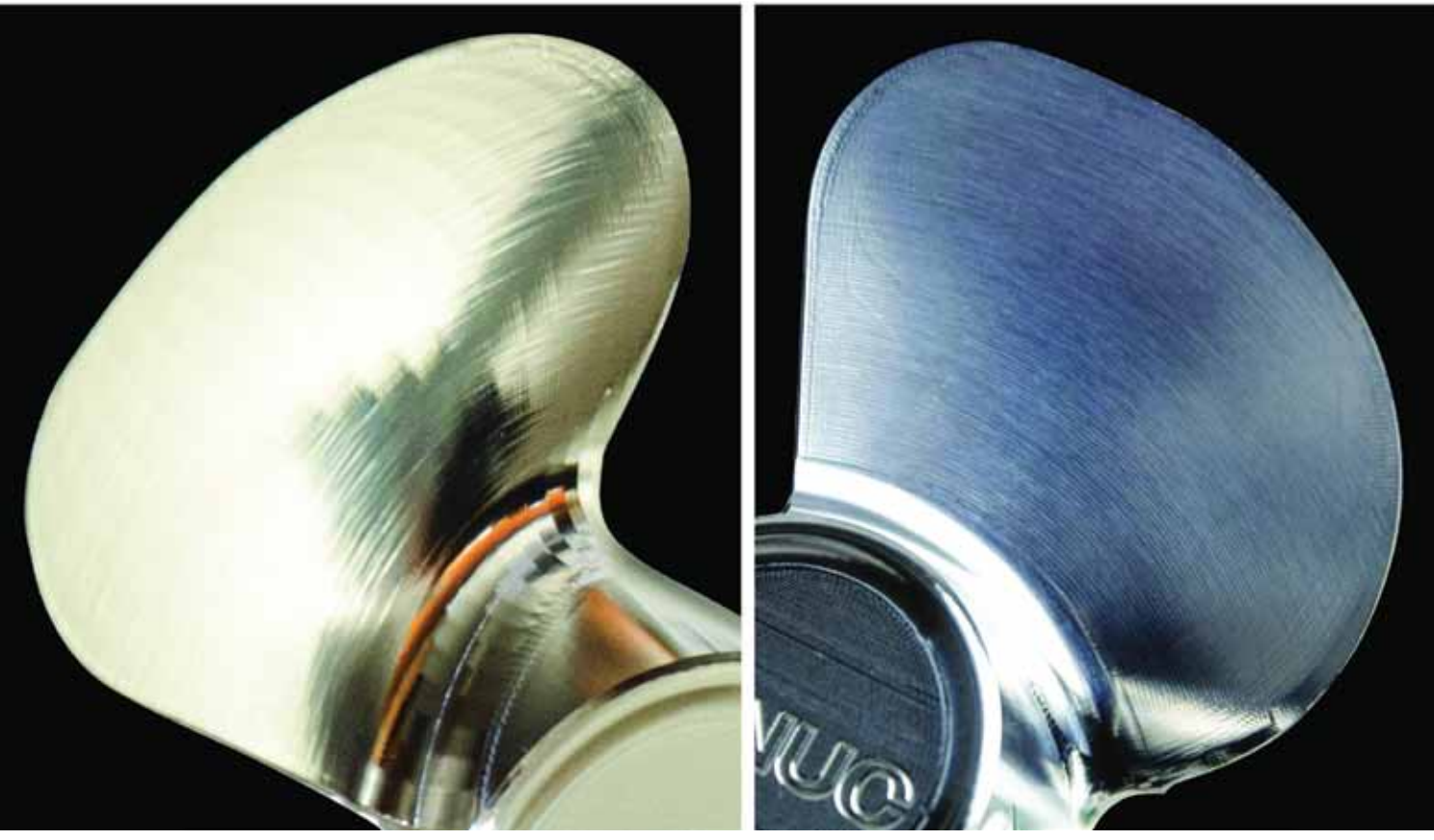
The Modern CNC Advantage

There are hundreds of aerospace manufacturing facilities capable of producing quality aerospace parts. However, in order to win new orders they all are looking for an advantage to be cheaper, faster and more accurate. The drive to reduce aircraft weight and assembly costs means an increase in part complexity. The facilities that maximize their equipment's capabilities will have the edge to win more complex part orders.

Going from dots to curves in aerospace CNC machining.



Side-by-side comparison of traditional (on left) and modern CNC machining.

