Why accelerating precision machining matters

Contents

The manufacturing state of play

by Theo Saville, founder and CEO, CloudNC

Before the COVID-19 crisis hit the world, it was already clear that the manufacturing sector was having trouble supplying the world with the goods and supplies people want and need.

In the West, manufacturing capacity has been hollowed out by globalization, as cheap labor overseas reduces the ability of developed countries to compete. Domestic production has dwindled away, and weak career prospects mean workers aren't being replaced as they retire, compounding the decline.

As a result, when crises happen and we need manufacturing to step up, the sector's not been in a fit state to help. When COVID-19 hit in earnest, hospitals desperately needed ventilators – but countries like the US and UK didn't have the capacity or ability to make them quickly and efficiently. Only a massive global mobilization effort[1] – involving procurement from thousands of suppliers – scrambled together what was required, at vast expense, and not quite on time.

Since 2020, the conflict in Ukraine, the ongoing effects of Brexit and the cost-of-living crisis have further stretched global supply chains to breaking point. In the UK, where I'm based, we expect to be able to get what we want, when we want: but in recent months we've run short of commodities like eggs, petrol and toilet paper, as well as microchips, cars and games consoles.

Can we fix our supply chain problems? Or is how we make what the world needs broken forever?

Trusting the production process

For answers, policymakers will naturally look at the big picture:

WHAT IS PRECISION MACHINING?

Precision machining lies at the heart of the manufacturing industry.

It involves the accurate fabrication and shaping of parts, ensuring the final products meet the demanding requirements of various industries. It's often carried out in a CNC machine.

Manufacturers rely on precision machining to create parts with intricate features, complex geometries and tight tolerances. These components are often crucial for the optimal functioning of larger assemblies or systems, and are found in (for example) aerospace systems, automotive engines, medical devices, electronics, and many other applications where precision and quality are essential.

Software plays a pivotal role in accelerating and optimizing the entire workflow, not least as CNC machines must be programmed carefully in order to be effective and efficient.

how to protect domestic industries with measures like trade barriers, tax incentives and talent development schemes.

However, measures like these cure only the symptoms of the disease, not the cause. We need to make manufacturing itself faster and more efficient so that when global crises hit, the sector becomes part of the solution, and not the problem.

Today, how everyone makes manufactured goods is pretty inefficient. For example, any metal component that comprises part of a larger item – a smartphone or laptop case, or a housing that connects a seat to a chassis – is precision machined in a CNC machine (the mini-factories that power much of today's manufacturing sector).

Precision machining is, effectively, the global mechanism for creating the metal components the world needs to function. But there's a problem: it's hard to do, which means it acts as a bottleneck for the global economy, preventing growth and innovation.

A CNC machine isn't easy to use. The interface is complicated and non-intuitive, and it requires a great amount of expertise to operate efficiently and safely. Even a simple component can be made in billions of possible ways, and if the machine is programmed non-optimally then the manufacturer wastes resources – both time and materials.

Estimates suggest that because of those problems, and combined with the further scheduling issues they create, many factories may run at as little as ten percent of their theoretical capacity.

In other words, there's a huge amount of redundancy built into the current system. If we could remove that – for example, by improving scheduling, tool usage or operator ability – we could dramatically improve how effectively manufacturers are able to operate. In this white paper, we take a deep dive into some of these issues, and identify potential solutions that could point towards a new future for precision machining. I hope there is some value in it for anyone interested in the future of manufacturing.

Theo Saville, CloudNC, August 2023

What are the challenges and opportunities in precision machining today?

The opportunity

Manufacturing is a sector under pressure: from inflation and rising costs of energy and materials, and a lack of skilled workers. Within the industry, precision machining is a specific bottleneck, as the difficulties inherent in producing components on time, to standard and on budget inhibits innovation and prevents the world from making what it wants, when it wants.

But as well as the challenges, there's opportunity. The observable precision manufacturing sector is enormous: as far as it's possible to tell, and according to internal CloudNC number-crunching, over $1 trillion of parts and components is produced worldwide, every year.

Within that vast figure, somewhere around $40 billion is spent on paying people to program CNC machines – but that process isn't as efficient as it could be. With all the myriad blockers, obstacles and inefficiencies involved (from shortages of skills to the challenges of accurately quoting for work, and then scheduling it), no factory is at 100% efficiency, and some inefficient facilities run at 10% of their theoretical maximum capacity.

So clearly there's a lot of slack in the system – and if you could tighten any of it, then there's a lot of potential upside. What might that look like?

Let's take a 'normal' factory – say, with three CNC machines – operating at industry-standard levels of productivity. According to our base assumptions (again, according to internal analysis), that normal factory might operate on revenues of $500,000 a year, with a profit of around 9%: or $45,000 a year.

Let's say we can fix all of that factory's inefficiency problems overnight. So all of a sudden its machines are running at full capacity, it can get all the staff it needs to operate them, and it's able to estimate and schedule work super quickly and efficiently.

According to our best estimates, formed by analyzing the sector and crunching the numbers, fixing those problems together would create around $175,000 a year in combined

THE SKILLS GAP

What is the skills gap?

Skilled older workers are retiring out of the manufacturing industry, taking their expertise with them

Not enough young people are entering manufacturing to replace the numbers leaving

Therefore, the sector that doesn't have enough skilled people working in it to meet demand.

Hence, the 'skills gap' = the gap in the amount of skills required, and those that are actually in play.

savings and profits for your average factory (in effect, increasing profits by around 4x).

Now, we're well aware that that improvement is purely theoretical: in reality, such a leap forward in efficiency gain would be practically impossible to achieve, at least in one step.

Still, the figure offers a glimpse of where technological gains might point for forward-looking factories that are able to effect even a small proportion of them: not just incremental increases on the balance sheet, but actual step changes in efficiency and profitability. And extrapolate any of those gains out across multiple facilities, and you end up with a much more productive manufacturing sector.

