Carbon®

The Business Case for Additive Manufacturing in the Automotive Industry

Practical tips and strategies to help you understand why, how, and when to implement additive manufacturing across the various stages of your product development efforts

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Introduction

The Continued Growth of Additive Manufacturing in Automotive

The automotive industry is in the middle of a revolution as it transforms additive manufacturing from a prototyping technology into a production solution. With a growing library of validated 3D printing materials and reliable production processes, industry leaders are now utilizing additive manufacturing across the product development cycle — from functional prototyping to support on the manufacturing floor with tooling, fixtures, jigs, and wearable parts. While additive's growth in the automotive space is undeniable, its full potential has yet to be realized.

As more automotive leaders begin adopting additive technologies, many questions arise as we enter into this new frontier. We at Carbon noticed that there were few resources available around why, how, and when to implement additive manufacturing across your product development efforts – that is, until now.

For this eBook, we combined insights from automotive industry leaders with additive manufacturing expertise to create a guide that helps you understand when and how to use additive manufacturing during automotive application development. Additionally, we cover the following topics:

- Reasons you should consider additive in automotive applications
- How to evaluate whether additive is right for your part
- How to fully leverage additive throughout your product development cycle, from unlocking design parameters to speeding up time-to-market
- How to develop standards and specifications for your additive manufacturing process
- And more!

Related Webinar

In addition, we hosted an online panel of automotive industry leaders featuring Ford Motor Co. leaders Ellen Lee, Manoj Patnala, and Harold Sears — representing Ford's research, product development, and manufacturing divisions. They share details about how Ford organizes its additive capabilities and their first-hand experiences of the value of additive manufacturing. Watch it here.

Get Sample Parts

If you're interested in experiencing 3D-printed automotive parts made from best-in-class materials, request a free sample part kit by reaching out to us at sales@carbon3d.com.

Why and Where Additive Manufacturing Makes Sense

1.1 Innovate to Survive

The automotive industry is one of the most cost-competitive segments of the manufacturing sector. Innovation throughout your product development process is crucial to staying afloat, let alone succeeding.

The automotive industry is under unprecedented pressure to work quickly: the platform development cycle today is 22% faster than it was in the 1980s, and the automotive market is much more fragmented, requiring cost recovery over smaller volumes. Consumers expect constant innovation and a wide range of choices, and regulators require aggressive powertrain development on short timelines.

In this highly competitive environment, additive manufacturing offers a crucial opportunity: it can reduce costs during the product development process as well as on the factory floor; speed the delivery of new products; and deliver better products that meet demand for performance, differentiation, variety, and customization.

1.2
Value Areas of Additive Manufacturing

Below are some of the major examples of how additive manufacturing has benefited our automotive customers:

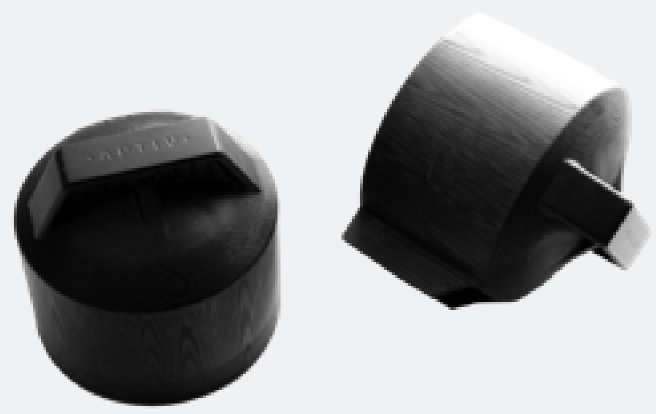
- Cost-effectively produce low volumes (under 10,000 units)
- Shorten time-to-market
- Eliminate warehousing needs through on-demand production
- Minimize assembly costs and improve performance through part consolidation
- Reduce post-processing through single-process surface finishes
- Drive down material costs through light-weighting
- Create radical new designs with geometries that would be impossible to mold or machine
- Customize products for a more customer-centric experience

1.3

Real-Life Examples

The following parts showcase real-life examples of the value additive manufacturing can bring to the automotive space. All were 3D printed with the Carbon Digital Light Synthesis™ (Carbon DLS™) 3D printing process and engineering-grade materials.

> *Having a proven track record is extremely helpful in gaining confidence from our teams that this process will work. These early successes help us define a way of working together in seeking and developing new additive manufacturing part applications.*
>
> **Ellen Lee**
>
> Technical Leader of Additive Manufacturing Research, Ford



Ford Super Duty Truck
Aptiv trailer-tow connector cap
With a tooling-free approach, Aptiv reduced cycle time by 50 percent, speeding up time-to-market by 16 weeks compared to traditional molding solutions.

