



# Diamond Machine Works Achieves Breakthrough Capabilities in High Precision Parts

## THE BUSINESS

Aircraft parts manufacturer

## THE CLIENT

Diamond Machine Works  
Seattle, Washington

### The Business Challenge

Diamond Machine Works (DMW) is a family-owned business that started in 1959 with manual machines, eventually expanding to CNC machining technology. The Seattle-based job shop now operates five CNC mills (two 50-taper and three 40-taper machines) and four CNC lathes using Mastercam X4.

According to David Pruett, the company's CNC programmer for 15 years, close to 90 percent of DMW's work is for aerospace and defense giant, Boeing. Their diverse capabilities drive other customers to DMW for intricate parts machining for skis, snowboards, and even the BMW Oracle racing sailboat.

"We do a little bit of everything," Pruett says. "As a job shop, we take a lot of work that other people won't bother taking. We excel at airplane parts that no one else wants to make, due to either their complexity, low volume, or both."

While many shops are looking for profitable high-volume aluminum parts, DMW is able to handle not only aluminum, but also complex jobs made from steel and other harder materials.

The complexity of the parts produced at DMW led Pruett to research the latest high-speed machining software. "Some of the parts we cut are complicated and some are overly complicated, with difficult-to-machine, tight-tolerance features," Pruett said. He discovered the VoluMill™ toolpath solution and began the two-week free trial offer.

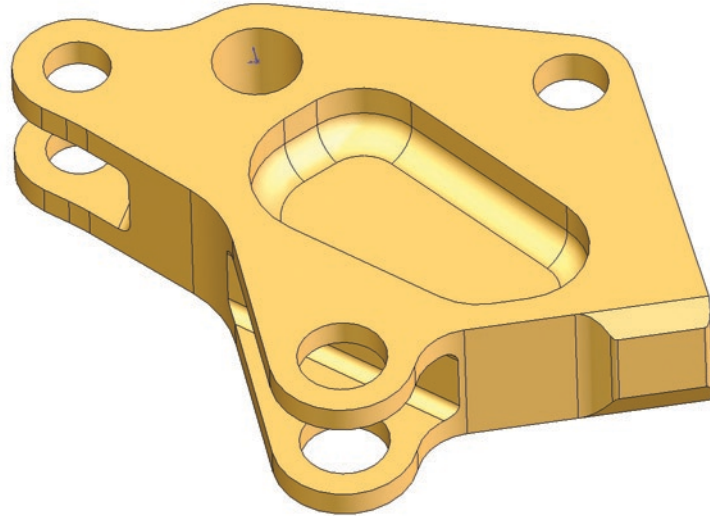
### The Business Solution

VoluMill is a plug-in toolpath engine from Celeritive Technologies that is fully integrated with DMW's Mastercam X4 system. This new genre technology generates toolpaths with smooth, flowing motion that place a controlled force on the spindle and cutting tool. VoluMill toolpaths enable the use of optimal material removal parameters that dramatically reduce cycle times and significantly extend the life of cutting tools.

“A four-minute roughing time was reduced to 1:30 minutes, and now runs at 450 surface feet and 111 IPM. VoluMill™ toolpaths reduced the roughing cycle time by 62.5 percent.”

**David Pruett, CNC programmer, Diamond Machine Works**

“During the trial period, I programmed four or five parts,” Pruett said. “At first I used VoluMill toolpaths on our oldest 50-taper machine, which is nearing the end of its useful life. We experimented with VoluMill toolpaths using solid carbide end mills instead of larger indexable insert tools. The toolpath itself was noticeably easier on the machine. We are now able to run much higher surface footage and much, much higher feedrates, especially with the chip thinning in the VoluMill metal removal strategy.”



**CAD model of defense industry part made from a 5 x 4 x 1.25-inch block of 15-5 stainless steel using VoluMill™ toolpaths.**



**Before and after—using VoluMill™, DMW now rough mills two of these parts in the time it used to take to rough one.**

Using VoluMill toolpaths, DMW has increased speeds and feeds and decreased cycle times and programming time for rough machining complex aluminum, stainless steel, and titanium aerospace and defense parts. The software has also given the aerospace-oriented job shop greater flexibility with respect to how machines are utilized.

Before VoluMill, DMW roughed a 5 x 4 x 1.25-inch 15-5 stainless steel blank into a classified airplane part with a 1.25-inch-diameter three-flute indexable insert cutter on an old 50-taper machine at 400 SFM and 22 IPM with a .400-inch deep cut. “Our 40-taper machines could not even come close to handling a cutter that large,” Pruett said. “It was very hard on the

“Our goal was to push the envelope and find the limits of the VoluMill™ toolpath solution. Instead, we found the limits of the machines—that was completely unexpected.”

