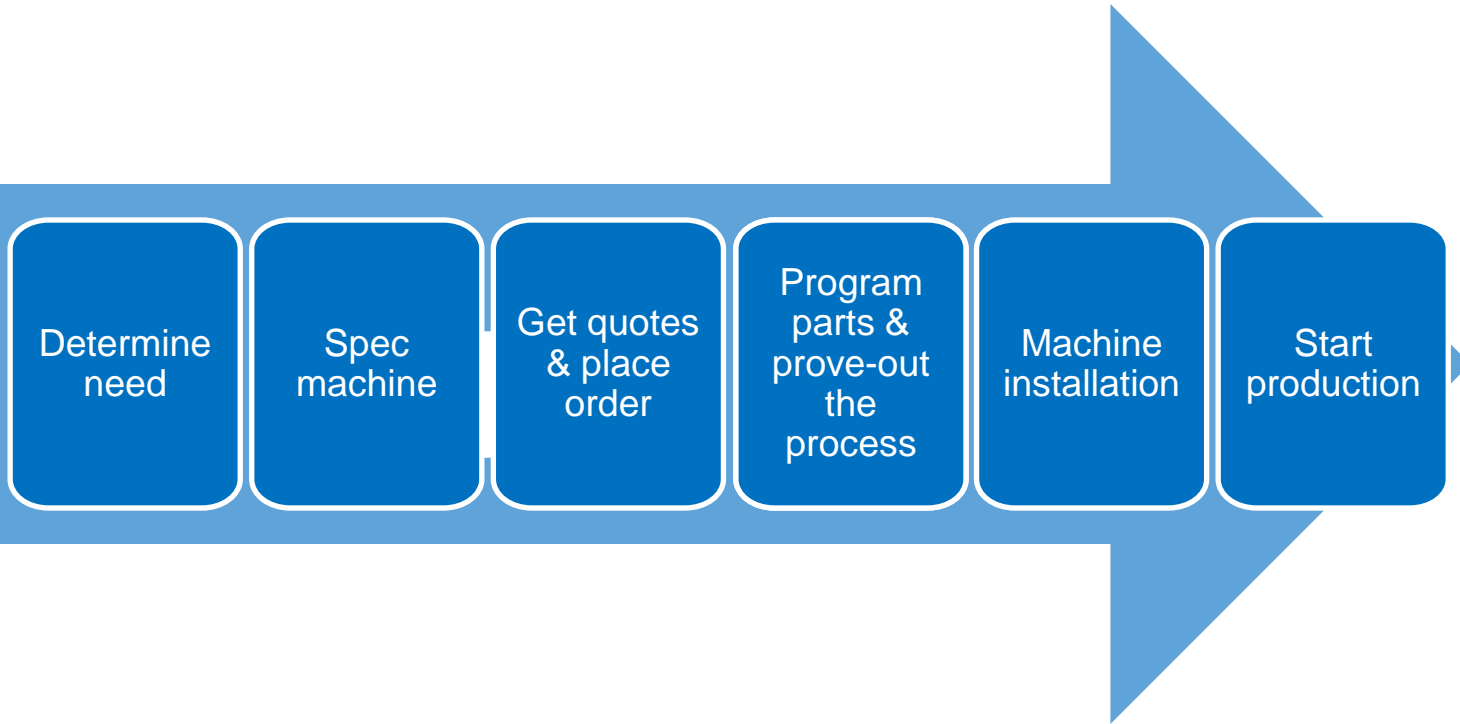
- Wrote his post while being built, and before it was installed in the shop.
- Able to debug 95% of his post before seeing the machine.
- Up and running at least a month early.



“If I made one mistake, that piece of metal was junk. So how do you deal with that stress? Simulation lets the programmer go home and sleep.”

- John Gates, Aerospace Manufacturing Group

Simulation can help even in the specification stage. PTC® Live Global



Sim Takes Flight

The use of simulation software allows GE Aviation to try out creative approaches to machining—without the risk of costly failures.

By Bryan Jacobs, CG Tech



Using the latest CNC simulation software technology, R&D engineers at GE Aviation, Broomfield, Quebec, are developing creative solutions to complex challenges. One such challenge was developing the manufacturing process for the titanium leading edges of 18 composite fan blades used in each GE9x jet engine fan blade used in the Boeing 787 Dreamliner and the Boeing 747-8.

The GE9x engine provides substantially improved operating economies over comparable current engines. With more than 1,100 GE9x engines ordered to date, it is the fastest-selling engine in GE Aviation's history. Composite materials and specialized coatings are used in the engine's lightweight, "super-high bypass" fan blades.

Super-high bypass refers to the dramatic improvements in the design of the fan blades and other engine components, such as engine nacelles, which allow for a large amount of air to be drawn into the engine and bypassed around the compressor and turbine sections.

The GE9x is GE's next generation turbofan engine for medium capacity, long range aircraft, including the Boeing 787 Dreamliner.

fan blades and other engine components, which help improve fuel efficiency and which help reduce engine noise by 30 percent compared to current engines.

GE9x engines need to add machining capacity at its own operations to

free, carbon-reinforced epoxy composite, which means there are no wrinkles or voids in the fibers. Each blade includes 600 edges of prepregged tape with the plus thimble from the base to the tip. The blades help the engine thrust, depending on the model.

Leading Edge Manufacturing

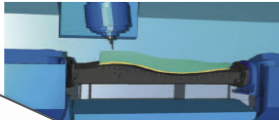
A 6-ft titanium leading edge is attached to the fan blades to protect the sharp-edged composite from fraying or being damaged by foreign objects. Traditionally, GE Aviation has subcontracted machining of leading edges for its aircraft engines to an outside supplier that uses a patented machining process. However, due to high demand for the GE9x engines, GE Aviation needed to add machining capacity at its own operations to

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Sim Takes Flight (continued)

software does not have any information about the remaining material when generating 3-axis motions, which creates the potential for collisions. After using Vericut, GE found that most potential collisions occurred with the toolholder. To mill the required deep pocket, GE modified its shrink-fit toolholder to fit into the space between the two walls. For example, the cavity is close to 7" deep in some areas but the tool is never more than 4.5" out of the holder.

