

CGTech VERICUT

A Product Review

December 2019

**Prepared by
CIMdata**

CIMdata[®]

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Foreword

CIMdata, Inc. prepared this product review as an independent and unbiased assessment of the functional capabilities of VERICUT and related products, a CAD/CAM software product suite developed by CGTech. This evaluation is one in a series of software product reviews produced by CIMdata, a worldwide strategic management consulting and marketing research firm. CIMdata has authorized CGTech to reproduce and distribute this document, without constraints from CIMdata.

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CIMdata is an industry-leading consultant on CAM software systems. It produces the NC Software Market Assessment Reports. Market research has been conducted by CIMdata on a variety of CAM related topics. CIMdata provides consulting services to CAM software users and solution suppliers and to the investment community.

Corporate Headquarters

CIMdata, Inc.
3909 Research Park Dr.
Ann Arbor, MI 48108
USA
Phone: 734.668.9922
Fax: 734.668.1957
<http://www.CIMdata.com>

Corporate Headquarters

CGTech
9000 Research Drive
Irvine, CA 92618
USA
Phone: +1 (949) 753-1050
Fax: +1 (949) 753-1053
<http://www.cgtech.com/>

CGTech VERICUT®

A Product Review

1. Introduction

VERICUT software is used to simulate CNC machining to detect errors, locate potential collisions, as well as identify and correct areas of inefficiency within NC programs. With a mix of direct sales and reseller sales throughout Europe, Asia, and the Americas, CGTech serves major markets worldwide.¹

This product review is the result of meetings with CGTech personnel, reviews of public information, and interviews with CGTech customers. The meetings with CGTech personnel took place in CGTech's Irvine, California, Corporate Headquarters where CIMdata conducted an in-depth review of the features and functions of several VERICUT software modules.

This product review details the full range of VERICUT's functionality, beginning with the capture of NC programs and related data from a CAM system, verifying and simulating CNC machining, and creating shop floor CNC machine set-up information and documentation. The product review also details the features, functions, and benefits of the VERICUT software module Force as applied to optimizing and improving the run-time of NC tool paths. The goals and characteristics of CGTech's training and support capabilities as well as CGTech's go-to-market strategy round out the topics.

2. CGTech

CGTech offers a comprehensive solution for verification, simulation, analysis, and optimization of CNC machine operations. Among verification, simulation, and post-processor providers, CGTech is the market and technology leader with nearly three times the revenue of their two closest competitors combined. CGTech provides its customers a means of asset protection for their machinery, equipment, and raw material—minimizing unnecessary and avoidable rework, improving profitability, increasing on-time delivery performance, increasing machine throughput, and realizing greater overall customer satisfaction.

They are viewed by CIMdata as an industry leader in providing software and services to manufacturers who require comprehensive verification and simulation of NC programs for the actual machinery located on their shop floor.

The company has particular strengths in helping NC programmers detect potential errors, and make corrections to the NC program before it is run on an actual machine, which keeps machines running productively and efficiently in the shop.

¹ Research for this report was partially supported by CGTech.

Another capability of the software is to optimize and reduce a CNC tool path's run-time, which can help its users realize a greater return on invested capital, reduce tooling cost, and improve dimensional and finish quality of machined parts.

CGTech has two modules that significantly complement the portfolio. They are Additive and Composites which are described in this review.

CGTech offers extensive service resources to support customization of the simulation of machine tool CNC controls, training, and consulting for its customers worldwide.

Pinpoint Focus

CGTech has maintained a focused market and product strategy, committed to providing the best customer service in the industry concentrating on verification, simulation, and optimization of NC cutter paths.

CGTech believes it is unique in the CAM industry as the only provider of CNC machining simulation and optimization software that generates the vast majority of its revenue solely through CNC machining simulation and optimization. Over the years, this pinpoint market focus, coupled with CGTech's company-wide goal and continued dedication to providing industry-leading direct support to its customers is making CGTech a hard-to-beat solution provider. CGTech considers its product's innovative material removal process to be unique in its ability to provide consistent simulation performance, regardless of the number of cuts or the size of the model.

CGTech milestones include the introduction of AUTO-DIFF™ for gouge and excess material detection; OptiPath's volume-based feed rate optimization; Force's physics-based maximum safe chip thickness optimization; Additive's additive manufacturing (AM) and hybrid operation simulation; Composite's layout, programming, and simulation; and VERICUT's full machine simulation, probe simulation, and support of multiple set-ups.

CGTech Background

Headquartered in Irvine, California, CGTech was formed in 1988, releasing its first version of VERICUT on a UNIX workstation, and established Eastman-Kodak, at the time a leading US camera manufacturer, as its initial customer.

Currently, CGTech provides numerical control (NC/CNC) simulation, verification, optimization, and analysis software technology for manufacturing, to customers in aerospace, automotive and ground transportation, mold and die, consumer products, power generation, and heavy industry. CGTech software is used by companies of all sizes, and also by universities, trade schools, and government agencies.

CGTech has experienced steady growth since 1988 and now has staff of 175 with 8,700 end-user customers. Products from the VERICUT suite are currently used in more than 11,000 installations around the world.

Strategy for Growth

The CGTech sales strategy is country dependent, with CGTech direct offices providing both sales and support where a significant established customer base exists.

CGTech prefers to avoid channel conflict as much as possible, so in most areas around the world there is only one way to buy VERICUT; either through the local CGTech office or from a local reseller. Countries that are primarily direct sales and support include the United States, UK, France, Germany, Italy, India, Singapore, China, Russia, South Korea, and Brazil.

In countries or regions where it is either customary, expedient, or required, it distributes products through resellers. CGTech maintains well-trained, long-time resellers in Japan, Turkey, Israel, Norway, Sweden, Korea, and many other countries. CGTech has 12 direct offices and approximately 180 resellers worldwide.

Whether a customer is serviced directly by a CGTech office or by a reseller, customers can get support on-site, by phone or e-mail, or by filling out a form on the CGTech website.

In areas supported by resellers, most support is provided by the reseller, with assistance from a CGTech office as needed. In areas where the reseller may be less technical, CGTech may choose to support customers directly, even if the sale is routed through the reseller.

Within CGTech there are two layers of support. Each office has their own technical support staff to support their region. However, if they get stuck on a problem or simply get overwhelmed with service requests, CGTech provides members of its corporate technical support staff to help. CGTech states that it is not uncommon for corporate support personnel to fly into a region to provide expert support to meet critical customer needs or schedules. CGTech’s goal is to provide its resellers with regular update training to ensure the support staff have the latest tools and expertise needed to do their job effectively.

Present & Future Outlook

In 2019, as shown in Figure 1, among all CAM software providers worldwide, CGTech is ranked by CIMdata as the 8th largest provider with an estimated 3.7 percent market share in 2019, based on CIMdata estimated revenues of \$55.7 million. Among the CAM verification, simulation, and post-processor software providers, CIMdata ranks CGTech the largest dedicated provider.

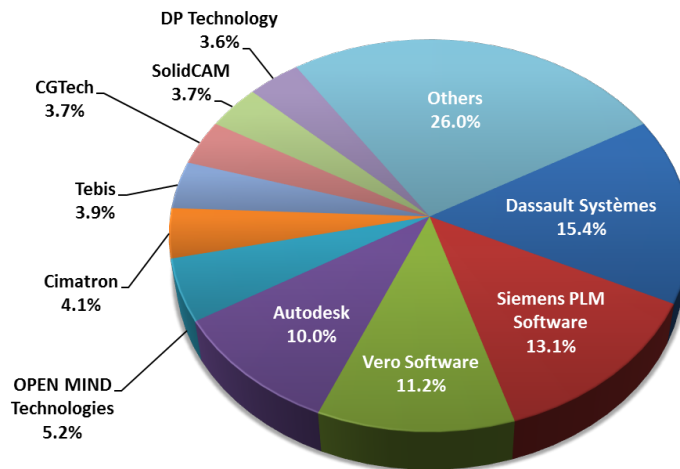


Figure 1— Market Shares of the Largest CAM Providers by Direct Revenue
(CIMdata estimates)

CGTech is one of the most rapidly growing NC software providers worldwide at 9.1percent. In direct revenue by brand CGTech was ranked 9th overall. In 2013, CGTech was the first and only company to have entered the top ten in CIMdata’s ranking of NC suppliers based on direct revenues where the company’s primary focus is not the creation of original NC programs. CGTech continues to be in the top ten in 2019.

CIMdata estimates that there are some 12,600 industrial seats installed, with CGTech having shipped an additional 700 in 2019. CIMdata also estimates that CGTech shipped 1,500 educational seats in 2019 bringing the total educational seats to 15,600.

VERICUT Version 9.0 is the version evaluated in this review. CGTech completes a major release on an annual basis. Smaller releases and service packs are provided several times a year.

3. VERICUT Version 9.0

CGTech’s VERICUT CAM solution offering includes products supporting a number of areas as shown in Figure 2. Many are described in the following sections.