Almost all modern aerospace parts require four or five-axis motion, and programming these complex geometries requires a quality CAD/CAM system. It would be difficult to dissect a typical aerospace part into a sequence of G1, G2, and G3's without a powerful CAD/CAM system to approximate the surface and generate a toolpath. To take full advantage of the power of today's modern CNCs, it's important to understand the basics of what CNCs can do and the changes necessary to push the manufacturing capability of machines to their limits.

Rick Schultz
CNC Aerospace Program Manager
FANUC America
Cincinnati, OH

Understanding the Basics

CNCs do exactly what they're told to do. Like most computers, there isn't a magic feature that turns a computerized device into something that knows what's in the user's head. The CNC will only do what the programmer instructs it to do.

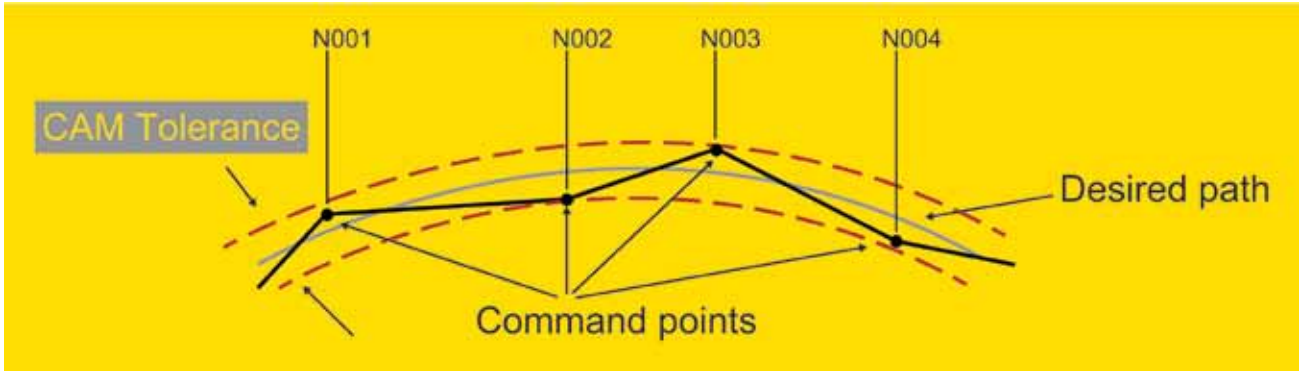
CAD/CAM systems generate a series of points based on a tolerance defined by the part programmer. These points typically are not exactly on the surface of the part as designed, but they are within the defined tolerance band from the surface of the part. The majority of part programs are simply an ordered series of points defined by the CAM system reformatted in G-code.

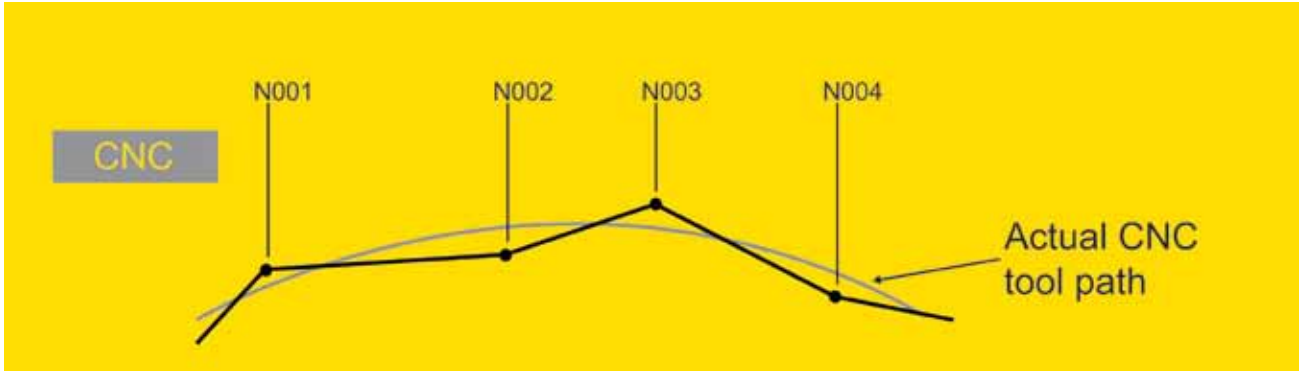
Connecting the Dots

With no additional information or advanced CNC features being implemented, the only thing a CNC knows to do is connect the dots defined by the CAM system. Without advanced features, a CNC's function would be similar to a child with a crayon connecting the dots in a simple dot-to-dot drawing. The higher resolution dot-to-dot drawings have closer spacing which can result in a more accurate representation of the object, but the end result is still lots of straight lines between points, as in the top diagram here.

