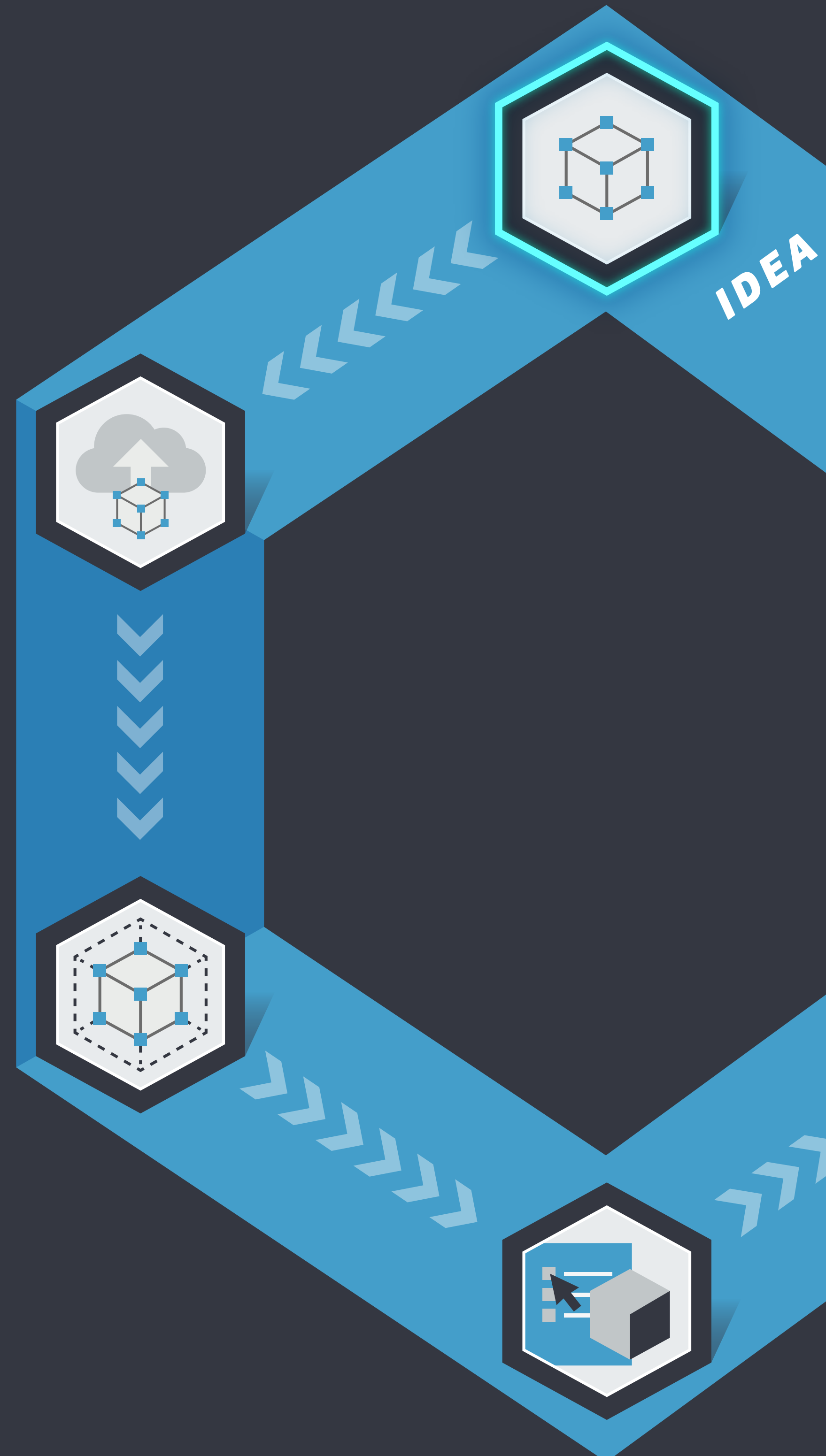
DIGITAL

MFG Guide

Accelerate development and reduce production costs to create agility throughout your product life cycle



PROTOLABS®

Contents

MATERIAL SELECTION

Choose from hundreds of plastic, elastomer, and metal materials, each with its own material property benefits. Our interactive material comparison tool can help you narrow down your options.

DIGITAL MANUFACTURING SERVICES

Injection Molding

- Bridge tooling
- Low-volume production
- Overmolding + insert molding

Sheet Metal Fabrication

- Prototype box builds + end-use components
- Large geometries
- Complex assemblies + custom finishes

CNC Machining

- Functional prototypes
- Jigs + fixtures
- End-use components

3D Printing

- Precision prototypes + production parts
- Complex geometries
- Component reduction in multipart assemblies

ACCEPTED 3D CAD FILES

CAD Programs	Neutral Formats
Solidworks (.sldprt)	IGES (.igs)
Autodesk Inventor (.ipt)	STEP (.stp)
AutoCAD (3D .dwg)	ACIS (.sat)
PTC ProE/Creo (.prt)	Stereolithography (.stl)
CATIA (.catpart)	

QUALITY CERTIFICATIONS

Minnesota Facilities

- ISO 9001:2015: Injection Molding and CNC Machining
- AS9100D: CNC Machining

New Hampshire Facilities

- ISO 9001:2015: CNC Machining and Sheet Metal Fabrication
- AS9100D: CNC Machining

North Carolina Facility

- ISO 9001:2015: All 3D Printing Processes
- AS9100D: Direct Metal Laser Sintering, Selective Laser Sintering, and Multi Jet Fusion

PROTOLABS

What is DIGITAL MANUFACTURING?

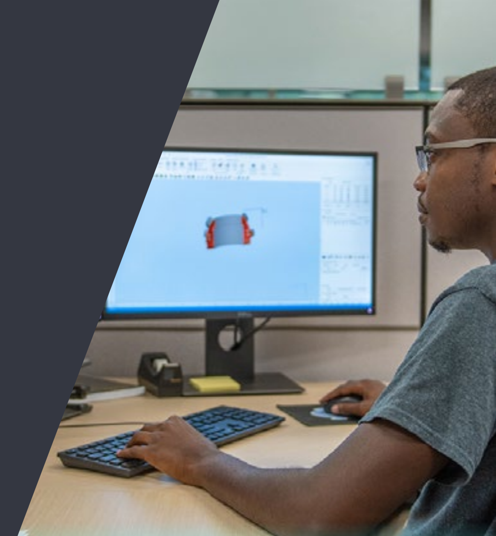
It's the complete digital integration of automation and advanced technology throughout the manufacturing process—from the moment you upload a 3D CAD model to when we ship your physical parts out the door.

Digital manufacturing is also much more than just 3D printing. It's technology agnostic, including everything from additive (3D printing) to subtractive (machining) to formative (injection molding) manufacturing, and any other fabrication processes like sheet metal that are enabled by software.

But really, it's accelerated turnaround times, cost savings, risk reduction, unlimited capacity, parts on demand, when you need them.
Ok, you get it.

This is digital manufacturing.

PROTOLABS



How Does Digital Manufacturing Work?

Our entire ecosystem is built around speed and automation to help transform ideas into products faster and optimize manufacturing throughout the product life cycle from prototyping to on-demand production. Just follow the *digital thread*.

Front-end Software

3D CAD Model

Hello! The *digital thread* starts here with a 3D CAD model of your part. We accept all common CAD file formats including STEP, IGES, SolidWorks, PTC Creo, and AutoCAD, among others. Once your CAD model is uploaded, you'll see things move pretty fast around here.

Upload

Have a CAD model ready? Upload it online at protolabs.com at any time, day or night, for an automated quote within hours. Either sign in to your account—or create a new account—for access to your all-new quoting and ordering platform.