Ford Focus
HVAC lever arm service parts
Ford reduced inventory and eliminated re-tooling for service parts that are no longer in production and can't be cost-effectively manufactured with traditional processes. This enables customers to source needed components.

Ford Mustang GT 500
Electric parking brake (EPB) bracket
Three parts were combined into one, which reduced assembly complexity. Learn more.

Lamborghini Sián FKP 37:
Central and lateral dashboard air vents
Lamborghini reduced its part development time by 12 weeks by moving swiftly from prototyping to production on the same additive manufacturing platform.

Ford Raptor
Low-volume cosmetic plugs for niche markets
Ford leveraged high-resolution and surface finish capabilities to cost-effectively produce this low-volume direct-printed, Class-A automotive part for a specific market.

Lamborghini Urus Super SUV
Textured fuel cap
Lamborghini reduced post-processing by directly printing a unique surface texture on their Urus fuel cap to improve grip.

Choosing an Additive Manufacturing Process

2.1
From Prototype to Production: Prioritize Versatility

Additive manufacturing has become a ubiquitous tool in prototyping, but recent advancements in 3D printing materials and processes are bringing it into production applications. The advantages of an additive manufacturing technology are multiplied when it can be used in both prototyping and production; when choosing an additive manufacturing process, consider whether it's capable of making the transition.

> "*As 3D printing materials become more and more robust, we're able to utilize additive manufacturing further down our product development cycles and ultimately avoid proto-tooling. If you can delay or avoid prototype tooling, that's a benefit for everybody because when you compare proto-tooling versus production tooling, proto-tooling is just an expense. When it makes its parts you throw them away, whereas an additive production tool is an asset for the company.*
>
> **Harold Sears**
> Technical Leader Additive Manufacturing Technologies, Ford

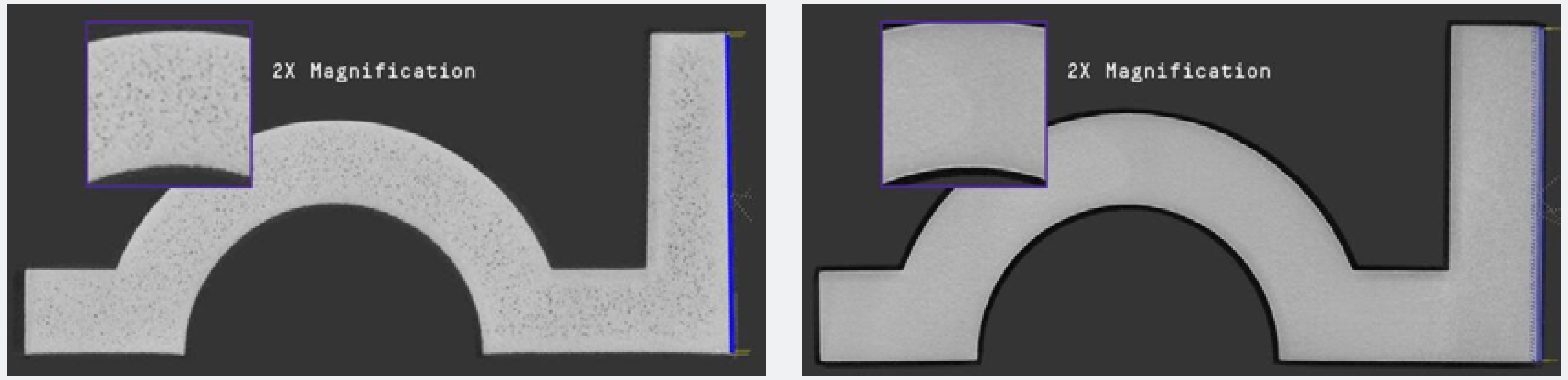
2.3 Comparing Additive Manufacturing Solutions

Compared to other additive manufacturing technologies, the Carbon DLS™ process produces the widest range of real, functional parts suitable for both functional prototyping and serial production. The surface finish, print speed, and material diversity of the Carbon DLS™ process are better than powder-bed fusion processes, which are limited to PA 11, PA 12, or TPUs. The mechanical properties, print speed, and consistency are substantially better than traditional photopolymer technologies such as SLA or DLP.

