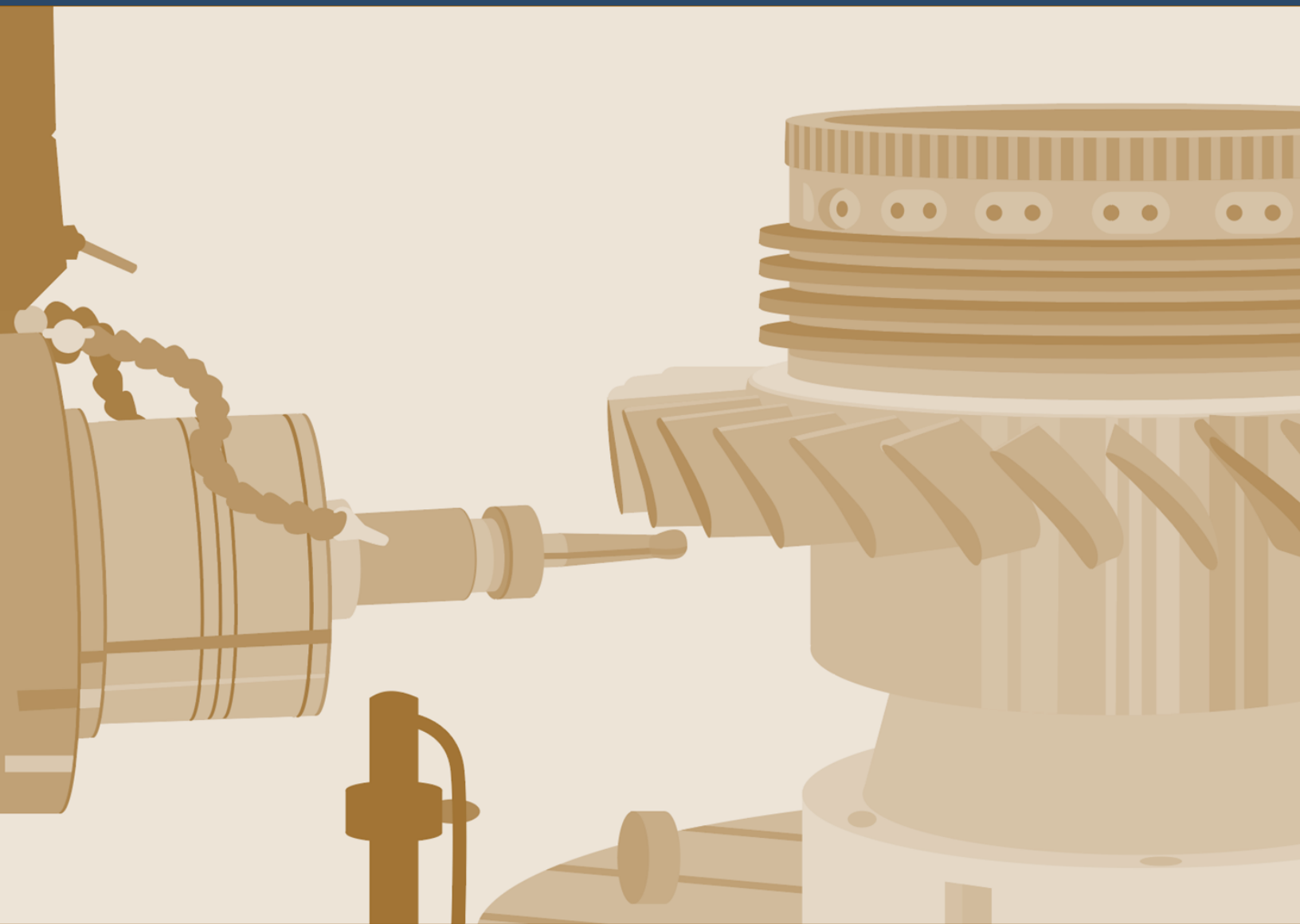
THE ROI GUIDE FOR MACHINE SHOPS

LIFECYCLE INSIGHTS



THE PATH TO PROFITABILITY

Are there real, substantial ways to grow profitably?

Once in a blue moon, machine shop owners get to ask themselves that question. Between maximizing cutting machine utilization, selling forward, and eating down backlog, there's almost never a good time to sit back and think hard about how to improve the business. Maybe it's once every six months. Maybe it's once a year. Whatever the frequency, it's not often enough.

