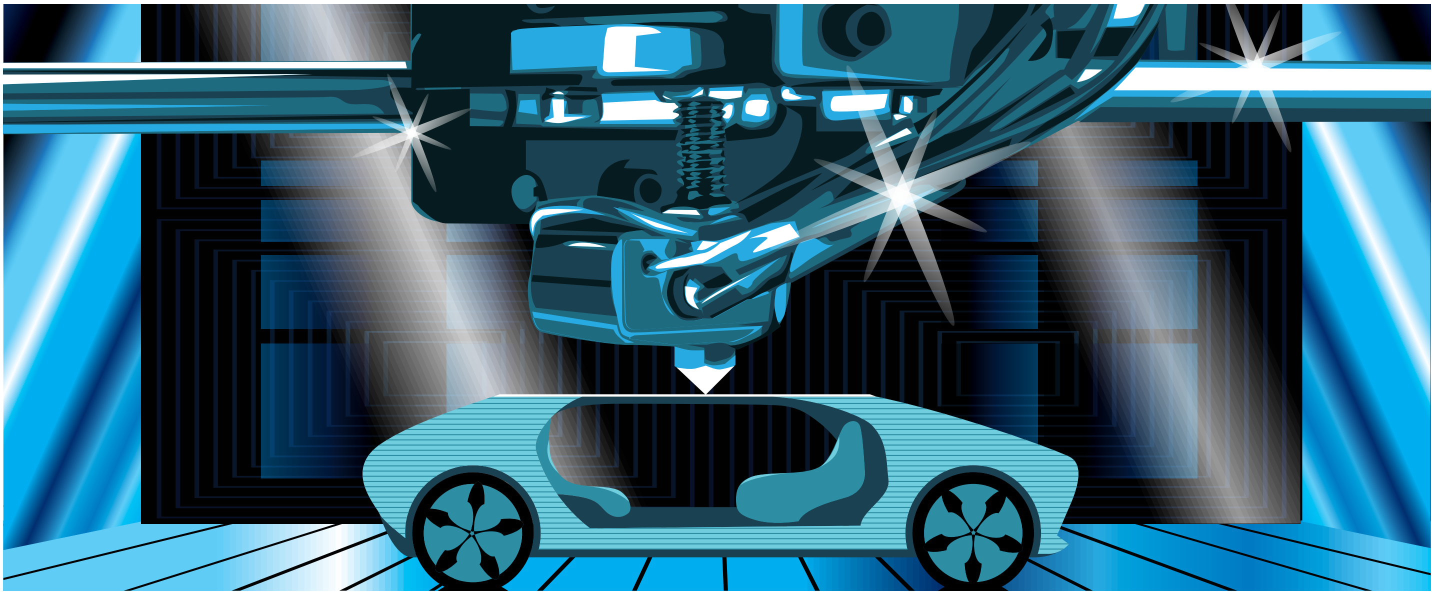

Driving differentiated value with additive manufacturing

Additive manufacturing is an opportunity to differentiate via unique designs and economy of production.

By Kevin Quinn
Director, additive design and manufacturing, General Motors
Based on an interview with Deloitte's Christopher Ongena, Kellen Smetana, and Ryan Robinson

GENERAL MOTORS (GM) has used additive manufacturing (AM) technology, operationally known as 3D printing, to produce component prototypes for three decades. This unique manufacturing process afforded us the ability to rapidly produce prototype parts and iterate much quicker than would normally be possible through lengthy, traditional manufacturing processes. Until recently, the aim of the additive approach was simply to support the component development process by finding and addressing part design issues prior to the manufacturing of production tools.

Now, GM is actively investing to develop AM capabilities as we see an opportunity to drive differentiated value in many ways. Two key areas stand out. First, AM can help make lightweight versions of many nonvisible, structural components. Lightweighting is vital to meet fuel-economy regulations and achieve longer ranges for our electric vehicles. Second, AM can deliver more flexibility to make unique designs.

From a business standpoint, prototyping physical parts is very costly, so the more we can do to validate a component in the digital space, the more we can control our costs. We obviously must maintain robust physical validation capabilities to ensure performance requirements are met, but there are huge benefits from being able to do some of the work upfront using digital tools.

In fact, we can simulate all input parameters for a given component before we print it. In this way, we're able to better set the conditions for success because we may only have to print a small number of iterations to get it fully dialed in prior to production.

Unlocking the potential benefits

In terms of implementing AM solutions, there are four key considerations: cost, throughput, postprocessing requirements, and material availability. Additive cost models can change the paradigm with the simple realization that you don't have to first build a tool anymore; you can go straight to building the part. The cost-benefit extends even further as unlike tools—that are typically built to support a five-year vehicle life cycle plus additional service part production—we can *reuse the same AM printer across multiple vehicle programs* and design generations.

As a manufacturer, it is a very compelling value proposition to think that you can now amortize the cost of tooling over a much wider volume and longer period. Achieving this leverage model is an important goal, as some industry estimates suggest that AM can increase the piece cost of making some parts versus using traditional methods by a factor of 10 to 100.

