BREAK THE MOLD

In the fast-moving world of 3D printing, Carbon has the strategy and technology to adapt to change.

BY DAVID BAUM | PHOTOGRAPHY BY BOB ADLER/THE VERBATIM AGENCY

Joseph DeSimone made a bold move back in 2015 when he took the stage at a TED conference to launch Carbon, Inc. He not only claimed that his company's 3D printing process was 100 times faster than competing technologies; he also proved it. "We own the intersection between hardware, software, and molecular science," the CEO at Carbon claimed, as a red geodesic ball took shape in a Carbon M1 printer nearby—a shape-shifting miracle he said was inspired by the movie *Terminator 2*, when a T-1000 android arose from a liquid-metal puddle.

Carbon's M-Series 3D printers use light, oxygen, and sophisticated software to "grow" 3D objects from a pool of resin. However, Carbon's scientific breakthrough isn't just about creating plastic parts more efficiently. It's about enabling big-name manufacturers such as Ford, Johnson & Johnson, and adidas to create custom parts—and even complete products—tailored to consumers' exact needs. BMW used Carbon's Digital Light Synthesis, enabled by Carbon's Continuous Liquid Interface Production (CLIP) technology, to create unique plastic parts for MINIs in its DriveNow fleet, and Johnson & Johnson is collaborating with Carbon to create custom surgical instruments. Meanwhile, adidas is producing

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the world's first 3D-printed performance footwear. Rather than mass-producing many identical copies of stamped or molded materials, the shoe manufacturer can fashion soles for each consumer's weight, foot contours, and running habits—finally attaining that much-vaunted goal of manufacturing: economically delivering goods to a "market of one" (see "Market of One" sidebar).

According to Luke Kelly, vice president of finance at Carbon, most 3D printers don't actually do 3D printing at all. Instead, they use traditional inkjet techniques to lay down plastic in successive layers, a repetitive 2D process that gradually builds a 3D object. Carbon's M-Series 3D printers, in contrast, transform liquid plastic into seamless objects in one continu-
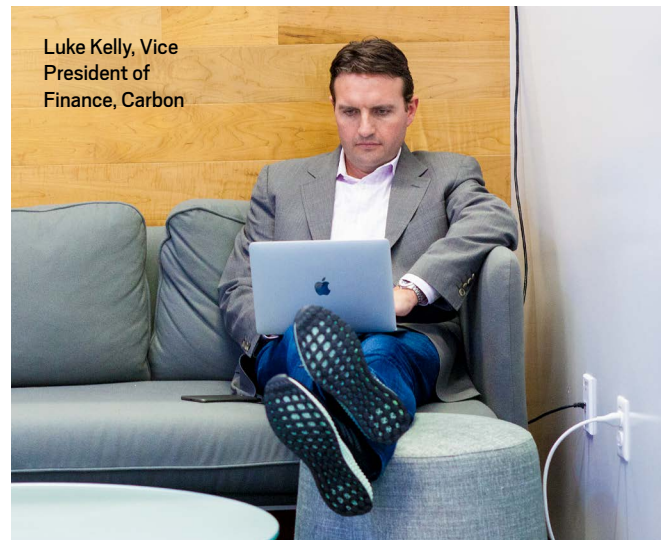
Luke Kelly, Vice President of Finance, Carbon

SNAPSHOT CARBON carbon3d.com

Industry:
Manufacturing
Employees:
200
Oracle products:
Oracle Human Capital Management Cloud, Oracle Enterprise Resource Planning Cloud, Oracle Supply Chain Management Cloud, Oracle Service Cloud, Oracle Enterprise Performance Management Cloud

LUKE KELLY
Vice President of Finance
Length of tenure:
Two years
Education:
BS, State University of New York, business management and political science; MBA, Duke University, Fuqua School of Business
Personal quote/mantra:
"You must be the change you wish to see in the world."
—Mahatma Gandhi

ous cycle, allowing designers to skip the intermediate steps of prototyping and tooling when creating finished products.