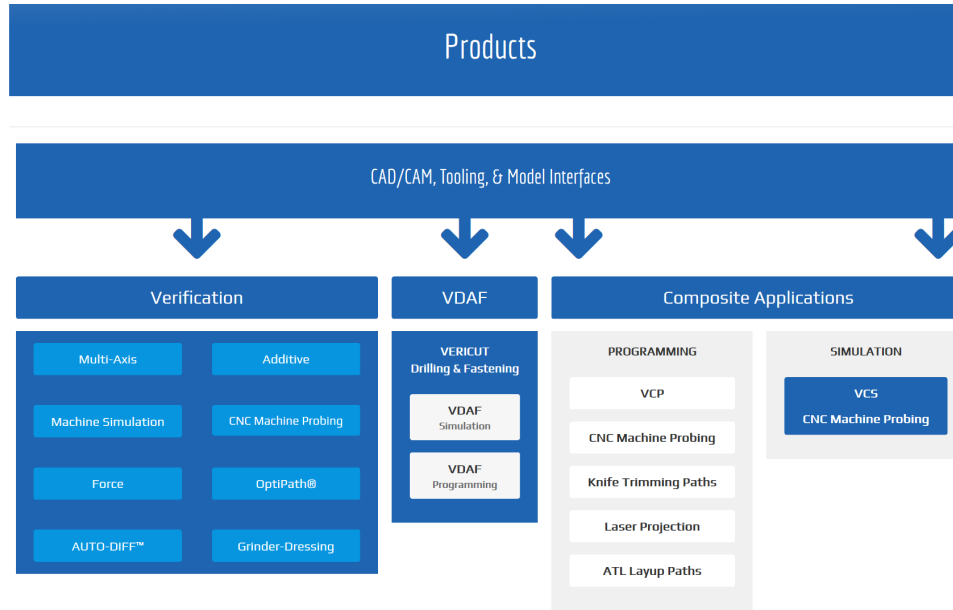


Figure 2—CGTech VERICUT Product Portfolio

Version 9.0, which is reviewed here, was released on November 26, 2019. It delivers a new graphics engine that provides sharper, clearer, and more realistic views of the machine and machined material. The user can switch between views and change model attributes such as color, translucency, or other appearance properties on demand. Major functions such as section, X-Caliper, and AUTO-DIFF can be used in any view increasing ease of use and user productivity. X-Caliper has been enhanced with more options to measure the part or machine. Simulation speed has increased with the new graphics capability for NC Program Review and the free Reviewer application giving better performance to the end user.

Mill-Turn simulation has been enhanced with the addition of a new Multi Tool Station component for turret lathes that can carry an arrangement of cutting tools instead of just one tool. A new turret setup feature allows selecting tools from a list or dragging and dropping from VERICUT’s Tool Manager, and provides easier setup for “Flash” multi-function tools and “sister” redundant tools.

VERICUT Capabilities

VERICUT software analyzes and visually simulates the CNC machining process in a virtual environment. It simulates both tool motion and material removed. It allows validation of the entire machining environment without committing or risking real business assets. The machining environment can include the machine structure, tool changers, multi-axis adaptors, part-holding fixtures, tooling, and tool holders—essentially any static or moving component that the end user deems necessary to fully simulate the use of real assets, and identify opportunities for process improvement and risk avoidance.

VERICUT is a stand-alone 3D solids-based software application that can accept data from a variety of sources, including third-party tooling and tool-holder databases, fixtures created in any number of CAD/CAM systems or from fixture vendors, and machine models provided by machine manufacturers or third-party providers.

Generally, the NC programmer’s use of VERICUT is a three-phase process:

1. Use one of CGTech’s CAD/CAM interfaces to integrate VERICUT into the CAM process, or collect data and settings from the CAM system, import the collected information into VERICUT, and place the data into its initial set-up position.
2. Simulate and verify the material removal process, identifying errors and areas of inefficiency in NC programs. This is also the stage in the process where users can choose to optimize NC program feed rates and cutting methods.
3. Document the entire machining process for the shop-floor.

CGTech offers VERICUT CAD/CAM Interface for most major CAD/CAM systems, see Figure 3. The interfaces tightly integrate VERICUT and the CAM systems to create optimal NC programs. They make verifying and optimizing NC programs and simulating CNC machines an easier and more efficient process. In most cases you can verify individual operations, a series of operations, or a set of complete NC programs used in a variety of machining setups. All stock, fixture, and design geometry are automatically transferred to VERICUT in the correct orientation, along with the NC programs, tooling, machine, and control data and other simulation parameters. VERICUT runs independently, so users can continue working in their CAM system while simulating and optimizing their NC programs. VERICUT can also verify and optimize NC programs from other CAM systems in CL, APT source, or post-processed G-code formats.



Figure 3—Current Supported Interfaces

Using the CAD/CAM system’s user-interface, a user selects a CAM operation in the CAM system, and then initiates the VERICUT CAD/CAM Interface function from within the CAM application’s user-interface. A CAM operation may contain one or more individual cutter paths, each possibly requiring a different set-up or even a different machine. From within the VERICUT CAD/CAM Interface, the user has the option of specifying various additional parameters, including the target machine for each cutter path contained in the selected CAM operation.

If set-up fixtures are defined in the CAD/CAM system for specific cutter paths, these models can be picked up as well by the VERICUT CAD/CAM Interface. The specified machine can be simply a blank machine table, or it can be a fully defined model of an entire machine-control combination and its environment, or any variation between those extremes.

From the VERICUT CAD/CAM Interface dialog, the user clicks the button “output files” and all tools, post-processed cutter paths, fixtures, and relevant setup information are automatically collected and input directly into the VERICUT stand-alone application.

When the data and settings land in VERICUT, VERICUT places the CAM system’s part file on the virtual target machine as specified in the VERICUT CAD/CAM Interface’s dialog. If a holding fixture was part of the collected data, both are placed in VERICUT in the applicable set-up position on the target machine. The as-designed part model enables users to verify there are no gouges committed against it and that all excess stock is removed as expected by the NC operations.

While the CAD/CAM system that created a cutter path can provide its data to be used in a simulation, selected elements of that data, such as tooling and holders, can be replaced in VERICUT with more precise models. A user may want to replace the CAM system’s tools with more accurate or correct versions to improve the quality of the simulation. For example, replacing a bull-nosed end-mill that was used to program a path that will instead use an inserted end-mill at the machine. This can avoid the situation where the simulation does not use the inserted end mill, thus not identifying a potential tool motion having a plunging ramp angle that exceeds the capability of the specific inserted end-mill being used at the machine.

VERICUT includes a Tool Manager that supports full 3D models. Tools captured from the CAD/CAM system, either interactively or through the VERICUT CAD/CAM interface, are brought into the Tool Manager’s tool library. Tools and tooling can also be defined from scratch using the Tool Manager, and any tool in the tool library can be edited with the Tool Manager, regardless of its source.

As with all software programs, the accuracy of the data input will directly affect the output. So, an accurate model of the cutting tool and holder is required for the effective and accurate simulation of the machining process. Most leading cutting tool manufacturers now make 3D solid model data available and VERICUT can load this model data for use in the simulation process. Many of these 3D models are available via the MachiningCloud App providing access to data from over 40 tool related manufactures and fixture suppliers. VERICUT’s Tool Manager takes advantage of Machining Cloud metadata which can significantly simplify the configuration of tools for use in VERICUT, and better describe their proper use and limitations. VERICUT also integrates with most major tool management systems. Suppliers including TDM, Zoller, WinTool, Speroni, and Kennametal’s NOVO can also interface to the software, so tool offsets and exact dimensions can be applied to the simulation session. A tool definition is shown in Figure 4.

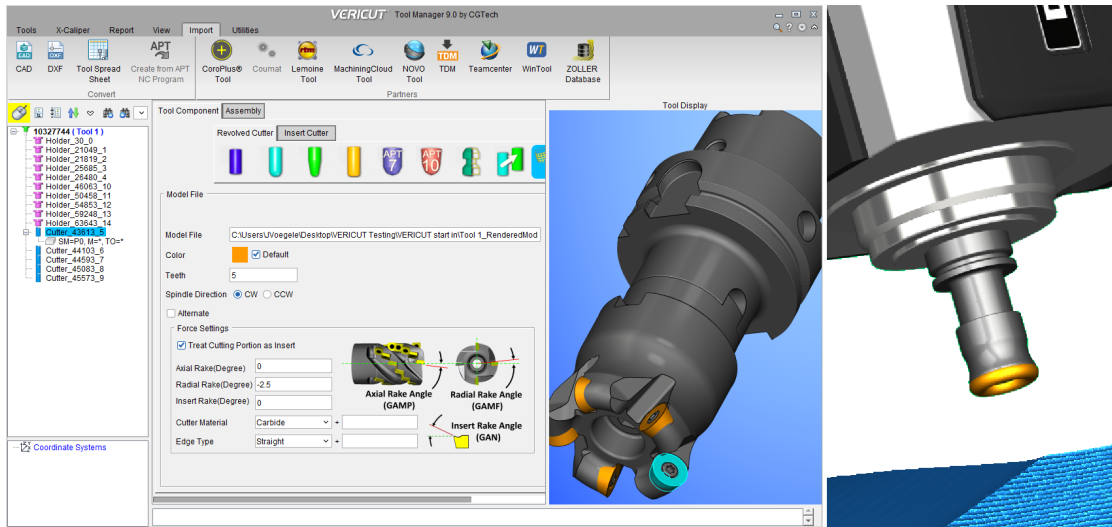


Figure 4—Tool Definition Example

The Tool Manager is capable of defining and managing any type of tool needed from simple spinning tools to angled head and live tooling.

