Carbon®

THE CARBON DLS™ 3D PRINTING PROCESS

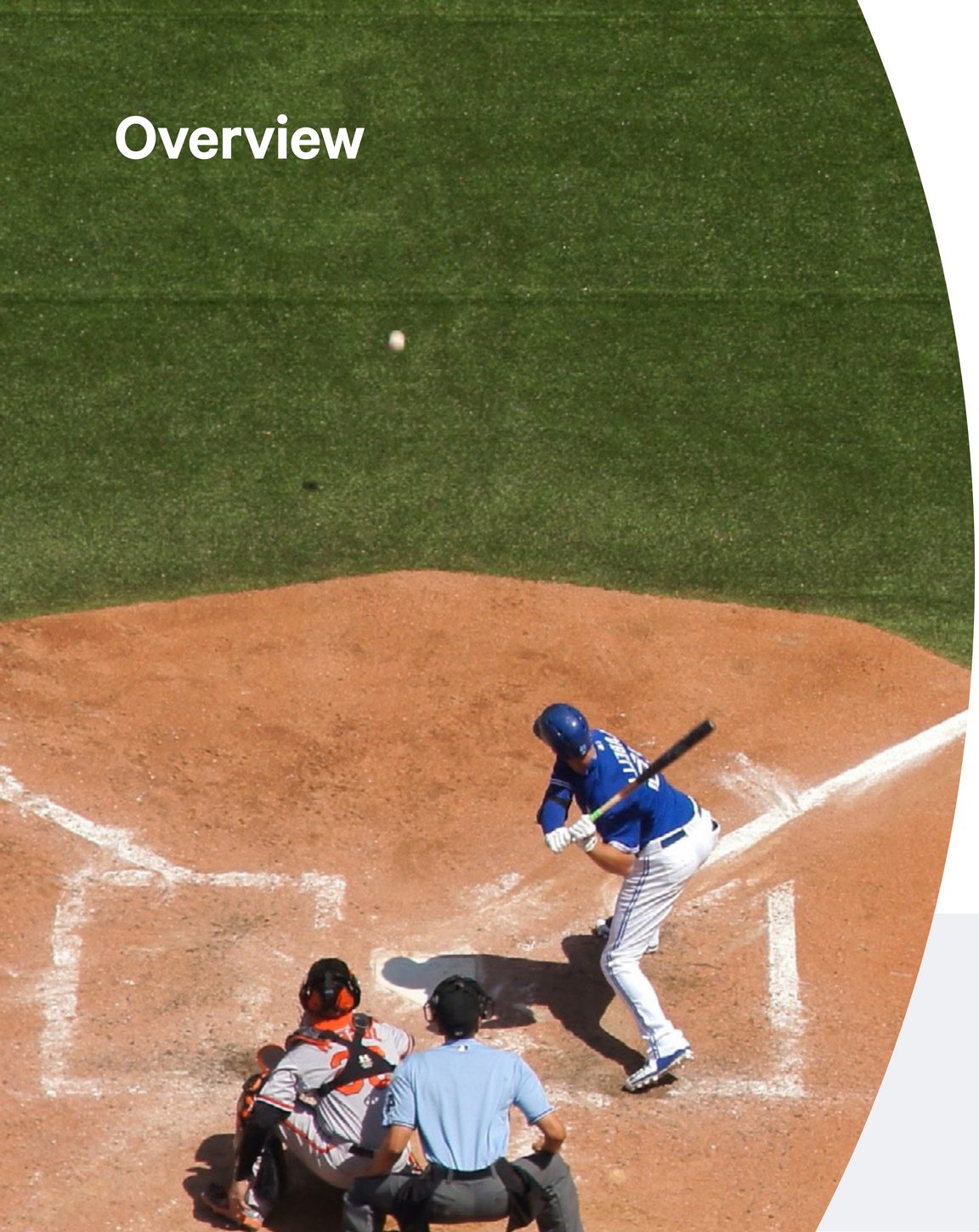
Additive Manufacturing Product Development Handbook

From Initial Concept to Final Production

A step-by-step roadmap to product development with the Carbon DLS™ 3D printing process and production ecosystem featuring the **Rawlings' REV1X** glove development story.