The time saved is also a critical benefit. Even if we're targeting low-volume production runs, we cannot have a build process that takes too long. Therefore, reducing the time it takes to manufacture a part with faster printers and more efficient processes is a key objective. Also important is the "box size," or the part density we can achieve within the usable printing volume, so that we are never printing just one part at a time.

The accuracy of the build process is the next benefit. Every time we need to alter a component in a postprocess environment, it adds to the overall cost. Getting the execution right in the initial build process can reduce the number of postprocessing steps, thereby cost.

Finally, we must consider the materials used in AM. There are opportunities to utilize both printed metals and plastics for the parts that make up our vehicles and the tools that produce the components. More material development must be done to enable the full suite of automotive-grade 3D printed materials that our industry requires. For example, the 3D printing industry has developed exotic metal powders, such as titanium and nickel base alloys, for the aerospace and medical industries. The automotive industry does not use many of these materials in production, so we need more development and focus on steel and aluminum to meet our specific needs.

Bringing parts manufacturing to the final assembly line

Parts production currently entails a complicated system of logistics connecting a multitude of tiered suppliers constantly shipping components back and forth across the manufacturing ecosystem. AM could minimize waste and downtime in this process by printing more components on location at the final vehicle assembly facility. While having an AM footprint on-site in all our manufacturing locations would help in this regard, there are cases where it doesn't always provide an optimal solution.

Sometimes we need more than just the machine that makes the part, as some components also require testing and analysis equipment. For this reason, we think the best approach is to *embark on the AM journey with our suppliers, encouraging them to evolve with this new technology* because of its potential transformative benefits for the entire ecosystem.

Having said that, one of the biggest practical challenges to implementing AM across multiple stakeholders in a manufacturing value chain is *cybersecurity*. The central question is: How do we ensure that both our physical manufacturing processes and underlying intellectual property assets remain secure when a breach on either front could result in catastrophic consequences?

> From an overall standpoint, industry estimates suggest there are approximately US$165 billion of tooling assets in North America alone dedicated to service part production. This puts a significant burden on the supply base for tooling maintenance and introduces an inherent risk of production downtime as the knowledge required to run these machines often resides in relatively few resources. Overall, converting from traditional production processes to additive manufacturing could free up a significant amount of capacity in the supply base.
>
> — Christopher Ongena, Additive Manufacturing practice leader, Deloitte LLP

Other AM benefits can occur further downstream in the manufacturing process. For example, instead of producing and warehousing large inventories of service parts, AM helps us envision a warehouse of printers producing parts on demand. Going a step further, we can potentially leverage our manufacturing network so that we could fully utilize idle printer capacity in a given plant when printers in a different plant are oversubscribed.

Driving the technology with the right talent

To integrate AM into our organization, we put together a team of additive design and manufacturing professionals who have the technical ability of simulation engineers, the creativity of designers, as well as expertise in the 3D printing process. Over the past two years, they've been focused on producing new, unique designs for components that are difficult or impossible to manufacture using traditional production methods.

This team is also working with software tools that enable capabilities to support this initiative. Historically, designers optimized existing parts, resulting in derivative design options with incremental gains in areas such as mass reduction and/or production efficiency. Tools using topology optimization and generative design principles, by contrast, can generate hundreds of different design options in the same amount of time, with performance requirements built-in upfront. This provides us more confidence in our design solutions meeting critical performance requirements, while dramatically increasing our ability to optimize the end product.

Change is never easy, but it is essential

One of the most important issues we tackle every day is *change* itself. AM represents a completely new way of doing things and it has the capacity to affect a wide variety of areas within the organization, so it's pertinent that we have the buy-in of our people. From purchasing and cost estimates to design conversations and the shop floor, we are asking people to think a long way out of their comfort zone.

We have to push ourselves to think differently, or we'll never get better. We're also working on some AM solutions that we expect will establish how thinking differently can yield better results.

We've installed several printers at our plants to produce specialized tools. However, just as we've had to convince our design engineers of the value of AM, we also have to demonstrate the value of AM to the employees on the line. To accomplish this, we've been running workshops with our plant staff to build advocates for the technology.

Creating advocates and, ultimately, adoption in additive manufacturing technology can often be more work than companies initially anticipate. Having said that, creating repositories of success stories, training material, and hands-on experience with the tools needed to be successful on the shop floor are critical in achieving the buy-in needed to push the technology forward.

What's ahead for additive manufacturing?

To move the automotive industry forward on AM, there must be more of a collective effort beyond what the OEMs can accomplish on their own. There needs to be an ecosystem approach involving everyone from the manufacturers and tier-one integrators to the tool shops, material suppliers, software developers, and next-gen machine makers.

We will have to work together to accelerate collective AM capabilities, establishing and communicating a consistent set of needs for the automotive industry. It is certainly going to be an interesting journey to scale this technology, but I'm confident we can get there.

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Thanks to Deloitte's ***Christopher Ongena****,* ***Kellen Smetana****, and* ***Ryan Robinson*** *for their contributions to this article.*

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