Skills gap

Talk to any manufacturer about the challenges they face, and there's a strong chance that any of them will raise one factor: the skills gap (see sidebar).
According to Deloitte[2], in the US, the manufacturing sector is expected to have 2.1 million unfilled jobs by 2030 – affecting the country's ability to build, well, just about everything, from nuclear submarines[3], to textiles[4] to metal fabrication[5] to semiconductors[6]. And it's a similar story in Europe too.

Where does this gap come from? In part, it comes back to technology, and the pace of change. At one end of the spectrum, you have a cadre of highly-skilled older workers who may have worked in manufacturing for 30 years or more. This group has built up a lifetime's worth of experience in how to make parts and components reliably, skilfully and efficiently.

However, manufacturing is a sector that over that period has been through huge structural and technological changes – whether that's new operating systems, new techniques, or new technologies such as robotics.

It's well known that as people get older, it's harder to learn new things[7], and so it is in manufacturing as elsewhere. So, if someone is comfortable enough, rather than have to adapt to another new management team, train another apprentice or learn how to use another operating system, they might retire. If a break point emerges, it's natural for this generation to decide to hang their boots up – and indeed, during the forced immobility of COVID, many did (in the US, around 1.4 million[8]).

At the other end though, technology is also a problem – but for the younger generation, conversely it's actually a lack of technological sophistication that acts as a deterrent.

While today's university graduates have grown up with smartphones and accessible online services, the manufacturing world is still pretty analogue and non-intuitive, and it takes a lot of training before a trainee is allowed on – say – a CNC machine. (In the UK, it takes an apprentice 3.5 years).

Marry that accessibility problem with other contributing factors, such as:

THE SKILLS GAP: THE IMPLICATIONS

According to Deloitte, 'leaving the open jobs unfilled in manufacturing could bring a potential negative impact to the US economy of more than US$1 trillion by 2030 alone' – simply because there is demand for manufacturing output, but because of the skills gap, the sector isn't able to deliver.

Specific problems include:

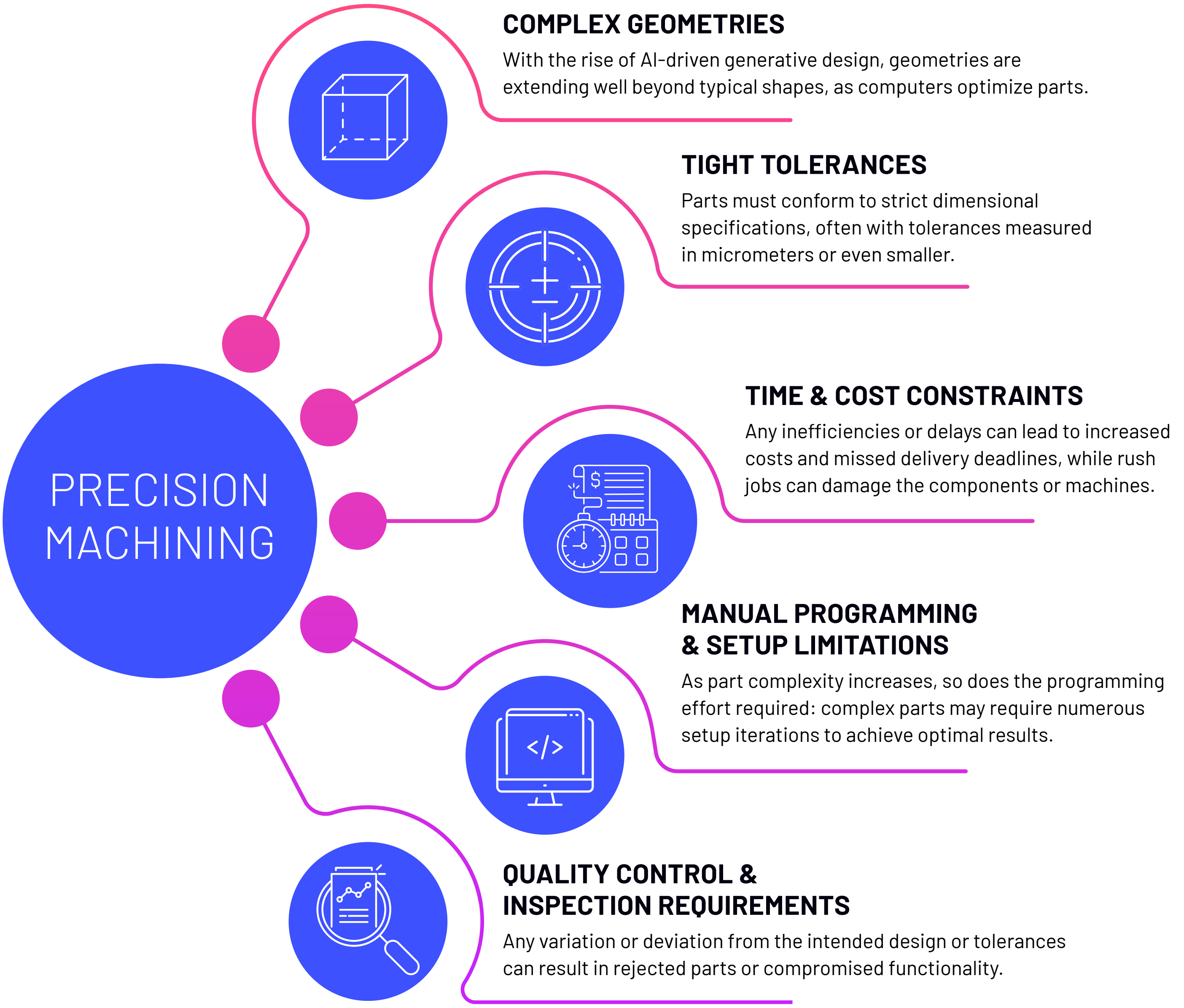
- REDUCED PRODUCTIVITY: lacking a skilled and adaptable workforce, manufacturers struggle to optimize production processes and fully utilize advanced technologies, leading to decreased productivity levels (both quantitatively and comparatively with other regions)
- MISSED GROWTH OPPORTUNITIES: inability to adapt to innovative manufacturing techniques prevents companies from diversifying their product portfolios and capitalizing on new market opportunities
- OUTSOURCING: to compensate for the skills gap, manufacturers resort to outsourcing production to countries that do have available workforces – solving one problem, but potentially leading to increased costs, longer lead times, potential quality issues, and a greater environmental impact
- STAGNANT ECONOMIC GROWTH: let's not forget that the manufacturing industry is often the bellwether of the domestic economy – if it's doing well, so is the nation (as people are both making things, and wanting to buy them).