There are, of course, many different *theoretical* ways to grow profitably. Automate the estimation and proposal process to win more jobs. Incorporate more automation or lean practices into inventory management to lower holding costs. Integrate robotics and tending to reduce lag on the shop floor. Each has potential. However, how feasible is each?

Due to recent changes, one such effort warrants another look. Technological advancements in Mechanical Computer Aided Design (MCAD) and Computer Aided Manufacturing (CAM) offer very real potential to accelerate time-to-quote and time-to-delivery. Furthermore, licensing shifts from purchases to subscriptions have lowered the investment side of the return-on-investment (ROI) equation significantly. The low cost and financial flexibility make it easy for machine shops to explore tangible improvements to how they bid on contracts and deliver final parts.

This report provides guidance on the ROI of MCAD and CAM solutions, specifically aimed at shortening time-to-quote and time-to-delivery. It contains four discrete chapters, as follows:

This report explores the return-on-investment of Mechanical Computer Aided Design (MCAD) and Computer Aided Manufacturing (CAM) for machine shops. Specifically, it explores this the improvement of estimation practices, model-to-toolpath processes, and transitioning to subscription-based solutions.

The first chapter, *ROI Calculations*, lays out three calculations that play a part in the profitable growth of machine shops.

The second chapter, *Accelerating Processes for Estimating and Operations*, details the technological advancements relevant to each step in the bidding and planning processes.

The third chapter, *Transitioning from CAPEX to OPEX*, dives into the ROI implications of the transition from floating, perpetual license purchases to software subscriptions.

The fourth chapter, *Summary and Recommendations*, recaps the highlights of this report and offers guidance on next steps for those pursuing profitable growth through their bidding and planning processes.

Assessing opportunities to grow profitably is extremely difficult with today's significant responsibilities. This report accelerates your education on what capabilities matter, what growth is truly possible, and how to calculate ROI.

This report contains quotes from two machining companies, Swissomation and Zodiac Engineering.

Swissomation manufactures high-precision small parts for aviation, medical, dental and consumer product companies around the world. They operate over eighty NC machines between Virginia and Texas. *Chris Welch* provides his commentary in this report.

Zodiac Engineering is a small machine shop that does commission-based jobs in California. *Ken Spaulding* provides commentary in this report.

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ROI CALCULATIONS

There are three models for assessing return-on-investment for machine shops. The first two focus on increasing revenues for a return. The third centers on reducing and evening out IT costs associated with enabling technologies.

Business can pursue all three independently. Nevertheless, two of these models—time-to-quote and time-to-delivery—work in tandem. Specifically, shops can win more jobs by accelerating time-to-quote and can deliver more jobs per year by accelerating time-to-delivery. Meanwhile, the third model, which reduces IT spend, augments the effectiveness of the first two.

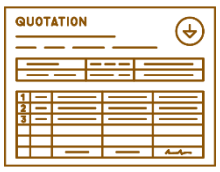
This chapter examines the three paths to improved return-on-investment for MCAD and CAM solutions for machine shops.

TIME-TO-QUOTE: ACCELERATING ESTIMATIONS, WINNING MORE JOBS

Time-to-quote is a critical measure in winning jobs for machine shops. Those that respond first often win jobs put out to bid. Reducing the amount of time to respond is a key to growing top-line revenues.

However, speed isn't the only factor in winning bids. A shop can hastily draw up a proposal and win the job. However, if the costs are too low, the shop is stuck delivering a job at a loss. Alternatively, overestimating costs is equally dangerous. Proposals with high pricing will lose to more competitive bids.

The key to success is developing an accurate estimate of costs quickly. To accelerate bid delivery, shops must navigate a simplified version of the model-to-g-code process. This involves receiving and opening foreign 3D



Accelerating the time to develop and deliver an accurate quote is one path to win more bids and increase company revenues. More details can be found in Chapter 2.

models, assessing and potentially preparing it for machining, and possibly generating simplified NC toolpaths.

Shops have a number of opportunities to accelerate these steps, as detailed in Chapter 2: Accelerating Estimations and Operations.

Another path to increase company revenues is to complete and delivery jobs faster. This translates to the delivery of more projects over the course of a month or a year. More details can be found in Chapter 3.