Quote + Design Analysis

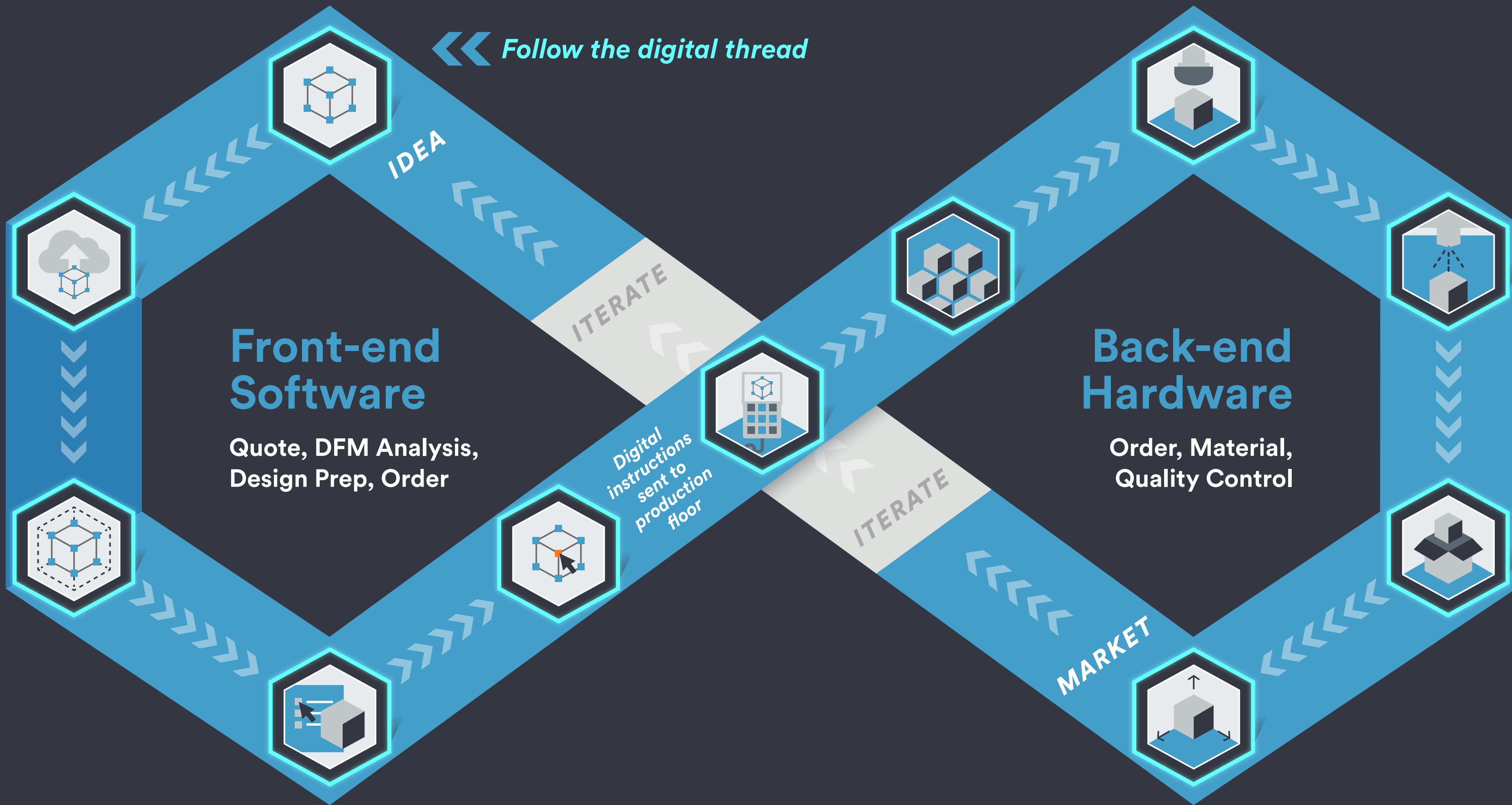
Inside the platform you can make critical selections in areas like materials, quantity, surface finish, and turn time. Once set, submit your request for quote to receive real-time pricing and free interactive design analysis on your CAD model to improve part manufacturability before production begins.

Order

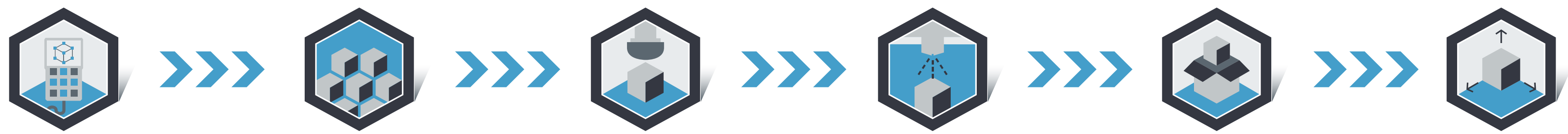
With your virtual part design optimized for manufacturing, you can review your order, set your billing and shipping information, and confirm any remaining details directly within the platform. The digital thread now moves to our in-house team of experts to prep and toolpath for manufacturing.

Digital Prep + Toolpathing

Your mold or part design now needs to be translated into a language called G-code, understood by a network of manufacturing machines. This translation process is called *toolpathing*. From there, a bit of geometric reasoning, some reach analysis and collision detection occur, and an automated fixture generation algorithm or two are tossed in.


Follow the digital thread
IDEA
ITERATE
Front-end Software
Quote, DFM Analysis, Design Prep, Order
Digital instructions sent to production floor
ITERATE
Back-end Hardware
Order, Material, Quality Control
MARKET

Back-end Hardware



Programming

We've reached the point of software and hardware convergence, where digital instructions are sent to manufacturing equipment on the production floor. Each manufacturing process varies, but once material is loaded and machines calibrated, part production is typically only a few clicks away.

Quick-Turn Production

As the digital thread continues to production, parts can be manufactured in as fast as 24 hours. Our sequence of orders is determined by our custom manufacturing software. Orders are not manufactured first in-first out; they are continuously optimized with existing orders to enable our consistent on-time delivery performance.

Finishing

Need any finishing processes to strengthen parts, improve cosmetic appearance, or provide customization? The information captured during your quoting and ordering process—at the start of the thread—is now applied in post-production—at the tail end of the thread. Things like laser engraving, pad printing, anodizing, painting, and hardware insertion are common depending on your chosen service.

Quality Control + Digital Inspections

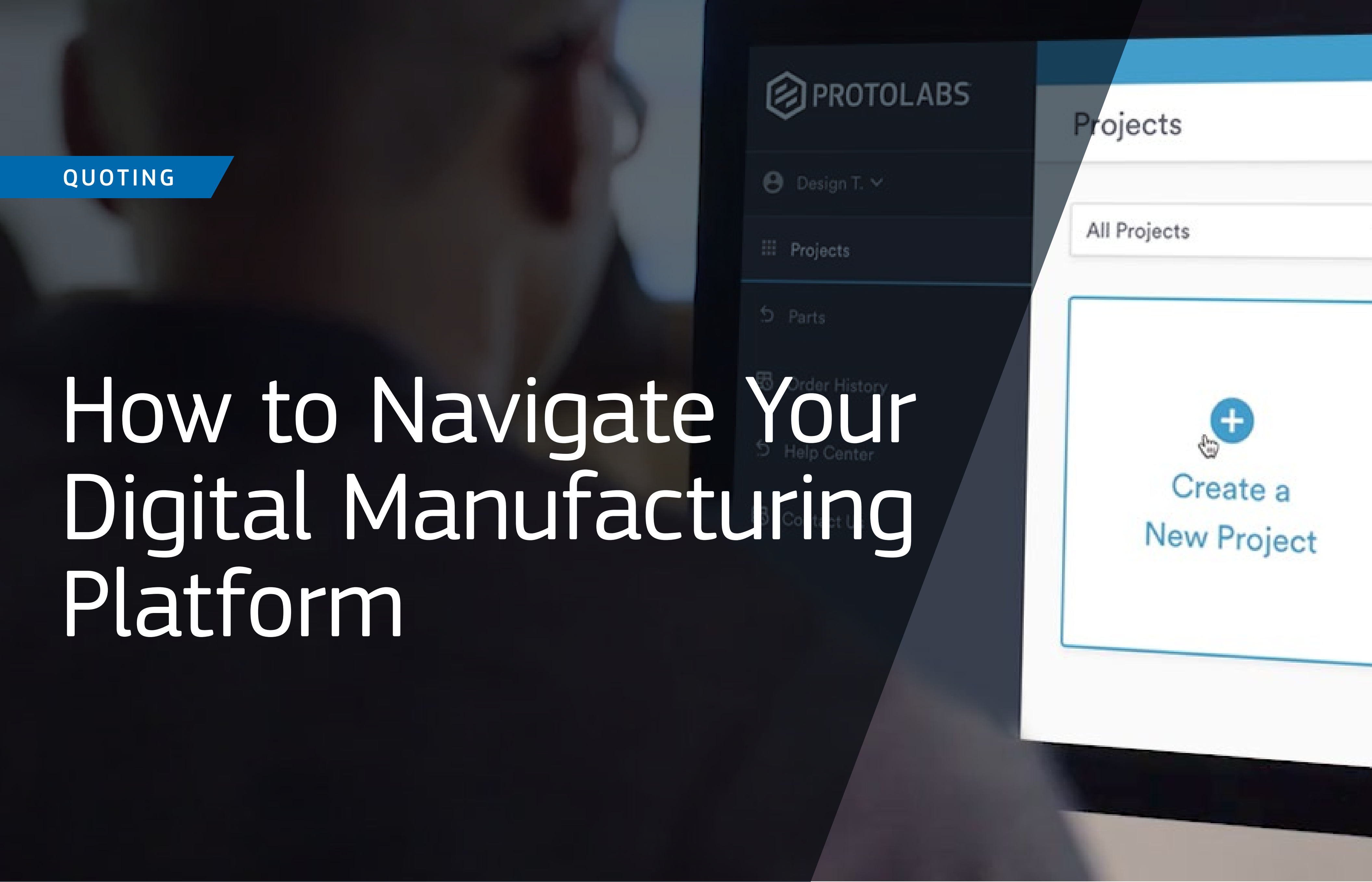
Quality checkpoints happen throughout ecosystem to ensure transparency and accuracy to your original design. On machined and molded parts, digital inspections are also possible. Our metrology lab uses 360-degree 3D scanners that collect data, identify dimensional variances, and create visual aids. Secondary operations inspections include 3D geometric dimensioning and tolerancing (GD&T), coordinate measuring machines (CMMs), and other digital inspection methods.

Shipping + Tracking

After parts are inspected and complete, they are prepped for delivery. Manufacturing information is confirmed, parts are packaged and shipped, and orders tracked until they arrive to your office. From the time a design is uploaded to when parts are shipped often happens in 10 days or less. In many cases, we ship parts in as fast as 1 day. And that is the beauty of the digital thread.