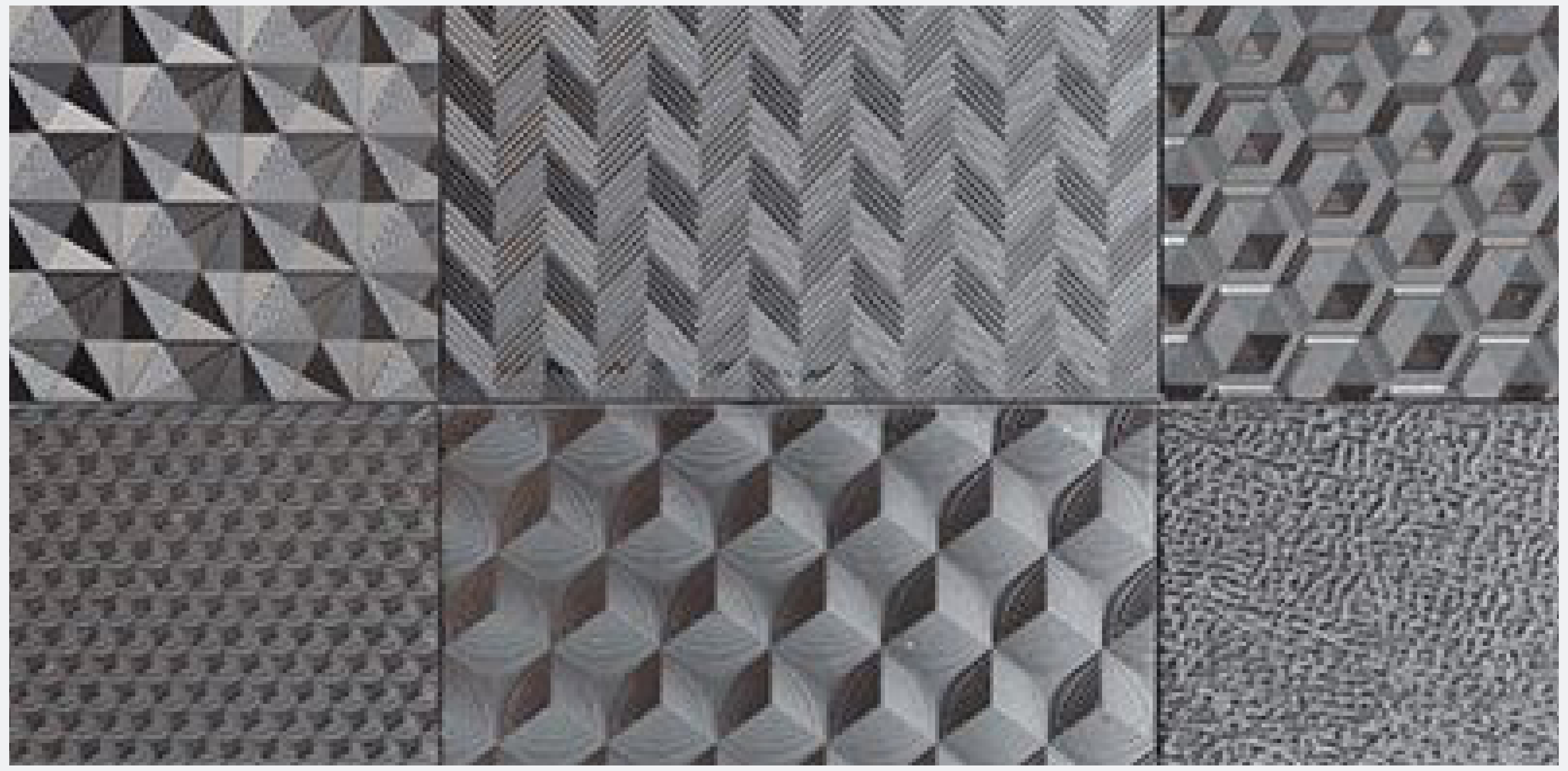
	Carbon Digital Light Synthesis™ (Carbon DLS™)	Stereolithography (SLA)	Fused Deposition Modeling (FDM)	Digital Light Projection (DLP)	Powder Bed Fusion (SLS, MJF)
Wide range of real, functional parts	✓		✓		✓
Excellent mechanical properties	✓				✓
Attractive surface finish	✓	✓		✓	
Fully dense	✓	✓		✓	
High feature details/ resolution	✓	✓		✓	
Durable	✓		✓		✓
Fluid channeling	✓	✓		✓	

2.3
Comparing Additive Manufacturing Solutions

Powder-bed fusion processes like selective laser sintering and Multi-Jet Fusion produce porous parts (left). Resin-based processes like Carbon DLS produce parts that are fully dense (right).



Variety of surface finishes available with the Carbon DLS™ process.



2.4 Evaluation Steps

Below are a series of questions to help determine what additive manufacturing process is right for your part.

What do you need the part for?