- A decline in the number of vocational and technical training programs
- A negative perception of career prospects in the manufacturing sector amongst students, parents and teachers, especially compared to white-collar industries
- A lack of sectoral diversity[9], which may dissuade women and minorities from seeking careers
- The West falling behind other countries, especially Asia, in STEM subject education[10], skills which are critical to manufacturing

Add that together and you end up with a scenario where, despite active government encouragement,[11] a career in manufacturing isn't seen as being as exciting or financially rewarding as, say, one in Silicon Valley or investment banking. The result – a skills gap, and an ongoing headache for manufacturers.

The process

Precision machining presents several challenges that arise due to the intricate nature of the parts being produced, the demanding requirements set by various industries, and the environment they are being created in – which is hot, noisy, and expensive! These include (see infographic):



Change

Another element that makes precision machining hard is that: every job is different.

When a customer asks for a quote on a new component, the manufacturer likely won't have seen it before. And that means they don't know how to make it, or how long it will take, or exactly how to meet the lead times or quality requirements.

As a result, it's incredibly difficult to get the quote right, and there's no manual to help a factory get there. Estimate too low, and they'll undercut the market and win the order, but end up losing money on every part they make. Too high, and they won't win the order.

There's a sweet spot in the middle where it's possible to both win the order and make money, but it's difficult to get to that spot as there's no process for finding it other than having knowhow, based on years of experience. Get it wrong consistently, and a workshop will fail.

Consequently, for quoting, workshops often end up relying on a single guru within the business, usually with 30 or so years of experience, who basically estimates under tight time pressures – hopefully accurately – on what the price point is. This person is therefore absolutely critical to a manufacturing business, and it's extremely difficult to replicate their experience and know-how and share it with colleagues, as it's all located in their head.

Exacerbating the problem is that even if a business has a person with that kind of experience, it's all specialized and localized to one specific factory – to the extent that if they were dropped into a new facility and asked them to do their thing, they'd struggle. Every factory has a different cost base, different machines, specialities and quirks, so the correct quote that would make a lot of money for one factory would end up losing it at another.

Timing

Just as difficult as quoting for a job, is scheduling the job once it's been won.

During the quoting process, the expert has guessed how long everything is going to take in a perfect world – but the business won't know how long it will take until the parts start being made.

That's problematic, as if the estimates are too low, then parts will be delivered late, and other parts will be delayed too. Compounding the problem is the manual nature of scheduling in factories, where work is still often scheduled using simple Microsoft Excel templates, or even whiteboards (at smaller companies with fewer machines).

So the challenges of scheduling work accurately mean there's already a garbage-in, garbage-out kind of situation at a factory in terms of timing – and that problem is exacerbated again by all the variables that mess up timing even further.

Variance

There's a trillion ways of programming every new component, and everyone will do it differently, based on their own expertise.

Then there are more variables to mix in. Programmers have their favorite tools that they prefer to use, and their favorite toolpaths. Tools can behave perfectly the first 50 times a component is made, but on the 51st, perhaps a tool chatters in a particular corner and wears out quicker than expected and breaks, then an area wasn't cleared out properly, and then the next 15 tools in the process all hit material that wasn't supposed to be there and snap too.

In an environment where one wrong move sends spindles at high speed into another solid piece of metal, that means there's now an expensive broken CNC machine.

And in the midst of all this chaos, a company might be trying to make a component that might need to be accurate to within thousandths of a millimeter, or even a sub-micron: the kind of tolerance where the slightest change (such as the thickness of concrete on a shop floor, whether the sun has come out and is heating one side of a machine through the window, or if an operator crashed the spindle lightly on a previous run and hasn't mentioned it yet) can create inaccuracies that take production lines out of those narrow tolerance bands.

Summary

All of these factors mean that the safest course for factories is to make their lives as simple as possible: remove the variance as much as possible, and specialize on one thing. The goal is to get to a situation where a manufacturer is working in a specific industry (say, oil and gas), making the same parts for the same three or four companies, so their business becomes predictable and they don't need to re-invent the machining wheel every day.

Economically, that makes sense: but strategically, it means a factory ends up being tied to a small number of potential customers, with little natural defense if the prevailing market winds change and your purchasers decide to go in a different direction. After all, what if you're an aerospace machining specialist… and COVID grounds the world's fleet?

So, how do manufacturers cope with all these challenges?

Unfortunately, the answer comes back to the skills gap issue: it's experience. People who've been in this industry a long time are really, really good at their jobs. They've seen enough to be able to predict a lot of these problems and intercept them before they happen – whether that's to realize that a new truckload of metal is behaving differently from usual, to seeing the challenges that a scheduled quote provides before work starts.

Why "unfortunately"? Well, because:

It's incredibly hard to find people with this expertise in the first place – it takes years and years of hard work to develop

When you've found these people, you can't scale them or share their knowledge easily with others – so they aren't replicable

As we've explored above, it's disappearing: these people are retiring from the industry, and not being replaced

Add that all together, and you have an intractable situation that can't be fixed within the industry itself – you need to look outwards, for solutions that look at the problem in an entirely different way.

The solution: **CAM Assist**

Some of these problems are systemic, and may seem insoluble – but all is not lost. There are ways forward!

Of course, many solutions providers are looking at ways of easing the pain for manufacturers. Here, we'll focus on the one we know best at CloudNC – our new solution, made available to the world in July 2023: CAM Assist.

CAM Assist – currently available as a plug-in within Autodesk's Fusion 360 software platform – uses advanced computer science techniques to generate professional machining strategies for 3-axis parts in seconds, which could take CNC machine programmers hours or even days to manually create.

