proto labs®

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JOURNAL

INDUSTRY

MACRO TRENDS

IN MANUFACTURING

FROM AUTOMOTIVE LIGHTWEIGHTING TO HUMAN-FACTOR ENGINEERING IN HEALTH CARE, EMERGING TRENDS TO WATCH IN 2016 • 4

We've experienced a lot of change over the past few years as our capabilities have grown and our company has expanded in Europe and Japan. One thing that has remained constant during all of this, and honestly, since Proto Labs began more than 15 years ago, is the breadth of product designers and engineers we service from nearly every industry — from automotive to aerospace, medical to consumer electronics.

Companies within these industries share a common manufacturing need as they develop prototypes and components for their products and devices. They want quality parts fast to rapidly test, iterate and refine products before launching them to market. This is a development stage we happen to know quite well.

But it's equally important for us to recognize the trends and challenges (aside from speed) that designers and engineers are facing in different industries. For our Journal cover story, we offer a look at a cross-section of four major industries and the macro trends guiding some of their development decisions.

For med devices and health care applications, an increasing level of focus is being placed on human-factor engineering. How can a medical device follow a human-centered design process so that its end-users are at its core? In the automotive sector, creative part design and lightweighting tactics are driving innovation to keep pace with aggressive fuel economy regulations. Airlines are addressing their aging fleets, products are becoming more connected every day, and the lighting industry is in the midst of a major shift in technology.

This means important times lie ahead for manufacturing as we help meet these challenges. It means we must keep our finger on the pulse of every industry to ensure we're in the best possible position to react to and meet customers' needs.

Those who are into music may also find our ProtoCulture feature interesting. We sourced the CAD models for all of the components of a Fender guitar, and built it with 3D printing, machining and molding processes. Then we virtually exploded the final guitar to see how it all fits together. It really showcases what's possible with digital manufacturing, and is just plain cool.

If there's one theme that surfaces from our first Journal of 2016, it's that product creativity is thriving in a wide-spanning, ultra-competitive commercial landscape — an aging generation is being equipped to live longer and better, while a younger generation is being equipped to live easier and more connected. At Proto Labs, we understand these needs and are equipped to meet them.

– Vicki Holt
President and CEO
@VickiMHolt

CASE IN POINT

Lockheed Martin

The commercial-grade Indago Quadcopter unmanned aerial vehicle (UAV) or drone, from Maryland-based Lockheed Martin, is soaring in popularity with law enforcement agencies, defense customers, firefighters, real estate firms, farmers and construction companies.

The high demand stems mostly from the drone's versatility, range and small, 5-pound, fold-up size, says Miguel Perez, an engineer for Lockheed's Procerus subsidiary, which developed the drone with prototyping and low-volume production help from Proto Labs.

Perez gave high marks to Proto Labs' speed and the feedback from the company's quoting system as being central to the successful development and delivery to market of the drone. The quoting system includes a design-for-manufacturability (DFM) component, which Perez says was key. "The auto-quoting system is amazing. Within a day, you immediately get an answer as to whether you can make the part, whether you need to make changes, etc. And you can do that quickly, upload a new version, and get a part in a couple of days as opposed to a week just for a quote from other manufacturers."

In addition, he found the DFM analysis served as a valuable tutor, guiding him through various part iterations and eventually leading him to shift from what was originally a 3D printing project to prototyping with injection molding.

To find out more about this project, read the full case study on our website: **go.protolabs.com/Lockheed-J**.

High-Tech High Heels

Dolly Singh, founder and CEO of Thesis Couture, and a former SpaceX employee, has applied rocket-science engineering to a new line of women's high heels launched in January that promise more comfort and less pain. Singh's team used structural engineering principles to redistribute the load on the ball and toes of the feet, and plastics and rubber for the shoe's frame and heel, the San Francisco Chronicle recently reported. These advances tout better shock absorption and arch support. The S-shaped sole, made from a molded polymer, hugs the foot's natural arch and pushes more weight toward the heel. As the Wall Street Journal mused, "The exteriors will put them in a class with Jimmy Choo, but the technology is pure Jetsons."

PRICE: $350–$950

thesiscouture.com

Wheels Up!