TIME-TO-DELIVERY: ACCELERATING OPERATIONS, COMPLETING MORE JOBS

Shops can win more jobs by reducing their time-to-quote metrics. However, time-to-delivery governs their ability to complete jobs quickly. This measure is the key to delivering parts and sending invoices for payment. By shortening time-to-delivery, shops can execute more jobs per month or per year.

To accelerate time-to-delivery, shops must find gains in either machining preparation or machining execution. Improvements to the former include opening 3D models, preparing them for machining, generating and verifying toolpaths, postprocessing toolpaths, and accommodating design changes. These planning and preparation tasks also directly affect machining execution, described as the efficiency at which metal is cut.

There are a number of opportunities to accelerate these steps, as detailed in Chapter 3: Accelerating Estimations and Operations.

"The time to generate NC toolpaths is a huge aspect of controlling costs. We have many short-run jobs, so we need to want to turn them around quickly. We accelerate the generation of toolpaths as much as possible."

Chris Welch
Swissomation

REDUCING IT CAPEX: ANOTHER OPPORTUNITY TO LOWER EXPENSES

Reductions in time-to-quote and time-to-delivery both represent opportunities to increase revenues. However, an opportunity also exists to decrease the cost of technology solutions that shorten those processes.

One means of improvement is to transition from large upfront capital expenses (CAPEX) associated with purchasing software licenses to lower subscription costs

as an operational expense (OPEX). Shops can rationalize the cost of new technologies over a longer period of time.

More details on this effort is provided in Chapter 3: Transitioning from Technology CAPEX to OPEX.

The transition from traditional license purchases as a Capital Expense (CAPEX) to a subscription as an Operational Expense (OPEX) is another means of changing the calculation of ROI.

TRACKING THE PURSUIT OF EACH IMPROVEMENT TYPE

In late 2016, Lifecycle Insights conducted a research project, called the NC Machining Study, to assess the objectives, intent, practices, and technologies of manufacturing job shops. One of the key findings related to the outcomes that these companies hoped to achieve, as shown in Figure #1.

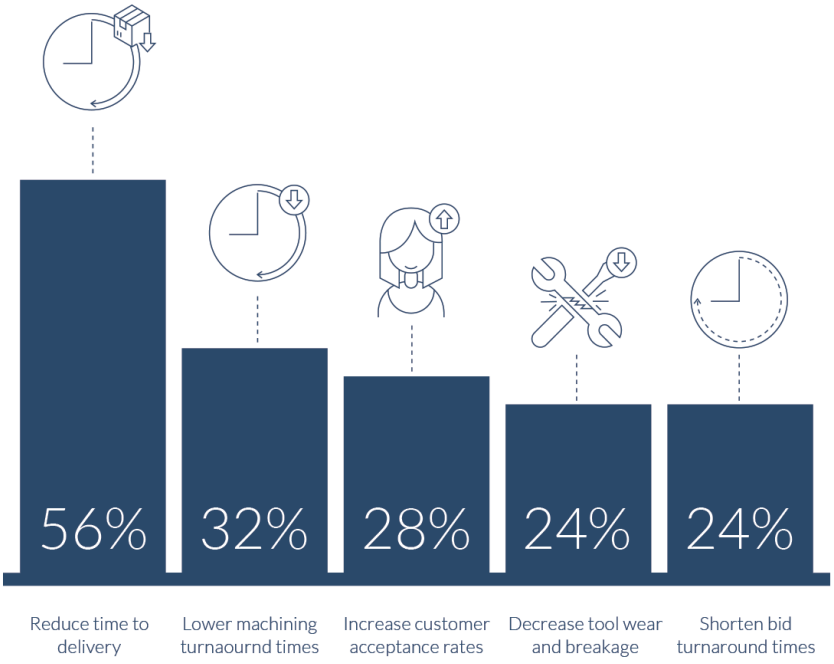


Figure #1: Selection of the Top Three Objectives for Machine Shops, The NC Machining Study 2016

"We switched over to a cloud-based solution with a subscription and actually increased our total users while reducing our costs."

Chris Welch
Swissomation

The following represent some of the key takeaways.

- At fifty-six percent (56%), the study found that the dominant objective of machine shops is to reduce time-to-delivery. The next closest outcome weighed in at thirty-two percent (32%).
- Despite the impact of the ability to shorten bid turnaround times of increasing revenues, such efforts came in at only twenty-four percent (24%). Many likely expect this cannot be dramatically improved further.
- Lowering machining turnaround times was the second most cited outcome, coming in at thirty-two percent (32%). This is seen as closely affecting time-to-delivery.