Syntax Error Checking

The “Simulation” phase of using VERICUT begins with an optional check for syntax errors in the NC program. This is especially important if the shop allows error prone hand-editing of NC programs. Syntax-check error messages relate to the actual line in the NC code, making it easy to identify the source of problems and where they can be corrected; then the revised NC program can be saved.

Once the NC program is syntactically correct, users can proceed with the next step, verification and simulation of the NC program.

Preview Scan

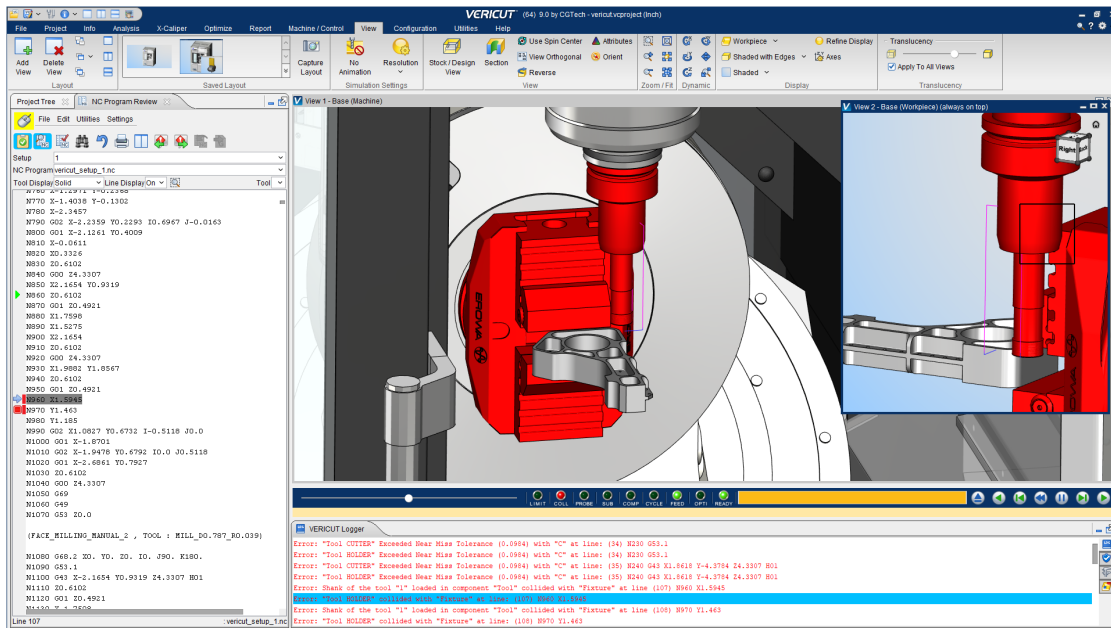


Figure 5—Preview Scan

Before doing a full material removal simulation users can use VERICUT’s preview scan (Figure 5) to check for gross errors. The preview scan is often done interactively as it executes quickly and identifies gross errors that should be corrected on the CAM system before proceeding with a full material removal simulation.

Preview scan moves the tool, holder, and the machine around, checking for gross errors, including gouges to the part. Problem areas in the part are shown in red. The user can click on an error message and the tool will position itself at that location. User-interface controls allow the user to move the tool program forward and backward to gain a better understanding of the situation.

Preview scan can detect a variety of errors including holder rubs, shank rubs, machine-head collisions, or near misses. Preview scan also checks for gross moves beyond any of the machine’s axis limits, a capability added to account for the dimensional uncertainty of specific elements in a model. It isn’t uncommon for cast components of a machine or fixture to vary significantly from the nominal dimensions used in the model. Preview scan can detect near misses and moves beyond any of the machine’s axis limits.

The VERICUT application uses an underlying architecture that can be thought of as a “smart part.” The “smart part” retains all the information gleaned during the execution of the NC program. So in the case of errors such as holder rubs or shank rubs, even if the area where the rub occurred were to be removed in subsequent cutting, the model still retains that information.

Being able to click on errors and see the exact situation at that point in the simulation helps the programmer understand what contributed to the problem, whether it be the wrong tool, the design version being out of sync with the cutter path version, the wrong path in the sequence of paths, or perhaps even a poorly defined clearance plane.

Verification & Simulation

In VERICUT, the verification and simulation of an NC program is a 3D solids-based interactive depiction of the material removal process. VERICUT simulates multi-axis milling/drilling as well as multi-axis turning and combination mill-turn machining. VERICUT offers views to see the entire machining process on machine tools as they appear on a shop floor, a “Workpiece” view that omits display of machine models so users can have unobstructed viewing of tool “reach” and the machining process, and a turning “Profile” view that provides clear viewing of inside and outside diameter machining on lathes and mill-turn machines.

Users can configure the screen to show single or multiple views of the simulation. During the simulation, views can be changed entirely, rotated or zoomed dynamically, and individual components or models can be blanked/displayed at will. The simulation speed can be changed dynamically at any time by using a slider bar. An error section is displayed at the bottom of the screen in an area called the Logger window. It can be resized and repositioned anywhere on the screen by the user.

The user interface is customizable and allows the ability to save processes and commonly referenced files as “favorites.” Various other display options help users track their part processing operations. A red color on the screen in the model visually highlights problems, accompanied by error notes in the Logger window which are dynamically linked to their NC programs. Identifying the root of a problem is only 1-click away. When a simulated cutter path is finished, it drops the resultant cut stock model into the next setup, and in the appropriate position for machining, even if it is on a different machine.

VERICUT’s X-Caliper™ feature supports taking measurements between points on the model. Precise measurements are possible because the VERICUT application uses a precise 3D solid model rather than a tessellated model typical of some NC cutter path verification and simulation solutions. With VERICUT’s precise model, simulation performance seems to be largely unaffected by model size.

Full Simulation

In VERICUT the full simulation can be used in a highly interactive manner to visually and programmatically study and review each and every motion made by the tool, holder, machine-head, and its interaction with the part, fixtures, machine table, and with any other parts of the machine.

In practice, however, VERICUT is often used as a go/no-go gauge by simply running the simulation in the background (known as “batch” processing) and examining the end result. Several simulations may be queued in a batch process to run in the background. Foreground use of VERICUT is possible while background simulations are being processed, presuming enough licenses are available.

After a simulation has been processed, just as with preview scans, users can click on errors in the logger window and review the cutting process at any stage of material removal, even though the simulation may have removed material in subsequent cuts. This way, the user may personally analyze the finished result as the user may want to choose when an error is significant enough to warrant remedial action.

Reviewing the entire simulation after processing is possible because VERICUT keeps a log file of each error encountered. It logs all errors and maintains sufficient data during the simulation to reconstruct any condition that occurred during the simulation.

AUTO-DIFF™

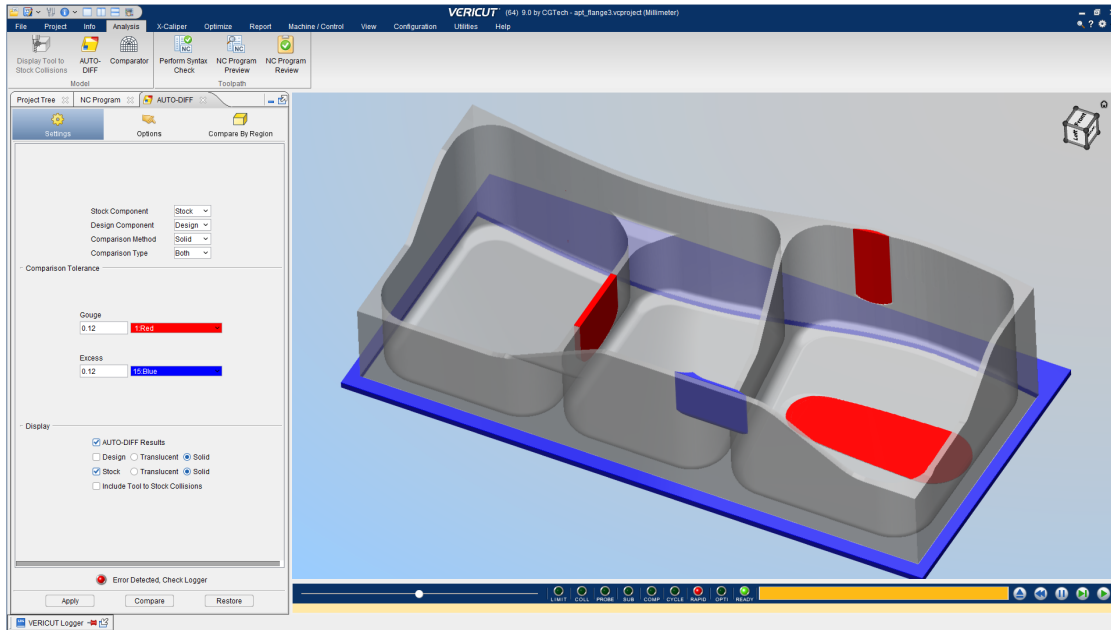


Figure 6—AUTO-DIFF Results; Gouges Shown in Red, and Excess in Blue

VERICUT’s AUTO-DIFF module compares a CAD design model to a VERICUT simulation and automatically detects both excess stock and gouge conditions. See Figure 6.