Courtesy of GE Aviation, GE used Vericut to detect the toolholder and predict tool collisions inside the V shape. Some of the toolholder



Challenges, such as the toolholder's position, were managed for GE product integration. A major challenge was the toolholder's position, which was not defined in the original design. The toolholder's position was defined in the original design, but the toolholder's position was not defined in the original design.

GE Aviation used Vericut to detect the toolholder and predict tool collisions inside the V shape. Some of the toolholder

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Sim Takes Flight (continued)

Due to high demand for the GE9x engine, GE Aviation needed to add machining capacity at its own operations to supplement that of its outside supplier.

The part is then inspected to confirm it is within tolerance. GE Aviation uses what it calls "free-state" inspection, meaning that the part is not constrained during inspection. Normally, a thin-wall part like the leading edge is constrained against a nominal shape and only the thickness and the external surfaces are checked. In free-state inspection, all of the internal and external surfaces are scanned with a Zeiss CMM, which detects any deviation.

The new machining process has worked so well for GE Aviation that it is buying two additional machine tools so it can increase production. The new machine technology, use of Vericut's OptiPath module and the application of new tooling and coolant and roughing strategies should allow GE Aviation to reduce total machining time for each leading edge to less than 24 hours.

Creating a Virtual Machine

In fall 2008, GE Aviation will begin producing leading edges

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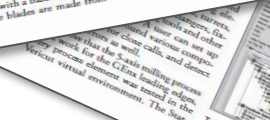
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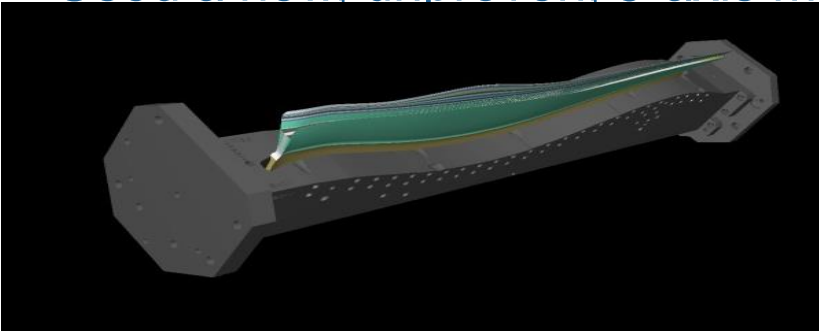
Sim Takes Flight (continued)

to produce that E-axis milling process work for the GE9x leading edges, every process was first tested in the Virtual environment.



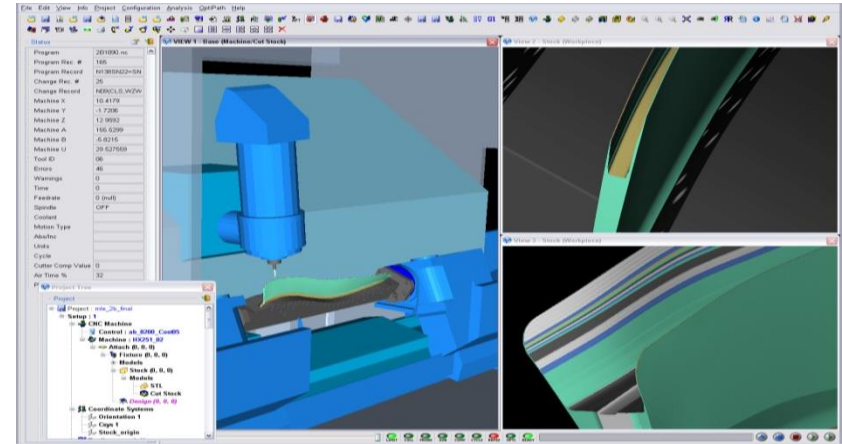
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- R&D project
- Developed the manufacturing process for the titanium leading edges for composite fan blades
- Used a new, unproven, 5-axis millir



Simulation proved an R&D idea was possible.

- Starrag heckert 5-axis milling machine
- Machine, fixtures, and tooling had to be tested
- Process was repeated hundreds of times
 - Not possible on actual machine
- Simulation showed it could be done
- Used video to show management



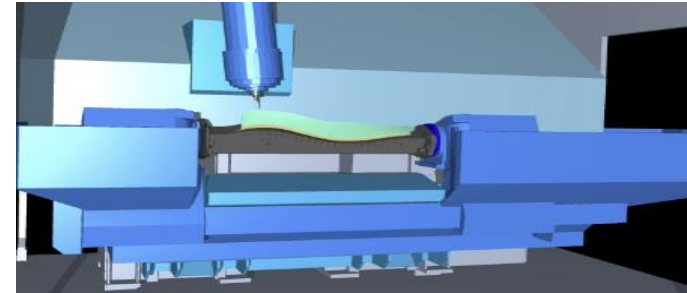
- Used simulation to modify virtual models of an existing Starrag heckert machine

“VERICUT allows us to test the latest machine technology without having the actual machine in place.”

Simulation models were sent to the machine builder.

- Starrag heckert delivered a custom-built machine based on the simulation models

Without simulation “we would have been forced to buy the identical machine that we proved the process on – not the machine best suited for our process.”