Updated 07.05.2021

Overview



This handbook is your back-stage view of what product development looks like with Carbon. Within these pages is a step-by-step roadmap of how you can get from an initial concept to the final production of a next-generation product by leveraging the Carbon Digital Light Synthesis™ (Carbon DLS™) 3D printing process and extensive Carbon production network. This handbook encapsulates the insights we learned while working with world-class brands like adidas, Riddell, and specialized to develop countless breakthrough products. We now feature Rawlings and its REV1X glove as a prime example of how you can bring a better product to market faster with Carbon. The goal of this guide is to show you the ins and outs of what developing your product on the Carbon platform could look like and point you toward the resources you need to make your next-generation product happen now.

Interested in experiencing parts printed with the Carbon DLS process?

REQUEST FREE SAMPLE PARTS

Table of Contents

Introduction

Carbon helps designers, engineers, and businesses bring innovative products to market faster. We believe you should be able to access 3D printing technology and expertise wherever, whenever, and however you need it so you can make better products, faster. From design to prototype to final production, each step toward creating a breakthrough product is vital. Both versatile and reliable, the Carbon platform, paired with our ecosystem of certified production partners, allows you to deliver prototypes or finished goods, small batches or fully scaled production. Whether your goal is creating the best performing helmet liners, top user-rated bike saddles, or high performance automotive parts, we help you solve your product development challenges by partnering with you each step of the way, not just selling you a printer. We are invested in your success. And we are here to help you make your design goals a scalable reality.

3D as It's Meant to Be

Why and Where 3D Printing Makes Sense

In a highly competitive marketplace, 3D printing offers a crucial opportunity: it can reduce costs during the product development process and on the factory floor, speed the production of new products, and deliver better products that exceed demand for performance, differentiation, variety, and customization. Additionally, 3D printing is enabling the production of unmoldable lattice geometries that allow products to be specifically tuned for varying performance needs.

Real Products Made with Carbon DLS

The following products, all 3D printed with the Carbon DLS process, are reaching new levels of performance across a wide range of industries. This is what happens at the intersection of engineering-grade materials, software-driven design, reliable 3D printers, and expansive production networks.

Learn more about products made with Carbon DLS **here.**

PADDING

Rawlings REV1X Glove
Ultra-lightweight, form-fitting, and game-ready –– a glove that consistently gives you unmatched playability across the field.

JINS Neuron 4D
A revolutionary new frame from the Japanese global eyewear company, JINS, with 3D printed lattice temple cushions to keep glasses fitting snugly and in place––while being flexible, breathable, and comfortable

HELMETS

Riddell SpeedFlex with Diamond Technology
Riddell used Carbon DLS to change the way they design and manufacture protective gear for football and beyond–– achieving the top 2020 rating by the NFL

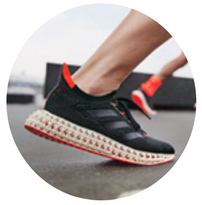
CCM Super Tacks X with NEST Tech
The Super Tacks X with NEST Tech is to fits an athlete's head, allowing for total customization. The helmet liner is then manufactured on the Carbon platform, utilizing a unique lattice design that offers superior breathability, premium comfort, and elite protection.

SADDLES

Specialized S-Works Power Saddle With Mirror
With Carbon DLS, Specialized developed a multi-zone bike saddle to address sit-bone pain experienced by riders; they accomplished this breakthrough twice as fast as with their normal development process, with over 70 iterations in 10 months.

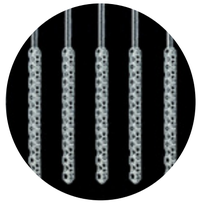
Fizik Antares Versus EVO 00 Adaptive
3D printing empowered Fizik to move beyond the performance limitations of foam and traditional production methods to develop top user-rated saddles.

MIDSOLES



adidas 4D Midsole
The world's highest-volume 3D printed shoes use a revolutionary athletic midsole designed to move you forward, manufactured with Carbon DLS.