Prototypes + Production Parts

You now have parts in hand. Well done! But we know the work doesn't stop there. Wherever your development and manufacturing projects take you, our digital manufacturing ecosystem is engineered to help you get there faster.

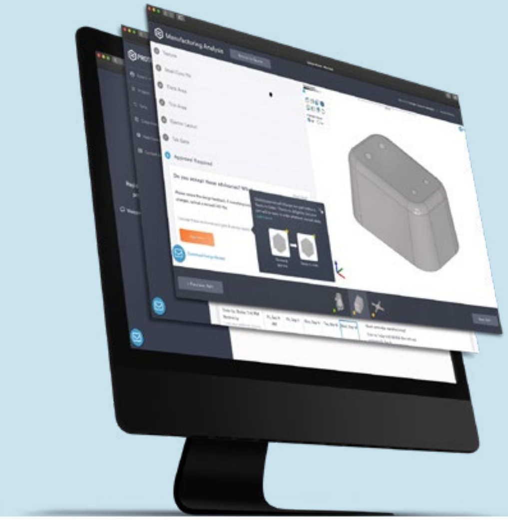


QUOTING

How to Navigate Your Digital Manufacturing Platform

PROTOLABS

From quoting to production to quality control, we've rebuilt our entire manufacturing system around speed to help transform ideas to products and optimize manufacturing throughout the product life cycle.



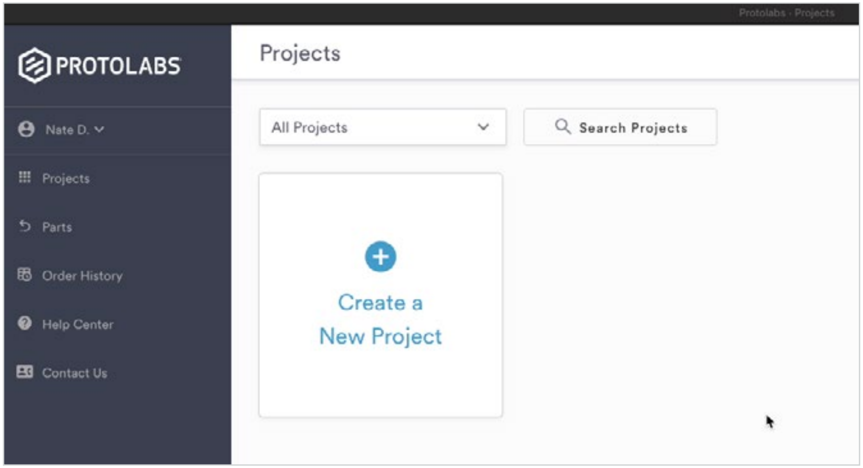
At the heart of the system is our new, user-friendly e-commerce platform for quoting and ordering.

The platform's modern, intuitive interface was designed so you spend less time uploading, quoting, and ordering parts, and more time bringing ideas to market. And it's a catalyst for new capabilities—more production options, multiple part configurations in a single quote, more of what you've asked for.

To get started, we want to show you around the platform a bit and highlight some of the key features around navigation, organization, collaboration, and other elements.

Sign In. Just hit **GET A QUOTE** in the upper right corner on any protolabs.com page or **SIGN IN** to your account directly above it. From there, you can either quickly create a new account—we just need a few pieces of information—or sign in to your existing Protolabs account. After your first sign in, we'll remember your info for future visits for easy one-click sign in.

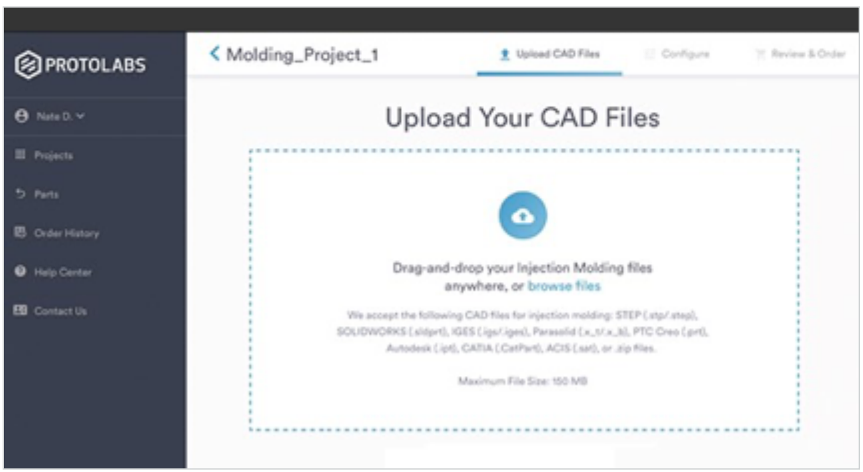
Start a Project. Once signed in, you'll arrive at your **PROJECTS** page. Welcome—it's good to have you here. High five. Ready to start a project? Just hit **CREATE A NEW PROJECT**. From there you'll be asked to name your project: insulin pump, metal bracket V2, aero heatsink_01, for example. Once you've named your project, click to **CREATE A NEW QUOTE**. Then, select your service: injection molding, CNC machining, or 3D printing.



▶ Once you've signed in to our e-commerce system and are ready to start a new project, just hit **CREATE A NEW PROJECT.**

Upload a Part. Pretty easy so far, right? Now it's time to upload one (or multiple) 3D CAD files, which you can do by browsing your saved files or simply via our drag-and-drop interface.

Configure Your Part Quote. Now that you've uploaded your CAD file/s to your project, just hit **CONTINUE** to start configuring your part with details like material selection, part quantity, finish, service-specific options, and things like ITAR requirements and special instructions. You'll notice as we move through the new platform that everything from upload to configuration is much more intuitive, and much faster. When you're all set, just hit **ANALYSIS**. You'll receive an interactive quote with free manufacturing analysis, often within 20 minutes. Grab a coffee and check a few emails—we'll be right with you.



▶ Upload one or multiple 3D CAD files by browsing your saved files or via our drag-and-drop interface as seen here. We accept a number of file formats (see list above this screen capture).

Review Your Order. How was that coffee? Waiting in your inbox will be an email from Protolabs that allows you to jump back into your project to **REVIEW & ORDER** your quoted parts. You now have real-time pricing and manufacturing analysis based on your selections. If you want to adjust part quantity and shipping—no problem. Updated pricing will be reflected in your quote. And with 3D printing, you can see instantly how changes in additive materials and resolution levels impact pricing.

New to the platform is a Receive By calendar; just choose the date you want to receive parts and see any cost implications. You also get complete shipping costs and tax provided at checkout, not after. This means no hidden fees so your quote is an accurate and trustworthy statement of cost estimates. You can even share your quotes with colleagues or procurement teams. It's a beautiful thing.

But before checking out and ordering parts, we need to visit the heart of our platform—the automated manufacturing analysis.

▶ After you've uploaded your CAD file/s, just hit **CONTINUE** to start configuring your part with details such as material selection, part quantity, and so on.

Manufacturing analysis. Simply stated, our manufacturing analysis provides feedback on the geometry of your CAD file to improve manufacturability. And in our new platform, manufacturing analysis has been enhanced to provide even more clarity on any design decisions. This analysis and any resulting design adjustments, in turn, can reduce manufacturing time and production costs. But hey, in some cases, your design may have no critical manufacturability issues. No required changes. Not even any suggested changes. You nailed it. But in other instances, you may need to make some tweaks.

Within your quote review, you notice small green, yellow, and red icons at the bottom of your specific part quote that vary depending on the attention needed. Green? You're good to go. But if you see yellow or red advisory icons, you'll need to hit the **VIEW ADVISORIES** button to review the design feedback. We look at things like draft, wall thickness, hole features, and many other variables depending on the manufacturing service you're using, and highlight features that are potentially troublesome. Any recommended changes are optional, but nonetheless, still recommended to improve manufacturability. Any required changes mean you'll need to update your part geometry based on the feedback and upload a new CAD file to proceed with your order. In some cases, with parts that will be injection molded for example, we may even provide a proposed revision that you can accept (or decline) to accelerate the ordering process. Still have questions on our manufacturing analysis? Don't worry, check our blog post that goes on a manufacturing analysis deep dive.

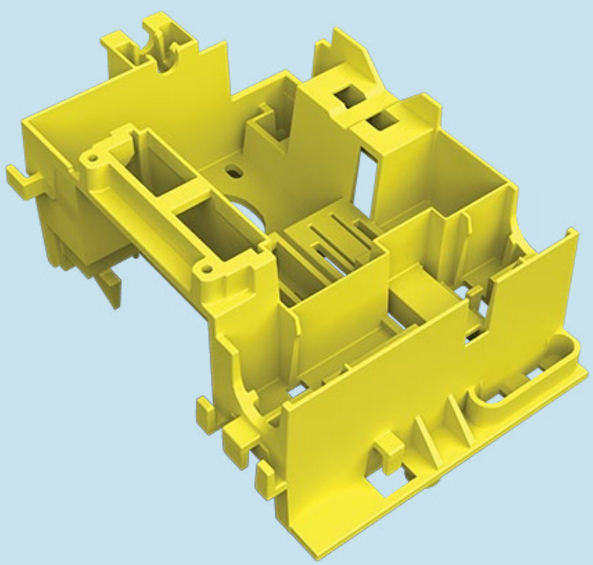
Checkout. When you're part design is optimized and any modifications addressed, and your pricing and shipping details are in order, just hit **CHECKOUT NOW** in the **REVIEW & ORDER** page. Plug in shipping (add reference number, drop ship address, export docs) and billing info (pay with CC or PO), confirm the details, and hit **COMPLETE ORDER**. Depending on your chosen ship date, parts can be sent out in as fast as 24 hours and in your hands soon after.