Stowing your carry-on luggage will be an easy task with G-RO luggage, which is set to reach the market this summer. Its size is compliant with TSA, FAA, airline and international travel regulations. We like it because of its smart design. Developed by New York-based Shaigi Design Studio, the luggage includes features such as patented, large, low-mass "all-terrain" wheels; a strong, ballistic nylon overall material for the case; a charging station with two USB ports to charge your laptop, tablet or smartphone; a location tracker and proximity detector; a built-in tablet stand; and even a waterproof bottom.

PRICE: $500

g-ro.com

A Shot in the Dark

BULLET lays claim to the world's smallest LED flashlight. With a design inspired by 9mm ammunition rounds, the product is bullet-shaped, and includes a weatherproof shell, made of aerospace-grade aluminum alloy, around a 5mm LED light. It includes an LR41 button cell battery. Uses abound: when you're in your car, out in your garage, when trying to finding keyholes and so on. Developed by San Francisco-based Slughaus, the product exploded on Kickstarter. At the end of January, nearly $200,000 had been pledged, far exceeding the original $10,000 goal. Developers aim for BULLET to hit the market in May.

PRICE: $500

slughaus.com

Hammer Time

How about a Stiletto Titanium Hammer. Why titanium for a hammer? Because, as Werd.com reports, traditional steel ones send 10 times more shock up your arm with every strike. Stiletto's pro-grade hammers feature Ti in the head and handle, which, in addition to shock absorption, is also lighter and stronger. For durability, the face of the hammer is steel and magnetic for easier nail starts.

PRICE: $70–$260

stiletto.com

Photos courtesy of product websites.

EYE ON INNOVATION takes a look at new products and technology. Read our monthly Eye on Innovation blog at **protolabs.com/blog**.

INDUSTRY MACRO TRENDS IN MANUFACTURING

FROM AUTOMOTIVE LIGHTWEIGHTING TO HUMAN-FACTOR ENGINEERING IN HEALTH CARE, EMERGING TRENDS TO WATCH IN 2016

These are transformative times in the manufacturing marketplace. Companies large and small are seeking innovation — make that, *demanding innovation* — like never before from their suppliers to meet a range of challenging market forces.

Take the auto industry. Because of government compliance and regulation issues, and increasingly complex customer expectations, automakers are building cars that are lighter, smarter and more efficient than ever.

Aerospace companies are immersed in a massive, industry-wide process of replacing or "re-fleeting" aging commercial aircraft. Additionally, many aerospace companies contracting with the U.S. Defense Department are contending with a decline in overall defense spending. Plus, this industry is coping with a dramatic surge in demand for unmanned aerial vehicles (UAVs), those increasingly ubiquitous drones. Medical-device makers are bracing for what's been called an impending "demographic storm," as the world's population swells and, in the U.S., as aging baby boomers live longer and shatter life expectancy records, creating an anticipated need for new devices and other medical applications to accommodate.

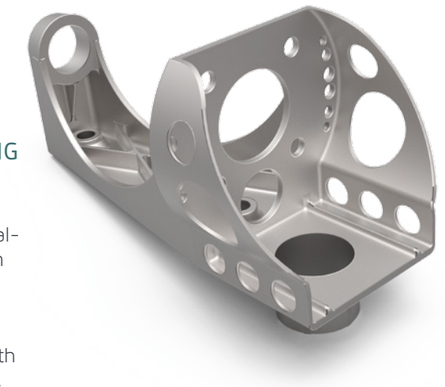
Trends Driving Automotive Changes

In the automotive industry, engineers and designers say it's all about lightweighting, in order to be in compliance with various government regulations such as corporate average fuel economy (CAFE) standards. Weight reduction through using alternatives to steel — in many cases thermoplastics — and adjusting overall product designs is pivotal to this industry. Lightweighting helps reduce the amount of material used to make a vehicle, cuts overall manufacturing and assembly times, drops shipping weight and reduces the carbon footprint. At the same time, lightweighting can improve part performance and fuel efficiency to meet increasingly stringent CAFE standards, while saving automakers' manufacturing costs.

TRENDS IN ACTION AT PROTO LABS

AUTOMOTIVE LIGHTWEIGHTING

One way to reduce component weight is to build the part using stereolithography (SL), a commercial-grade 3D printing process, and then add a protective metal coating on the thermoplastic-like SL part *(such as the* **motor mount** *pictured right)*. This gives the look, feel and strength of metal without the added weight, and can, in some cases, replace die-casted or machined aluminum, magnesium or zinc.