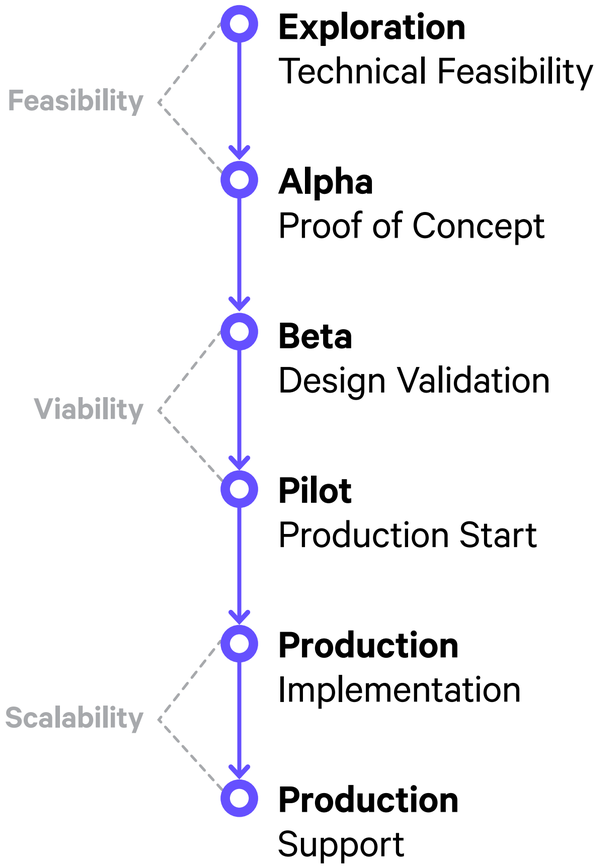
LIFE SCIENCES



Resolution Medical Lattice Swab
As COVID-19 surged in the US, manufacturing supply chain disruptions were causing severe testing swab shortages across the world. This lattice testing swab went from concept to launch in just 20 days.

Product Development Roadmap

Below is a summary of the steps we use to help you solve your product development challenges.



Now, let's dive into each step!

Discovery

0: Understanding Your Product Development Challenges

Goal:
Understand the background of innovation in your industry and your existing product line, as well as where you can improve your product and how Carbon DLS can help.

Process:
- **In early discussions, you help us better understand your product development challenges:**
- **What is the history of innovation in your industry?**
- **What problem are you trying to solve?**
- **Where can you innovate throughout the product development cycle to make your product better?**

- **The background? Baseball gear innovations had largely been novelty upgrades throughout the years. Rawlings wanted to innovate for better performance through product design.**
- **The problem? Traditional glove materials take a long time to break in.**
- **The idea? A next-gen glove that 1) enables faster reaction times and 2) becomes game-ready faster.**

Rawlings, the Oficial Glove of Major League Baseball®, is a leading manufacturer and marketer of sporting goods in the United States. By continuously developing technologically-enhanced products, Rawlings dominates the baseball gear industry with innovative new products that enable serious athletes to reach their full potential and achieve peak performance.

Rawlings' products for the baseball industry are closely tied to the sport's pride in tradition. Because the sport is both simple and timeless, Rawlings has continually focused on developing premium products that can stand the test of time.

For its next innovation, Rawlings wanted to look outside the mold and leverage new manufacturing technologies to elevate equipment design based on performance. However, introducing a new technology meant that Rawlings' latest development had to meaningfully outperform products with almost a hundred years of proven performance. Hence, the search for an end-to-end product development platform and robust manufacturing solution commenced.

Discovery

1: Exploration and Technical Feasibility

Goal:
Identify applicable products or parts to prove Carbon DLS technical feasibility with minimal resources.

Process:
Carbon works closely with you and your teams, specifically product managers and leadership, to explore and identify potential products or parts that can leverage the Carbon DLS process. Part ideation is typically carried out in a cross-functional workshop setup with engineering, manufacturing leadership, and business leadership.

Duration:
2–4 weeks per part design

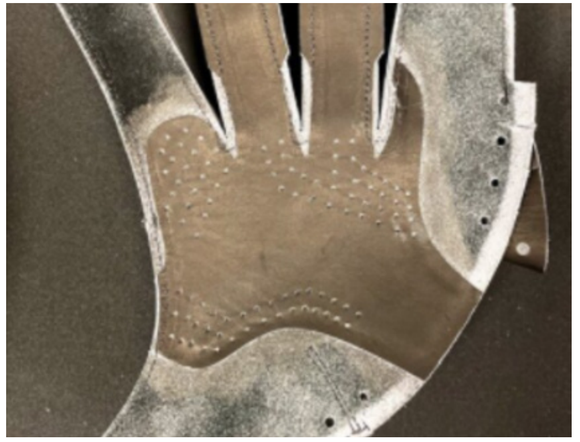
Carbon led a design sprint workshop at Rawlings, which resulted in a clear vision, support from executives, and set product requirements.

Clear Vision for Glove Development

Knowing that traditional gloves can take weeks or even months to become game-ready, Rawlings sought to reduce this time without compromising on durability so that a glove could hold its ideal, playing form longer. Rawlings decided it wanted to tackle defense, setting out to make a new glove that would revolutionize defense by enabling faster reaction times and by becoming game-ready faster.