**Steve Kidd, President, CIMtech Inc.**

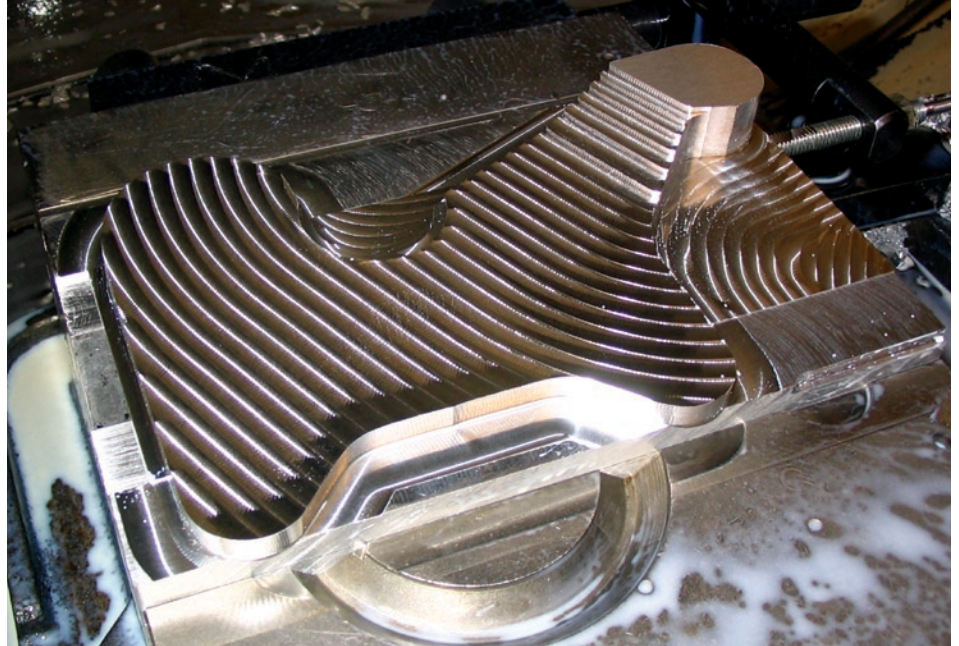
machinery. When roughing parts with indexable tools, we sometimes had to stop the part program cycle mid-way to change inserts, and an operator had to watch the machine 100 percent of the time. A failed insert could destroy the cutter body, at a \$300 cost.

“With VoluMill, speed was increased to 800 SFM and feed increased to 153 IPM, all with a .5-inch diameter end mill. Once we were able to see how easily and fast the material was being removed using VoluMill toolpaths on the 50-taper, we decided to give it a go on the 40-taper. We were pleasantly surprised to find out that the parts machined just as well on the 40-taper as they did on the 50-taper.”

### **Third-Party Tests Exceed Expectations**

Mastercam reseller, CIMtech Inc., hosts user groups to promote new technologies as part of their commitment to a consultative approach to doing business. Advanced machining technology is an initiative focused on pushing new technologies to their limits. By bringing together teams of experts, CIMtech believes customers benefit from independent testing.

Before recommending VoluMill to DMW, CIMtech scheduled rigorous testing of the VoluMill toolpath solution in August 2008. In partnership with a



**Prior to VoluMill™, DMW used two separate tools to machine this aluminum part with a cycle time of 3:53 minutes. Using VoluMill, DMW is able to use one tool and reduce cycle time to 1:58 minutes.**

leading machine tool manufacturer and a respected cutting tool manufacturer, experts ran a series of tests they believed would identify failure points in the machining process.

“We brought together a team of professionals, each with more than 25 years of experience in machining and with special knowledge of the unique demands presented by the aerospace industry,” said Steve Kidd, president of CIMtech. “Our goal was to push the envelope and find the limits of the VoluMill toolpath solution. Instead, we found the limits of the machines—that was completely unexpected.”

Tests included dry cuts, pushing hard on the tools, and high RPM machining. Without exception, VoluMill amazed the test engineers at every level.

“At the end of the day we realized VoluMill had more room to perform, but the machines could not keep up,” said Kidd. “We tried more aggressive cuts, increased pressure on the tools, and tested dry cuts without coolant—what we got was a 35 percent increase in performance that we did not think was possible. Not only did we find considerable performance increases and time savings, but we also saw that the tools themselves would have longer usability. The tests

“Our goal in moving to VoluMill™ was to machine parts faster and more efficiently on a smaller machine. When we’re machining around the clock, we know the VoluMill toolpath can be relied on so that roughing operations can run without being monitored.”