"Most of the parts that come off of 3D printers are not strong enough for production use," explains Chris Hutton, director of business operations at Carbon. "They fall apart, they are powdery, and they are porous. Our printers yield finished parts with mechanical properties comparable to the thermoplastics that you traditionally see in injection molding."

Based on its patented CLIP technology, Carbon moved quickly out of stealth mode following DeSimone's 2015 TED talk. The company now has a worldwide customer base, US$222 million in funding, and a team of 200 employees working feverishly at its Redwood City, California, headquarters.

Hutton came on to oversee the operation and implement the information systems necessary to launch this promising startup into a global company. "We suddenly found ourselves competing in some of the world's largest manufacturing markets," he recalls. "We wanted to build our business on standard software applications—with an emphasis on configuration, not customization."

To get up to speed quickly, Carbon looked to Oracle Cloud.

"We have a complex business, with global field service, continual hardware and software updates, and the need to coordinate materials from third-party providers via a global supply chain," says Kelly. "We needed a cloud solution that could give us complete visibility into our connected manufacturing process. We decided to work with Oracle because it had a platform that could run our business. Not having to build and maintain data centers is an advantage for a startup, even a well-funded startup."

Connected Business Flows

Carbon doesn't sell its printers, but rather it offers them in a hardware-as-a-service model via three-year subscription agreements. Each subscription agreement includes unlimited use of the printer, automatic software updates, and extensive customer support. (Carbon also has production partners that handle one-off jobs for customers.)

When it comes to the business processes that support fundamental operations, Carbon has figured out the key to success: put your effort into the handful of information systems that differentiate your firm. They mapped out *signature* processes that differentiate the company (such as their Internet of Things–enabled predictive service), *core* processes that are critical to operations (such as asset management for subscriptions), and *infrastructure* processes that simply have to work (such as accounts payable).
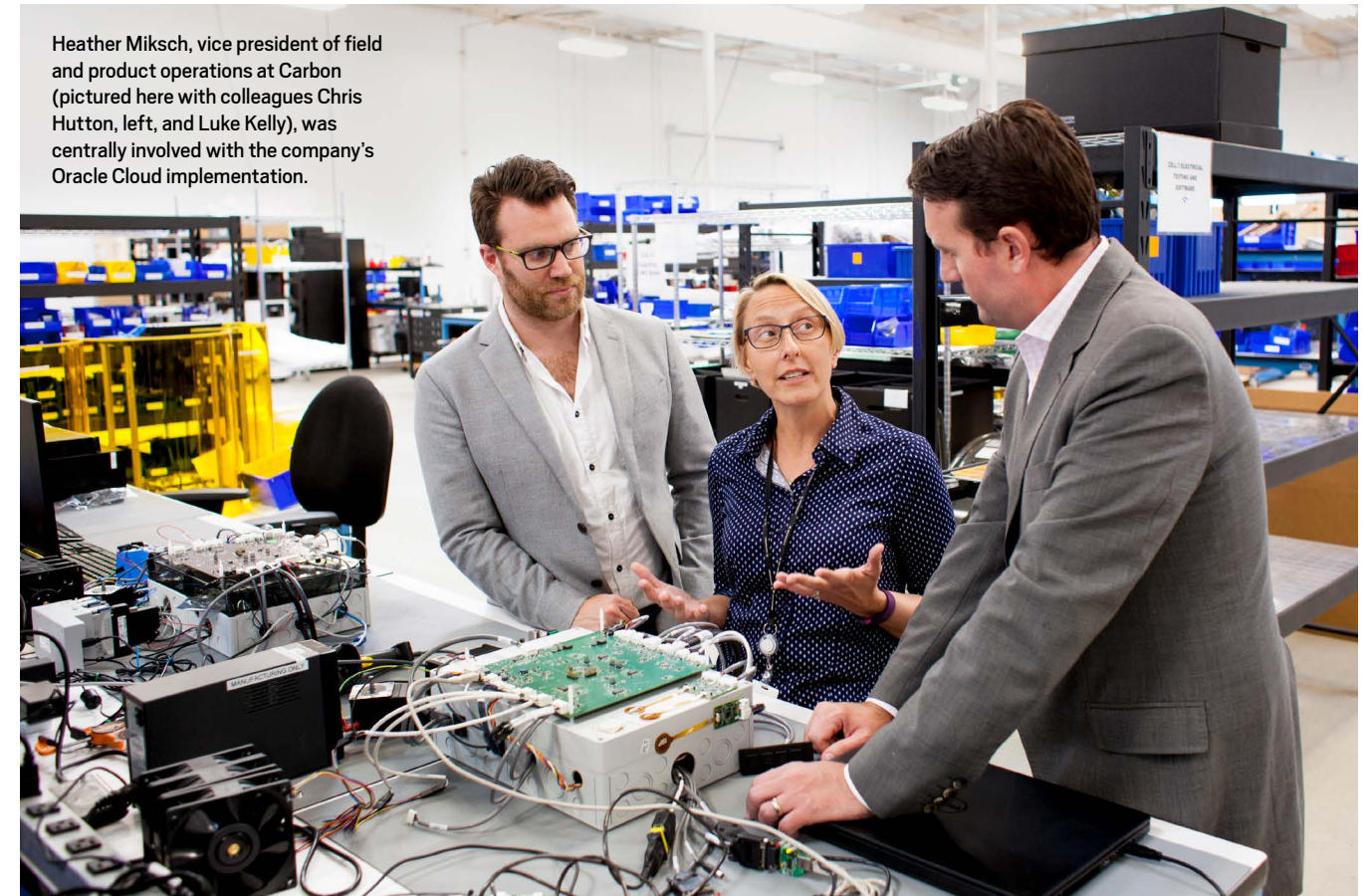