Product Requirements

Traditional methods of glove construction use felt inserts to reinforce the thumb and pinky, but to meet these new high performance standards, Rawlings needed a material that would allow fine control over the stiffness without increasing weight. The catching pocket needed to be soft and complement a stiff pinky and thumb to give the player confidence while securing the ball on the diamond.



Development

2: Proof of Concept

Goal:
Carbon or a certified Carbon production partner delivers an early proof of concept and confirms the design can achieve your performance requirements by producing a small number of samples.

Process:
Among the products or parts identified in step 1 as feasible, Carbon or a certified Carbon production partner works on your design to deliver an early proof of concept. If you are starting with an original design file, you share it with Carbon or a production partner so it can be redesigned for the Carbon DLS process.

You receive preliminary **part cost estimates** to ensure costs are within your budgetary constraints. Additionally, **the material family** used for the part is typically finalized at this stage with performance requirements in mind.

Between 5 and 30 parts per application are printed and tested. The Carbon application engineering team or a certified Carbon production partner can provide a proof of concept to you in just 1–3 weeks, which, when compared to 6–23 weeks per design iteration with injection molding, takes almost 50%–80% less time.

Duration:
1–3 weeks per design iteration

Material Validation

After testing Carbon's EPU material against FPU, Rawlings found that Carbon's FPU 50 material provided the optimal stiffness-to-weight ratio. FPU 50's malleability allowed the glove to conform to the player's hand and maintain its ideal shape longer than traditional materials.

The Value of an In-House 3D Printer

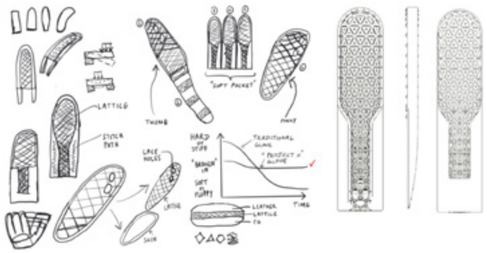
Carbon provided iterative lattice design services to Rawlings and shipped proof-of-concept parts while building out a business case for the Carbon M2 printer. Rawlings was originally hesitant to use a 3D printer for production because it had only used 3D printing for prototyping. However, once Rawlings began to prototype on its in-house printer with the lattice design files that Carbon provided, Rawlings was sold. Having a printer on-site allowed Rawlings to experience firsthand the robust nature of a Carbon 3D printer as a truly end-to-end production solution. This gave Rawlings the confidence to go ahead with Carbon as its main manufacturing technology for the Rev1x.

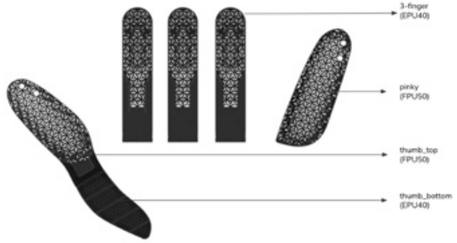
The Value of the Carbon Ecosystem

While having an in-house printer can dramatically accelerate your product development, we understand that it doesn't make sense for everyone. Thankfully you can work with our **ecosystem of certified production partners** to leverage the Carbon DLS process. Carbon certified production partners provide you with access to Carbon 3D printers, vast Carbon DLS process knowledge, and design expertise.

"Carbon's team really helped us push the limits with this glove,; having our own printer in house meant that we could try designs as soon as we thought of them."