**David Pruett, CNC programmer, Diamond Machine Works**

we ran normally cause a 30 percent back-off and loss of productivity; instead, we found significant gains.”

With customers specializing in aerospace, where one company alone requires thousands of machine-cut parts manufactured to extremely precise specifications in a variety of metals, CIMtech is confident that the VoluMill toolpath solution is truly a breakthrough in machining technology.

**VoluMill™ Saves Time, Extends Tool Life**

The ability to efficiently run jobs on a smaller, lower-powered machine, with smaller, less-expensive cutting tools, provided DMW with a significant economic advantage. Cost savings were realized immediately on inserts and machine wear and tear, as well as increased dependability throughout the process. DMW also benefitted from time savings when applying VoluMill toolpaths to an important defense industry part machined from 5 x 8 x .75-inch 6061 aluminum.

“Before VoluMill, we were using two separate tools—a 1-inch indexable insert end mill and a .5-inch ball-nose end mill—to machine the part,” said Pruett. “Cycle time was 3:53 minutes, using .25-inch step-downs for each pass. With VoluMill, we use one .5-inch three-flute carbide end mill at 7,640 RPM and 275 IPM, triple the previous rate. The new cycle time

is 1:58 minutes, a reduction of 50 percent. Even on smaller parts made of harder materials such as titanium, productivity has improved thanks to VoluMill toolpaths.”

Machining other difficult components has also improved, according to Pruett. One part made from 3 x 3.5 x 1.75-inch 6Al4V titanium had to be sent out to be heat treated mid-process. DMW is now able to eliminate the mid-process heat treating using the VoluMill toolpath on the hardened material.

In addition to speeds and feeds and cycle times, DMW has found that VoluMill makes programming parts faster and easier. DMW management also believes the greatest benefit in VoluMill’s efficiency is the flexibility to move work from its old 50-taper machine to 40-taper machines, which

has a significant bearing on the company’s future capital expenditures.

“When we first got VoluMill, there were only about four or five jobs that I thought we’d want that style of toolpath for,” Pruett said. “Once I started working with it, I discovered I could use it for a lot more than I originally thought. Creating the path is easy and fast enough that you can quickly generate a new path from an existing model. Even if it’s not required for the application, we can make gains in cutting performance. I can program the thing so fast using VoluMill that I can typically program a part and have it on the machine within an hour. I have found that it is actually faster and easier to make a VoluMill toolpath inside of Mastercam than it is to make a Mastercam toolpath inside of Mastercam. That was a pleasant surprise.”

**Application Parameters**

	<b>OLD PARAMETERS</b>	<b>NEW PARAMETERS</b>
<b>Material</b>	6Al4V titanium	6Al4V titanium
<b>Toolpath</b>	Native Mastercam®	VoluMill™
<b>Cutter</b>	3/4" solid carbide, 5-flute	1/2" solid carbide, 5-flute
<b>SFM</b>	200 ft./min.	450 ft./min.
<b>RPM</b>	1,019	3,438
<b>CLPT</b>	0.003"	0.0065"
<b>IPM</b>	15.28	111
<b>ADOC</b>	1.000"	1.000"
<b>RDOC</b>	0.375"	0.035"

## The VoluMill™ Advantage

VoluMill was designed to eliminate the poor machining conditions that traditional toolpaths have produced since the advent of numerically controlled milling machines. CNC machines can only execute commands given by a toolpath, which historically have given poor instructions that require machine tools and cutting tools to operate under adverse conditions. VoluMill, which can work with any CAM system, generates toolpaths that establish and maintain ideal machining conditions, enhancing machine utilization and shop productivity.

VoluMill toolpaths increase the return on the investment in machine tools, cutting tools, and fixturing components by increasing machine-utilization efficiency, shop productivity, and cutting tool life. These savings are particularly important in adverse economic environments. VoluMill offers the lowest-cost approach to increasing productivity for the manufacturing shop, and it usually pays for itself in a single job.

VoluMill integrates seamlessly into Mastercam versions X, X2, X3, and X4.

*Celeritive Technologies, Inc. was founded in 2007 to develop and market advanced productivity-improving CAD / CAM technologies. VoluMill™ offers a new genre in high-performance toolpath engines that significantly increases machining productivity and product quality. This innovative, powerful toolpath engine is easy to use, performs on any part geometry, and can be used with any CAM system.*



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