DESIGN

15 Design Tips to Reduce Manufacturing Costs

PROTOLABS

Everyone wants to save money on manufactured parts, and depending on what process you're designing for and where you are in your product life cycle, cost can be removed through well-designed parts. Here are a handful of helpful tips to help you to design cost-efficient parts for any manufacturing process at Protolabs.



Injection Molding

1 Keep an Eye on Undercuts

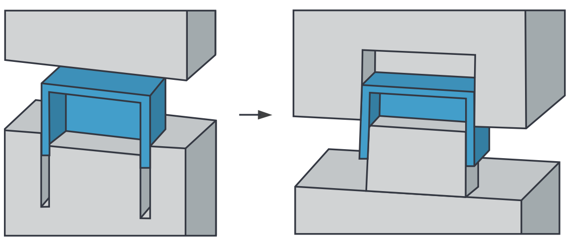
Undercut features complicate and, in some cases, prevent part ejection. Get rid of them if you can, but maybe that's not possible, if, for example, you need a side action, sliding shutoff or pick out. One alternative may be using sliding shutoffs and pass-through cores, or by changing the parting line and draft angles to provide an easier mold build. These reduce tooling costs as you avoid additional pieces to the mold that add to manufacturing costs. In addition to the rise in manufacturing costs of using hand-loaded inserts, this also may have an impact on your piece part price because of longer cycle times and manual mold operation.

2 Avoid Unnecessary Features

Textured surfaces, molded part numbers, and company logos look cool, but be prepared to pay a bit extra for these and other non-mission critical features. That said, permanent part numbers are a requirement for many aerospace and military applications. Use a mill-friendly font such as Century Gothic Bold, Arial, or Verdana (san-serif fonts), keep it above 20 pt., and don't go much deeper than 0.010 to 0.015 inch. Also, be prepared to increase draft if part ejection is a concern.

3 Use Core-Cavity Method

If you need an electronics housing or similar box-shaped part, you can either sink the wall cavities deep into the mold base, requiring long thin tools to machine ribs into the mold, or machine the aluminum material down around the core and mold the part around it. The latter approach is known as a core cavity, and is a far more cost-effective method of molding tall walls and ribbed surfaces. Better yet, this makes it easier to provide smooth surface finishes, adequate venting, improved ejection, and can eliminate the need for super-steep draft angles.

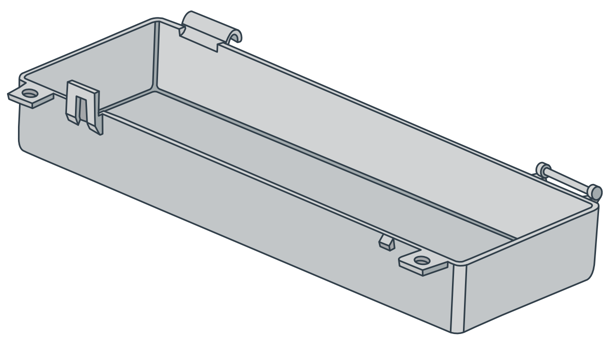


▸ **Using a core cavity, as shown, can be a cost-effective method of molding tall walls and ribbed surfaces.**

4 Try Self-Mating Parts

Maybe you're designing a snap-together case for some medical components, or two interlocking halves of a portable radio. Why build two mating parts when you can make one? Redesign the snaps so that the halves can be fit together from either direction, thus building a so-called "universal" part. Only one mold is needed, saving production expenses up front. And you can now mold twice as many of one part, instead of half the quantities of two.

Maybe you are after a higher volume of parts? You can still achieve high volumes using aluminum tooling with two-, four-, or eight-cavity molds depending on size and part geometry. That can reduce your piece part price, although this would impact your tooling costs.



▸ **This is an example of one half of a self-mating part, which fits together in either direction with its other half, building a "universal" part.**

5 Leverage Multi-Cavity and Family Molds

Got a family of parts that all fit together? How about multiple molding projects at one time? There's no reason to build a mold for each individual part, provided A) everything is made of the same plastic, B) each part is roughly the same size (e.g., have similar processing times), and C) all elements be squeezed into the same cavity, while still allowing for proper mold functioning.

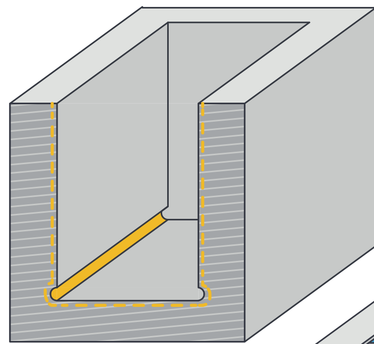
In addition, maybe you can join some of those parts with a living hinge? This method is a great way, for example, to mold two halves of a clamshell-style container. These parts would otherwise need a pin-type assembly to open and close. The only caveat here is that a flexible and tough material must be used, such as polypropylene (PP).

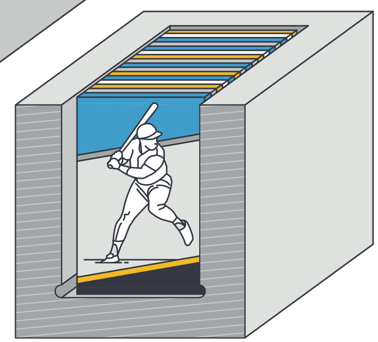
CNC Machining

1 Provide Relief to Corner Pockets

Consider the corners of a machined pocket—perhaps the inside of an electronics housing, or a bracket used to capture the body of a rectangular component. One common design oversight is leaving the intersection of the vertical walls on those part features perfectly sharp. To illustrate, think about machining a stainless steel box to hold a collection of baseball trading cards. The only way to get the perfectly square vertical corners needed to fit those Babe Ruths and Hank Aarons is with electrical discharge machining (EDM), or, multiple flat plates bolted together. Both can be slow and expensive processes.

Instead, we'll equip one of our machining centers with the smallest end mill available to clean out the corners. In 304 stainless steel, that means a 0.031 in. (0.8mm) end mill, which leaves a corner radius of 0.016 in. (0.4mm). That's pretty sharp, but the depth is limited. The length of most steel-cutting end mills in this size range maxes out at five times the cutter diameter, barely deep enough to fit your favorite center fielders. Machining with small end mills such as this is also slow and delicate work, driving up the cost of your project because of added milling time.





▸ Here's an example of adding reliefs to sharp corners— this case a stainless steel box that holds a collection of baseball cards—which helps achieve the perfectly square corners needed to fit the cards.

A more budget-friendly approach is machining a relief in each corner of the pocket. This removes that pesky radius, leaving a U- or C-shaped clearance instead. It also allows for far deeper pockets—by cutting a 0.25 in. (6.35mm) wide relief in each corner, functionally sharp corners to around 1-1/4 in. (32mm) in depth are possible. And by switching to aluminum or even plastic, pocket depths twice that of steel are possible. Best of all, designing pockets in this manner reduces part cost, because larger end mills can be used and material removal rates increased accordingly.

2 Avoid Text Until Molding

Similarly, text engraving is an aesthetically pleasing but time-intensive operation, one that might be best to avoid if possible. Here again, a ball end mill is used to trace whatever letters, numbers, and symbols are called for on the CAD model. It looks cool, and might be a valid requirement on your machined part, but it's probably more appropriate on injection-molded parts, where additional machining time is amortized over higher part volumes. Because of our toolsets for metals vs. plastics, we have a minimum feature size of 0.035 in. (0.90mm) in metals and 0.020 in. (0.51mm) in plastic.

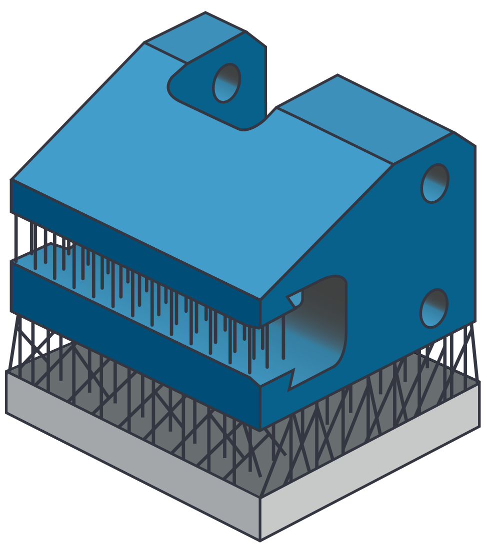
3 Be Cautious of Thin Walls and Features

Our standard part tolerance is +/- 0.005 in. (0.13mm). If you have a feature that is 0.020 in. (0.51mm) or smaller, our automated quoting system will highlight it as a thin-wall geometry, but keep in mind that we'll still allow it to be machined—so the machined part may differ slightly from your original design. Any thin walls that are 0.020 in. or less are not only subject to breakage during the machining operation, but may flex or warp afterwards. Beef them up as much as your part design allows.