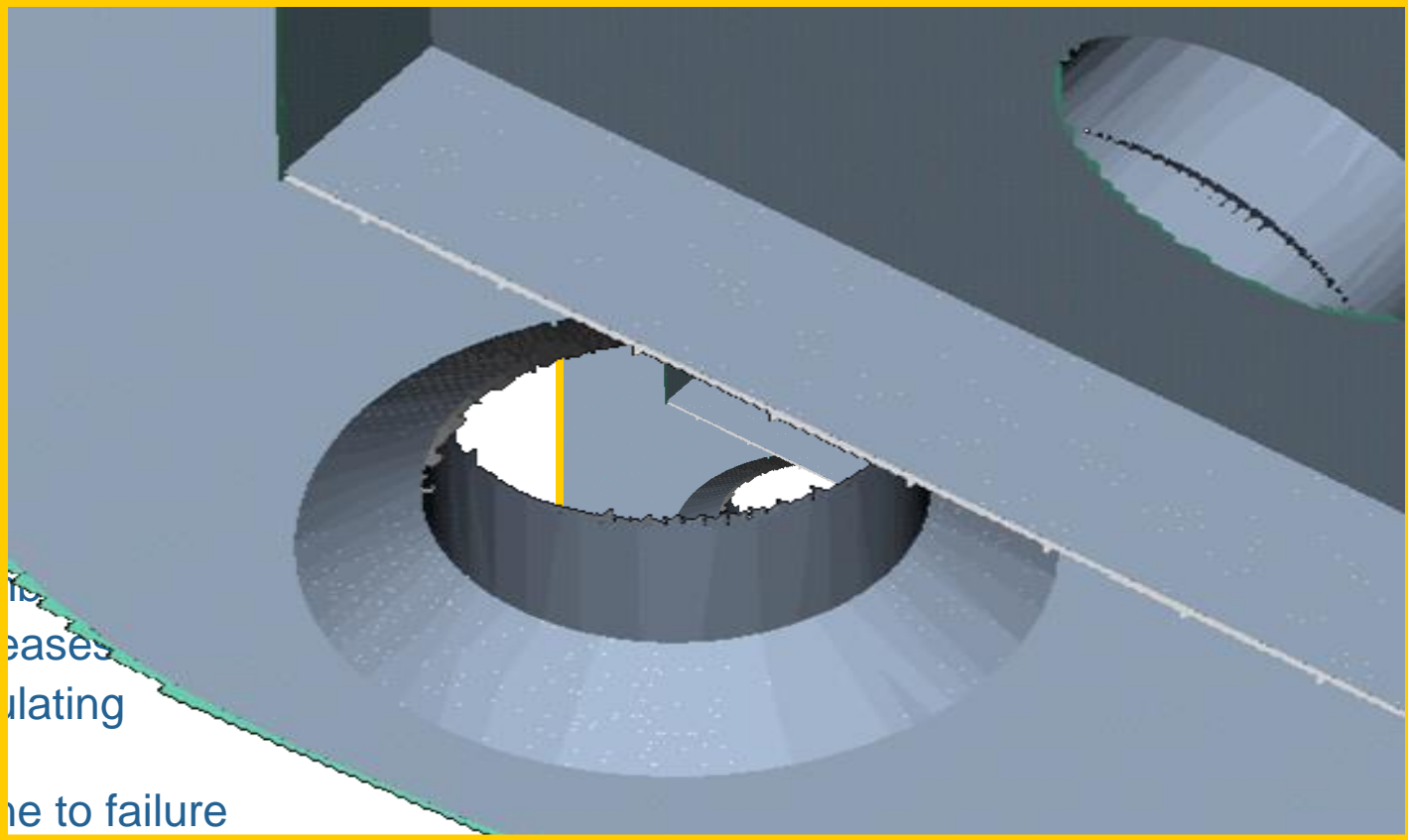
100% confidence in the simulation is required.

- If there is any doubt, prove-outs will be required.



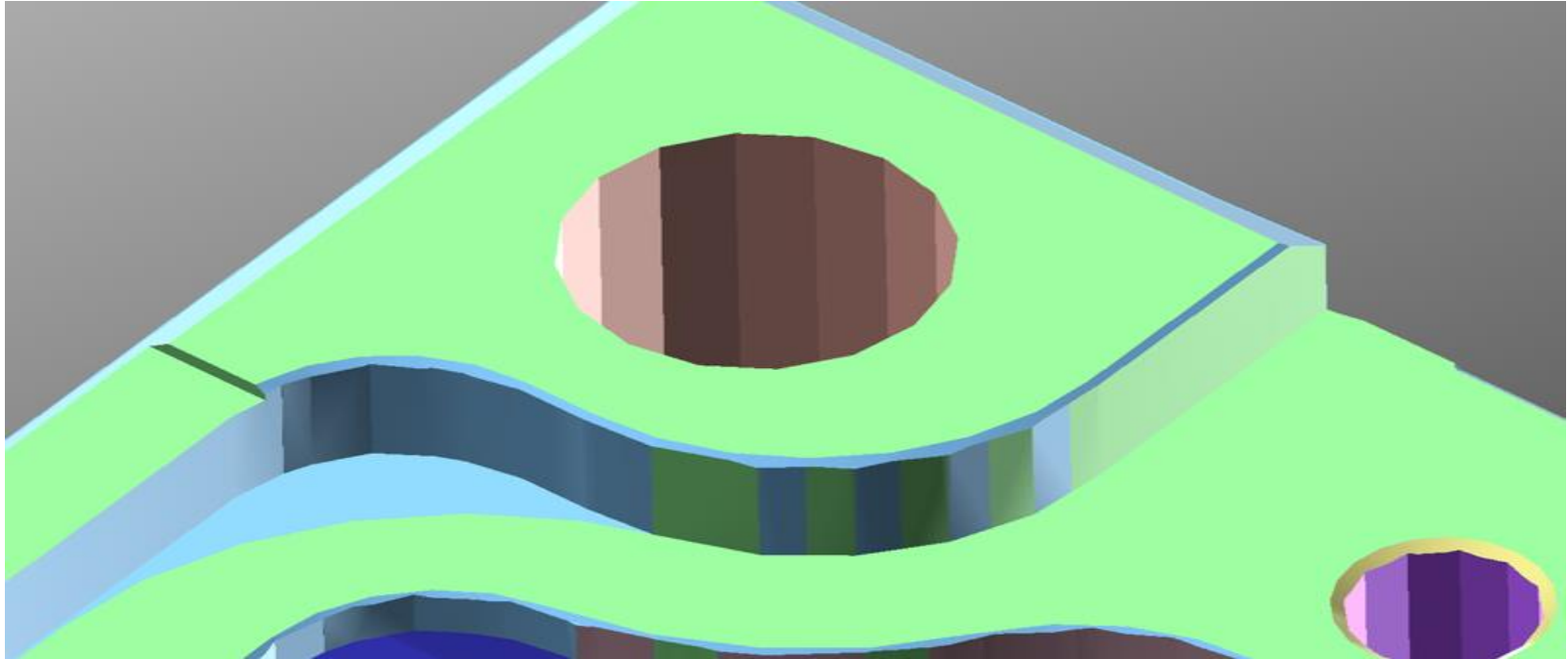
- Easy to use, but robust capabilities
- Fast and accurate
- Must simulate from the same code that will be run on the machine (g-codes)
- Cut stock must match final output