AEROSPACE PROTOTYPING

When Trinity University needed to develop its asteroid-sample retrieval device dubbed **SHARC** for NASA *(pictured right)*, it turned to Proto Labs for 3D-printed and machined components. The university then successfully tested the device in the Johnson Space Center Neutral Buoyancy Lab, with hopes of one day sending the SHARC on an actual mission.

HUMAN-FACTOR ENGINEERING

In some cases, human-factor engineering also means developing and creating applications and devices that help keep patients comfortable. Opus KSD engineers essentially fused technology and biology when they designed a hand-held medical stapler *(pictured left)* for minimally invasive surgery that dispenses bio-absorbable fasteners beneath a patient's skin. The fasteners hold the tissue during healing and then are absorbed by the body. The nine-piece **SubQ It!** stapler had its entire plastic assembly injection molded at Proto Labs.

Accordingly, rapid manufacturers are supplying prototypes for this industry using commercial-grade 3D printing processes, such as stereolithography (SL), which is ideal for small, complex parts and larger parts with hollow internal features or coring around the outside; and direct metal laser sintering (DMLS), which can build nearly fully dense parts that are comparable in strength to machined parts.

Beyond plastic, magnesium has emerged as a preferred alternative to steel and aluminum because of its lighter weight. Though lighter, magnesium still has superior stiffness and strength/weight ratios and favorable heat dissipation. With magnesium injection molding, also known as thixomolding, a variety of components are now being fabricated, such as transmission parts, seat frames, throttle bodies, pedals, mirrors, valve/intake covers, motor mounts and bumper-engine brackets. Since 2005, BMW has used magnesium for its N52 six-cylinder crankcases and cylinder head covers. The Big Three American automakers — General Motors, Ford and Chrysler — are also big on magnesium, according to government and industry sources, including the automakers themselves. Carmakers are using the material in several models for items such as engine cradles, lift gates in SUVs and instrument panels. Beyond lightweighting, the automotive industry is on a quest for improved powertrain efficiencies. Though fuel prices are currently low, most business analysts do not expect prices to remain at these levels, especially given that many oil suppliers have already cut back on drilling. As a result, carmakers are looking to improve efficiencies on several fronts:

- Making traditional internal combustion engines more efficient;
- Advancing hybrid engine development;
- Improving overall performance (including distance capabilities) of electric cars;
- Exploring other non-traditional power sources such as zero-emission hydrogen fuel cell engines.

For rapid manufacturers working with original equipment manufacturers (OEMs) as well as its tier-one suppliers, this will mean more prototyping and more short-run adjustments as OEMs ramp up research and development in this area.

Keeping Aerospace Industry Aloft

Lighweighting is also a focus of the aerospace industry because it directly relates to fuel efficiency. Aerospace manufacturers face continuing pressure to find greater fuel efficiency, which is probably one of the biggest factors contributing to the operational profitability of an airline. Along these lines, commercial-grade 3D printing is again playing a prime part, with DMLS in a starring role.

DMLS is significant in this industry because, from a production setting, this method allows companies to often manufacture the unmanufacturable, or at least build complex aluminum parts that are nearly impossible to machine. For example, a part that could not be machined in the past as a single part — due to its intricate geometry — would be machined as multiple parts and bolted together. In many cases, with DMLS, one component can now be made, thereby reducing weight, costs and material.

In addition, a major, industry-wide upgrading and replacing of aging commercial aircraft, which started several years ago, continues apace. This will require supply chain innovation where value is placed on cost efficiencies and on-demand manufacturing, as

airline companies diligently work to provide the latest and greatest in in-flight comfort and technology demanded by their passengers. As GE Capital recently forecast, this "re-fleeting" process will likely mean that large commercial aircraft deliveries will grow 4 to 5 percent through 2019.

Also, aerospace firms that contract with the Department of Defense, will likely continue to see a decline in overall defense spending, which will require these firms to be even thriftier and more efficient to win these projects. Fewer dollars will mean fewer contracts, which will intensify competition, spurring even more innovation needs.

Additionally, companies in this segment are looking for innovative ways to manufacture engine components, given that these are the most complex parts to make, must withstand extreme temperatures and also help fuel efficiency.