- AUTO-DIFF can verify that a part has been completely finished or conforms to a minimum allowable excess condition. AUTO-DIFF creates a list of gouges and/or excess material conditions which is interactively linked with the cut stock model and NC programs, making it easy to identify where the errors occurred by just clicking on them in the list.
- AUTO-DIFF produces a mathematically precise model allowing discreet measurements to be taken to precisely determine excess at any point on the model. Color shading based on range of excess material is also available.
- AUTO-DIFF may be used interactively or in a batch-verification session. Many users want to apply their judgment to each condition to determine if the presumed error is critical to producing the desired result.

Shop Floor Documentation

For shop floor documentation, VERICUT includes an integrated reports system with fully customizable templates that can be used to provide a multitude of information about the NC program, images of the part, setup and CNC machine, along with images of the 3D cutting tool assemblies.

Setup visuals can include dimensions and notes. The part shown in the setup pictures is color coded to be consistent with a bar chart depicting the range of existing unremoved material. The tools are depicted in the report as thumbnails but can be clicked-on to show the tool in greater detail.

The system’s reports are in HTML format which makes it easy to use preferred methods of distribution. They can be emailed, printed, or placed on a server for access by users. Since they are HTML documents, they can be opened for viewing and printing from any browser. PDF and text formats are also available.

Additionally, a Reviewer File can be created that contains all the documents intended for a shop floor session and show a review of the machined part or parts at various stages in the process. The Reviewer File can be used by a no-license-required VERICUT Reviewer application available for both the PC and the iPad.

For the PC, the Reviewer File can be distributed to contain data that allows the viewer to step forward or backward in a cutter path and visually see the material being restored that was removed by the cutter. The iPad reviewer provides the same functionality as the PC version, with the exception of adding material back in with backward movements in the cutter path.

QA personnel can use the viewer to take actual precise measurements since the Reviewer File contains the full model of the part.

Simulating the Machine & Its CNC Controller

Using simulation to eliminate actual try-out with physical assets necessitates the inclusion of equivalent virtual assets in the simulation process. Simulations that only include tools, holders, the part, its holding fixture, and the machine table can only protect the included assets from damaging or destroying one another. It cannot protect other assets, or the CNC machine itself from collisions with the machine's static structure, the machine head, head attachments, or tool-changers.

With VERICUT, users are able create a virtual environment that includes any static or moving component, including the physical machine, its kinematics, and its unique machine-control logic. This is shown in Figure 7.

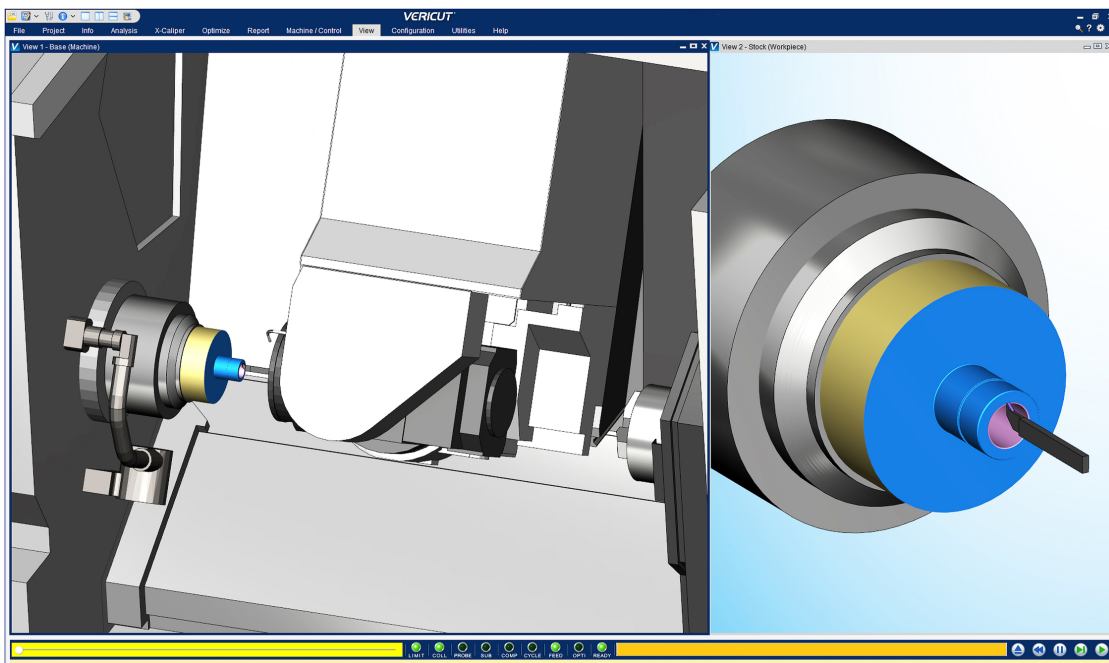


Figure 7—Machine Simulation with Control Logic

To simulate an actual machine, VERICUT can simulate the machine's controller and mimic how it actually is connected to, and configured with, the physical machine. This is a critical element of the simulation process as on the shop floor each machine-control combination is a discrete entity; even if they appear to be the same. Two machines sitting side-by-side of the same model and with the same controller model can be, and often are, different in how they react to the same post-processed cutter path data.

CIMdata believes CGTech’s approach to providing customized machine control simulation offers a distinct advantage over simulation solutions that simulate pre-post-processed cutter paths. This is also the case for solutions that use post-processed cutter paths, but cannot simulate the control logic that matches the precise machine/machine-control combination upon which the post-processed file is to be executed.

In a CIMdata interview, Michael Worth, a 3rd-generation principle at TCI Precision in Gardena, California, indicated their policy is never to run anything on the shop floor without first running it in VERICUT. Dan Balmer, the programmer responsible for NC programs sent to the shop floor observed: “VERICUT software allows me to simulate what’s going to happen on the shop floor, not what appears to have happened in the CAM system.”

Elements of VERICUT Machine Configurations (VMCs)

In VERICUT, a virtual machine, including its control, is called a VERICUT Machine Configuration (VMC). A VMC includes kinematic properties (definitions for how machine axes move plus their motion limits, if any), the control logic, and optionally can incorporate 3D models to graphically represent machine components and other hardware. Sample VMCs are included with the VERICUT software. A Sample VMC can be used directly in VERICUT or it can be used as a starting point to configure a more precise or specific VMC.

Several CAD model formats, including STL, IGES, or STEP model formats, may be used to represent machine components. Machine components can also be directly modeled in VERICUT. In some cases, machine builders provide customers with a virtual physical model. For example, virtual physical models of DMG Mori Seiki machines may be acquired directly from DMG Mori Seiki using a machine’s specific model number. Third-party suppliers specializing in providing machines models offer another option for acquiring machine models.

With VERICUT, a feature-tree allows the user to connect and arrange the pieces of the machining environment, create the machine kinematics, and attach virtual physical models to bring the digital twin machine to life.

To emulate the actual machine’s control, and its interaction with the machine, users have the flexibility to configure the virtual machine control such that it precisely mimics the behavior of a user’s specific machine-control combination.

The machine control configuration functionality in VERICUT allows each controller in the shop to be accurately simulated to account for different types of machines, programs, parts, and functions. In the creation of a VMC, about 20% of the effort is directed toward the creation of the virtual physical model, and the rest is spent configuring the virtual control to reflect exactly how the control and machine interact.

Users access pull down dialog boxes where G-code characters and numerals are defined in a logical “word/address” format, and then configured to call CGTech action macros which simulate control functions. The control logic also supports conditional checks (i.e., other codes in the block, current variable values, machine states, etc.) that can alter how the word/address is interpreted. VERICUT includes a library of flexible, easily modified controls from makers such as:

- Allen-Bradley
- Bosch
- Cincinnati Milacron
- Fadal
- Fanuc
- General Electric
- Heidenhain
- Mazatrol
- NumeriPath
- Okuma
- Phillips
- Siemens
- Yasnac

VERICUT is designed to support a variety of advanced control functions including:

- Look-ahead or 3D cutter compensation
- Tool tip programming and tool length compensation
- Gage length reference point programming
- Canned cycles and fixture offsets
- Rotary-axis pivot points
- Variables, subprograms, and macros
- Subroutines, looping, and branching logic

Whether an example VMC is used as-is or as a fully customized VMC, each one is shown in the list of target machines in the CAD/CAM interface dialog. Many customers create their own collection of VMCs. Additionally, CGTech offers a service to create or enhance custom VMCs, in which case the VMC is developed exclusively by CGTech personnel.

Creating a VMC

Customers have full access to all the resources required to build a fully customized VMC. Nothing is hidden from the customer, with everything available through the VERICUT interface to build a full VMC machine model on their own. CIMdata counts this as a big plus for VERICUT.