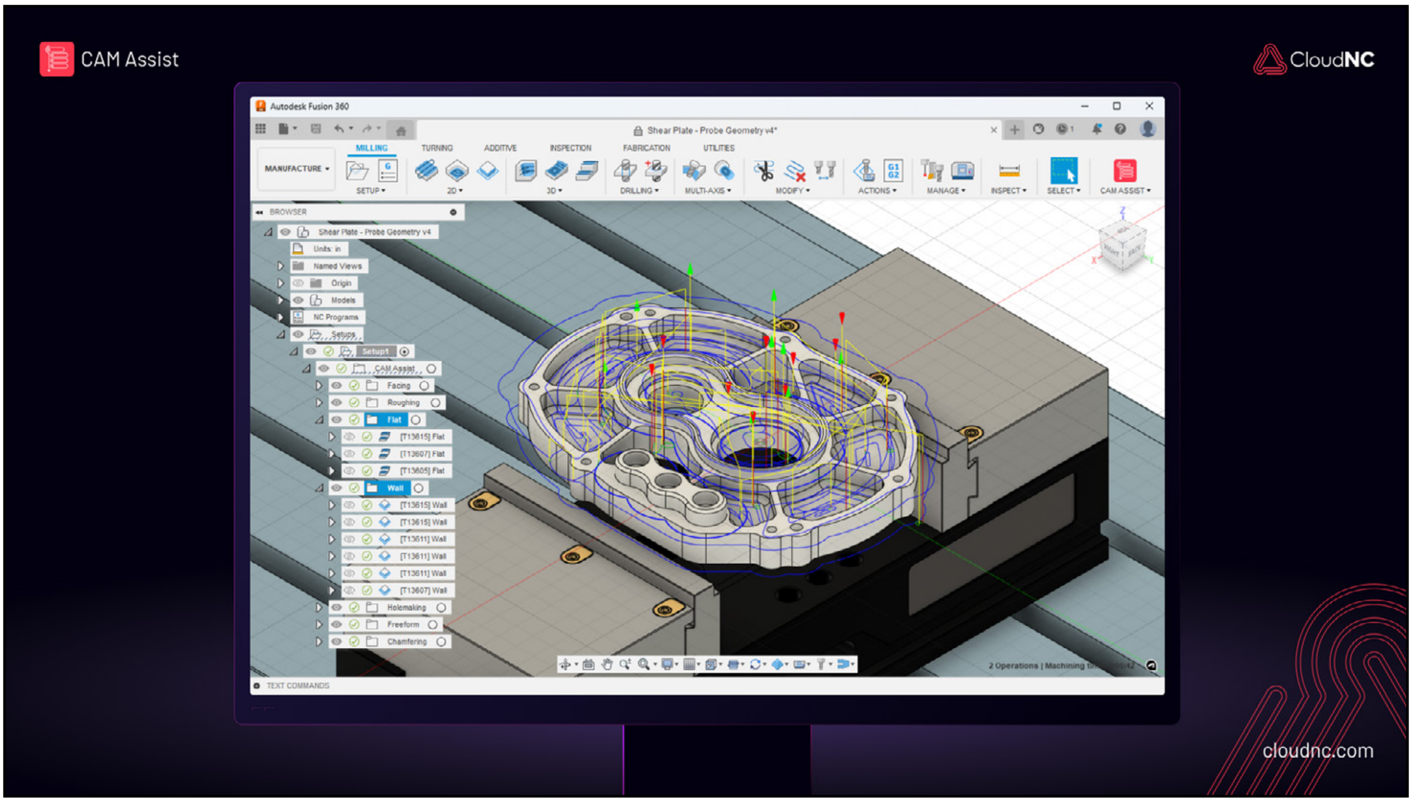
As a result, the amount of time it takes to program a CNC machine to make a component – a bottleneck in many factories, due to a global skills shortage – is reduced by up to 80%, compared to the previous manual programming process.

That gain enables manufacturers using CAM Assist to raise productivity and shorten lead times. In addition, the software frees up time for experienced programmers, while also allowing junior employees to program more complex parts and be productive faster, helping fill the manufacturing sector's widening skills gap.

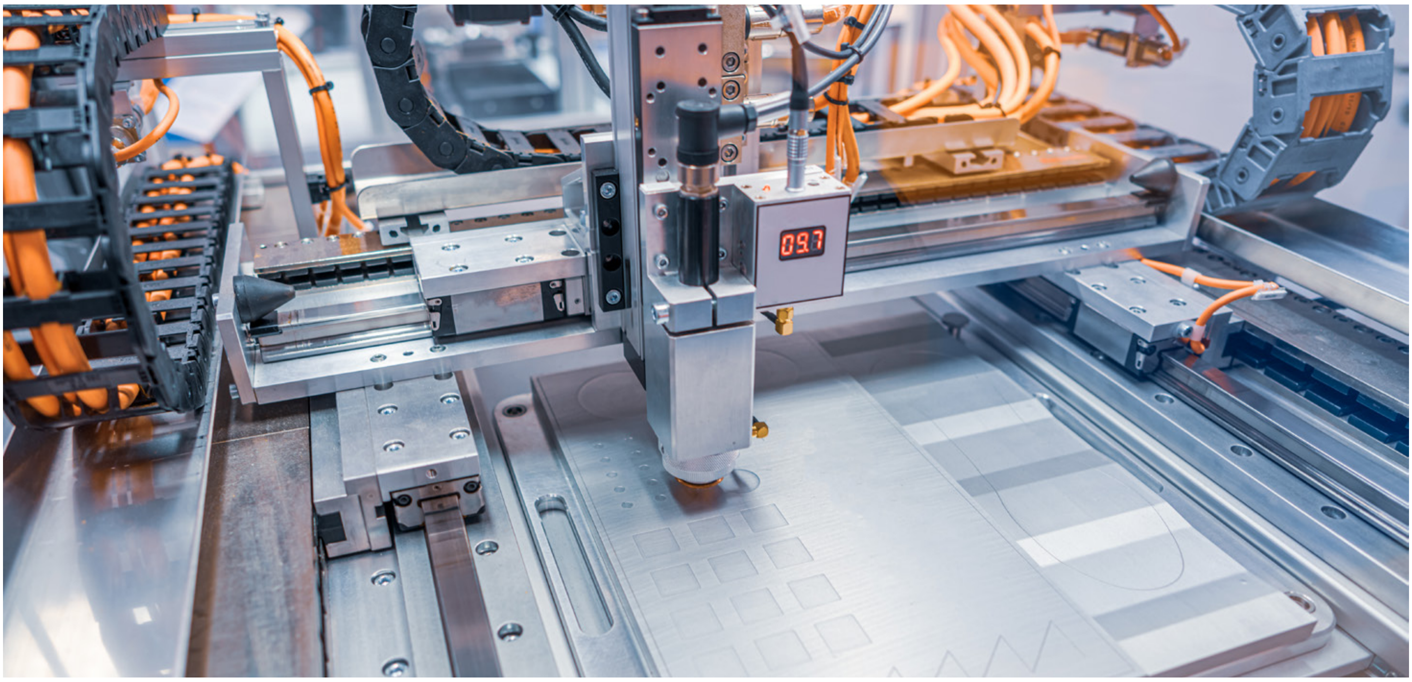
Theo Saville, founder of CloudNC:

CAM Assist is the biggest paradigm shift for the precision manufacturing sector in decades. By making CAM programmers faster, CAM Assist enables manufacturers to increase machine uptime, slash lead times, improve process stability, and upskill staff to become expert machinists

CAM Assist



CAM Assist in Fusion 360



more quickly. These advances will re-energise precision manufacturing companies struggling with rising costs, aging workforces and competition from globalization – shortening supply chains and keeping the costs of everything down for us all.

Previously, depending on complexity, it could take a CAM programmer between an hour to several days to determine the best strategy to CNC machine a new component. This includes selecting the correct tools, toolpaths, and techniques – determining between hundreds of thousands of potential variables and approaches.

Instead, CAM Assist uses advanced computational optimisation and AI inference techniques to rapidly determine a professional strategy and toolset needed to manufacture a part, along with the appropriate cutting speeds and feeds from the user's library.

As a result, a Fusion 360 user can today upload a 3D model of a component and the software determines the best milling tools needed from those available, and how they will be used. In seconds, CAM Assist drafts the code required to instruct a CNC machine how to make it, within the user's existing CAM platform.

CloudNC has conducted side-by-side trials of CAM Assist with senior CAM programmers. According to the results, CAM Assist users can reduce programming times by up to 80% in comparison to manual programming methods, saving time for more senior programmers by completing tasks associated with program set-up and toolpath creation.

New users can also use CAM Assist to start to learn how to use software platforms like Fusion 360 far faster, producing components on the day of first use. CAM Assist will be made available for other popular platforms in 2024.

“ Andy Soos, Managing Director at Bedford CNC who had early access to CAM Assist:

I now use CAM Assist every day with Fusion 360, and it's opened up many new opportunities for my business and made life a lot easier with regards to programming – which means we've been able to speed up delivery times to our customers even further.

“ Theo Saville, CloudNC founder:

CAM Assist is the solution to the lost output problem – it frees up time for senior programmers, and helps unskilled workers get up to speed far faster. If you're a workshop owner, it's what you've been looking for: it allows someone who's never previously used Fusion 360 before to start making components on the day of first use, all within an existing CAM package.

Q&A:
CAM ASSIST

WHAT IS CAM ASSIST?

CAM Assist is a software solution that generates professional machining strategies in seconds at the click of a button, accelerating CAM programming time by up to 80%.

WHAT DOES IT DO?

CAM Assist uses advanced computer science techniques to generate professional machining strategies in seconds, which could take CNC machine programmers hours or even days to manually create.

WHO CAN USE IT?

CAM and CAD programmers using CNC machines, via a plug-in for Fusion 360: it will be available to users of other CAM packages soon (in 2024).

HOW DOES IT WORK?

CAM Assist uses advanced computational optimisation and AI inference techniques to rapidly determine a professional strategy and toolset needed to manufacture a part, along with appropriate cutting speeds and feeds from the user's library.

As a result, a Fusion 360 user can today upload a 3D model and the software determines the appropriate milling tools needed from those available, and how they will be used. In seconds, CAM Assist drafts the code required to instruct a CNC machine how to make it, within the user's existing CAM platform.

IS ALL THE WORK DONE BY AI?

A hybrid of stochastic, probabilistic and statistical inference AI techniques drives CAM Assist.