3D Printing

1 Optimize the Design

Well-designed 3D-printed parts follow many of the same rules as those made with injection molding. Use gradual transitions between adjoining surfaces. Eliminate large differences in cross-section and part volume. Avoid sharp corners that often create residual stress in the finished workpiece. Watch that thin unsupported walls don't grow too tall, or else buckling or warping may occur. Also, surfaces with shallow angles tend to leave ugly "stair-stepping" that makes them unsuitable for cosmetic features—flatten them out where possible.



Support structures on DMLS parts help prevent curl that can occur during the sintering process.

2 Throw Out Tradition

The most dramatic 3D printed part designs leverage 3D's ability to create "organic" shapes, such as honeycombs and complex matrices. Don't be afraid to use these shapes, provided doing so creates a lighter, stronger part. Nor should you fear placing holes—lots of them—into your part design. With traditional manufacturing, drilling holes in a solid block of material increases part cost and waste. Not so in the additive world, where more holes mean less powder and less processing time. Just remember, 3D printed holes don't need to be round. Quite often, an elliptical, hexagonal, or free-form hole shape would better suit the part design and be easier to print.

3 Consider Next Steps in the Design Cycle

Just because you can print parts with lots of holes, however, doesn't mean you should, especially if the plan is to make lots of such parts later on. Because 3D printing offers tremendous design flexibility, it's easy to paint yourself into a corner by not considering how parts will be manufactured post-prototyping. Based on our examples at the start of this design tip, an increasing number of companies are finding 3D printing suitable for end-use parts, but many parts will transition from printing to machining, molding, or casting as production volumes grow. That's why it's important to perform a design for manufacturability analysis early on in the design cycle, assuring cost-effective production throughout the part's life cycle.

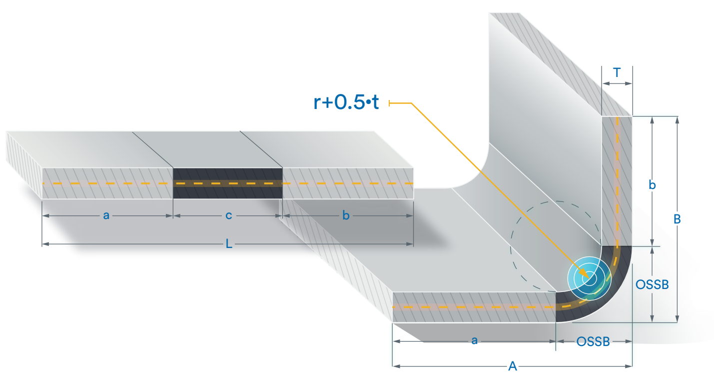
Read Full Cost-Saving Design Tips Online By Service

- Injection Molding
- CNC Machining
- 3D Printing
- Sheet Metal Fabrication

Sheet Metal Fabrication

1 Consider Plating, Welding Costs for Sheet Metal Fabrication

Let's start with this premise: Pre-plated sheet metal can't be welded safely. When you super-heat the treated metal, the coatings release zinc oxide, a highly toxic compound that vaporizes into gas. Ultimately, that's not good for workers, or the environment. If welding is required, you have one choice. Use uncoated cold rolled steel. Afterward, you can get your parts coated to enhance anti-corrosion properties. The downside to this is that it will definitely increase your lead times and cost. Instead, take a close look at your designs and see if there are ways to avoid welding. If you do that, you can use pre-plated steel. If joining sheets is critical, consider using rivets.



2 Bending the Curve: Optimal Bend Radius for Sheet Metal Parts

One of the easiest ways to save money and time is to incorporate geometries in your part designs that consider a manufacturer's standard tooling. For example, internal bend radii should always be between 0.030 in. (0.762mm) and material thickness. These specifications tend to be in the wheelhouse for most shops. They will be able to form your radii with tools specifically made for these specs, rather than having to use a specialized toolset or an alternative method to get that precise geometry.

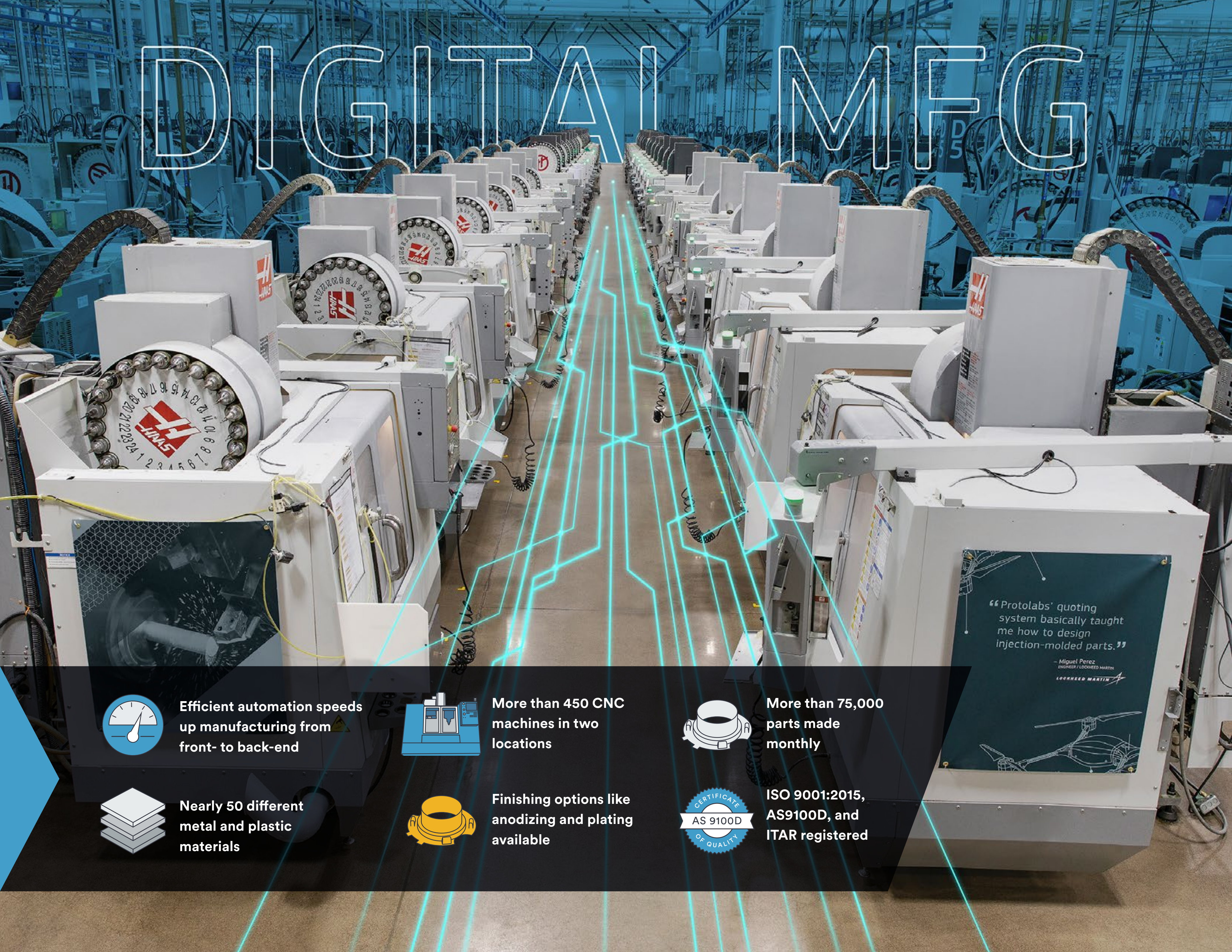
3 Be Flexible with Your Sheet Metal Designs

When you include punch-form features in your designs, such as bridge lances, embossments, and ribs, aim for standardized sizes to avoid manufacturing delays and added cost. If you do need very specific dimensions for these features, you should include that information in your RFQ by saying so in your model. For example, let's say you request a bridge lance that is 0.100 in. (2.54mm) tall, 0.100 in. (2.54mm) wide, and 0.625 in. (15.875mm) long. Simply changing two of those dimensions to 0.090 in. (22.86mm) wide and 0.600 in. (15.24mm) long will put you into in-house tooling, reducing costs and time.

4 Stick with Fast, Frugal Fasteners for Sheet Metal Parts

Ordering fancy fasteners is a sure way to drive up costs and slow down manufacturing. It's always best to stick with **fasteners that are readily available**, such as those in the PEM catalog. Its website has a solid inventory search tool that can let you know which suppliers/vendors have stock for any given PEM hardware item. Also, if you are looking for aluminum or 400 Series stainless steel hardware, it's important to know that inventories can be inconsistent. PEM can supply these, but generally you'll face a 10,000-piece minimum order and six to eight weeks of added lead time to get your special hardware. That means that you might have a whole lot of hardware lying around your warehouse that you might never need—an expense that could prove substantial.