- Fac
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- Poor
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increases
simulating
- Prone to failure

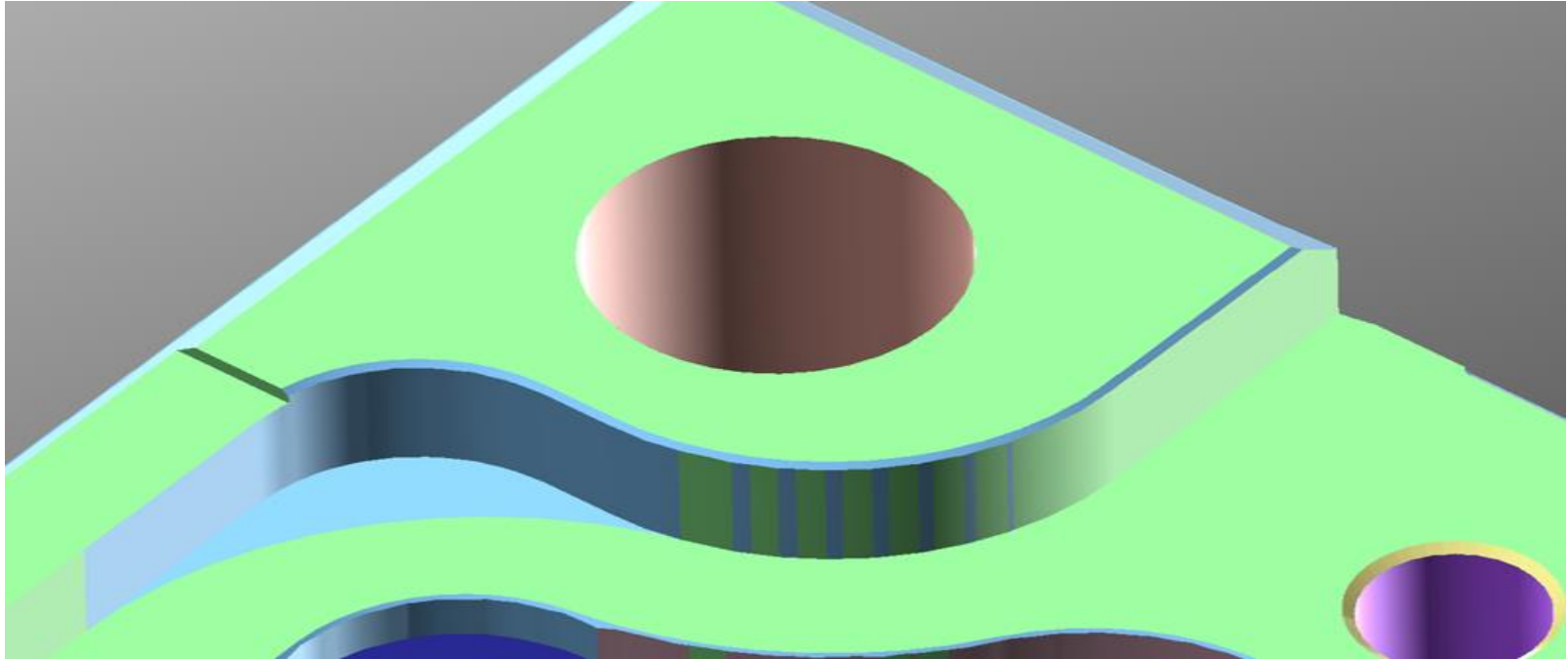


- Poor 5-axis trajectory sweep

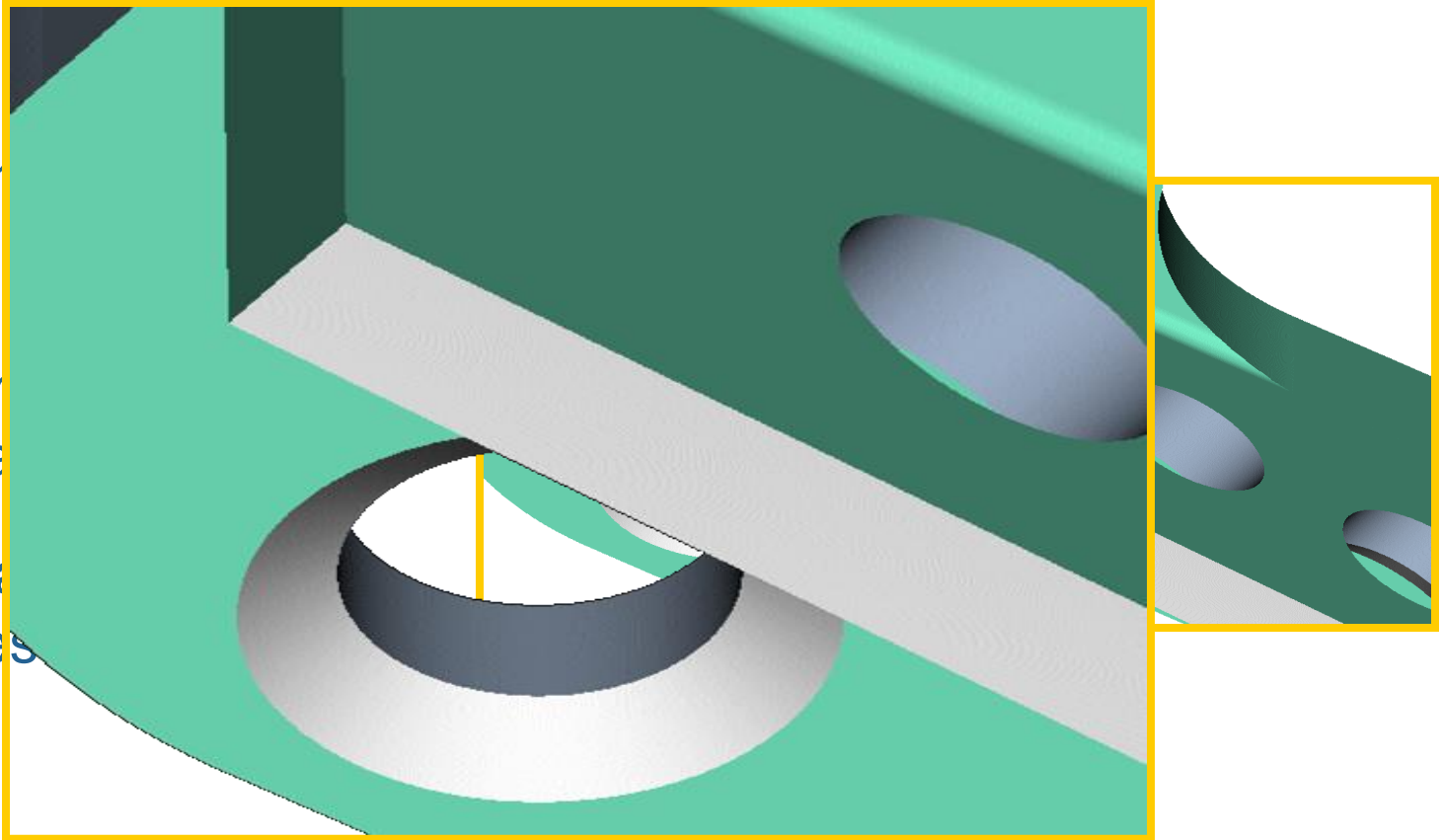
Polygons are inherently inaccurate.