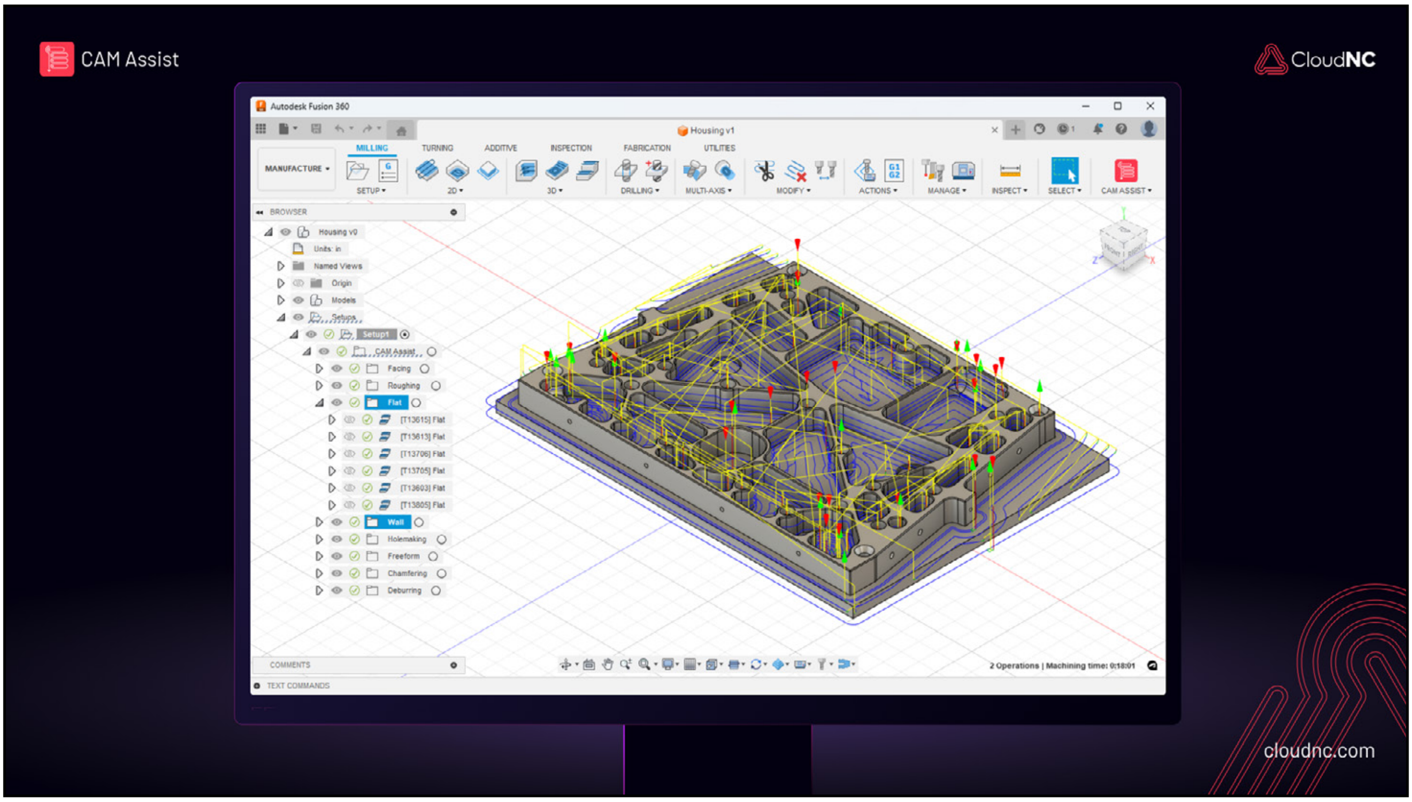
There are more possible part shapes and ways of machining them than there are atoms in the universe, so CAM Assist leverages these AI techniques to rapidly calculate an appropriate way to machine a part in seconds, without needing to simulate and compare quadrillions of possible solutions to find an answer.

HOW DOES IT LEARN?

Our AI inference techniques use data and learning from the real world, gathered from experiments in our own manufacturing facility, to validate and refine the mathematical models that drive CAM Assist.

In simpler terms, CAM Assist uses inference techniques to make expert predictions about what's going to happen in a CNC machine, based on its always-growing understanding of the science of machining.

CAM Assist



CAM Assist in Fusion 360

WHAT'S THE DIFFERENCE BETWEEN CAM ASSIST AND FEATURE-BASED MACHINING?

Feature-based machining is a manufacturing approach that utilizes computer-aided design (CAD) models to automatically recognize and define specific features on a workpiece, such as holes or pockets. You can then assign your workshop's own preferred means of producing these features.

In theory, by identifying these geometric features, feature-based machining software can generate tool paths and machining strategies that produce those features. It's like building up a macro library of different types of features, which the software can join together.

That approach can work well if you're making the same sort of parts all the time, as you can press a button and it will make those parts, with the same kinds of features, in the same way.

The downsides though are that the systems take a very long time to set up – months, in fact, as well as years to take to maturity – as you have to specify yourself exactly how you want every type of feature to be machined. In addition, they only really work on simple parts: they don't really function well if you ask them to make something outside of what you've set it up to do.

So, there's no flexibility – feature-based machining can do one thing, and one thing only, and that's make components with specific identified features. It's not particularly suitable for job-shops where the variability of parts coming through the door from customers is extremely high.

Ultimately, feature-based machining is quite limited. It's an attempt to replace a CAM programmer's decision-making process with a big book of set rules, which is essentially impossible – there are trillions of possible geometries, and trying to come up with a rule for every one is impossible for a human, and it can take years to build a decent library of machining macros.

But even then, that library is going to be pretty specific to the parts you make, tools you already have, and machines you've set it up for. And, as every machinist knows, nearly every part and feature has exceptions to the rules, and therefore to cover them all, you'd need a book that's thousands of pages long.

CAM ASSIST CASE STUDY

Mark Hyde, technical director, Hyde Engineering

TELL US ABOUT HYDE ENGINEERING?

We're based in Lichfield in Staffordshire (UK), and we're a precision CNC machining company, using mostly 5-axis machines. We employ 8 people.

WHO ARE YOUR CUSTOMERS, AND WHAT DO YOU MAKE FOR THEM?

It's a mixed-bag! We specialize in defense and agriculture, but we also support other customers across a range of industries, including medical. In terms of what we make, again it's all sorts, from aluminum to high-carbon, high-tensile steels, alloys and titanium.

AS A BUSINESS, WHAT CHALLENGES ARE YOU FACING TODAY?

There are two main issues: capacity, and staffing, and they are closely connected. We're growing as a business as there's lots of demand, so we're currently adding capacity with new machines. But, spindles don't turn unless someone is programming them, so you also need new staff.

CAM ASSIST: THE DIFFERENCE

That's not how CAM Assist works, and the difference is that whereas feature-based machining can identify a certain feature on a part and you can make a macro for how to make it, CAM Assist is an AI that's been programmed to know how to make the whole component.

That means instead of recognising features and working out the best way to make them, CAM Assist works out the best toolpaths and strategies based on all the elements that a component consists of, because CAM Assist understands the part holistically, as a whole.

At its core, CAM Assist is like a machining technician: It has a practical understanding of the physics and processes of cutting metal so it can make the sort of decisions that a machinist would make, and would know – for example – that it's a bad idea to run a tool into a corner the same diameter as the tool, as the physics engine knows that will suddenly increase engagement and therefore force, resulting in chatter.