-Ryan Farrar, Senior Director, Ball Gloves, Rawlings





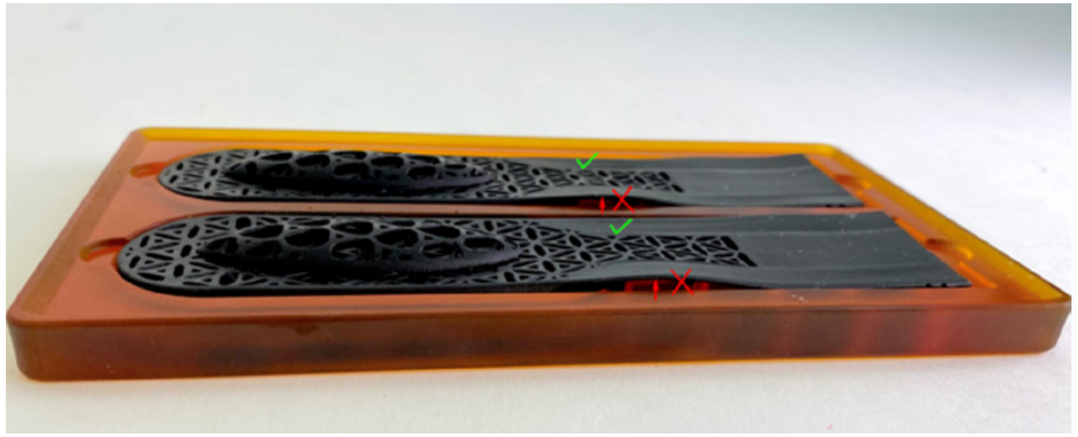
Development

3: Design Validation

Goal:
Finalize the design and confirm functional and commercial viability with 30–100 parts.

Process:
For parts that pass the proof-of-concept stage, this step involves locking the part design and carrying out any design iterations as needed. At this time, you and your team complete functional part testing to ensure viability of the solution. Process capability topics such as variations within the build platform, printer-to-printer, and resin-lot to resin-lot are quantified and optimized at this stage. Additionally, a detailed cost model is shared with you to ensure the business case of manufacturing with Carbon DLS is viable.

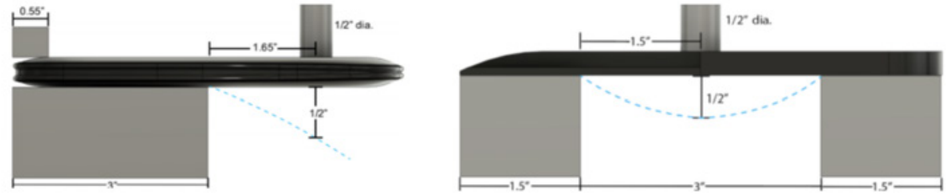
Duration:
1–3 weeks per design iteration



Over multiple months, Rawlings iterated on countless lattice designs before landing on the optimal pattern. With unlimited access to an in-house Carbon M2 printer, Rawlings' team of designers could iterate very quickly, testing ideas and avoiding the usual expensive pitfalls of traditional development processes along the way.

At this stage, Rawlings' engineering validation was complete, and C-level alignment on product sourcing and the launch plan commenced.

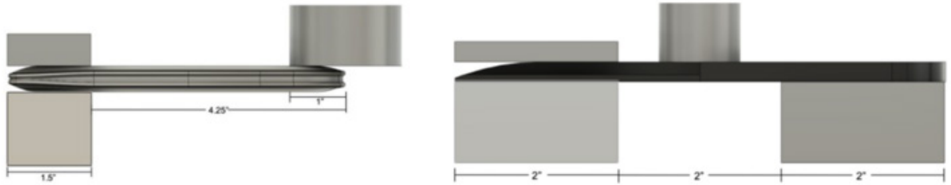
- **Test Method 1**: Flexural testing



(1.1) Cantilever beam bending test

(1.2) Three-point flexural test

- **Test Method 2:** Fatigue test



(2.1) Cantilever beam bending fatigue test

(2.2) Three-point flexural fatigue test

Production

4: Production Start

Goal:
Confirm printability, efficiency, and economics over 100–1k parts and multiple printers.

Process:
With production in sight, process capability is confirmed over many parts and multiple machines. The focus is on the end-to-end process from mixing to baking, to achieve the yield, uptime, throughput, and economic targets required by the part. Carbon helps optimize process development for speed and/or accuracy as required by you and your team, and production transition plans are discussed. **Will you produce your product or parts in house or outsource it to a Carbon production partner?**

It is important to note that any product design issues discovered this late can still be addressed and fixed given the flexibility of the Carbon DLS process and digital approach to manufacturing.

Duration:
Typically 2–6 weeks, could be more depending on the complexity of the process and unforeseen process optimization challenges.

Even with an in-house printer, Rawlings decided to outsource production to **Fast Radius,** a certified production partner. Why? Because Fast Radius brings vast Carbon DLS process engineering expertise to projects that are ready to scale.