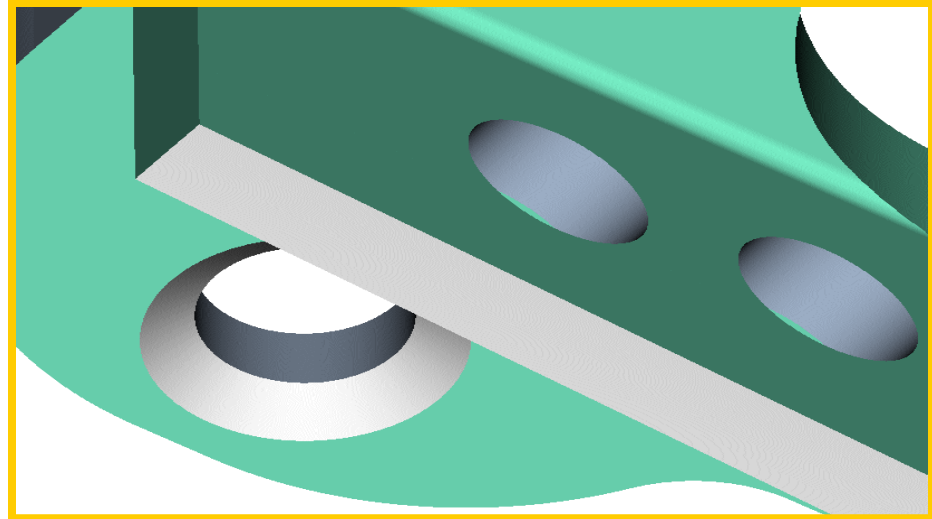
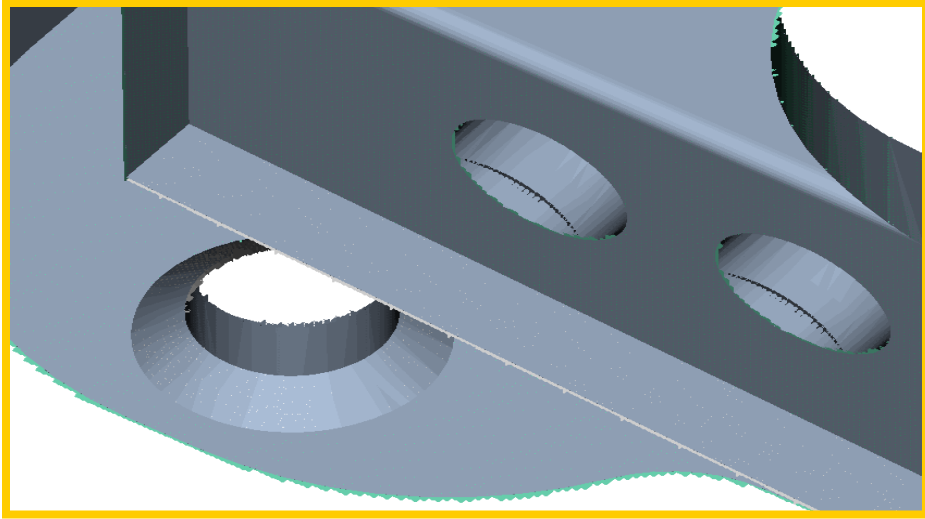


But there are smoothing tricks...



- Feature
- Most
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proces





Simulated features must match the physical process in order to be used with confidence.