- Design iteration prototype?
- Functional prototype?
- End-use production part?

How many do you need? How big?

- Serial production? Is it scalable?
- Low-volume?
- One-off production for on-demand or custom parts?
- Bridge-to-tooling?

What does the part need to do? Class-A or Class-B?

Isotropic? Some other processes such as fused deposition modeling are sensitive to the orientation of the part in the printer, and printed parts are weaker in some directions than in others. With resin-based additive processes like the Carbon DLS™ process, parts are equally strong in every direction, regardless of orientation within the printer.

Fully dense? Thermal 3D printing processes like FDM, selective laser sintering, and Multi-Jet Fusion produce porous parts that can be riddled with microscopic voids. Resin-based processes like Carbon DLS produce parts that are fully dense.

Durable? Use an additive process with a library of engineering-grade materials designed for end-use parts or functional prototyping.

Fluidics? For a water-tight part, use a photopolymer process with materials that are compatible with the fluids that will pass through your part.

High feature details? Use a resin-based additive process to achieve excellent feature resolution.

Attractive surface finish? Every 3D printing process can be supplemented with post-processing to achieve desired surface finish, but these steps add significant cost. An additive technology like Carbon DLS that can produce high-quality surface finish during printing will save time and money.

2.4
Evaluation Steps

“Material and design have to work hand-in-hand. You want to leverage the strength of the material and pair it with the right design philosophy for the part.

Manoj Patnala
Senior Core Engineer Additive Manufacturing, Ford

Carbon EPX 82 material is durable and has proved ideal for multiple automotive applications. In particular, it has passed Ford’s rigorous performance standards and withstands critical requirements such as interior weathering; short- and long-term heat exposure; UV stability; fluid and chemical resistance; flammability (ISO 3795); and fogging (SAEJ1756) for selected applications.

	RESIN	ULTIMATE TENSILE STRENGTH	ELONGATION AT BREAK	TENSILE MODULUS	SHORE HARDNESS	IMPACT STRENGTH *	HEAT DEFLECTION TEMP**	COMPARABLE THERMOPLASTIC	BIOCOMPATIBILITY: CYTOTOXICITY
2 PART	CE 221	85 MPa	3%	3900 MPa	92D	15 J/m	230° C	Glass filled nylon	✓
2 PART	EPU 40	9 MPa	300%	N/A	68A	N/A	N/A	TPU	✓
2 PART	EPU 41	15 MPa	250%	N/A	73A	N/A	N/A	TPU	✓
2 PART	EPX 82	80 MPa	5%	2800 MPa	89D	45 J/m	130° C	20% glass-filled PBT	✓
2 PART	FPU 50	25 MPa	200%	700 MPa	71D	40 J/m	70° C	Polypropylene	✓
2 PART	MPU 100	35 MPa	15%	1300 MPa	81D	30 J/m	50° C	-	✓
2 PART	RPU 70	40 MPa	100%	1700 MPa	80D	15 J/m	60° C	ABS or PC ABS	✓
2 PART	RPU 130	35 MPa	>50%	920 MPa	100D	76 J/m	119° C	Nylon 6	-
2 PART	SIL 30	3.5 MPa	350%	N/A	35A	N/A	N/A	TPE	✓
1 PART	DPR 10	45 MPa	4%	1800 MPa	N/A	20 J/m	61° C	-	✓
1 PART	PR 25***	29 MPa	>15%	920 MPa	N/A	18 J/m	49° C	-	✓
1 PART	UMA 90	30 MPa	30%	1400 MPa	86D	30 J/m	45° C	-	✓

Carbon offers a wide range of resins with properties that can be leveraged for your specific application’s needs and that are comparable to common thermoplastics.

What material performance is required?

- Are there specific tolerances or mechanical properties that need to be met?
- Are there specific environmental conditions the part will need to withstand?

What type of material will be sufficient based on the part performance requirements?

- Was the part made in a comparable material previously?
- Do internal or industry standards specify a particular material?

2.4
Evaluation Steps

What's the business case?
Does it make sense to use additive over traditional manufacturing?


Cost savings?


More durable?


Less inventory?


Light-weighted?

After going through this evaluation process, make sure to benchmark the economics of the additively manufactured part against its conventional counterpart. It's helpful to refer to the preceding additive value areas (section 1.2) when determining whether the additive process is the right fit.