Customers who develop or customize their own VMC also have access to the same CGTech service team that internally develops VMCs. The help system and related help documentation are complete in their characterization of available macros that need to be called to mimic what the machine is actually doing, and customers have access to the service team to get the support they need to model even the most complex machines.

The CGTech Services team can create Machine Tool Modeling and Control Building models to simulate CNC machines. If there are special or complex simulation requirements CGTech can model those machines and do everything required to make running simulations a push-button operation, building virtual CNCs for graphical simulation and collision checking, as well as non-graphical kinematic representations designed to enable VERICUT to accurately process G-code NC programs. The CGTech team can also be used for other needs such as:

- NC Program Optimization to improve the quality and throughput of NC machining
- CAD Model Export for having an accurate CAD representation of the finished part into an ‘as-machined’ model
- Custom tool libraries and custom software development to build VERICUT tool libraries from scratch or from existing spreadsheets and databases

The G-code files that drive complex machines with multiple heads often contain G-codes created by macros unique to the head. In most cases the macro source can be captured from the control and used in the VMC definition to emulate the control macro and ensure the simulation matches the actual machine logic and behavior. When the macro cannot be acquired from the control users can use the macro language CGTech supplies with the VERICUT software to emulate the control macros.

Noteworthy Capabilities

VERICUT verification and simulation supports complex Swiss-style machines with gang-tooling and Swiss-style machines with live tool motions where a milling cutter can be positioned perpendicular to either the diameter or the face of the part. Also supported are Swiss-style machines with a “B” axis, programmable, and articulating milling spindle capable of moving in an arbitrary five-axis plane.

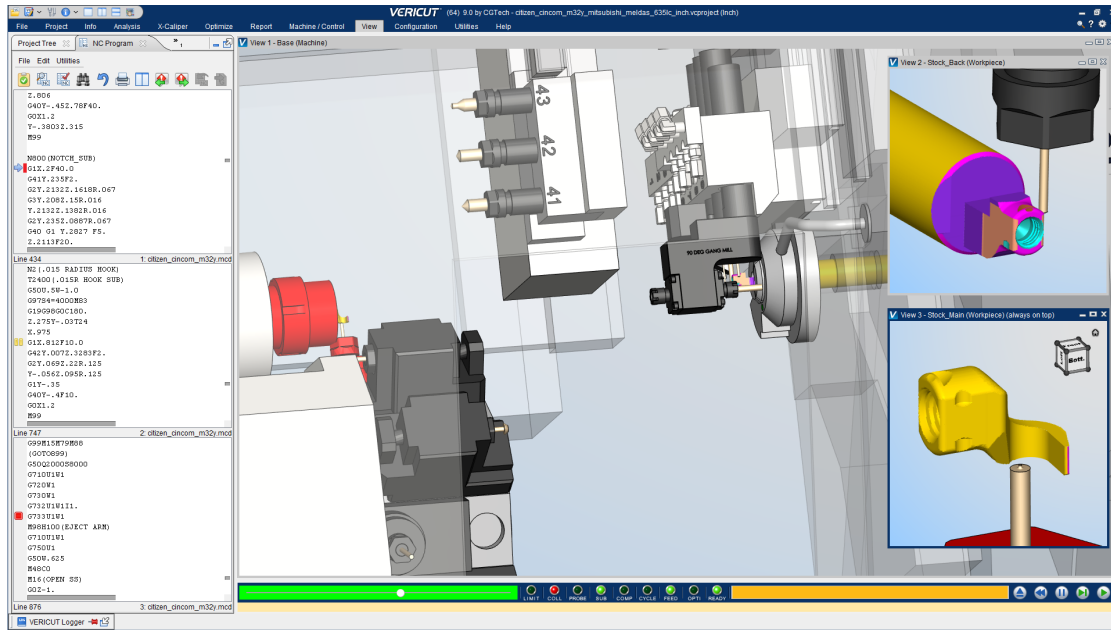


Figure 8—Swiss-Style Machining

To support the multi-spindle, multi-tool capabilities of a Swiss-style machine (Figure 8), it is common for the cutter paths to be programmed in the CAM system independently of one another, and then synchronized automatically by the CAM system, manually by the programmer, or a combination of both.

When executed on the shop floor, the machine operator loads each program into its own execution channel, and the machining begins with the sync-codes orchestrating the program flow of each execution channel. Clearly, it would be very risky to expose these complex precision machines to damage caused by synchronization errors without first verifying the manner in which the sync-codes orchestrate the cutter paths.

With VERICUT, users can verify the programs with their sync-codes, and can also edit sync-codes if necessary to balance the execution of the individual channels. Conflicts can be resolved during the simulation by modifying the sync-codes that coordinate the execution of the independent channels. Sync-codes can be modified to improve the run-time of the combined operations. In this sense, VERICUT is being used to optimize run-time as well.

VERICUT accommodates shops and programmers that do cutter compensation NC programming including 5-axis cutter compensation.

VERICUT can be used in the pre-planning stage of manufacturing to execute feasibility studies for parts for which a NC program does not yet exist. For example, the user can place the part on a candidate 5-axis machine, pick a tool, and to test-out the asset, can move the machine manually by using the control’s manual data input (MDI) capability, or can actually use the part geometry by a screen-pick to drive the tool to that specific point.

Force

VERICUT Force is an optimization strategy that can be used independently and complimentary to the standard “optimized machining” strategies offered in certain CAM systems. VERICUT Force is a physics-based optimization strategy that was initially designed to improve the manufacturing of superalloy and high-technology products including helicopters, aircraft engines, and aerospace and defense systems.

VERICUT Force’s optimization calculates ideal feed rates by analyzing tool geometry and performance parameters, material properties of the stock and cutting tool, detailed cutting edge geometry, and VERICUT cut-by-cut contact conditions. Force uses a proprietary set of materials coefficients, obtained through on-machine dynamometer testing, to account for the strength of material and the effects of friction and temperature. Force optimization calculates feed rates to promote ideal chip thickness for machining, while simultaneously ensuring safe cutting forces and spindle power levels for machining.

VERICUT Force excels in difficult to machine materials, and especially complex multi-axis cuts such as 5-axis flank milling. It can be used to optimize milling, turning, and mill-turn cutter paths.

The use of Force can have a significant cost savings to a company so an in depth look here is warranted.

Force enhances NC programs by correcting poor approach and poor programming methods specifically looking at non optimal feedrates used by the CNC programmer and the inability of CAM systems to change the cutting feedrate as the machining conditions change.

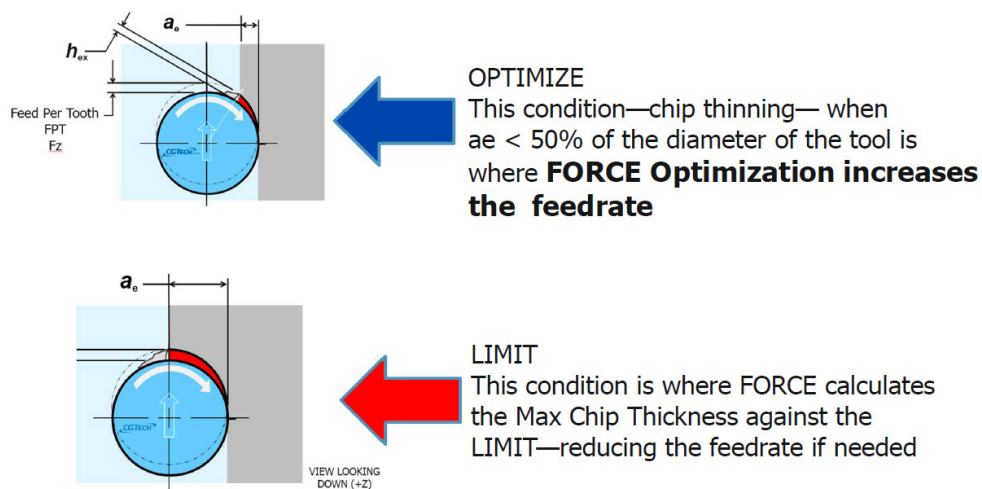


Figure 9—Force Calculation Example

Force analyzes the physics of interactions between the cutting tool and stock material to achieve maximum safe cutting chip thickness and optimal cutter speed, while simultaneously protecting the machine and part from overload. This process is illustrated in Figure 9. A thin chip with a hex value (maximum chip cutting thickness) that is too low, as seen in the upper left side of Figure 9, is the most common cause of poor performance resulting in low productivity. This can negatively affect tool life and chip formation. A chip thickness that is too high will overload the cutting edge, which can lead to breakage. Keeping the chip thickness maximized and constant ensures that a tool is doing as much work as it can within any given cut and set of machining parameters. Insuring that the tool is performing to its full potential. Other benefits include: substantial time savings through higher cutting speeds, increased metal removal rates, reduced rubbing, less heat, and improved tool life.

Force uses a number of charts to depict to the user the areas of calculated changes, as shown in Figure 10. The difference between the original program and the Force optimized program is the opportunity for time and cost savings. Force uses a balanced approach for optimization maximizing the chip thickness and keeping it constant while setting machine limits to prevent failure due to exceeding the maximum feedrate, the maximum force, and the maximum tool deflection.