So, with CAM Assist:

- You're not coming up with macros. It already knows what to do, and we're making it smarter every day
- Give it a hundred tool libraries and a hundred machines, and it knows how to get a result for every combination
- CAM Assist works straight away – you don't need to tell it how you think it should do the work

Effectively, it's like having that technician on your desktop that is going to make its best effort at completing the component as a whole every time, and will supply you with a workable strategy that could be good to go, or might require some final edits and improvements from a CAM programmer so it works for their factory and machines. (The ambition, ultimately, is to get to a point where you can make every part, in its entirety, with a single click.)

And what's more, CAM Assist teaches someone who has never machined a part before, as it shows them the strategies that it recommends to make any kind of component. That's pretty much the opposite of feature-based machining, which could only show you what it's been taught to do in a very specific scenario.

So in summary – while feature-based machining is a solution that is of relatively niche usage to a small cohort of businesses, CAM Assist is much more flexible, and can be a game changer for all precision workshops, from individual users all the way up to large production lines.

As we're growing, the number of customers is growing, and the types of parts and the quantities of them that we are making is increasing. We're also quoting more and more – so although we have capacity for new business, if everything lands at the same time then something has to give somewhere!

WHY ARE YOU GROWING AT THE MOMENT? WHY IS DEMAND INCREASING?

Honest answer is we aren't completely sure! However, we are collaborative in the way we work with customers, we have high-quality machines (DMG Mori 5-axis) and we've invested in the facility. So from the outside in, if I was looking at the company, it would be one I'd want to send my work to.

HOW WERE YOU LOOKING TO COPE WITH THOSE CHALLENGES?

The biggest issue we struggle with is quoting for new work, and being able to do so in a timely manner – mainly because so much else of what we do relies on that. We've spent a lot of time and effort working out ways to speed that up and improve the process, but today a lot of it relies on one person manually completing quotes.

That will change, but (at the moment) if a quote comes in when we are busy it might be a week before we can respond, at which point somebody else might have won the work. That's not so much of a problem now, but as we increase capacity in the factory we need to ensure that we're able to quote more quickly.

WHEN DID YOU START USING CAM ASSIST?

We literally placed the order on the day it was released.

WHY DID YOU START USING IT?

The most important reason was to increase the speed of quoting. I now use CAM Assist as a platform to quote parts against – as you can generate all paths with multiple set-ups, you can very very quickly get a rough cycle time for a part of a family of parts – probably with about 80% accuracy. That speeds up the quoting process and allows us to be more efficient.

We also plan to start using it on the shop floor, to allow our people with lesser levels of experience to start programming parts.

WHAT'S BEEN THE IMPACT SO FAR?

Well, estimating quotes in this industry is a complex problem. For a part, it might take me an hour to work out every element and generate a quote. Now, CAM Assist means I can do that in 5 minutes.

It also means you can be more consistent. With the detail in a component, the way that each person will program them is slightly different, and that may have an effect on the cycle times. Now, we can be confident that our cycle times for parts will be pretty similar, even if it's months since we programmed it previously.

WHAT'S THE EFFECT OF THAT ON THE BUSINESS?

Ultimately this all frees up time, which is precious. If you're giving me 55 minutes back in time, that I can spend time on doing something else – whether that's quoting for another job, or the million other things I have to do!

WHAT HAPPENS NEXT?

I think when we start using it on the shop floor, it will be quite valuable for the people that end up using it. I'm careful of not wanting to deskill the workforce, but the beauty of CAM Assist is that you can look at what's been generated [by the software] and look at the detail of what it's created. So if somebody's not sure how to generate a certain type of tool path, then they can look at what [the software has generated] and learn from it.

ANYTHING ELSE TO MENTION?

For what it gives you, it's not expensive. I know that more features are on the way, like different CAM systems – I'm confident that it will keep developing.

WHAT WOULD YOU SAY TO SOMEONE THINKING ABOUT GETTING CAM ASSIST?

Buy it yesterday!

CAM Assist

Precision manufacturing: Why is this such a hard problem to solve?

By Chris Emery, CloudNC founder

Somewhere close to $1 trillion-worth of components are made every year, but producing them isn't as simple as using a 3D printer. Instead, the machines need to be told how to make each part, via a process called Computer Aided Manufacturing (CAM). And for that, you need a skilled human in the loop to program the machine.

As discussed above, having that human element involved creates variance. Programming a CNC machine requires training and expertise, and there aren't that many people who can do it (and the skills gap is growing as demand for components rises and the number of those entering the industry lags behind the number retiring out).

There's even fewer who are experts, and skill levels matter. There's an infinite number of potential ways of making any component, and a new programmer is much more likely to be less efficient and more wasteful than a very talented one.

What we want to do with our solutions is automate as much of that process as possible, helping those with less experience program as quickly and optimally as the best CAM programmers out there – reinventing the manufacturing process for everyone.

CHALLENGE 1: INFINITY

That word 'infinite' though: that's where much of the problem lies. If you think about the process for programming how a single component is manufactured, the potential solution space is very large.

It's not like 3D printing where you have one tool and you can work out the best way forward layer by layer – with a CNC machine, there are multiple tools (of different sizes and types) that can all be used to achieve certain results, all of which can be deployed at different angles or depths or speed, and in any order.

So, the number of solutions is, in effect, exponentially large, and that creates huge problems from a computational point of view. Simply put, considering them all in order to work out what the best path forward requires a computer to multiply near-infinity by near-infinity, many times (combinatorial complexity!) – which takes far too long to produce results that might be useful to anyone.

The challenge therefore: make the scale of the problem tractable. Without giving away too much of our 'secret sauce', one element of the CloudNC process is to reduce the scale of the problem: for example, by rejecting impossible or very difficult tool paths, while making sure that optimal solutions are retained.

As a result, our algorithms are able to locate the potential best ways forward, without having to consider every possible solution that there is – meaning we can deliver results in seconds, as opposed to years.