Production

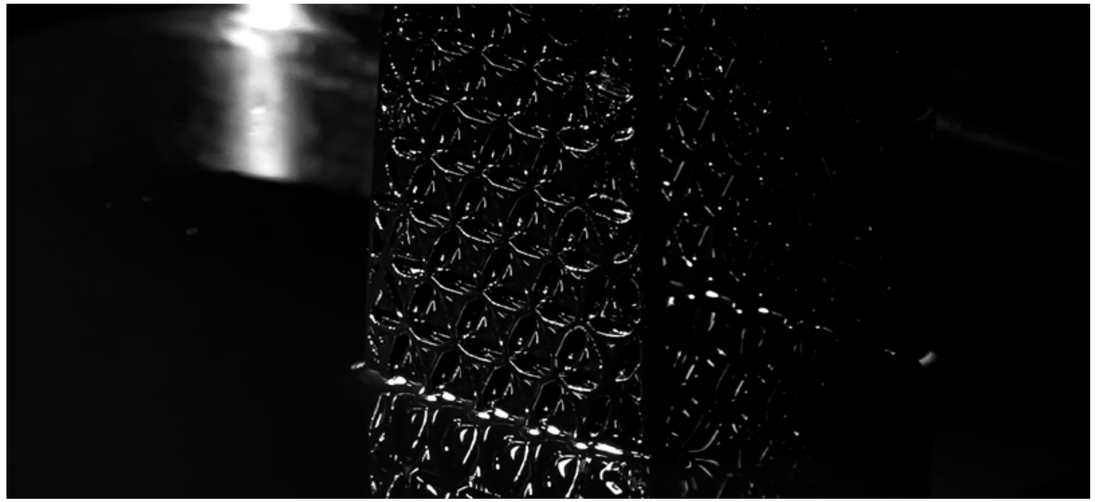
5: Production Implementation

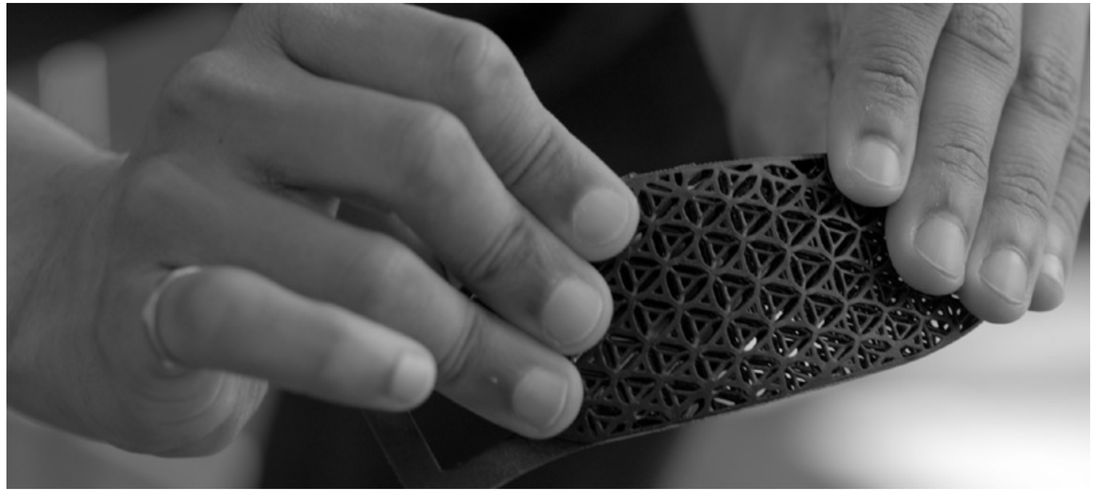
Goal:
Transfer proven production process to your in-house production efforts or a certified Carbon production partner (contract manufacturer). Replicate efficiency and throughput proven at Carbon.

Process:
Complete pre-production runs are carried out either by your in-house production facilities or the Carbon production partner. The key deliverable in this step is to replicate efficiency, yield, and throughput previously proven at Carbon. Carbon provides all necessary guidance to your production team or Carbon production partner as needed. Carbon engineering resources are also made available for on-site help and troubleshooting for a smooth transition.

Duration:
Typically 2–6 weeks, could be more depending on the complexity of the process and unforeseen process optimization challenges.

Once the design of the inserts was locked, Rawlings collaborated with Fast Radius to lock in the digital workflow, optimizing for production efficiency, yield, and speed. It was critical that the handoff of projects from design to production was thorough, frictionless, and transparent to ensure success and return on investment for Rawlings.





Production

6: Production Ramp-up and Support

Goal:
Your in-house production facilities or Carbon production partner ramps up production and delivers part output goals.

Process:
In this last stage, production is independently ramped up to meet output goals for your 3D printed products or parts. At this stage, Carbon or your Carbon production partner plays a supporting role and helps with troubleshooting or solving unforeseen technical challenges. With production in full swing, you and your team can now build on the success of this engagement and start working on your next projects.