Heather Miksch, vice president of field and product operations at Carbon (pictured here with colleagues Chris Hutton, left, and Luke Kelly), was centrally involved with the company's Oracle Cloud implementation.
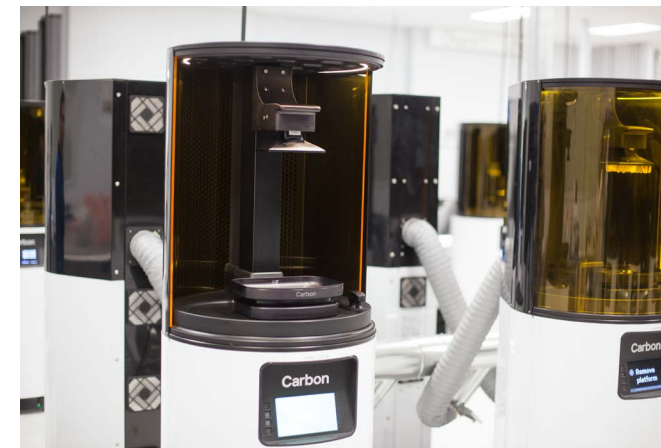
25–100
Percentage by which the Carbon M1 printer process of pulling 3D objects out of a bath of photosensitive resins is faster than the stereolithographic methods that characterize other 3D printers
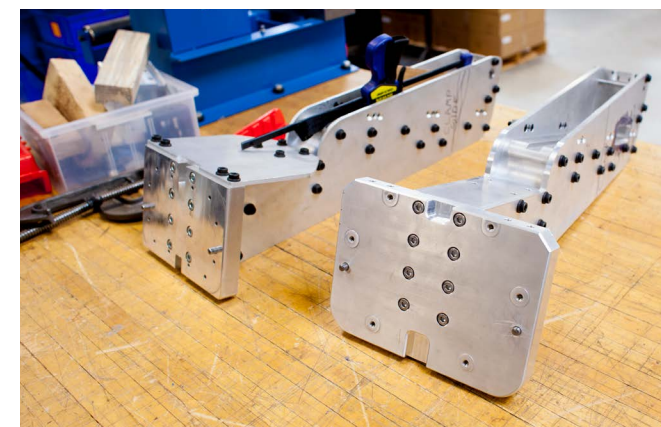
"We have invested significant time and customization in only approximately 10 of 200-plus Oracle Cloud processes," Hutton says. "All the others we took exactly as they were, out of the box from Oracle."