DIGITAL MFG



- Efficient automation speeds up manufacturing from front- to back-end
- More than 450 CNC machines in two locations
- More than 75,000 parts made monthly
- Nearly 50 different metal and plastic materials
- Finishing options like anodizing and plating available
- ISO 9001:2015, AS9100D, and ITAR registered

MANUFACTURING

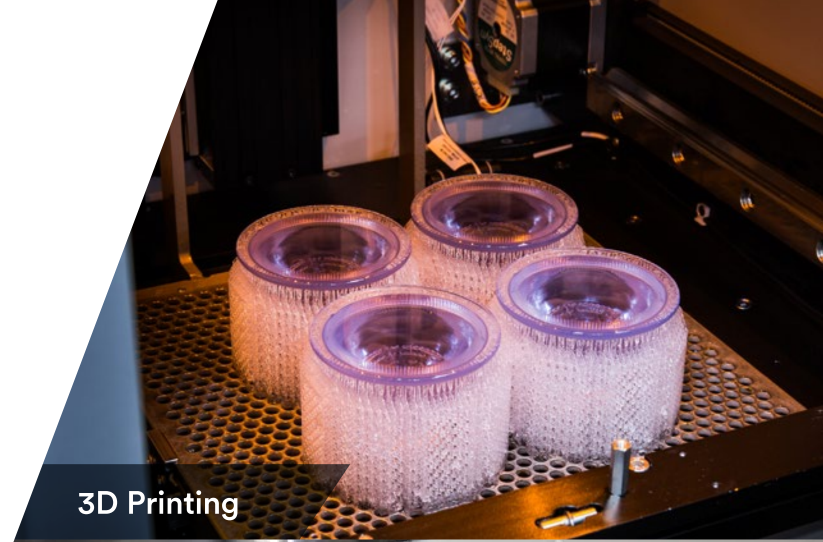
Selecting a Digital Manufacturing Process

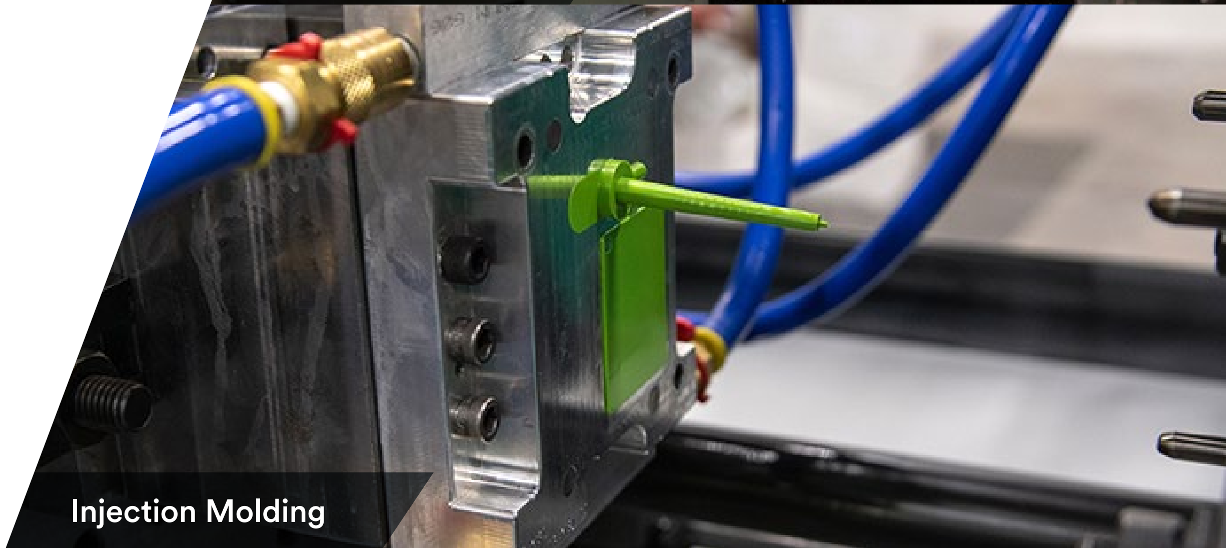
PROTOLABS

Compare various 3D printing, CNC machining, and injection molding technologies to find a process best suited for your project.

Using rapid prototyping to manufacture parts to test for component fit and function can help get your product to market faster than your competition. Adjustments in design, materials, size, shape, assembly, color, manufacturability, and strength can be made following the results of your testing and analysis. Many rapid prototyping processes are available to today's product design teams. Some prototyping processes use traditional manufacturing methods to produce prototypes while other technologies have more recently.

There are dozens of ways prototypes can be made. As prototyping processes continue to evolve, product designers are constantly trying to determine which method or technology is best for their unique application. Here we'll explore the advantages and shortcomings of the major prototyping processes now available to designers. We'll provide process descriptions and discuss material properties of parts produced by each specific prototyping option. Ultimately, the goal is to help you select the best prototyping process for your product development cycle.

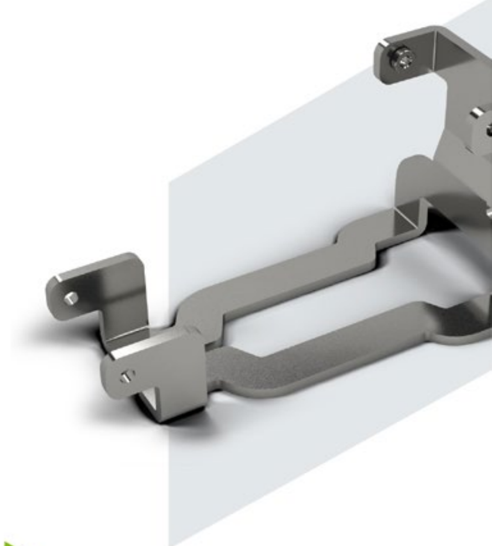




Comparing Manufacturing Processes

Process			Description	Strength	Finish	Example Materials
	SLA	Stereolithography	Laser-cured photopolymer	2,500-10,000 (psi) 17.2-68.9 (mpa)	Additive layers of 0.002-0.006 in. (0.051-0.152mm) typical	Thermoplastic-like photopolymers
	SLS	Selective Laser Sintering	Laser-sintered powder	5,300-11,300 (psi) 36.5-77.9 (mpa)	Additive layers of 0.004 in. (0.102mm) typical	Nylon, TPU
	DMLS	Direct Metal Laser Sintering	Laser-sintered metal powder	37,700-190,000 (psi)	Additive layers of 0.0008-0.0012 in. (0.020-0.030mm) typical	Stainless steel, titanium, chrome, aluminum, Inconel
	FDM	Fused Deposition Modeling	Fused extrusions	5,200-9,800 (psi) 35.9-67.6 (mpa)	Additive layers of 0.005-0.013 in. (0.127-0.330mm) typical	ABS, PC, PC/ABS, PPSU
	MJF	Multi Jet Fusion	Inkjet array selectively fusing across bed of nylon powder	6,960 (psi) 48 (mpa)	Additive layers of 0.0035-0.008 in. (0.089-0.203mm) typical	Black Nylon 12
	PJET	PolyJet	UV-cured jetted photopolymer	7,200-8,750 (psi) 49.6-60.3 (mpa)	Additive layers of 0.0006-0.0012 in. (0.015-0.030mm) typical	Acrylic-based photopolymers, elastomeric photopolymers
	CNC	Computer Numerically Controlled Machining	Machined using CNC mills and lathes	3,000-20,000 (psi) 20.7-137.9 (mpa)	Subtractive machined (smooth)	Most commodity and engineering-grade thermoplastics and metals
	IM	Injection Molding	Injection-molded using aluminum tooling	3,100-20,000 (psi) 21.4-137.9 (mpa)	Molded smooth (or with selected texture)	Most commodity and engineering-grade thermoplastics, metal, and liquid silicone rubber

Functionality, Manufacturability, Viability

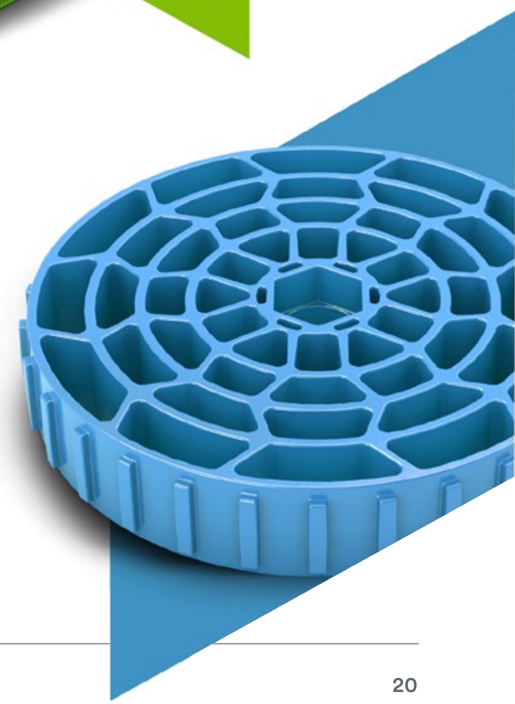


Prototype models help design teams make more informed decisions by obtaining invaluable data from the performance of, and the reaction to, those prototypes. The more data that is gathered at this stage of the product development cycle, the better the chances of preventing potential product or manufacturing issues down the road. If a well-thought-out prototyping strategy is followed, there is a far greater chance that the product will be introduced to the market on time, be accepted, perform reliably, and be profitable.

What is the best way to get a prototype made? The answer depends on where you are in your process and what you are trying to accomplish. Early in the design process, when the ideas are flowing freely, concept models are helpful. As the design progresses, a prototype that has the size, finish, color, shape, strength, durability, and material characteristics of the intended final product becomes increasingly important. Therefore, using the right prototyping process is critical. In order to most effectively validate your design, pay close attention to these three key elements of your design: functionality, manufacturability, and viability.