This report references numerous findings to Lifecycle Insights' 2016 NC Machining study.

ACCELERATING ESTIMATIONS AND OPERATIONS

Machine shops can realize revenue growth by accelerating time-to-quote and time-to-delivery. To accomplish this, they must improve the steps in their estimation, planning, and execution processes. Such improvements include a mix of procedural changes, skill upgrades, and the implementation of recent technology advances.

This chapter details improvement opportunities in tasks common to both the estimation practices and model-to-toolpath processes.

OPENING MODELS

Today, manufacturers use a range of Mechanical Computer Aided Design (MCAD) applications. Each saves 3D models in its own proprietary format. As such, machine shops must be able to work with foreign models as part of their estimation and planning processes.

The traditional approach has been to receive 3D models in neutral formats and import them into their MCAD or Computer Aided Manufacturing (CAM) application. These import methods are flawed. Different applications use different geometry definitions and accuracies. Moving a 3D model from one to the other frequently results in geometric errors such as misaligned surfaces, curves, or intersections.

Opening a model is the fundamental step to development complex NC toolpaths. This task is difficult for many machine shops due to the wide variety of CAD formats used in the industry.

These issues undermine a machinist's ability to quickly assess manufacturability and generate toolpaths. Furthermore, such flaws can result in out-of-specification machined parts the customer may reject. Many times, machine shops have to recreate the 3D model in their applications, representing a significant delay in their processes.

In the NC Machining Study, respondents cited transferring data between different software and teams as one of the biggest challenges. This issue is a significant problem in most machine shops as shown in Figure #2.

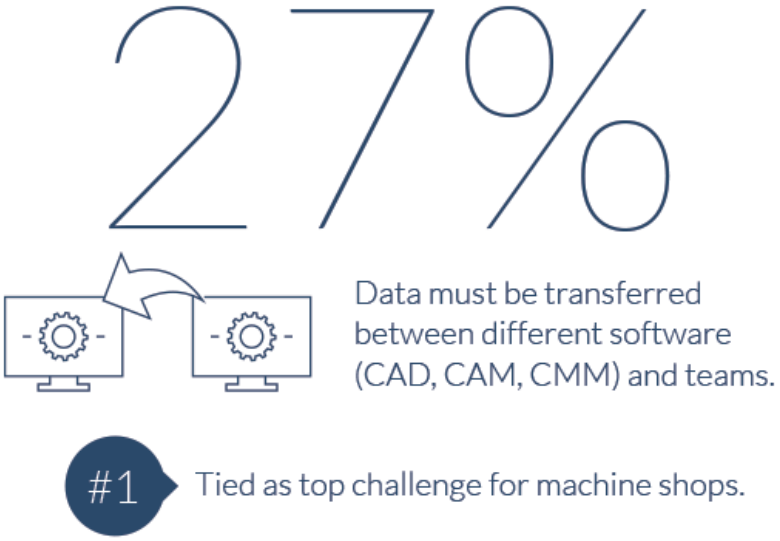
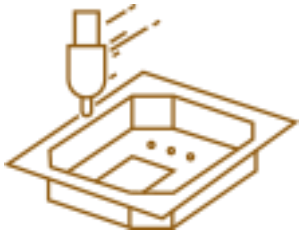


Figure #2: Selection of Top Challenges for Machine Shops, The NC Machining Study 2016



Machinists often modify designs so they can be machined more easily or at a lower cost. Assessing design manufacturability is key improvement area.

The modern approach to opening models relies on recent technology advances. A number of MCAD and CAM applications now provide the ability to natively open foreign 3D models. Solutions providing this capability allow machinists to validate the customer's geometry and move quickly to estimation or planning.

Adopting this change relies primarily on deploying MCAD or CAM applications with this capability. Little to no process or training changes are required.

PREPARING MODELS

Machining complexity is a prime factor that drives pricing. Shops can provide more competitive bids and deliver parts more quickly by simplifying machining operations. Such efforts involve small changes to component

geometry that often do not affect form, fit, for function. Shops need to mock up such modifications and provide them to customers for validation, initiating a collaborative check. This activity is critical to providing aggressive quotes while still validating with the customer that changes are approved. All this needs to happen rapidly in an effort to minimize time-to-quote.

