PROTOLABS
Manufacturing. Accelerated.

BRIEF

DESIGNING
for CNC Automation

2020 | VERSION 1.0

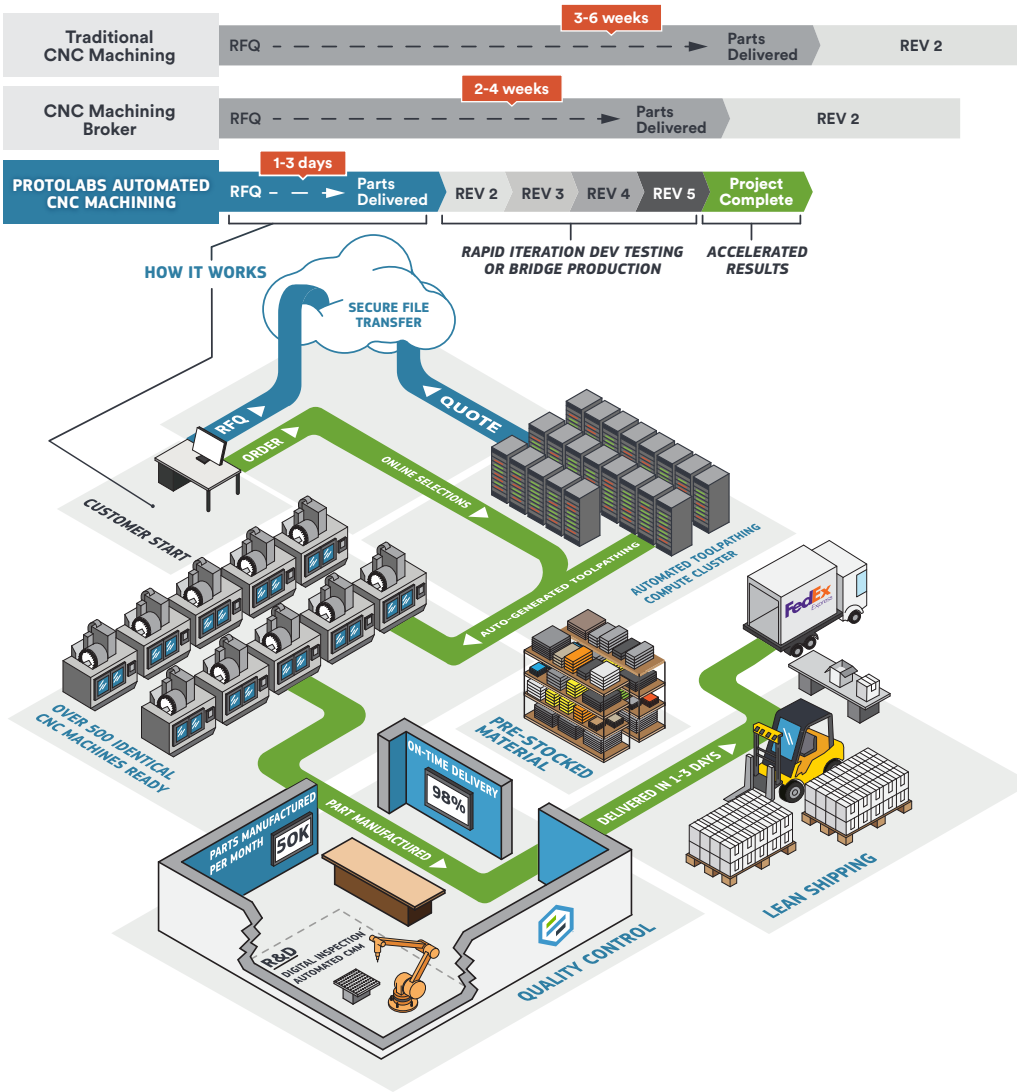
Contents

How Automation is Different at Protolabs

Once you upload your 3D CAD model online and request a quote (RFQ), our auto-toolpathing software analyzes your CAD model and generates manufacturing information and instructions specific to your design within hours. This data is used to automate not only the digital quote with design for manufacturability feedback, but the eventual digital machining instructions as well. Because this information is generated and collected up front, we can quickly cut and ship custom CNC machined plastic and metal parts in as fast as 24 hours—sometimes faster! This is useful for development testing, part qualifications, bridge production, and many more depending on your industry or product, especially when lower initial quantities are needed.

Automating the entire process from front to back via a digital thread is what makes us truly unique. In comparison, all other manufacturers will manually quote your request and rely on a highly manual manufacturing process. During this process, traditional manufacturers typically adjust availability of their services based on current capacity whereas we are able to offer consistent and reliable lead times by maintaining a disciplined 70% capacity, even if that means quickly scaling up to more CNC machines.
As a final point on this introduction page, as you continue on, it is important to think of the automated CNC a tool. Like any basic tool, there can be a variety of ways to make use of it and benefit if you understand how it works.