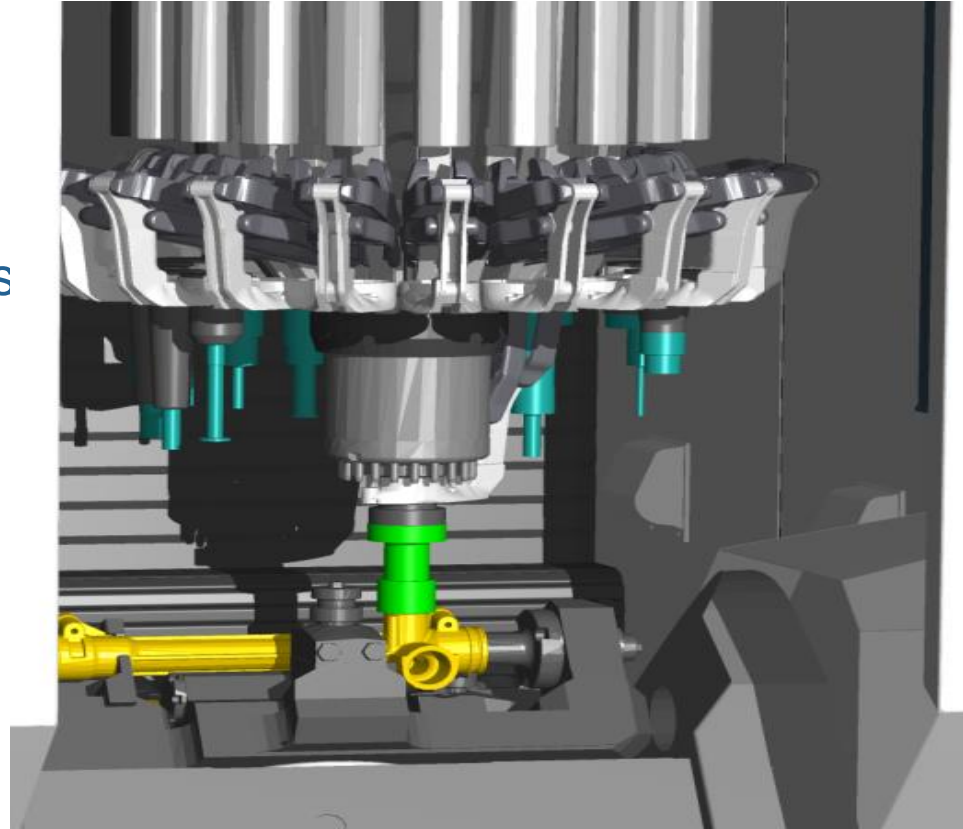
The screenshot displays the VERICUT (64) 7.4 Alpha software interface. The main window shows a 3D model of a workpiece with a yellow cylindrical feature and a purple cylindrical feature. A red arrow points from the X-Caliper tool to the purple feature. The X-Caliper tool is positioned to measure the distance from the center of the yellow cylinder to the plane of the purple cylinder. The X-Caliper tool's data panel is open, showing the following information:

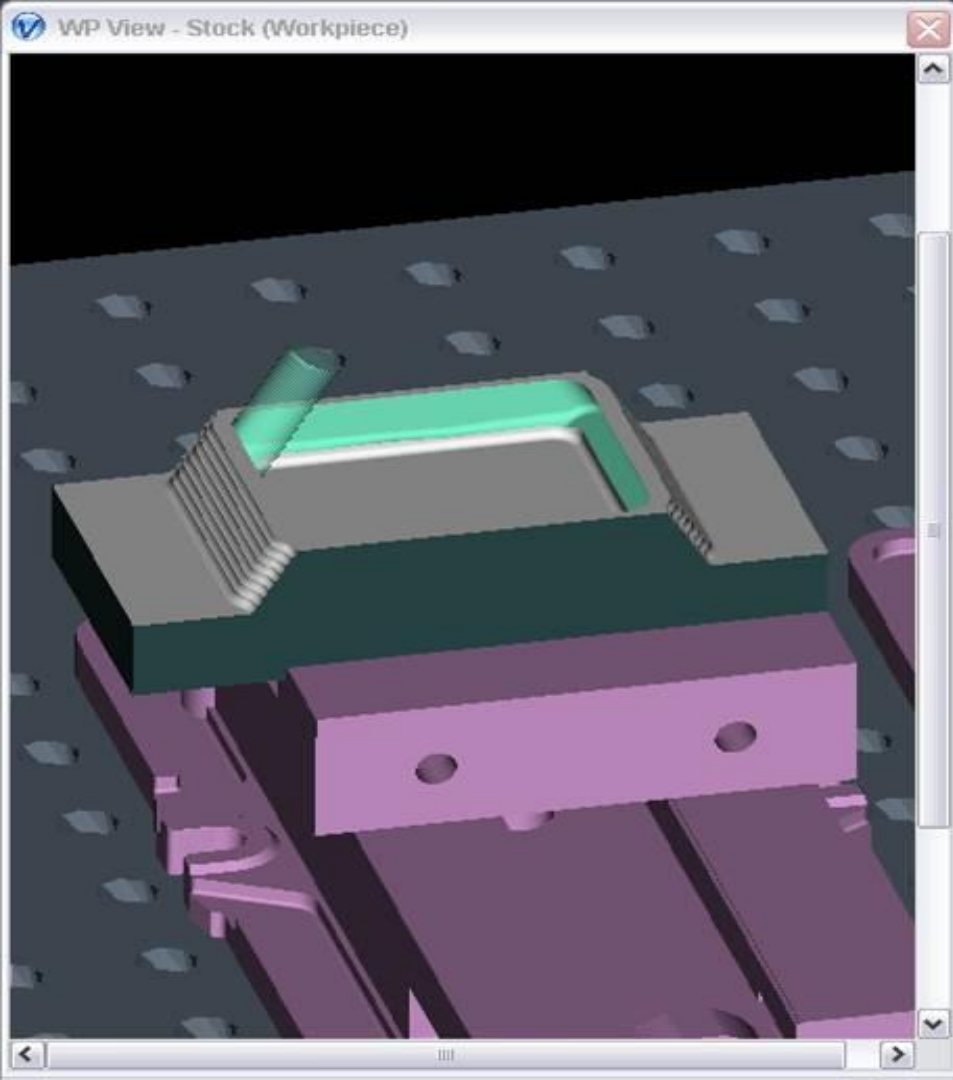
- Distance/Angle
- From: Circle Center
- Location: -241 322.25 88
- To: Plane
- Location: -233 339.2148 95.22
- Direction: -1 0 0
- Distance/Angle
- From Circle Center
- ... Location -241 322.25 88 (Radius 4.5)
- Middle Point
- ... Location -237 322.25 88
- To Plane
- ... Location -233 339.2148 95.22
- ... Direction -1 0 0
- Distance 8 (X = 8 Y = 0 Z = 0)
- Active Coordinate System
- Machine Origin