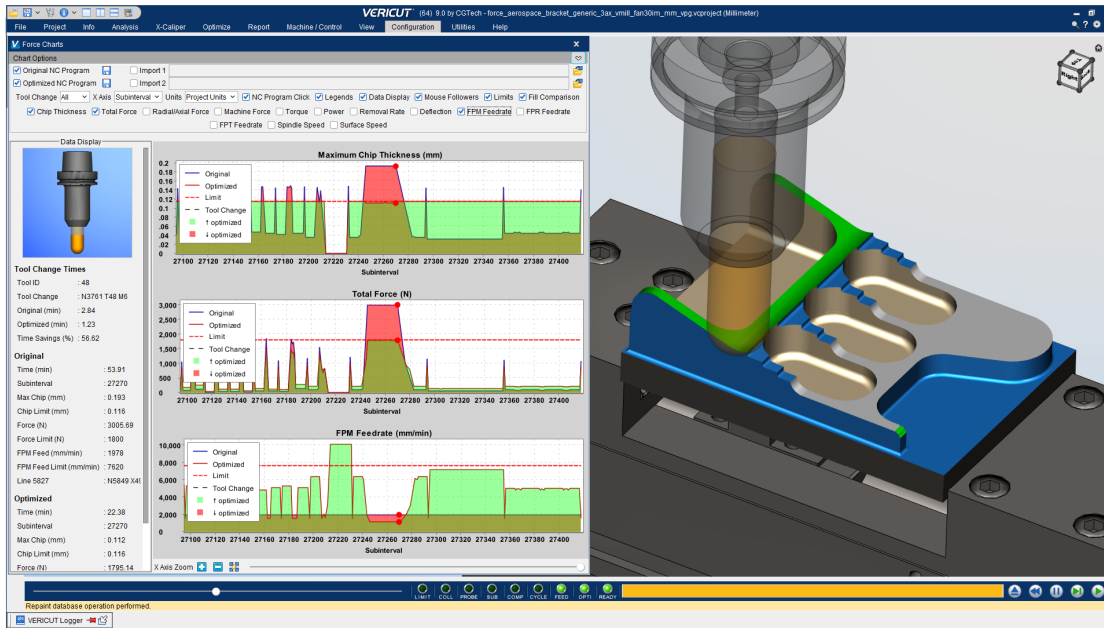


Figure 10—NC Program Optimization Resulting from the Use of Force

Force appears to be easy to use. The few values that it needs can be entered by the user or read from tooling databases describing the tool attributes such as tool diameter, teeth/flute count, helix angle, and radial rake angle. Next the user selects the stock material and starts the simulation/optimization process. User-selected charts of the original program results versus the optimized program are displayed during the simulation; including a chart depicting the optimized time savings as shown in Figure 11 and Figure 12.

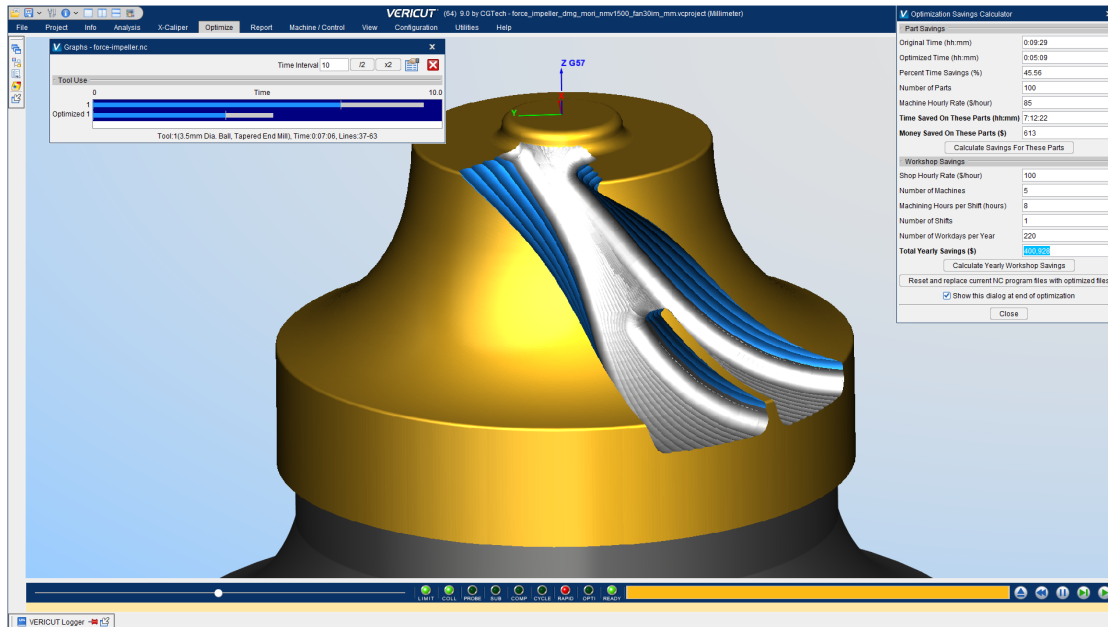


Figure 11—Time Savings Chart (Upper Left) that Updates Throughout the Programming Process

Force can be used for any NC machining that cuts a chip (milling or turning) in most cases regardless of age of the CNC machine/machine control; for all materials hard or soft from Inconel to aluminum, CFRP

and plastics; and for all cutting tools of any sized or shape from micro-milling to large multi-insert pinecone cutters.

Force works bidirectionally with Siemens NX CAD making changes in the original CAM program easier.

CIMdata sees another opportunity by optimizing feedrates in existing part programs through the Force batch program. A shop could significantly increase its throughput by shortening the run time of multiple parts.

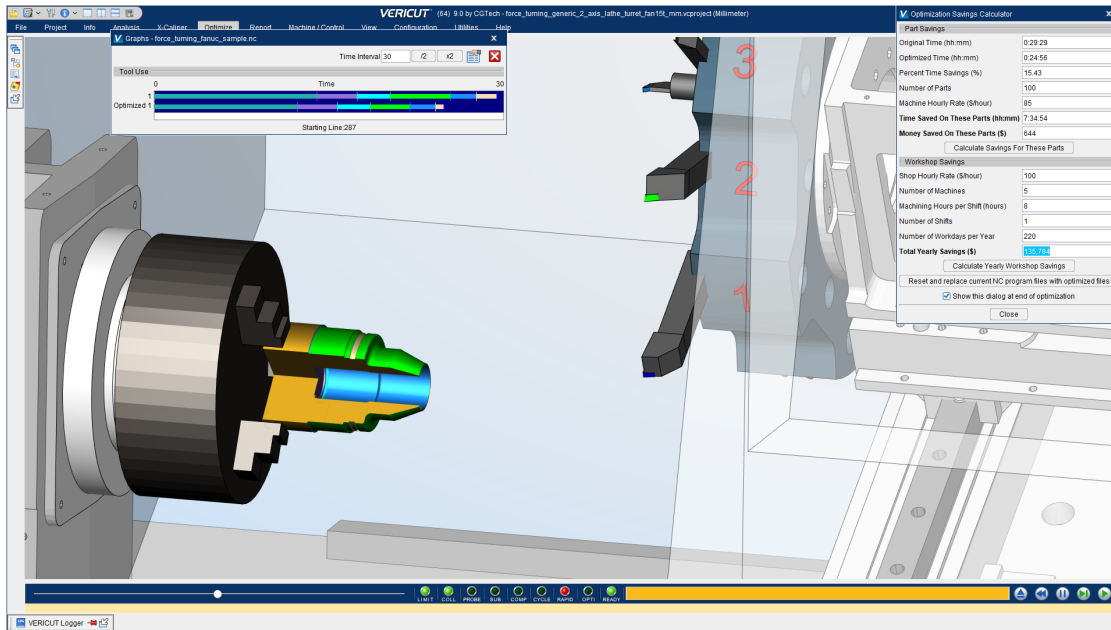


Figure 12—Time Saving (Upper Left) in Turning Using Force

Force can also be used for turning applications with turning inputs similar to those for milling. Turning operation speed improvements can be measured as shown in Figure 12.

Force benefits include:

- Significant cycle time savings
- User friendly (especially for NC programmers)
- Charted cutting condition information for NC program analysis and data driven decisions
- Fast analysis and iterations for testing various cutting scenarios for optimal NC programs
- Maximized and more consistent chip thickness throughout the machining process
- Prevention of undesirable cutting conditions
- Force reduction, HP/Torque, and tool deflection
- Improved cutting tool performance utilizing cutting tool technologies to their full potential
- Machining improvements that are balanced between tool life and speed.

Force will improve delivery times (beat due dates), increase capacity (increase throughput), improve margins (increase profits), provide the opportunity for quote price / bid price reduction, improve part-to-part and job-to-job consistency (regardless of NC programmer).

CIMdata thinks that the use of Force consistently throughout a shop could positively impact a shop's competitiveness and increase its profitability.