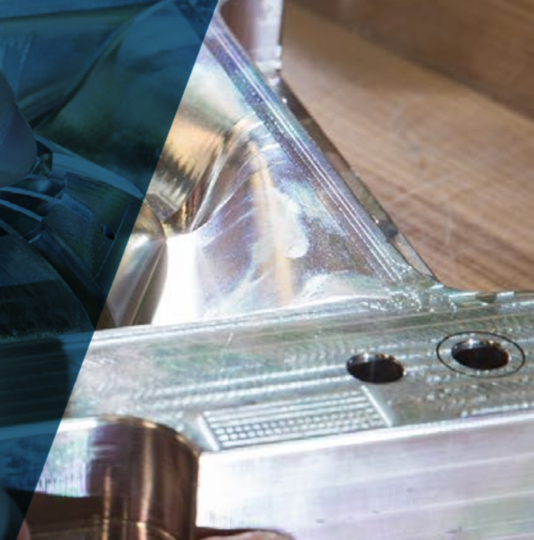
If your prototype can faithfully represent the attributes of the end-product, it is by definition *functional*. These requirements often include such things as material properties (e.g., flame resistance), dimensional accuracy for fit-up with mating parts, and cosmetic surface finishes for appearance.

If your prototype design can be repeatedly and economically produced in a manner that supports the requirements of the end product, it is by definition *manufacturable*. These requirements include the ability to maintain the functionality of the design as described above, keep the piece-part cost below the required level, and support the production schedule. No matter how great a design is, it will go nowhere if it can't be manufactured. Make sure your prototyping process takes this into consideration.



Finally, even if your prototype design is functional and manufacturable, it doesn't mean anyone will want to use it. Prototypes are the only true way to verify the *viability* of the design in this sense. If your design can also pass the challenges associated with market trials (e.g., usability testing) and regulatory testing (e.g., FDA testing of medical devices), you're well on your way to a successful product launch.

PRODUCTION



Bridging the Gap Between Prototyping and Production

Reduce risks at launch with bridge tooling and on-demand production.

In the traditional approach to product development, there is a sharp line between development and production. Development begins with a light bulb over someone's head, proceeds through napkin sketches and CAD models, and ends, ultimately, with prototypes. At one or more points in the development process there may be input from the market, be it someone's best guesses, one or more focus groups, or actual market tests. And from start to finish there is always pressure to "get on with it," either because you need to catch up with a market leader or because you are the leader and someone may be catching up with you. But then, when you have reached your goal—a fully developed, marketable product—everything comes to a screeching halt and the drawings and/or models disappear into the "production machine," from which, weeks or months later, a whole lot of deliverable product appears and the rush begins again as it heads off to market.

In plastic molding, as in most other technologies, some aspects of this transition are unavoidable. Production molds are costly, and they take time to manufacture. It would be risky to begin producing them before the design had been fully proven in development, when even a small change could turn tens of thousands of dollars' worth of molds into doorstops and boat anchors.

Traditionally this has always presented manufacturers with a dilemma. They could keep development and manufacturing sequential and live with the resulting delay. Or they could treat them in parallel, starting on production molds before the end of development, cutting their time to market but running the risk of having to go back and start tool-making over again. It was a painful choice, because today's competitive global markets reward both speed and low cost. Manufacturers already recognize that rapid injection molding as a prototyping method can reduce both cost and delay in the design of plastic parts. They are now beginning to see that it can also help reduce the post-development delays when bringing a product to market.

Bridge Tooling

While rapid injection molding is not identical to traditional production tooling, it is similar enough in process and technology to solve several problems and help speed up production. First, in addition to proving the design itself, it confirms that a part can actually be molded. Second, while production-tool molding can incorporate capabilities that rapid injection molding can't—internal cooling lines or sophisticated venting, for example—adapting a part to the demands of rapid injection molding by equalizing wall thicknesses and maintaining draft can actually simplify and speed up the manufacture of production molds while reducing their cost. In other words, rapid injection molding doesn't just produce prototype parts; it prototypes the production method that will produce those parts, allowing avoidable problems to be eliminated before the start of final mold making.

Perhaps even more important in today's fast-moving markets, tools made for rapid injection molding also can be used to mold parts in actual production resins and in production volumes—thousands or even tens of thousands of parts—while the official production tools are being made. In other words, yesterday's prototyping molds can produce today's go-to-market parts while tomorrow's ultra-high-volume molds are being made.

On-Demand Production

In fact, once it becomes clear that you can take prototype parts to market, you may actually find reasons to simply postpone the production of steel tools. One reason might be the ability to reduce up-front expenditures by ordering parts in smaller quantities than you commit to when you turn to production molds. This makes particular sense if there is any uncertainty about market demand for your new product. It's a way of going beyond mere market tests and actually releasing your product to the market in order to gauge response before committing to full-scale production. If the market's reaction to your product suggests the need for tweaking, you can make changes quickly and be back on the market in days with an improved product.

If necessary you can repeat the process several times, each at modest cost, before committing to mass production. In a sense, this sort of bridge tooling lets you treat a physical product in much the same way that software developers treat theirs, with versions tumbling onto the market one behind another as features are added.

There's really no reason that releases of Widget Mark I, Mark II, and Mark III have to be years apart if the market really wants an improved product. For those used to traditional methods this may be a novel approach, but if it eliminates that painful wait while production tools are being made, so it may be worth a try. And if it saves you the cost of sending tens of thousands of parts along with costly molds to the landfill because the market wants something slightly different, so much the better.

PROCUREMENT

Is it Time to Reboot Your Supply Chain?

PROTOLABS

▸ The speed of digital manufacturing can help mitigate risk especially when you factor in the total cost of ownership all along the supply chain. For example, if your product is sitting on a container ship for three months, that's all a part of your total cost.

As the pandemic recedes, it's a good time to reassess your supply chain risk contingency plan, or better yet, consider a major overhaul.

There was noticeable global business and commerce fallout from the coronavirus. As recent news stories have reported, supply chains for companies large and small were dramatically disrupted—from **toys and Teslas** to **stranded lobsters and missing wedding dresses**. The damaging economic and market impact is a stunning reminder of China's worldwide reach.

Of course, if you're a buyer or procurement manager, this issue gets added to the already existing supply chain disruptions you navigate every day: trade wars, on-again off-again tariffs, increased government regulations, freight issues, poor or unacceptable part or product quality, and more.

There's also the ongoing challenge of unforeseen downtime. A **recent study** by Information Technology Intelligence Consulting reported that a single hour of downtime can equate to $100,000 in losses in a manufacturing environment. Further, the study said that this number is likely higher, potentially exceeding $300,000.

Given all of these issues, this may be a good time to look at a supply chain risk contingency plan, or, better yet, consider a major overhaul and reboot.

Supply Chain Emergency/ Contingency Planning

As Yossi Sheffi, director of MIT's Center for Transportation and Logistics, and the author of two books on supply chain risk management, recently wrote in a Wall Street Journal article on this topic, "Hoping for the best while preparing for the worst may not seem like a rigorous business approach to the [coronavirus] crisis. But given our lack of knowledge, it is the most prudent strategy for managing risk." Sheffi urges companies to act quickly to minimize short- and long-term impact on their operations. Among a long list of items, he recommends:

- Setting up a central emergency management center
- Planning for operating to maximize cash flow rather than profits in the short term

- Reviewing your company's product portfolio and customer base in order to set priorities
- Reviewing your suppliers to figure out who makes critical parts and if there are there alternate sources

Beyond this short-term, contingency mode that Sheffi outlines, if you are considering a supply chain reboot, here are some brief points on how digital manufacturing suppliers can tame supply chain disruption with rapid manufacturing, regional sourcing, on-demand production, and customization.

Reliable, Fast Lead Times Aid Supply Chains

As Sheffi recommends, acting quickly can help minimize disruptions. Accordingly, turning to a digital manufacturer that can pair manufacturing scale with reliable, fast lead times enables companies to quickly adapt to market demands and unforeseen forces in your supply chain. Indeed, under a fully digitized process, accurate price quotes can be provided in hours, if not instantly, and the manufacturing can be completed often in a matter of days, sometimes even the same day. This speed can make a difference especially when you factor in the total cost of ownership all along the supply chain, from concept to distribution. For example, if your product is sitting on a container ship for three months, well, that's all a part of your total cost.

Regional Suppliers Mitigate Risk

Using regional suppliers can be an effective way for companies to avoid being blocked by global disruptions, especially if those regional suppliers also use regional suppliers. What do I mean? At Protolabs, for example, we have global manufacturing facilities—we operate in 12 locations in eight countries—yet we work with regional sources as well.

Indeed many companies have been discovering the benefits of onshoring options, taking advantage of contract manufacturers that use digital technologies on our own shores and insulating their companies from the macro-economic unpredictability.

At Protolabs, we're seeing an increasing number of our customers turning to localized and on-demand manufacturing alternatives to avoid off-shoring. Manufacturing locally, or closer to the point of consumption, has been made more economically feasible with the proliferation of digital manufacturing.

On-Demand Production Can Tame Demand Volatility

On-demand manufacturing can help your company tame demand volatility, gain greater control of inventory cost, and deliver the right products at the right time at the right total cost. Manufacturing on demand helps companies navigate market volatility so that they're not tied to massive production forecasts. When demand spikes, you can gets parts quickly. On-demand sourcing can also lower overall inventory costs and warehousing expenses because you're no longer focusing on mass producing products with high minimum order quantities (MOQs). Instead, you're opting for on-demand production in low volumes, thereby creating a supply chain that is truly driven by customer demand, not by (and dependent on) a supplier's lead time.