The traditional approach for this activity is to use parametric modeling to adjust the customer's model, which often comes from a foreign MCAD application. The challenge with this approach is that parametric modeling requires parameter-controlled features to make geometric changes. Foreign models, even ones opened natively, do not contain features. Modifications can be made with *new* features that add or remove geometry. However, parametric modeling provides few capabilities to change *existing* geometry. In extreme cases, machinists remodel the part completely. This approach blunts a shop's ability to quickly respond with bids and impairs their ability to prepare for machining.

"By using our cloud-based tool, Fusion360, we can easily show them what modifications we need to make for manufacturability. It runs in the cloud. All they need is a link. They don't need to install anything. They don't need any files. Just the link."

Chris Welch
Swissomation

Like the opening model step, the modern approach to preparing models relies on a recent technology advancement: direct modeling. This capability allows machinists to select existing geometry and modify it directly through push, pull, and drag actions. Such changes can be used for feature-based models and feature-less foreign ones.

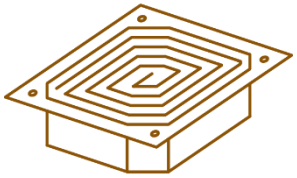
Implementing improvements to this step requires MCAD or CAM applications with this new capability, an orientation or training for machinists, and some procedural changes for the estimation and planning processes.

GENERATING TOOLPATHS

Producing toolpaths is one of the key tasks on the critical path for machine shops. This step determines the time a part is machined on each piece of equipment. This drives proposals in the estimation process. This drives the actual

execution of machining on the shop floor. The goal here is to minimize the amount of machining time the part requires. When that happens, shops can deliver their parts more quickly.

The traditional approach to generating toolpaths is rife with manual or semi-automated tasks. Desktop-based CAM applications generate the first iteration of a toolpath. Depending on the complexity of the machining operation and the desktop's compute power, this can take some time. With a first pass complete, machinists then heavily edit the moves in that toolpath manually with a text editor. Fifty-one percent (51%) of the respondents in the NC Machining Study stated they manually modified toolpaths at least weekly as shown in Figure #3.



Many CAM applications provide capabilities to automate the creation of toolpaths. However, it is rare that such toolpaths are used without manual reviews or modifications.

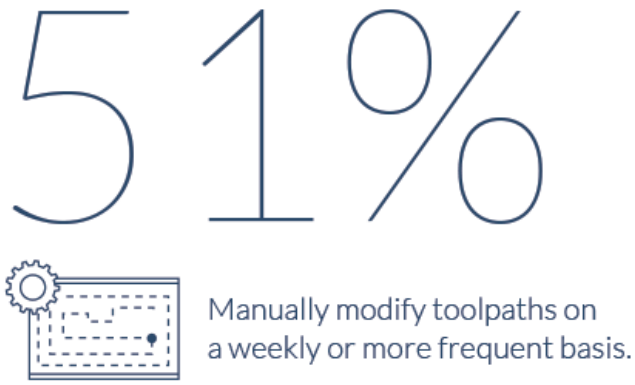


Figure #3: Percent of Respondents citing Specific Issues in the Toolpath Development Process, The NC Machining Study 2016

Even with a highly experienced machinist, manual modification of toolpaths is open to the risk of human error. Such issues can result in broken tools, inefficient air cutting, and in the worst case, clashes that can damage machining equipment. In the NC Machining Study, thirty-two percent (32%) of respondents stated they have a tool-to-part clash at least once a week. Twenty-one

percent (21%) separately stated they had a tool-to-fixture clash once a week as well.

Figure #4: Percent of Respondents citing Specific Issues in the Toolpath Development Process, The NC Machining Study 2016

Another issue lies in the inefficiency of NC toolpaths. Twenty-six percent (26%) of respondents in the NC Machining Study cited that machine operations are inefficient due to air cutting, low material removal rate, tool overload, chatter, and more. This direct affects how quickly shops can finish machining parts and deliver them to customers as shown in Figure #5.

There is not just one alternative to the traditional approach, but several. Feature-based machining allows machinists to apply *machining strategies*, sets of integrated toolpaths, on the company's practices and the component's geometry. This method can be further enhanced when applied to a Model-Based Definition (MBD), a model with embedded non-geometric information such as tolerances, geometric dimensioning and tolerancing (GD&T), and annotations. This capability leverages a high degree of automation and standardization that minimizes manual edits of toolpaths.