OptiPath

The VERICUT OptiPath module is used to improve the real-time machining performance of existing milling cutter paths. With OptiPath it is possible to reduce run-time, and also to gain improvements in a variety of material-cutting concerns—they include:

- Improved machine-tool utilization through reduction in run-time
- Extended tooling life
- Improve surface finish
- Reduced machine wear-and-tear

OptiPath subdivides an existing cutter path into a collection of small incremental segments and adjusts the feed rate at the beginning and end of each segment based upon path-monitoring optimizing strategies. To optimize a cutter path, a user can choose to apply a single optimizing strategy, or can apply a combination of optimizing strategies. Users can adjust the underlying parameters of each optimizing strategy. During an optimization, OptiPath increases or decreases the feed rate according to the applied strategies. The marketplace offers a variety of software applications to improve the performance of existing cutter paths. While some offer limited strategies for optimization, OptiPath offers users several standard path-monitoring optimizing strategies, including:

- Air Cuts
- Chip Thickness
- Volume Removal
- Spindle Speed
- Surface Speed

Users can invoke one or more monitoring criteria. The combination of the selected monitoring methods will either increase or decrease feed rate at each of the subdivided points on the cutter path.

Improved results can be achieved for various combinations of materials and cutter types by novice users who have minimal knowledge about ideal feeds and speeds, and by users who have a great deal of experience specifying ideal feeds and speeds.

This is possible because, in addition to allowing full control of all monitoring parameters, OptiPath has a “learn mode.” With learn mode, users can use an existing cutter path program that seems to run well, to establish path-monitoring parameters. A program that is thought to run well generally has feed and speed limits based upon worst-case conditions regarding chip-load and material-volume removal rate (see Figure 13).

OptiPath “learn mode” can use that existing program’s upper limits as the basis to optimize feed rates at points in the path where cutting conditions, such as chip thickness, are less than the maximum chip thickness found in other locations in the cutter path.

It is possible for an experienced user to extend the upper limits of the monitoring parameters and produce exceptional improvements, but it is not necessary to do so to achieve the modest improvements offered through the use of “learn mode.”

Learn mode monitors both chip thickness and volume, applying its adjustments to feed rate based upon which of the two require a lower feed. As such, learn mode is a conservative approach to cutter path optimization, and due to its conservative nature, is very effective for hard materials.

For softer materials, such as aluminum and soft cast-iron, the user can choose to optimize feed for roughing operations based only upon the volume of material being removed, and can use chip thickness monitoring only when finishing. Surface speed monitoring is a very effective monitoring strategy for mold and die work.

CGTech claims that restricting monitoring to only the “air cuts” strategy results in savings of as much as ten percent of machining time. Since this strategy only increases the program’s feed rate when there is no engagement between the cutter and the part, it produces a significant improvement in machine tool utilization with very little risk.

OptiPath’s standard optimization strategies are based upon the simulated sweep of the tool’s envelope through the workpiece material.

Composites

The use of composite material in a manufacturing setting is a widely-accepted practice. In some industries (automotive and aerospace) composites not only represents an established process, but one that continues to mature. However, the transition from hand layup to automated composites manufacturing is a difficult, time consuming, and costly endeavor with many barriers. CGTech has addressed this concern by offering a very thorough product to create tool paths to drive automated composites machines.

VERICUT composite applications are broken down into two segments: programming and simulation. Programming contains VCP (VERICUT Composite Programming), Knife Trimming Paths, Laser Projection, and ATL (Automated Tape Layout). VCP also offers programming of probes. Simulation contains VERICUT Composite Simulation (VCS) and CNC machine probing.

VERICUT Composite Programming (VCP) reads CAD surfaces and ply boundary information and adds material to fill the plies according to user-specified manufacturing standards and requirements. Layup paths are then linked together to form specific layup sequences and output as NC programs for the automated layup machine. The creation process is as follows (see Figure 14). Read a CAD file that defines the boundary geometry, ply direction, axis or rosette system, and start point. Use the geometry within VCP such as axis systems, points, lines and curves to form subsequent sequences. Next generate layup paths based on manufacturing engineering specifications. Next the add thickness, then, visualize roller orientation to detect and avoid collision and visualize roller conformance to the layup surface.

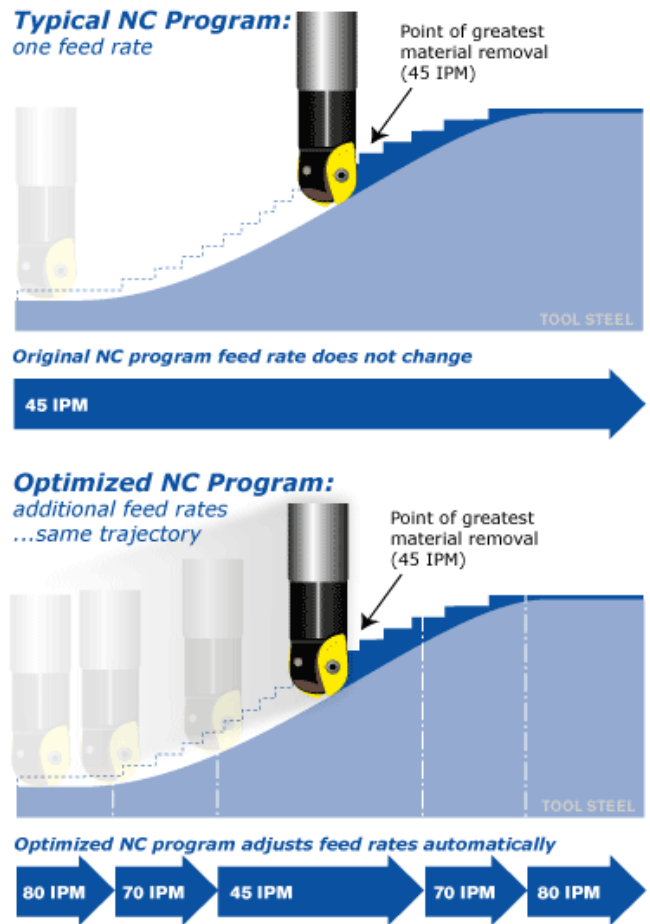


Figure 13—OptiPath Feed Rate Optimization

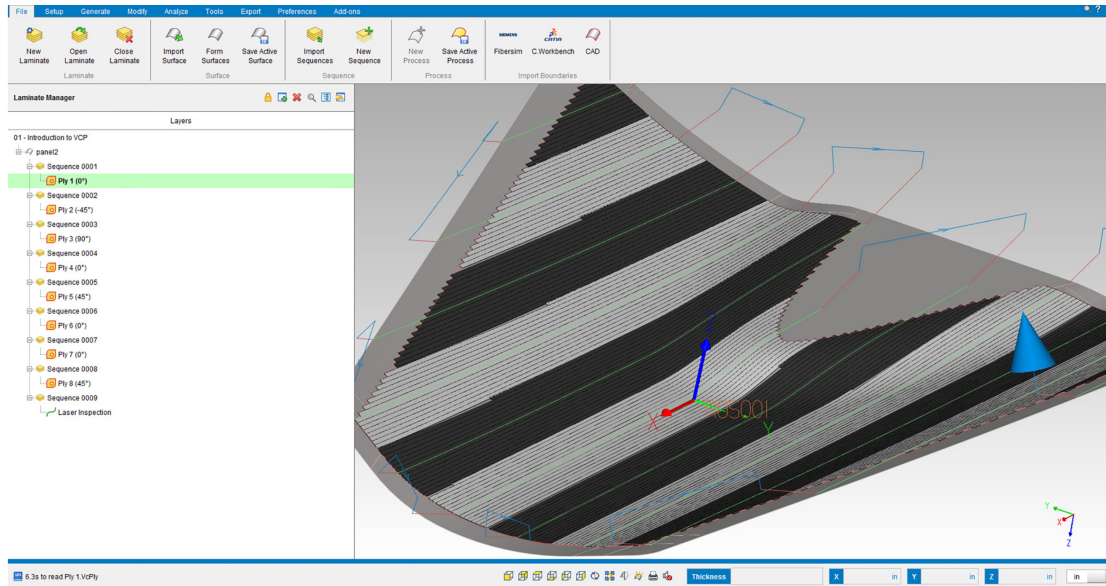


Figure 14—Composite Layout

Paths are linked to create layup sequences automatically or manually based on shortest distance and the form's topology, machine-specific commands are inserted, and actions such as safe start and restart events are created. Using a machine specific post-processor, the paths are converted to CNC code which the machine controller interprets as motion commands. To verify that the machine places material where the user anticipates, VCP generates exportable files for laser projectors that contain definitions for head paths, ply boundaries, safe restarts, tow gaps, as well as other features. VCP can calculate and balance material usage keeping track of material on each composite material spool and alter head paths to re-distribute material as required. VCP checks for material conformance with a new heat map. The user can visualize ply angle deviations, steering violations, and roller compression, as well as analyze gaps, overlaps, and staggers.

Additive

For several years, CIMdata has seen a continued push towards the support of and adoption of AM. The increasing power of cheap computing has made topology optimization a technique of choice to apply AM to create products not possible with traditional subtractive processes using machine tools. Software providers delivered dedicated packages or modules to the market and have partnered with specific 3D printer suppliers to deliver solutions to their clients. CIMdata sees AM as a rapidly growing sector in manufacturing. The challenge will be capturing all the required data for the lifecycle. CIMdata supports the use of PLM as an integral part of managing the data associated with AM.