Mass Customization Supports Supply Chains

Finally, yet another way to tame supply chain disruption is to deploy a mass customization approach. Today's market demands are more customized. This low-volume and high-mix ratio of products is not the supply chain of the past where mass production was the normal way of doing business. Indeed, customization is changing how manufacturing needs to react and on-demand manufacturing has the digital capacity and rapid capability to meet those mass customization needs.

In summary, during the pandemic what has happened in China and elsewhere stands as yet another example of the global uncertainty that we as buyers and procurement managers face every day. And, beyond the business and market considerations, what's happening is of concern to all of us as caring world citizens.

Checking the Boxes on Your AVL

To make it as painless as possible to add us to your company's approved vendor list (AVL)—and streamline part ordering as a result—we pulled together some of the most important areas that procurement and supply chain teams often look for when sourcing a [manufacturing supplier](#).

PROTOLABS

CHECKLIST

Competitive Pricing

Competitive and accurate pricing is available with your quote in a matter of hours. Production pricing is also available for injection molding, CNC machining, and additive manufacturing. Plus, our applications engineers are always available to discuss key cost trade-offs for designs.

Quality Assurance

Unlike quality measures of traditional manufacturing systems—usually conducted at the end of the production chain—our quality system is embedded throughout the entire process. Traceability and transparency of projects are found every step along the way.

Injection Molding. Process development reports and basic inspection reports are included with each order, and enhanced inspection reports, like FAIs, are available upon request. In addition, our **on-demand manufacturing** option allows for ISO 13485-certified injection molding for plastic medical device components.

CNC Machining. All machined parts are inspected for cosmetic conformance to workmanship standards and dimensional conformance along at least three dimensions (typically X, Y, and Z). With production parts for machining, we also provide conventional inspection reporting like FAIs, Certificate of Compliance (CoC) documentation, and additional certifications like ISO 9001 and AS9100.

3D Printing/Additive Manufacturing. To ensure high-quality parts, we offer powder analysis, material traceability, process validation, and inspection reporting on printed parts, and our metal 3D printing process is ISO 9001 and AS9100D certified. With metal 3D printing, you're also able to choose from several secondary processes like post-process machining, tapping, reaming, and heat treatments that produce end-use production parts.

Sheet Metal Fabrication. Sheet metal fabrication happens in our New Hampshire facility and is ISO 9001:2015 certified. Inspections provide design verification for sheet metal parts, and in addition to our standard internal inspection process for all manufactured parts, additional inspection services are available upon request. This includes FAI, CoC, and material and finish certifications. We also offer welding, hardware insertion, plating, silk screening, and powder coating to provide complete sheet metal components—and total traceability—all under one roof.

View all of our facility certifications **here**.

CHECKLIST

Quoting and Manufacturing Speed

We provide interactive quotes with free design analysis within a few hours and have expedite options across all four of our manufacturing service lines, so we can ship parts in as fast as day.

Production Scheduling

Automated algorithms have been programmed to help prioritize and streamline ordering and scheduling processes to accelerate the manufacturing process. This is a key element in the digital equation that allows us to ship parts in as fast as 24 hours.

Capacity

More than 1,000 pieces of automated manufacturing equipment run at 80% capacity to avoid production delays. You're always at the front of the line so we are a reliable option if you run into a supply chain emergency or line-down situation.

Equipment

We're technology agnostic with many different equipment providers, so we're not reliant on one OEM. And when we add new machines to our manufacturing floors, they are typically customized for speed and accuracy like our existing equipment.

Security

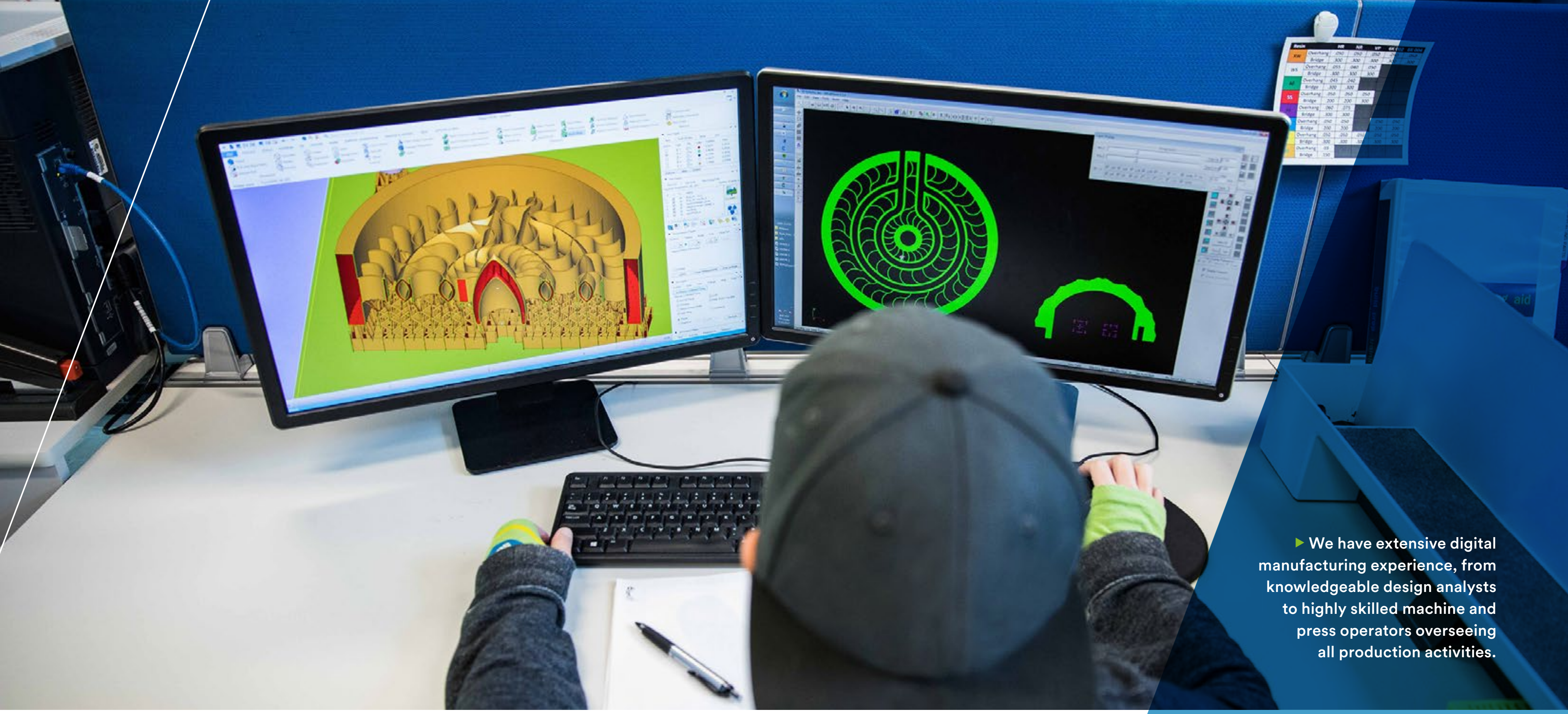
All proprietary 3D CAD files, intellectual property, or customer information is protected. And server redundancies are in place so data is protected and backed up. We are also ITAR compliant, and since we are a global company, we must ensure that employees outside of the U.S. don't have access to any parts or part information for ITAR classified projects. This means keeping separate databases for different countries, having procedures in place to ensure that any parts or information we share publicly or between locations aren't ITAR controlled, and not allowing employees from other locations access to the manufacturing floor or other secured areas. We also prohibit photo, video, and audio recording from visitors in our offices and manufacturing facilities.

Safety

Multiple measures are in place to ensure a safe work environment on the production floor including sound dampening, robotic block handlers, and safety harness systems. At our CNC machining facility, for example, we installed a Gorbel Tether Track fall protection system, which is an engineered track-and-trolley system over each milling machine. The system uses a self-retracting life line and a personal fall arrest harness to protect our employees as they work on top of a mills which immediately locks and stops like a seatbelt if it senses a fall.

We've also put in place many different safety precautions to protect both our employees and customers against COVID-19. Currently, facility tours with customers have been paused but you can virtually tour our CNC machining facility, molding facility (sampling), and additive manufacturing facility online.

You want capacity? With more than 1,000 pieces of automated manufacturing equipment that run at 80% capacity to avoid production delays, you'll always be at the front of the line.



▸ We have extensive digital manufacturing experience, from knowledgeable design analysts to highly skilled machine and press operators overseeing all production activities.

CHECKLIST

Material Inventory

You can choose from more than 100 different thermoplastic and elastomer materials for molding and more than 30 plastic and metal materials for CNC machining. With 3D printing, we have 20+ plastic resins and metal powders for both prototyping and production-grade, end-use parts. Also, we have a handful of sheet metal options including galvanized and galvannealed steel. We accept customer-supplied materials and provide custom color matching for molded parts. Basically, we have a variety of materials that can meet nearly any project requirement.

Extensive Manufacturing Experience

We have experienced engineering, quality, and procurement teams and highly skilled machine and press operators overseeing pre-production, production, and post-production activities. With additive manufacturing, for example, we've seen over 1 million 3D-printed part geometries over the past 20 years. And if you have any manufacturing or procurement questions, you can talk with an in-house applications engineer at any time.

PROTOLABS

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