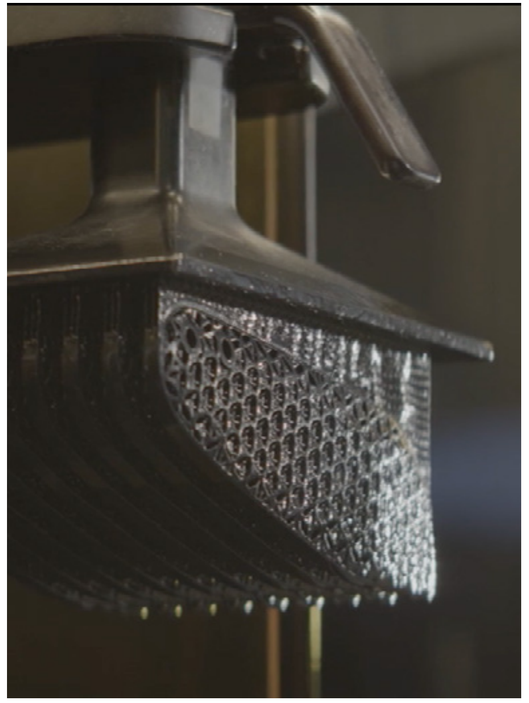
Duration:
Depends on complexity of production process, geography, and number of production sites.

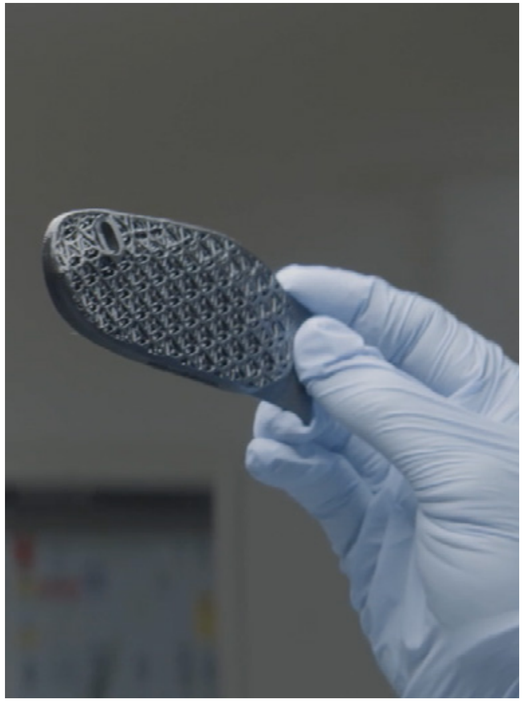
Fast Radius won the opportunity to start off producing 1,200 gloves for Rawlings, with plans to continue to ramp up production next season.

By tapping into the Carbon ecosystem and passing production to Fast Radius, Rawlings was able to continue design iterations for new projects using their in-house Carbon 3D printer.

“The process was truly seamless and fast; it got us to a phenomenal result in the end.”

-Ryan Farrar, Senior Director, Ball Gloves, Rawlings





Results

Rawlings, with the initial design help from Carbon paired with production support from Fast Radius, was able to develop an ultra-lightweight, professional glove that can be game-ready faster and stay game-ready longer.