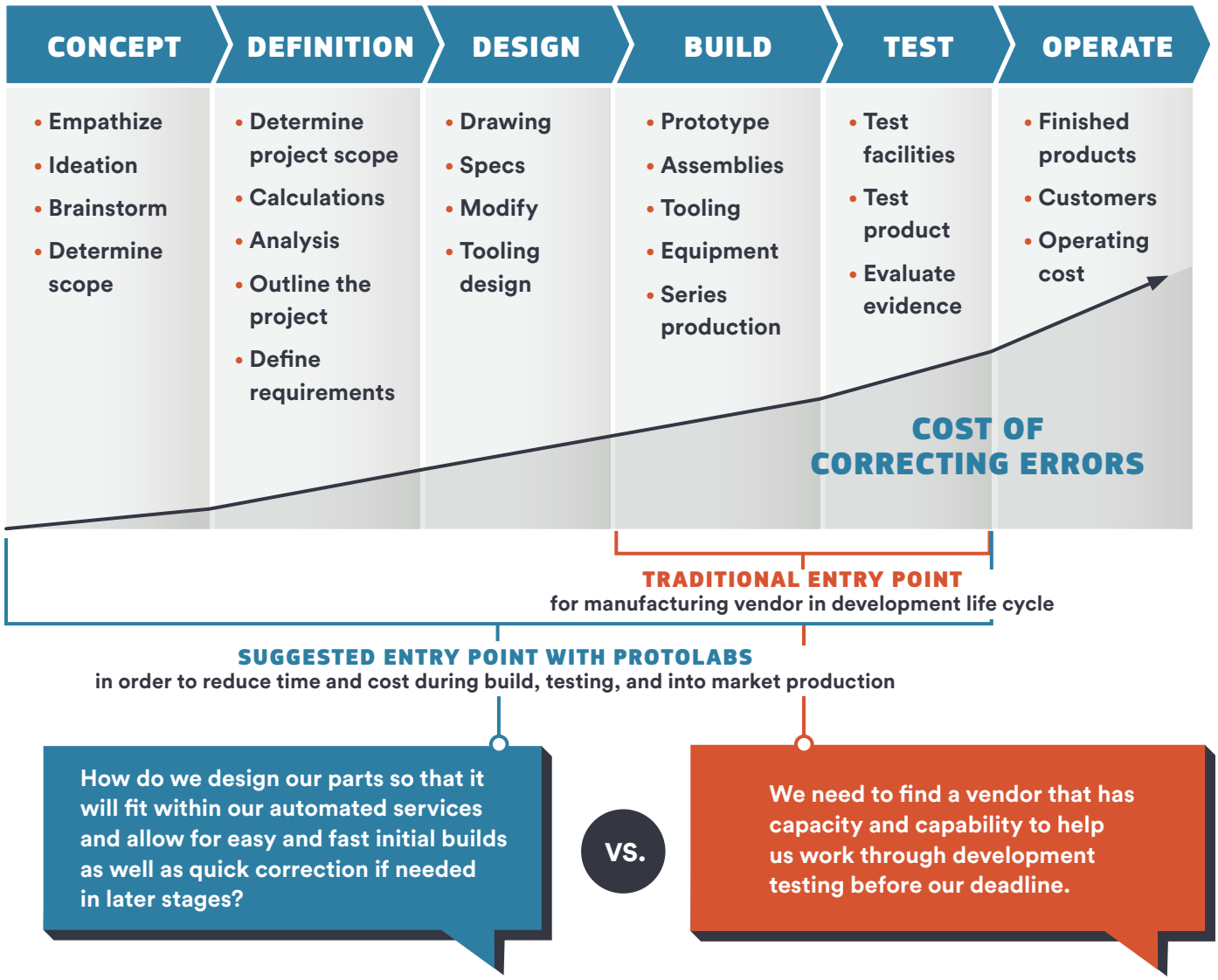
CNC AUTOMATION vs. BROKERS vs. TRADITIONAL SOURCING



Protolabs Role in Development

The purpose of this document is to educate you on the base principles of our digitalized approach to custom CNC machining, and illustrate the automation backbone that makes it possible for Protolabs to machine 50,000 parts a month on average (within a 1-3 day lead time). Our intent is that you will have a foundational understanding of how the digital thread carries the critical manufacturing parameters and drives the entire automated process.