Finally, the aerospace realm is responding to a soaring demand for UAVs from government, military, commercial and even consumer markets. Drones have never been more popular. More than 700,000 drones were expected to be sold in the U.S. in 2015, and that's mostly just on the consumer side of things. The 2016 International CES, the annual consumer electronics show in Las Vegas, featured a drone rodeo in the desert outside of the city. Advancing research and development, prototyping and overall innovation efforts will be required for this proliferation of drones.

Aging Population Influences Health Care, Medical Applications

The giant elephant in health care's waiting room these days is a fast-approaching "demographic storm." This term is from Kenneth W. Gronbach, a demographer, futurist and author, who used it at the recent Global Plastics Summit in Chicago. He was referring to a surging world population growth, combined with a sizeable, aging baby-boomer population that's living longer and setting new life expectancy records.

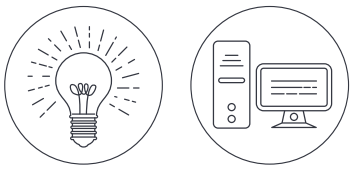
This demographic storm means that the health care industry will have significantly larger numbers of people to care for, creating a need for improvements to existing products, as well as an anticipated demand for new medical applications and devices.

Other prime influencers for this industry are greater patient engagement and a continuing move to human-factor engineering — or user-centered design. Greater numbers of hospitals, clinics and other medical facilities are now being measured, rated and compensated based on a number of overall performance indicators, one of which includes customer feedback.

Accordingly, a human-factor engineering approach that's based on the patient or user experience will drive the design of products and technology in this industry. In addition, because medical products need to pass a significant number of functional tests before being approved for the market, prototypes for these new products will need to be produced as close as possible to the finished product. This will mean using similar, if not identical, materials and manufacturing methods for prototypes as production parts.

Additionally, another key trend in this segment is the customization of medical devices, such as prostheses, dental implants, other body implants and more, all enabled by advances in 3D printing.

CROSSING ALL INDUSTRIES



LIGHTING AND CONSUMER ELECTRONICS

MagWerks LED, a Michigan-based company serving the automotive, transportation and lighting industries, chose Proto Labs and its liquid silicone rubber (LSR) molding process to develop this optically clear LSR component *(pictured)* for a high-efficiency, high-performance LED silicone fog light.

This product is just one example of how the need for manufacturing innovation is also influencing the general lighting industry, which crosses automotive, aerospace, medical and essentially all manufacturing industries.

Consumer electronics is another industry that plays heavily within nearly every other industry. A recent example is the Fighting Walrus telemetry radio, made by California-based Fighting Walrus, LLC. Proto Labs produced the magnesium injection-molded parts that clamp the radio to an iPad or iPhone. The radio uses open-source software, and allows a mobile device to communicate with popular small drones already on the market.

In addition, consumer electronics in the automotive industry are driving the growing sophistication of inside-the-car technology and connectivity that consumers now expect in their vehicles. These tech components keep advancing as cars become mobile command centers — computers on wheels. Industry sources also point out that these information and infotainment systems help provide a way for OEMs to differentiate their products. Moreover, a recent Consumer Reports survey found that infotainment equipment was the most troublesome feature in 2014 vehicles, suggesting a potent upside for companies that can devise superior systems.

FENDER BENDER

CUSTOM GUITAR CRANKS RAPID MANUFACTURING TO 11

1 **Body:** SLS nylon with custom paint finish.
2 **Neck:** SLS nylon with custom paint finish.
3 **Bridge Plate:** Milled brass.
4 **Bridge Saddles:** Milled brass.
5 **Control Plate:** Milled brass.
6 **Jack Plate:** Milled brass.
7 **Control Knobs:** Turned brass.
8 **Pick Guard:** Milled ABS.
9 **Headstock Logo:** Milled brass.
10 **Neck Spacer:** Injection-molded LSR.
11 **Neck Plate:** Injection-molded stainless steel.
12 **Strap Button:** Milled brass.
13 **String Guide:** Milled brass.

We thought it would be cool to showcase what was possible with rapid manufacturing by building a replica of a vintage Fender guitar using 3D printing, CNC machining and injection molding processes at Proto Labs.

Individual 3D CAD models of each component — which were free and found online from various sources — were tweaked and used to create the glossy white axe, and a number of Proto Labs' manufacturing processes pitched in: selective laser sintering (SLS), CNC milling and turning, and metal and liquid silicone rubber (LSR) molding.