The VERICUT interface also shows a status bar with 0 errors and 16 warnings, a program list, and a log window at the bottom.

Why simulate the machine?

- Detects collisions and near-misses between machine components
- Eliminate costly machine repairs and delays
- Increase shop safety
- Improve process efficiency
- Reduce the time it takes to implement a new machine

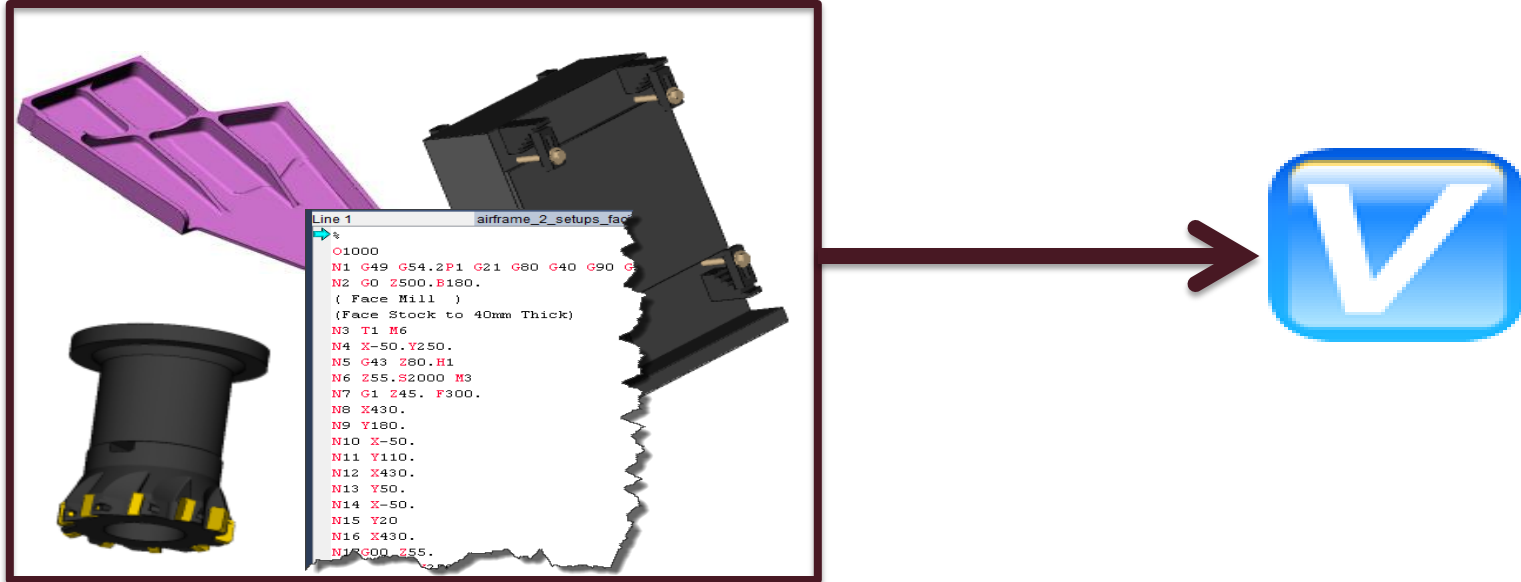




Do I really need to simulate the entire machine?

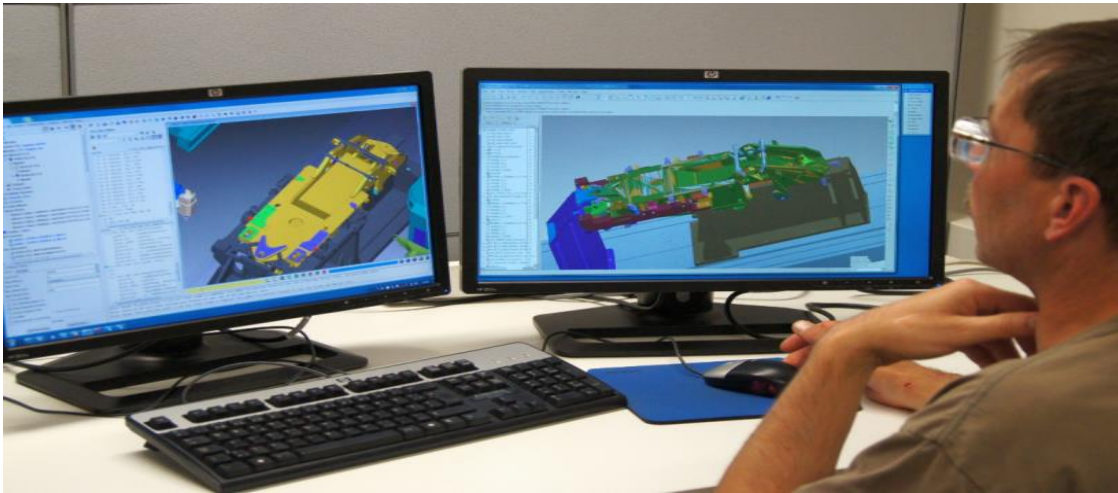
The simulation process is simple.