"Having modeling and machining in one cloud-based tool is really beneficial. I don't have to switch back and forth, moving files and models. I can follow my entire process without any changes. And I can do it from any device because it runs in the cloud."

Ken Spaulding
Zodiac Engineering

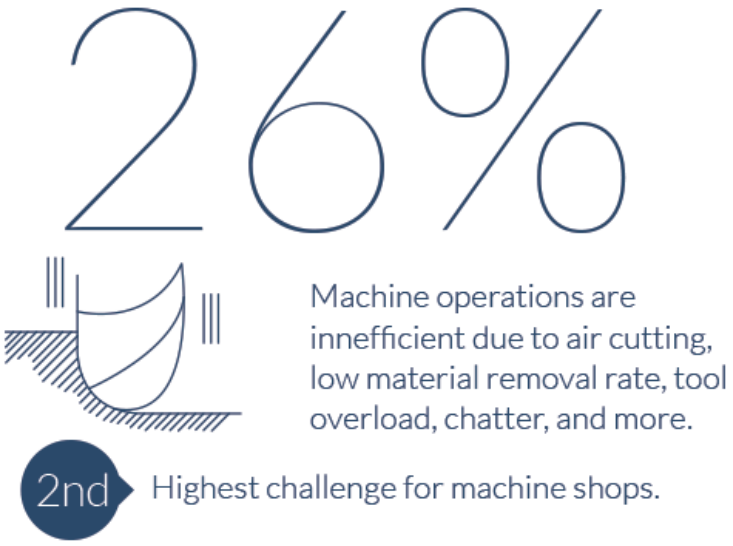
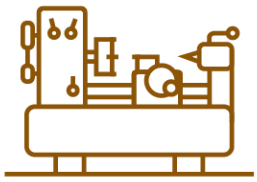


Figure #5: Percent of Respondents citing Specific Issues in the Toolpath Development Process, The NC Machining Study 2016

Another alternative lies in the use of CAM applications that utilize modern architecture . These solutions utilize the computing power of the multiple core processor, generating toolpaths far more rapidly than desktop-based CAM applications can.

Deploying feature-based machining requires the agreement upon and documentation of a company's machining standards that must be codified into the CAM application. Leveraging an MBD requires the delivery of one from a customer. Using a Cloud-based CAM solution requires training for machinists.



Machinists must walk a fine line between creating toolpaths fast, making them efficient, and ensuring they won't cause harm to tools, tooling, or equipment.

VERIFYING TOOLPATHS

Numerically controlled (NC) cutting equipment represents a significant investment for machine shops. If one is damaged or broken, it may go offline, directly affecting the company's cashflow. To mitigate these risks, machinists run simulations of the machining operation to verify that their toolpaths will not result in clashes.

The traditional approach depends on desktop-based CAM applications with limited compute power. Such simulations require significant amounts of time to run. If it catches errors, then machinists produce new toolpaths and rerun the simulation. This can represent a significant delay in estimation and planning processes. Findings from the NC Machining Study verified this issue. Twenty-four percent (24%) cited the need to manually validate that NC programs (g-code) work as expected as shown in Figure #6.

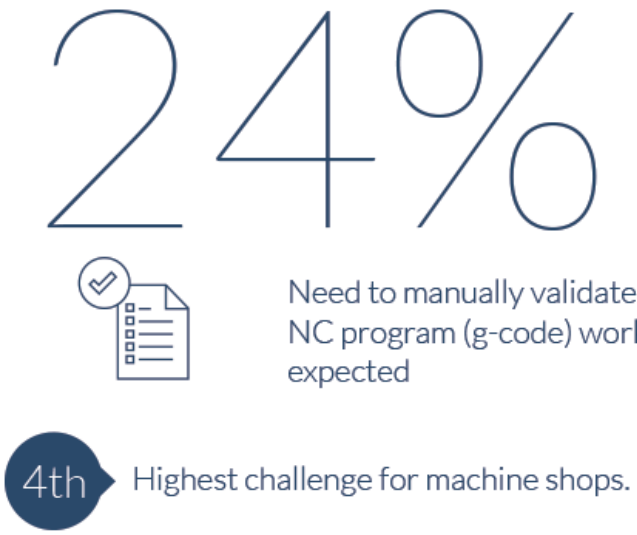


Figure #6: Percent of Respondents citing Specific Issues in the Toolpath Development Process, The NC Machining Study 2016

"Any of our machinists in Texas or Virginia can now jump into the same model on the cloud. They can see what we're doing. We can see what they're doing. We can work through any machining questions or issues by actually seeing each other's work."