The advanced technology needed to be more accurate than a child's simple dot-to-dot drawing has been available for a decade or more. When using advanced CNC capabilities, there is no additional investment in software systems or existing CAD/CAM systems, and the existing approximated series of points can work with limited to no modification depending on what CNC features are activated.

Modern CNCs have advanced features that interpret the series of CAM points differently. As described above, with no CNC advanced features used, the result is a linearized approximation.





However, if advanced lookahead algorithms are used, the CNC can interpret the series of points as a definition of a smooth curve. The result is an optimal, more accurate toolpath, as shown in the second diagram above.

Because the features use the abilities of the CNC and servo system to interpolate a single curve rather than numerous point-to-point moves, the time to produce the high-quality part will typically be significantly less and the surface will be smoother and more accurate. As an example, on a FANUC CNC the advanced lookahead feature is called "High Speed Smooth TCP".

A racecar example is an easy way to visualize the speed difference: Run the same car on the same track without going off the road or planned route. In the first lap, the car drives in straight lines with sharp changes of direction whenever a line nears the edge of the road. This is an example of a CNC without advanced features. Then, in the second lap, the car follows the smooth curve. The smooth curve lap takes significantly less time and the car can achieve higher speeds, similar to a CNC using advanced features.

Early Adoption for Success

The best time to adopt and use these features is when a new machine is purchased or an older machine is retrofitted with a new CNC. There is planning and expertise required to maximize the performance, but an experienced CNC vendor will have staff dedicated to helping facilities through this process.

Allow the CNC vendor to help you write the specification for a new machine or retrofit. A quality CNC vendor can review the manufacturing requirements and define the features most critical for optimal performance in quality and speed. The machine tool builder's expertise regarding the dynamics, rigidity and repeatability of the iron is also critical. If there is good coordination between the CNC and machine tool builder and their expertise is consulted very early in the decision-making process, there is high likelihood of success with the highest possible manufacturing performance and minimal to no unexpected headaches as the machine is moved into active production. Too many machines are purchased or selected based on minimal specification information and the result is a machine that will require significant effort to upgrade the machine's capabilities after the machine hits the manufacturing floor.

Close-up of the FANUC Series Oi-TF CNC.

Most aerospace facilities have a basic specification. On review, there's typically great expertise given on at least one aspect of the machine requirements: accuracy, torque, spindle speed and/or feed rate. However, due to limited resources and cutbacks through the years, many facilities' CNC specification is often just a manufacturer name and maybe a model number. This is the equivalent of going to a car dealership and telling the salesperson you want to buy a vehicle and don't give him any specifics. This would leave the engine, color, tires, options, number of seats, etc. to the discretion of the salesperson.

Machine specification with little to no CNC functional detail will typically result with a CNC setup and functionality similar to the child's simple dot-to-dot drawing. This can cause significant unplanned delays putting the machine into production and often results in emergency intervention by the CNC vendor and machine tool builder. Properly including the functional detail in the specification is the only way to prevent this.

For existing machines it is possible to add this advanced capability. However, on existing programs/machines it is important to have a step-by-step plan on what needs to change in the machine and how to incorporate the new functionality for the optimal end result. To do this, an experienced CNC vendor can work closely with maintenance, programmers and machine tool builders/distributors to define what steps need to be taken, and in what order, to achieve success.

Optimal Setup and Expertise

It's common for a member of an organization to attend a trade show or talk to a sales organization and learn of a "magic" advanced CNC feature. This feature may even be a critical feature like the "High Speed Smooth TCP" example earlier. Simply adding that feature and expecting instant success is not realistic. With any feature or change to how a CNC functions, there will be setup requirements to get the feature working properly. There are often other related features that need to be enabled and set up properly as well to maximize effectiveness.

Changing manufacturing from a child's simple dot-to-dot drawing to one that reproduces the smooth curve defined in the CAD drawing of the part is easily achievable. Additionally, reduced production cycle times with increased accuracy and better finish are also likely. Careful planning and taking advantage of the expertise of the CNC vendor and machine tool builder early in the decision-making process will ensure a wise investment and help gain an important competitive advantage for aerospace manufacturers with the vision to maximize the capabilities of their equipment. ✈