On the manufacturing technology side, the increase in the use of multi-task machine tools, the growing demand for physics-based cutter path strategies, and the creative use of AM are driving the need for more sophisticated CAM software.

On the product design side, the trend for more aesthetic designs that involve increasingly complex shapes continues to drive the need for CAD/CAM software that can model complex shapes and create sophisticated, efficient NC programs. Design for Additive Manufacturing (DfAM) demands the use of analytics, generative design, and topology optimization to create more optimal part geometry tailored to the nonstandard shapes and more sophisticated CAM programming demanded by consumers. Additive

manufacturing plays a critical role here because it is possible through generative design techniques to create shapes that could not be made using conventional subtractive machining or would be too costly to make.

Improvements in AM techniques are having a growing impact on the CAM market. While a relatively small portion of industrial production is using additive techniques today, CIMdata believes that the extra creativity that AM can offer will increase the complexity of product designs and allow more flexible manufacturing, which will in turn increase demand for more sophisticated AM combined with subtractive CAM.

Several of the larger PLM solution providers are now delivering full solutions dedicated to the AM area, supported by their analysis software, automated generative design, topology optimization, and specialized CAM solutions. It is CIMdata's opinion that the focused delivery of these tools will increase the rate of expansion of the AM market.

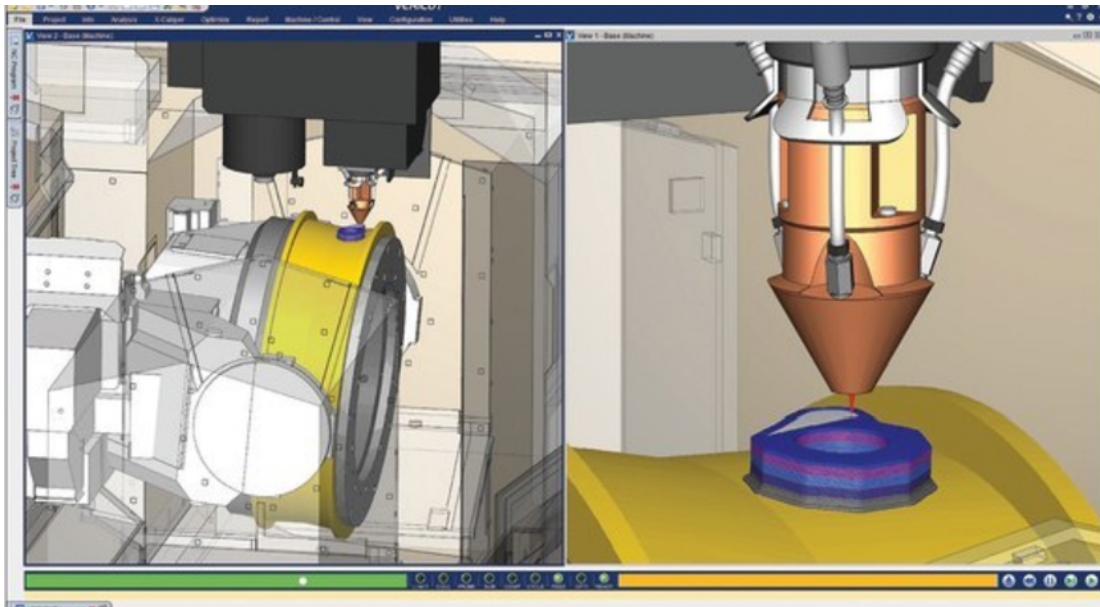


Figure 15—Additive Manufacturing Example

As shown in Figure 15, VERICUT's Additive module simulates both AM and traditional CNC machining capabilities applied in any order. Simulating both processes together identifies potential problems that can occur when integrating AM methods with traditional subtractive methods. The user has access to detailed history stored with VERICUT's Droplet technology, which saves programmers time by quickly identifying the source of errors with a single click. This additive capability shows realistic laser cladding and material deposition, detects collisions between the machine and additive part, and finds errors, voids, and misplaced material.

VERICUT simulates the post-processed NC code that controls the CNC machine ensuring proper usage of additive functions and laser parameters. Users can experiment with combining additive and metal removal (subtractive) processes to determine optimal safe hybrid manufacturing methods.

VERICUT Additive Benefits & Features:

VERICUT Additive verifies laser activity, power, material feed, and gas flow; verifying proper settings and use of laser additive parameters as VERICUT reads the laser parameters, controls laser wattage, flow of carrier gas, and metallic powder specific to each job/material type.

VERICUT can detect collisions between hybrid machined and additive parts. Identifying errors protects additive/hybrid machines and equipment from expensive crashes, voids in the product, and misplaced material. VERICUT detects collisions between the machine and additive part with its collision checking extended to cover additive parts as they are being built. This provides the ability to gauge potential problems with expensive hybrid machine laser equipment beforehand.

The user can realistically visualize the appearance of material deposition and additively-built part features. Droplet technology in VERICUT's smart-part models makes it easy for programmers to identify exact source of problems. Each bead contains valuable history information about how it got there. This saves time investigating errors, voids, or misplaced material, since the source of the problem is revealed with just one-click. The realistic appearance lets the Additive module offer superior simulation of material deposition that is easily distinguished from cut stock, therefore, providing the ability to clearly see where each bead of material is placed in a step-by-step process. This is essential for validating successful AM processes

VERICUT with the Additive module supports additive deposition, laser sintering, welding, 5-axis milling, turning, and can simulate G-code programs for virtually any hybrid machines.

With Droplet technology, VERICUT's additive model is much more than just "deposited material."

Simulation is powered by the same post-processed NC code used to drive CNC machine simulations, which enables the user to ensure additive functions are within proper ranges. VERICUT simplifies alternating from additive, to cutting, and back to additive in any sequence.



Figure 16—CGTech Additive Machining Partners

To ensure developing software that solves real-world problems, CGTech partners with additive machine tool suppliers and advanced manufacturing and technology centers, such as those shown in Figure 16. Currently, BeAM, OKUMA, Univ. of Sheffield/AMRC, and CCAT use VERICUT Additive from CGTech to help ensure their additive strategies will be successful, and protect valuable additive assets.

4. CGTech Training & Support

VERICUT's documentation and help system appear to be in-line with CGTech's stated philosophy of offering the highest possible customer experience. The help system is context sensitive. Typing F1 on the keyboard while in the VERICUT user interface opens a window relevant to your context from one of the nearly 2,000 pages of documentation. The documentation includes information on all aspects of the software, including how to define machines (VMCs), how to customize the G-code processing required to emulate a machine's control, and efficiently utilizing the many features for verifying and optimizing NC programs.

It is CGTech's intent to deliver an exceptional and comprehensive help and documentation system. They strive to maintain an on-going level of investment in their help system that is well above the industry average as a portion of their total development costs. CGTech justifies doing so based upon their recognition

that help and documentations are critical and essential parts of the product, and their determination to differentiate themselves from those in the market whose help and documentation systems seem to have been done as an afterthought.

For customer support, the CGTech direct-support team is coached to behave based on the belief that in buying VERICUT, the purchaser is also buying a wealth of knowledge and a level of support unmatched in the industry. In short- companies purchasing CGTech software are viewed as entering into a partnership with CGTech that will help be successful, and position them more competitively in the marketplace.

CGTech offers phone support as well as on-site support. CGTech has offices throughout North America, Europe, and Asia, plus a global network of resellers. New customers, or customers who are expanding their operations, can use CGTech's implementation specialists to accelerate their return on investment. Their objective is to set-up VERICUT to work in a manner consistent with how the user is accustomed to doing the job, rather than having the user change processes to accommodate VERICUT. For example, each CAM system has a distinct way it defines tools, and is distinctive in how its viewing rotation controls work. An implementation specialist can speed the set-up for a new customer by mapping the VERICUT rotation controls to match those in the user's CAM system, and can even adjust the way tools are defined to do so in a similar way to how tools are defined in the CAM system, lessening the user learning curve.

VERICUT is sold in a modular format. CGTech offers its base VERICUT for those who only want to protect the minimum set of assets and see parts get machined. More than a dozen add-on modules add capabilities to the base Verification capability. This way, customers need only buy the modules that match their specific functionality and asset protection requirements, and can add to their VERICUT installations as needed, or when ready to do so.

5. Summary

By using the broad range of capabilities of CGTech's VERICUT software to detect errors, locate potential collisions, and identify areas of inefficiency within NC programs, users can send their NC programs to the shop-floor with exceptional confidence, no matter how complex the CNC machine or the NC program.

Companies can use CGTech's products and services to achieve a means of asset protection for their machinery, equipment, and raw materials—minimizing unnecessary and avoidable rework, improving profitability, increasing on-time delivery performance, and realizing greater overall customer satisfaction.

Companies of any size can receive the benefits of validating their entire CNC machining environment and processes, identifying opportunities for process improvement and risk avoidance, all without committing or risking real business assets.

CGTech continues to expand the boundaries of NC verification with their Force capabilities and support for additive manufacturing combined with their established subtractive verification techniques.

VERICUT's broad range of capabilities make CGTech a preferred solution provider for industries as diverse as machine tools, automotive, aerospace, and medical instrument design and manufacturing.

—end of report—