A key element to fully understanding the benefit of using CNC automation throughout the development cycle and into production is knowing where Protolabs fits within a standard development cycle. As illustrated, supplier selection is traditionally considered towards the end of the concept and design stages, when 2D/3D models and other manufacturing information actually exists, which is generally required in order for a traditional manufacturer to quote. However, if reducing cost and compressing your development timeline is strategically valuable, implementing automated CNC machining processes becomes an essential tool. By integrating Protolabs capabilities into your product design during the earlier stages opposed to the later stages, you can ensure that the Protolabs automated CNC will be able to make your parts within days when you get to build stages. This will also enable you more flexibility when in design stages of development, testing, initial production and even market production, as well as the obvious benefit of rapid iteration development.



DESIGN GUIDELINES: CNC MILLING

Our basic guidelines for CNC milling include important design considerations to help improve part manufacturability, enhance cosmetic appearance, and reduce overall production time.

Size

Maximum Dimensions (3-axis milling)

10 in. x 7 in. x 3.75 in. (254mm x 177.8mm x 95.25mm)
10 in. x 14 in. x 1.75 in.* (254mm x 356mm x 44mm*)
22 in. x 14 in. x 0.75 in.* (559mm x 356mm x 19mm*)
22 in. x 14 in. x 3.75 in.** (559mm x 356mm x 95.25mm**)

Maximum Dimensions (5-axis milling)

2.6 in. x 2.9 in. x 3.9 in. (66mm x 73mm x 99mm)

Minimum Dimensions

Size	0.25 in. x 0.25 in. (6.35mm x 6.35mm)
Nominal Thickness	0.040 in. (1.02mm)

Typically, Protolabs can hold a machining tolerance of +/- 0.005 in. (0.13mm). Part features are recommended to be thicker than 0.020 in. (0.51mm) in all regions and a nominal part thickness above 0.040 in. (1.02mm) is required. Maximum depth that can be milled is 2 in. (50.8mm) from either side of part. For specific milling dimensions by material, see maximum part extents for machining.

*These part sizes can only be milled from two sides, and in ABS, acetal, and aluminum 6061 and 7075.

**This part size can only be milled from two sides, and in Aluminum 6061 and 7075.

Advanced CNC Milling Capabilities

Production Parts

Reduce your CNC machining costs when you order higher quantities of machined parts. Our production capabilities for machining—powered by our New Hampshire-based facility, Rapid Manufacturing—allow up to 1,000+ machined parts along with first article inspection (FAI) reporting, material certifications, part assembly, and additional finishing options like anodizing and chromate plating. Learn more about your production options for machining.

5-Axis Milling

We use 5-axis indexed milling—in addition to 3-axis milling and turning—to machine parts. 5-axis indexed milling (also referred to as 3+2 milling) allows for more complex geometries and non-orthogonal features like off-axis holes. Better finishes are also possible on non-orthogonal surfaces and because 5-axis milling increases machining efficiencies, more cost-efficient parts can be had. Read about designing complete features on machined parts.

Surface Finishes

Typically, we break (debur) the edges on all machined parts. All machined plastic parts are left as-machined, which may leave visible tool marks. Some metal parts, on the other hand, allow more choice. Parts left with sharp edges should be handled with care.

Plastic	Edges broken with visible toolmarks
Aluminum	Edges broken with visible toolmarks, edges broken with light bead blast, or sharp edges
All other metals	Edges broken with visible toolmarks or edges broken with light bead blast

Materials

- ABS
- Acetal
- CPVC
- HDPE
- LDPE
- Nylon
- PEEK
- PEI
- PET
- PMMA
- Polycarbonate
- Polypropylene
- PPSU
- PS
- PSU
- PTFE
- PVC
- Aluminum
- Brass
- Copper
- Stainless Steel
- Steel Alloy
- Steel Mild Low Carbon
- Titanium
- PTFE

Threaded Holes

We currently support UNC and UNF threads from #2 up to 0.5 in., and metric threads from M2 to M12. Avoid modeling internal threads on your part design.
VIEW THREADED HOLES GUIDELINES >

Radii

Sharp inside corners on a part will be radiused (rounded) as a natural result of the CNC machining process. Resulting radii will be identified on your quote.

Text

Recommended text considerations for CNC milling:

- **Plastic and soft metals:** Minimum width of 0.018 in. (0.457mm), depth of 0.0118 in. (0.3mm). Example text size would be 16 point Ariel Rounded MT font.
- **Hard metals:** Minimum width of 0.033 in. (0.838mm) and depth of 0.0118 in. (0.3mm). Example text size would be 22 point Ariel Rounded MT font.
- If design permits it, opt for recessed text versus raised.

CNC Service Options

GENERAL USE CASE