Rawlings' REV1X Performance Stats

30%
Reduction in Weight

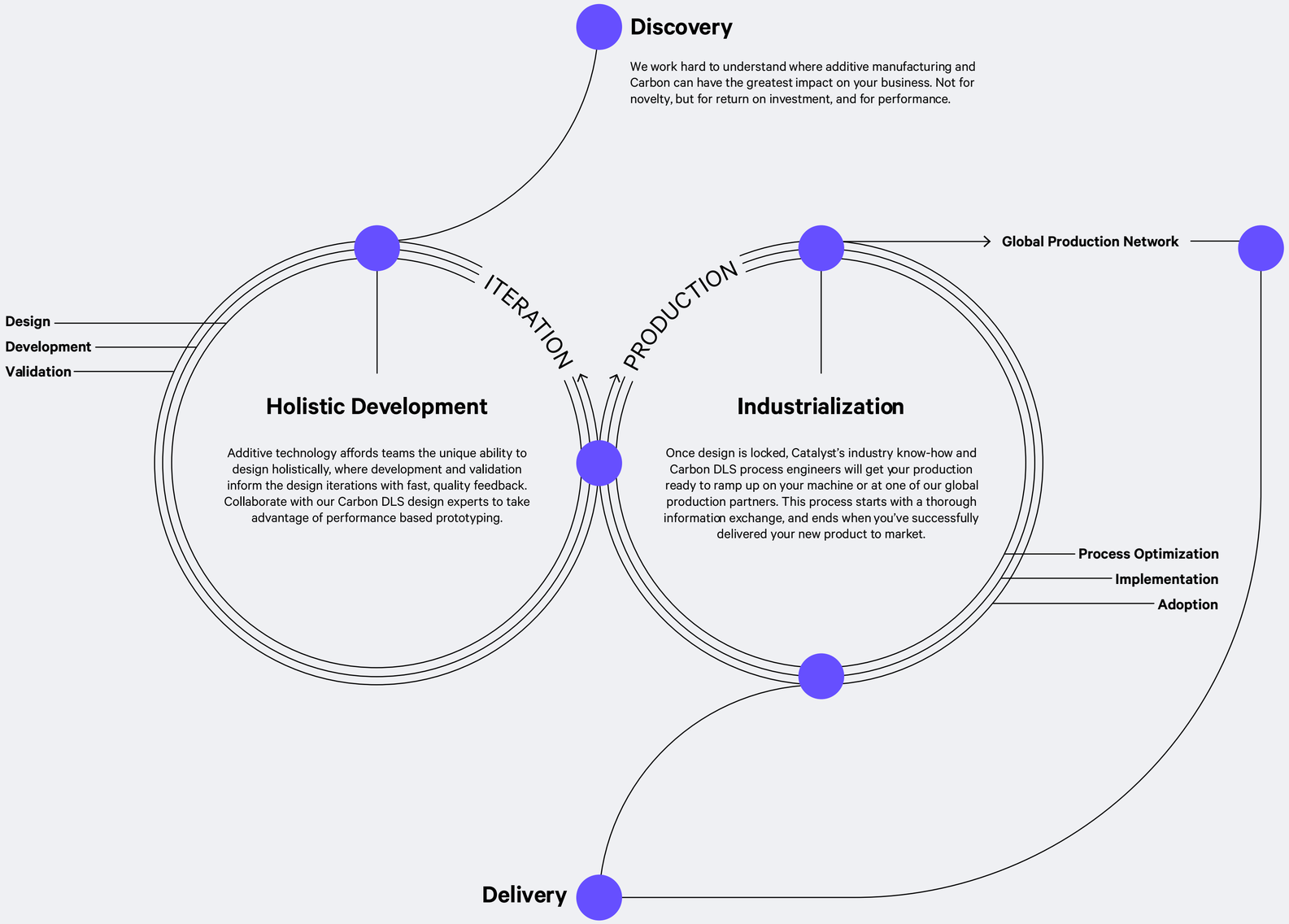
2X
Stiffness to Weight Ratio

21%
Tougher than Felt

Summary

The Carbon platform is currently being leveraged by medium- to large-enterprise customers in consumer goods, automotive, life sciences, and industrial segments. These companies are creating highly complex and differentiated 3D printed parts previously unthinkable with traditional manufacturing technologies.

Working in close partnership with our customers, Carbon has developed a robust process that can significantly reduce time to market for new products, depending on the complexity of the process, complexity of the parts, and the ability of all stakeholders to align on the key deliverables around material, design, business, and the production process as highlighted below.



Conclusion

We hope this guide has given you a deeper understanding of product development with Carbon and has inspired you to lean into the design freedom and economic advantages of 3D printing. Now you can clearly envision what developing your next-generation products with Carbon could really look like for you and your team.

Request Free Sample Parts

Interested in experiencing parts printed with the Carbon DLS process?
Visit our **Get Parts page** to request sample parts.

Our free engineering kit includes an elastomeric lattice puck made of EPU 41 and three tensile bars made of our versatile rigid polyurethane materials, RPU 130 and RPU 70, and our epoxy-based material EPX 82.

GET THE FREE ENGINEERING KIT

Get Part Pricing

Get a quote from a certified Carbon production partner. These manufacturers are certified experts in the Carbon DLS 3D printing process––from design to production. Tell us more about your product or part needs **here** and we will connect you with the right manufacturer from our **global network of production partners.**

GET PART QUOTE

Get Your Part Made

Do you have a part you would like printed with the Carbon DLS process? Give us some basic information and we will connect you with the right partner from our global network of production partners.

GET YOUR PART MADE

If you have questions or would like to learn more about product development with Carbon, please reach out to **info@carbon3d.com.**

Carbon®

3D as It’s Meant to Be