Step 1: CAM Interface sends information to the simulation session.



The simulation process is simple.

Step 2: Run the simulation. You do not have to watch it run. Work on other things, or use batch mode to run jobs overnight



The simulation process is simple.

Step 3: Review the output. If there are problems, investigate and fix. If not...

The screenshot displays the Vericut simulation environment. On the left, a 3D model shows a machine tool cutting a green part. The Vericut Logger window at the bottom left contains the following text:

```
Fast feed rate removed material with tool "1105" loaded in component "Tool" at line: (2352) N2349 X135.8635 Y9.2557. Removed volume 12.6281
Error: Cutter of the tool "1105" collided with "Fixture" at line: (2352) N2349 X135.8635 Y9.2557
Fast feed rate removed material with tool "1105" loaded in component "Tool" at line: (2353) N2350 X251.5993 Y-13.9621. Removed volume 12.6281
Fast feed rate removed material with tool "1105" loaded in component "Tool" at line: (2354) N2351 Z22.2222. Removed volume 12.6281
Error: Cutter of the tool "1105" collided with "Fixture" at line: (2922) N2919 X103.7024 Y.3019
Fast feed rate removed material with tool "1105" loaded in component "Tool" at line: (2946) N2943 X135.8635 Y9.2557. Removed volume 12.6281
Error: Cutter of the tool "1105" collided with "Fixture" at line: (2946) N2943 X135.8635 Y9.2557
```

The NC Program Review window in the center shows the following code:

```
Line 2922
N2910 X13.5751 Y31.4
N2911 X12.6341 Y31.4
N2912 X5.4225 Y31.4
N2913 Z16.0978
N2914 Z17.1419
N2915 Z26.032
N2916 G0 Z40.
N2917 Z41.
N2918 X6.3759 Y31.4
N2919 X103.7024 Y.3019
N2920 X103.7024 Y0
N2921 Z40.
N2922 Z26.032
N2923 G1 Z17.1419
N2924 Z16.0978
N2925 Z16.032
N2926 X54.5068 F1000.
N2927 X53.5075 Y.9634
N2928 X53.0134 Y14.4565
N2929 X53.0134 Y14.4565
N2930 X44.9939 Y25.8675
N2931 X38.9011 Y28.4934
```

The AUTO-DIFF Report window on the right provides a summary of the simulation results:

File

Comparison Type: Gouge and Excess
Gouge Tolerance: 0.15
Excess Tolerance: 0.015

DESIGN COMPONENT(S):

Component Name: Temporary Design
Component Type: Design
Model Type: STL (U:\Applications\Vericut\Windows\)

SUMMARY:

Maximum gouge of 6.442655 occurred at record 4684
Number of Gouges: 20
Maximum excess of 201.670345 occurred at record 501

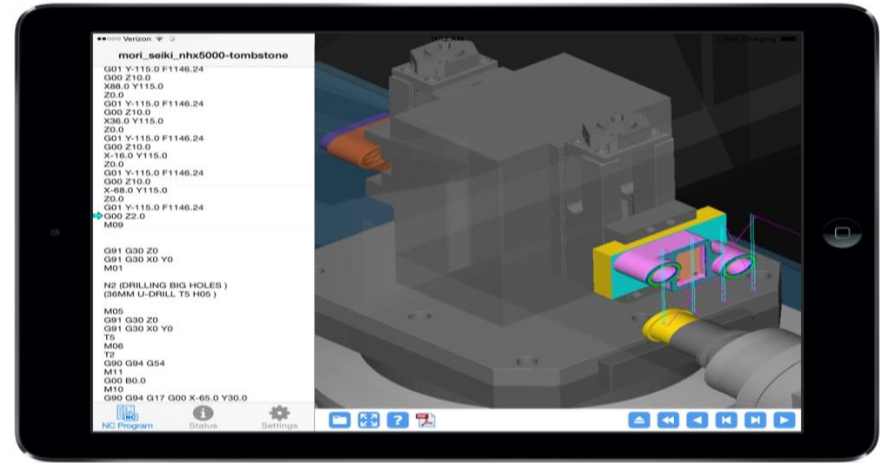
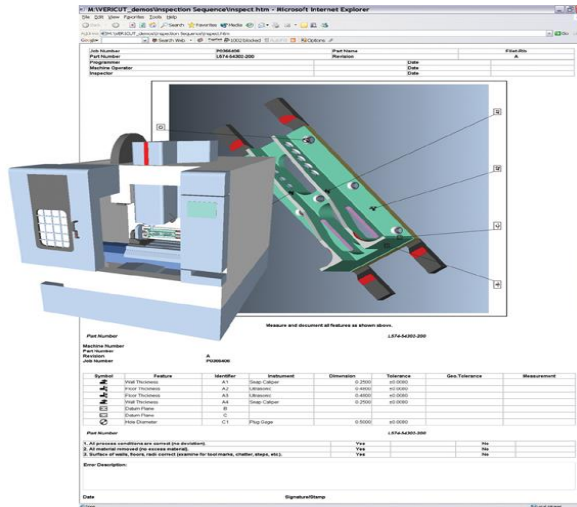
Record Num...	Deviation	Tool ID	NC Program
24	40.00000	1	airframe_2_setups_1
28	4.83534	1	airframe_2_setups_1
30	34.97735	1	airframe_2_setups_1
32	40.00000	1	airframe_2_setups_1

Red arrows indicate the link between the error messages in the Vericut Logger and the corresponding NC code lines in the NC Program Review window.

Errors are linked to the problem NC code

The simulation process is simple.

Step 4: Automatically output set-up sheets and inspection documents. Send the job to shop. Done.



- Simulation can significantly shorten the time required to get a new machine in production
- Not all simulation is equal
 - Confidence requires proven technology



- Your feedback is valuable
- Don't miss out on the chance to provide your feedback
- Gain a chance to win an instant prize!
- Complete your session evaluation now

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