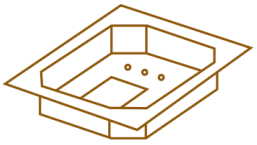
Chris Welch
Swissomation

The modern approach relies on Cloud-based CAM applications with significantly more compute power. Simulations run on Cloud platforms complete far faster, allowing machinists to iterate and explore more options. That, in turn, allows them to not just find the first feasible toolpath to run without errors, but uncover other machining options that run faster.

There is a minimal effect adjusting to running simulations through a Cloud-based CAM application. Processes must be updated to allow for more exploration of toolpath options.

ACCOMMODATING DESIGN CHANGES

Today, design changes are a reality for machine shops. Even after a customer has awarded a contract, they may come back with tweaks and changes to the component the machine shop must deliver. Charges for change orders cover some of the costs. However, design modifications can introduce significant delays in delivery. That affects the company's cashflow.



Dealing with change requests can make or break the profit margin on a job. Being able to incorporate changes from the customer in the format they supply has traditionally been a significant challenge.

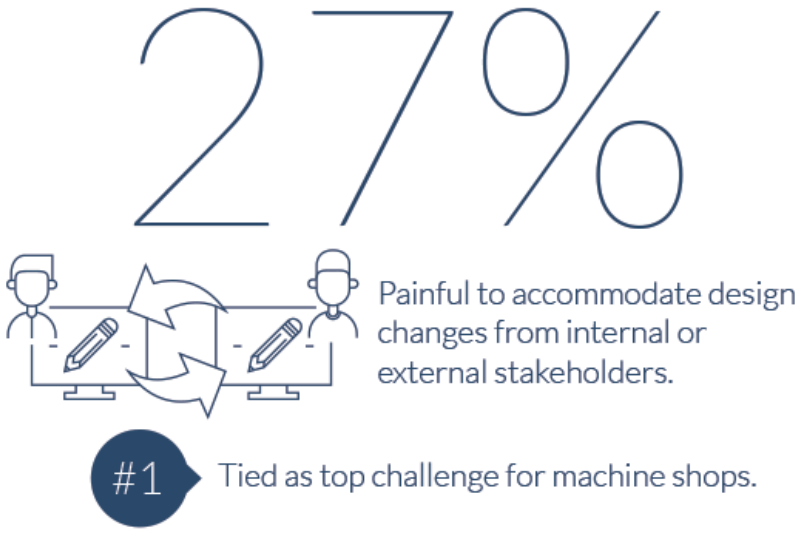


Figure #7: Percent of Respondents citing Specific Issues in the Toolpath Development Process, The NC Machining Study 2016

The traditional approach to accommodating design change relies on parametric modeling and significant rework. Prior to the change, the machine shop has opened models, prepared models, generated toolpaths, and verified them. All of those tasks depend on the 3D model from the customer. Once that changes, all of those tasks must be redone. If the contract does not include terms to delay delivery upon a change request, the machine shop must work overtime just to keep up.

Respondents from the NC Machining Study concurred with the difficulty of this issue. Twenty-seven percent

(27%) found it painful to accommodate design changes from internal or external stakeholders, tying as the top challenge overall as shown in Figure #7.

The modern approach relies on *associativity of foreign models*. This capability allows a machine shop to receive model updates from a customer. This is an extension of a MCAD or CAM application's ability to open native models. The customer shares their changed model and the machine shop's model updates as well. Furthermore, all the deliverables dependent on that model also update, including any NC toolpaths. This is powerful functionality that lets machine shops avoid painful rework and delays in the process.

TRANSITIONING FROM CAPEX TO OPEX

Improvements in time-to-quote and time-to-delivery both represent gains on the return side of ROI. However, there is an opportunity to approach the investment side of ROI differently, as well.

This chapter details changes in how software can be purchased and how it affects ROI calculations.