Developing Standards and Specifications for Additive Manufacturing Processes

3.1 Earlier Process Monitoring and Part Testing

There can be multiple sources of variation in additive manufacturing (machine-to-machine, printer-to-printer, batch-to-batch, etc.). A major advantage of additive manufacturing is the ability to conduct extensive process variation testing early on, because prototyping and production occur on the same platform. You can begin part testing much earlier in the product development cycle, which is not something that can typically be done using traditional manufacturing methods without incurring significant additional costs. The ability to test multiple, functional variations allows you to analyze your performance spread, letting you understand where the variation is, optimize quickly through rapid design iterations, and ultimately speed up your time-to-market.

Additive manufacturing offers many opportunities to incorporate modern digital process-improvement techniques. Look for an enterprise-grade 3D printing system that provides network-connected monitoring at the part level, the machine level, and the fleet level. These features become particularly important if you're considering customization.

3.2 Writing Specifications

Because additive manufacturing is still a relatively new process for production parts, many companies and industries have not yet written standard requirements for 3D printed parts.

Before you start writing specs for your part, ask yourself: is this process predictable and is its performance repeatable? If the performance spread meets your part's needs, you can begin writing specifications for the process to establish a PPAP (production part approval process).

With a dialed-in process that demonstrates reliable and consistent production of parts at spec and within tolerances, you have the opportunity to continue perfecting your part through an optimization approval process and to seamlessly scale production.

Internal Adoption of Additive Manufacturing

The adoption of additive manufacturing is a journey for not just the automotive industry at large but also for individual teams. Below are some tips on how to seamlessly speed up the adoption of additive in your company:

1. Help engineers and product designers unlearn traditional design limitations and lean into the design freedom of additive manufacturing.

- Share successful 3D printed parts and circulate additive manufacturing design guidelines as resources and reminders.
- Host design and/or application discovery competitions to experience new design freedom and encourage out-of-the-box design ingenuity.
- Engage outside experts for help getting started. Many contract manufacturers like those in the Carbon Production Network have extensive experience identifying applications, developing designs for 3D printing, and running serial production at small and large scales.

2. Educate product development teams on the pain points that additive manufacturing can help overcome.

- Share application discovery resources among teams so they can start to thinkmore critically about what types of applications can best leverage the benefits of additive manufacturing.

3. Clarify and align around what additive can and cannot do for your company.

- Additive manufacturing cannot do everything. Be honest ahead of time and help your colleagues understand both what it can and can't do.
- 3D printing doesn't have to require radical reinvention; in many of its most successful applications, it works alongside conventional methods. Position your in-house additive manufacturing resource as a complement to traditional manufacturing technologies with applications like jigs, fixtures, and bridge tooling.
- Discuss the realistic current potential and the future potential of additive manufacturing and how you can incorporate that into your business strategy.

The Future of Additive Manufacturing In Automotive

As validated, high performance additive materials continue to advance, agile automotive leaders will have more opportunities to produce innovative parts that are differentiated from their competitors. Not only will automotive OEMs gain more flexible production solutions, but product development timelines will be drastically shortened, ultimately eliminating months-long tooling lead times and speeding up time-to-market. With expanded on-demand capabilities, customizable features at scale will become a reality, and more customer-centric opportunities will arise.

“

Companies using additive manufacturing will be the leaders in the automotive space.

Manoj Patnala
Senior Core Engineer for Additive Manufacturing, Ford

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The Carbon DLS process is allowing our engineers to shorten their design iteration time and reach a final part more quickly, which is exciting because it means higher quality and more cost-effective products for our customers.

Ellen Lee
Technical Leader of Additive Manufacturing Research, Ford

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[With the Carbon DLS process] we were able to reduce cycle time by 50 percent, pass every test, and perform the same PPAP as we would have had it been an injection molded design.

Jerry Rhinehart
Additive Manufacturing Technology Manager, Aptiv

“

We wanted to give our designers and engineers the ability to produce better parts, and we can do this by leveraging the Carbon DLS process. We were also able to simplify the supply chain and reduce the time-to-market for these parts. Moving forward we are putting more effort and resources on using additive manufacturing technologies for production of parts for Lamborghini vehicles, and in working with Carbon, we have found a partner that shares our vision for creating best-in-class products that push the limits of what’s possible.

Stefan Gramse
Chief Procurement Officer, Automobili Lamborghini

“

With the Carbon DLS process, we were able to go from an initial concept to showing the final part on a show car in only three weeks, passing through many different design iterations to get the best result. Just three months later, we were able to move into production.

Maurizio Reggiani
Chief Technical Officer, Automobili Lamborghini

Get Sample Parts

We hope this guide has inspired you to consider additive manufacturing as a versatile production solution for your next project. If you're interested in experiencing 3D-printed automotive parts and best-in-class materials, reach out to us at sales@carbon3d.com to receive a free sample part kit.

Carbon®

3D as It’s Meant to Be