The body is a standard Fender Telecaster design, hollowed out to reduce weight — although all the access ports to the hollowed area are concealed. The neck is a classic Fender Stratocaster design and an amalgam of several different versions of Strat necks.

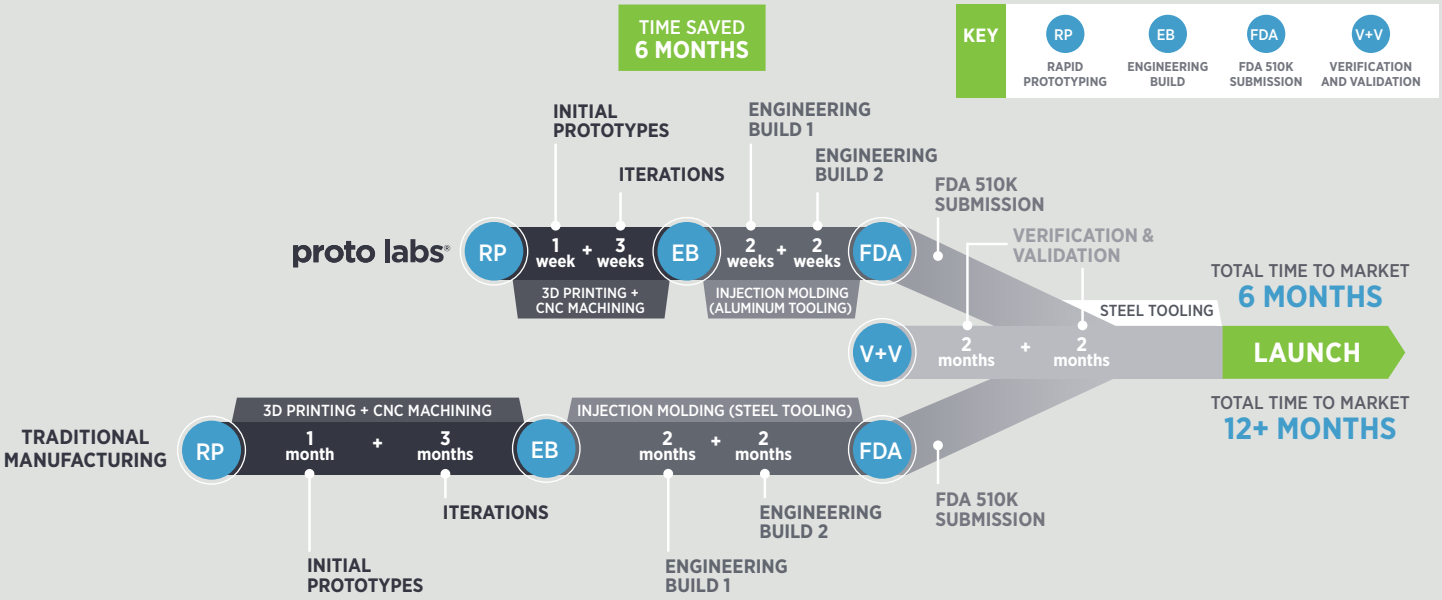
The only "non-standard" parts (i.e., parts you would not see on a Fender-made guitar) are on the headstock. The Proto Labs logo was designed using a sketching program on an iPad. The clip that retains the B and E strings was designed in SolidWorks because the standard clip is just stamped sheet metal and we wanted a gold-colored part to match the rest of the guitar.

Finally, the frets were all installed by a luthier using traditional tools and processes.

The guitar should strike a chord with music lovers and engineers — especially those engineers who happen to be musicheads. Look for it on tour at several trade shows around the U.S. we'll be attending this year *(see page 8 for upcoming shows)*.

INFOGRAPHIC

RAPID MANUFACTURING FOR MEDICAL DEVICE DEVELOPMENT



Upcoming Trade Shows

Look for Proto Labs at a variety of trade shows this year. We'll be at:

- BIOMEDevice in Boston (April 13-14)
- Lightfair in San Diego (April 26-28)
- RAPID in Orlando (May 16-19)
- Atlantic Design & Manufacturing in New York (June 14-16)

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Know someone who could benefit from rapid manufacturing? Simply head to **go.protolabs.com/Refer-J16Q1** to enter their information and we'll send you a FREE Proto Labs gift.

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