PERPETUAL, FLOATING LICENSES

Traditionally, the technologies that enable an initiative are purchased as perpetual, floating licenses. The number of licenses determine the number of users that can open the software at any one time. A floating license allows one user to close the software and another user to open the software in a different location. The license floats to anywhere the software is installed. A perpetual license allows the purchasing company to use that number of licenses in perpetuity. Such perpetual, floating licenses often require both an initial purchase cost and an annual maintenance fee, which governs technical support and access to new software releases.

The challenge with perpetual, floating licenses is their sizeable upfront cost. The initial purchase qualifies as a capital expenditure (CAPEX) and requires a significant cost justification. The return on that purchase needs to be significant due to the high costs. This is a considerable barrier to acquiring new technologies that can enable beneficial initiatives.

Traditionally, MCAD and CAM applications are purchased as a perpetual floating license with a large upfront cost, commonly referred to as a Capital Expense (CAPEX).

SOFTWARE SUBSCRIPTIONS

The alternative lies in floating software subscriptions. Access to the software can float is based on a login and password, just like perpetual, floating licenses. However, the access is not perpetual. The subscription is either monthly or annually. Maintenance fees are part of the subscription.

One advantage of software subscriptions is that they have no large, upfront acquisition cost representing a CAPEX. Instead, it qualifies as an operational expenditure (OPEX) that requires a much lower cost justification. The barrier to acquiring the enabling technology is lower.

Another advantage of software subscriptions is their ability to scale the number of users up or down depending on need. During a heavy month, a shop might add three seats. During light months, it may instead reduce the number of seats by three. This offers OPEX flexibility for shops.

MCAD and CAM software applications can now be acquired through a subscription with a lower monthly or annual cost. This falls into an Operational Expense (OpEx).

BE WARY OF MISCONCEPTIONS

There are misconceptions regarding software subscriptions. Many believe that this licensing model only applies to Cloud-based solutions. However, this is not true. A subscription model can be used for locally installed software as easily as a perpetual, floating license model. Cloud-based software packages have other beneficial capabilities, such as expandable compute power and accessibility, that warrant consideration.

Another consideration when assessing perpetual, floating licenses and software subscriptions is long term total cost. The large, upfront CAPEX of perpetual, floating licensing is fixed and paid only once. The going OPEX of software subscriptions is small but repeatable for as long as the shop will use it. When comparing long-term costs, always include maintenance fees. Also, take other factors such as scaling for more or fewer users into account.

Perpetual license purchases are often associated with locally installed software. Subscriptions are often associated with cloud-based solutions. However, this is not always the case. More solution providers are mixing and matching these options.

SUMMARY AND RECOMMENDATIONS

It is not easy to assess profitable growth opportunities for machine shops. However, due to technology advances and a change in licensing models, time-to-quote and time-to-delivery reductions through MCAD and CAM software solutions represent a tangible opportunity.

SUMMARY

- Shortening time-to-quote capitalizes on anecdotal evidence that those who respond to proposals first often win bids, leading to revenue growth.
- Reducing time-to-delivery accelerates invoicing and thus cashflow. It also opens the opportunity to deliver more projects per month or year, leading to revenue growth.
- The licensing shift from perpetual license purchases to subscriptions corresponds to a shift from large, upfront CAPEX to lower cost OPEX. This lowers the barrier to cost justification.
- Natively opening models is an opportunity to eliminate remodeling tasks. Direct modeling allows users to modify foreign models, also eliminating remodeling tasks. This accelerates bidding and planning processes.
- Feature-based machining and Model-Based Definition automation accelerates and standardizes bidding and planning processes. Cloud-based solutions with more compute power helps complete this task faster.

- Cloud-based solutions also offer more compute power to verify toolpaths will not damage tooling or machining equipment.
- Associatively opening native models enables the propagation of change from customers to machine shops, reducing rework and delays in the planning process.

RECOMMENDATIONS

- Investigate the proposal responsiveness of your company. If a faster response would translate to winning more bids, look more closely at modern Cloud-based MCAD and CAM solutions for your company's proposal process. Note that turning more bid success, however, relies on the company's ability to deliver a higher volume of jobs.
- Assess the throughput of your shop floor. If there is an opportunity to increase the speed of machining completion, investigate Cloud-based MCAD and CAM solutions in your company's planning process. Note that to realize revenue growth from this effort, the company must win more bids.

Chad Jackson is the chief analyst and researcher at Lifecycle Insights, providing insights on a range of technology-led initiatives across mechanical, electrical, embedded software, system, and IoT engineering.

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