CHALLENGE 2: PHYSICS

OK, so we can deal with the potentially infinite number of ways of making these components. But the other problem here is that this is a complex physical environment to consider, with – literally – many moving parts.

When machining a component, materials get very hot. They expand and contract. The milling machines have to cut chips away from metal blocks, and if the chips are too thick then the tool breaks, or if too thin then the surface of the metal cleaves. Tools get damaged, and wear out. The whole assembly vibrates.

Combining these physical restrictions with the exponential number of solutions is what elevates the difficulty level of solving the precision manufacturing challenge from 'hard' to 'nightmare'.

It's not enough to find a solution that uses the quickest and most efficient toolpath. Instead, your way forward also has to take into account multiple different physical aspects of the tools and raw materials you are using, and one miscalculation potentially ruins hundreds of thousands of dollars-worth of expensive machinery.

So – what's the cheat code? Well, again it's about making the problem tractable. Realistically, we can't understand the integration of every physical element with every possible way of machining a component. But we can generate and assess the most optimal and align these with an understanding of the most common, regularly-used and applied techniques, and ensure our solutions incorporate these today.

As a result, our solutions can already be applied to the majority of CNC machining challenges, and we're improving and fine-tuning how they work all the time. As a result, we can accelerate the process of programming the manufacture of a relatively complex component in a CNC machine from hours (or even days) to seconds.

CLOUDNC LIVE TESTING

In Chelmsford, a small city east of London, CloudNC operates a high-spec factory, which specializes in machining precision components for manufacturers in the aerospace, automotive, and oil and gas sectors.

Before the company moved in, it was a decommissioned soft drink production plant (the old Britvic building). It's been transformed into a modern facility employing some 50 people, all working to meet the requirements of some of the UK's most prestigious and well-known companies and corporations.

By operating our own facility, CloudNC has a dedicated space to test, refine and improve its software solutions – live. It serves as a real-world testing ground, allowing us to observe and analyze how our software interacts with the complex machinery, materials, and processes involved in precision machining.

Having the factory also means there's also a team of skilled machinists feeding back. If there's a physical problem with some code, those experts are often able to provide a way forward – precisely because they understand the physical nuances of the problem and what other customers would be looking for.

That feedback loop is critical, as the information they share with the software team is at a level of detail way above what you'd receive from a typical manufacturer. To make our solutions like CAM Assist perfect, really specific scientific data is needed – the kind that all customers don't have the time to source, and likely wouldn't share anyway as it's so valuable.

THE OPTIMAL PATH

Of course, the above description of our solutions is light in detail, as you'd expect for a short essay summing up 8+ years of work and millions of lines of code (and counting). Equally, I don't want to give away the farm: exactly how our algorithms work is proprietary to CloudNC – we've spent a lot of time and effort building them!

This discretion does therefore under-sell what we've had to build: for example, complex algorithms to accelerate and finesse complex aspects of computational geometry, combining the machining of different shapes and aspects with each other, and producing results in a timeframe that adds value for users.

In addition, it doesn't emphasize enough the tight parameters within which we operate. We're literally creating machining solutions that are being used to create parts for fighter jets and nuclear plants – which means they have to be exact. There is no margin of error.

That's why we've taken our time getting CAM Assist ready – there's been a lot to solve. And we're not especially close to the end of the journey: our vision of bringing single-click manufacturing to the world will remain some distance off for some time yet – we're still conquering a previously intractable problem!

But we are making massive inroads to it, and what we've made tractable so far is a substantial part of the overall challenge. We're making accelerating CNC machine programming possible, so that we can make components faster and quicker, enabling innovation and helping fill the skills gap in manufacturing.

Conclusion

Today, precision manufacturing is a critical part of the global supply chain, but it's also a bottleneck. Solutions like CAM Assist can change all that:

Experts can spend less time on time-consuming programming, and are able to invest their time and knowledge in much more complex tasks

Junior programmers can be more productive more quickly, and can machine more difficult components

By reducing their reliance on manual machine programming, factories can manufacture more parts, faster and with less waste

So, that's the benefit per factory, or per manufacturer. But what happens when you take a step back at the macro view?

If you can make not just one factory more economic, but many factories, then suddenly a lot more options become available:

We can level the global playing field, as factories in developed nations are again able to compete against their counterparts elsewhere – whether through pricing, efficiency gains, or flexibility

Stronger domestic sectors means shorter supply chains, reducing the geopolitical threat from disruptive global crises

Shorter supply chains means less environmental impact – less cargo going back and forth

We can narrow the manufacturing talent gap, meaning we help manufacturers meet rising demand with their existing and future workforces, not least through helping them employ younger talent.

Add all those factors together, and you have a situation where domestic manufacturing sectors are attractive places to work, fuelled by cutting-edge technology and set up to compete for the future – instead of dwindling assets competing forlornly against cost-cutting adversaries in a race to the bottom.

What does that look like in practice? Well, maybe it's the difference between old Detroit – a collapsed 'donut' city that's empty in the middle, as its manufacturing core has been hollowed out as the US automotive industry falters – and a new, dynamic Detroit, where new manufacturers, supported by cutting-edge technology, are able to fill the gap, creating prosperous shops and skilled jobs that support the local ecosystem and reinvent a city.

Now, we're not yet living in a world where CloudNC's software is changing how the world makes things – it's too early for that. But in the near future, we will start to see signs that manufacturers are rethinking their global strategies, and that solutions like ours and others create the green shoots of recovery that manufacturing needs.

About CloudNC

CloudNC enables manufacturers to make anything in a single click.

Today, we are reinventing precision manufacturing by automating CNC CAM programming, enabled by data and experience from our high-spec factory. Our goal is to further develop our solutions across the manufacturing sector, helping companies and people make what they want, when they want.

The technology company, founded in 2015, consists of a world-class team combining expertise in computer science and physical manufacturing, and is backed by leading venture capital firms Atomico and Episode 1 Ventures, alongside Autodesk and Lockheed Martin as strategic partners.

Our CAM Assist solution is available today for CAM and CAD programmers using Autodesk Fusion 360 at **https://www.cloudnc.com**.

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