Carbon is now rolling out standard Oracle Cloud processes for customer service, finance, procurement, human capital management, inventory, order management, manufacturing, and supply chain. Its business is based on eight key business flows such as *plan to make*, *design to release*, and *order to cash*, each anchored by Oracle master data natively embedded in the cloud systems.

"We completed our first cloud implementation in just three months, with help from DAZ Systems," Hutton adds. "All the modules are natively integrated, everything is upgraded together, and we don't have to worry about maintaining hardware."

Dawn of the Predictive Service Model
Carbon didn't have an IT team when it started the journey to the cloud, so Hutton oversaw the Oracle Cloud implementation—with ample help from line-of-business managers

Heather Miksch, Vice President of Field and Product Operations at Carbon, with colleagues Luke Kelly (left), Vice President of Finance, and Chris Hutton, Director of Business Operations

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including Heather Miksch, vice president of field and product operations at Carbon. "My service operations manager, Maya Apolinario, handled the upgrade to Oracle Service Cloud," Miksch reports. "She's not an IT person, yet she managed the cloud implementation herself."

Miksch spent the first two weeks of her tenure at Carbon trying to make sense of the charter that DeSimone had given her: "Make sure our customers love us and love our products." *Love* is a strong word in a business context, and as she pondered the CEO's directive, it gradually dawned on her what the difference is between "like" and "love" in business dealings. "You may like companies that execute transactions for you," she says. "You reserve love for companies with which you have relationships."

Based on this premise, Miksch set lofty goals for Carbon's service organization. She knew that responding to breakdown repair in two days was standard for capital equipment companies. Could Carbon resolve customer issues the same day they were logged? How about *before* they were logged?

Miksch and her team decided to use machine data from the printers to reveal early signs that a customer might be struggling, so they could proactively intervene. "Instead of focusing on how quickly we could respond to customer problems, we decided to focus on predicting them," she reports.

The key to achieving this milestone involved collecting Internet of Things (IoT) data and establishing real-time links with Oracle Service Cloud. This venture coincided perfectly with what Kelly and Hutton were striving to accomplish with their connected cloud systems: they wanted a real-time supply chain driven by data from the 3D printers.

MARKET OF ONE

When it comes to commodity markets and global supply chains, there are few sectors as steady, predictable, and difficult to disrupt as footwear. How do shoe manufacturers bring innovation to a stalwart, US$52 billion market that produces tens of billions of shoes each year?

adidas might have the answer. The popular footwear brand is leveraging Carbon's 3D printing technology to create customized athletic shoes for each customer.

It all began when adidas set out to create shoes with variable properties across the midsole, tailoring shoe performance for different sports. However, its goals presented a manufacturing quandary: there is no easy way to create injection- or compression-molded objects with variable properties. Previously, the only way to achieve this level of customization was to assemble the sole from multiple injection-molded parts, an expensive and labor-intensive process that introduced multiple potential points of failure.

adidas' designers knew they could create custom soles with a 3D printing process, but 3D printers are generally not designed for manufacturing scale. And while adidas could

use a 3D printing process to create prototypes of their midsoles, the final design would be constrained by the ultimate production process—injection and compression molding. To overcome this constraint and "print" final midsoles, adidas is leveraging Carbon's factory-ready 3D printing method.

"We are not just creating prototypes for assessing a design's visual appeal," explains Chris Hutton, director of business development at Carbon. "We can actually test midsole performance in the design stage, because each iteration is produced with the same process and material as the final product."

Rather than mass-producing many identical copies of stamped or molded materials, adidas can now fashion athletic shoe soles for each customer's precise weight, foot contours, and running habits. adidas expects to ship 5,000 pairs of its FutureCraft 4D shoes by the end of 2017 and more than 100,000 by the end of 2018, according to company reports.

Better Service with IoT

Each of Carbon's 3D printers has more than two dozen sensors that measure machine data such as oxygen levels and motor variables, as well as operational data such as how much resin is being used, what type of resin, who the operator is, and whether or not the operator aborts the print jobs. "We are streaming about 1 million data points per day from each printer," says Hutton, "including analytical data on the performance and output of each printer. We want to eliminate all downtime. Thus, we measure how each motor in each printer is performing."

To supplement this machine data, Miksch created a feedback loop that allows customers to rate the quality and experience of each print job. Clicking the "request for help" button in the printer's user interface automatically opens a ticket in Oracle Service Cloud. When a field agent or relationship manager clicks that ticket, they can see troubleshooting information from Splunk—a software package for searching, monitoring, and analyzing machine-generated big data—with the exact print job linked to that ticket. They can escalate the ticket through JIRA, an issue-tracking software product from Atlassian.

"Our relationship managers don't have to hunt for information or retype anything," Miksch says. "Information is drawn together from a bunch of different systems, but it's all linked through Oracle Service Cloud."

Welcome to the Connected Enterprise

According to Kelly, having connected information systems in the cloud makes it easier to interact with a global supply chain in an economical way. "We can accommodate new customers and move into new regions without capital investments in infrastructure," he notes. Carbon plans to use the Oracle Cloud software to streamline interactions with the partners that produce Carbon's essential printer components. "A time will come when the vast majority of our inventory is entirely outside of our walls," Kelly explains. "Being able to seamlessly integrate with those providers via real-time data feeds and manage inventory globally through our integrated Oracle Supply Chain Management Cloud system will be a huge enabler for our business."

Miksch foresees a similar progression in the service department. When field service engineers open a ticket in Oracle Service Cloud that requires ordering parts, the inventory will be automatically decremented from the Oracle warehouse management system and added to the field stock, and the

Oracle accounting system will be updated with the appropriate entries in the general ledger. "All of the data will flow naturally to keep the inventory, finance, and supply chain modules updated," she says. "We have integrated Oracle Service Cloud with a number of our databases to share information. Our entire business, not just the service business, depends on printer data."

Soon, Carbon's Oracle Cloud software will streamline the integration and management of contract manufacturers as well. Having a constant read on capacity and lead times with tier 1 resin suppliers will be critical to how Carbon operates its business. "We can identify where we are with our suppliers and provide them accurate, up-to-date forecasts as we change our inventory position," Kelly says. "Our vision is for seamless integration with key suppliers and with our own engineering and manufacturing teams. This type of versatility and scalability was the driving force behind our move to the cloud." □
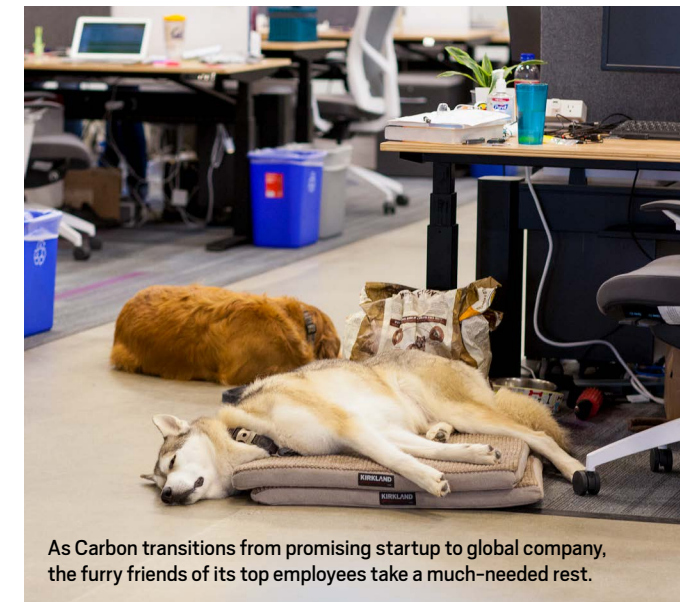
As Carbon transitions from promising startup to global company, the furry friends of its top employees take a much-needed rest.

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ACTION ITEM

Scan to learn more about the Oracle solutions featured in this story.