

CLOUD MANUFACTURING



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Executive Summary

The manufacturing industry is on the brink of a sweeping transformation.

Advanced digital technology will reinvent the manufacturing industry as dramatically as the steam engine or the assembly line did. Still, manufacturing has lagged behind nearly every other industry in adopting digital technology to simplify operations and provide a frictionless customer experience. There's no shortage of new digital tools meant to simplify portions of the manufacturing process, but these tools often make things more difficult because they don't integrate with existing systems. Manufacturers yearn for efficient solutions to the complex challenges they face — like streamlining complex global supply chains and minimizing the risk of investing in new technology.

At Fast Radius, we are advancing the industry with an integrated digital and physical platform that simplifies the way we design, make, and move parts around the world. We call it Cloud Manufacturing, and we believe it will transform an industry that's overdue for digital disruption.

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This white paper:

01

Defines Cloud Manufacturing as a single, end-to-end solution that integrates design, production, and fulfillment operations through a common digital infrastructure to manage a part's entire lifecycle.

02

Draws connections between Cloud Manufacturing and cloud computing and explains the components of Cloud Computing — physical and digital infrastructure; digital thread and learning engine; operating system; and applications.

03

Demonstrates how Cloud Manufacturing overcomes the biggest obstacles to adopting new technology by integrating disparate operations, providing open access to cutting-edge factories, and sharing data to create transparency in the manufacturing process.

04

Introduces Fast Radius's vision for Cloud Manufacturing and our current solutions, which include Additive Launch, the Virtual Warehouse™, and on-demand manufacturing.

05

Previews the Fast Radius Cloud Manufacturing roadmap for the next 2-3 years, outlining the ways our software will advance application discovery, design, manufacturing, and fulfillment.

06

Illustrates the benefits of Cloud Manufacturing for businesses of all sizes.

Introduction

Manufactured goods build the physical world around us and power our global economy. Innovations in manufacturing can mean material improvements to the human condition, but making the products that shape our lives is a massive global effort. Given the capital expenditures and resources required to mass produce, move, assemble, inspect, and fulfill physical goods across the world, transformation in the industry doesn't happen overnight. It's no surprise then that manufacturing has been slower to experience the kind of digital disruption that has reshaped other industries in the past two decades.

Manufacturing is ripe for disruption because technology and market forces are aligned to unlock a digital transformation. Here are three reasons why:

Innovation driving hypergrowth:

Technologies for design, manufacturing, and fulfillment have driven hypergrowth in digital manufacturing and software. For example, global revenue from 3D printing-related products and services neared \$12 billion in 2019 and is expected to grow nearly 3x to \$35 billion by 2024.*

User expectations:

B2B customers expect a modern, frictionless user experience thanks to the evolution of enterprise software platforms like Salesforce, Oracle, and SAP. Organizations are ready for manufacturing solutions that can provide a similarly streamlined online experience

Supply chain challenges:

Manufacturers are hungry for more agile, resilient, and sustainable supply chains. Risk, cost, and speed were already major pain points, and they became significantly worse in the pandemic. Most companies are accelerating changes toward flexibility and speed that can be achieved with digital technologies.

Manufacturing is hard, even though there is no shortage of technologies and services that aim to make it easier. The very technologies that are supposed to simplify operations are often part of the problem because they don't easily integrate with existing systems and are difficult to implement. We can eliminate this friction by solving three specific problems:

Offer manufacturing as an integrated, end-to-end solution.

The work required to create new manufacturing supply chain can be impossibly complex, requiring integration between separate systems that support different steps in the manufacturing product lifecycle.

Make manufacturing innovation accessible.

Many organizations want to access modern manufacturing technologies but lack the resources required to implement them. Small companies lack the capital and expertise, and large companies don't want to take a risk on an unproven technology.

Create transparency and trust.

Today's contract manufacturers work in isolation and rarely provide transparency into their operations. In the best case, engineers hope to get (but aren't guaranteed) correctly made parts on schedule. At worst, they receive parts that don't meet specifications with little explanation or recourse.

These problems are far from intractable. After all, the history of manufacturing is marked by Industrial Revolutions — sweeping transformations in how we make and move things around the world. Harnessing the power of digital technology to reimagine manufacturing is the challenge of our generation, and we have the solution. Our team at Fast Radius is building an accessible platform that simplifies the manufacturing process using advanced production equipment and digital intelligence.

The solution is Cloud Manufacturing, and it represents a paradigm shift akin to previous industrial revolutions. Just as mechanization, mass production, and automation triggered new eras in manufacturing, Cloud Manufacturing allows us to realize the potential of the digital age by democratizing, integrating, and connecting manufacturing activities across the world.









*Wohlers Report 2019, 2020.

What is Cloud Manufacturing?

Cloud Manufacturing is a single, end-to-end solution that integrates design, production, and fulfillment operations through a common digital infrastructure.

Cloud Manufacturing and Cloud Computing

The term Cloud Manufacturing draws its name from cloud computing, and there are many similarities between the two. Both employ internet-connected facilities where users access shared physical resources; both use software to orchestrate operations between systems and information; and both allow users to build applications without having to invest in complex infrastructure. The chart below draws a direct comparison to the components of each concept.

CLOUD COMPUTING	CLOUD MANUFACTURING
 Applications and services: User-facing applications accessed via internet that run on data center resources	 Applications and services: Customer-facing interfaces for order management, design, production monitoring, fulfillment, and warehousing
 Network infrastructure: Software and communication protocols that manage data center resources and transport traffic	 Operating system: Software that manages and consolidates data between different parts of the platform
 Data-driven learning and AI: Data collected and analyzed at every step in the computing workflow to improve operations and outcomes	 Digital thread and learning engine: Data collected and analyzed at every step of the production process to improve operations and outcomes
 Data centers: Physical locations that house shared computational, network, and storage systems	 Physical and digital infrastructure: Hybrid factory/fulfillment sites that produce physical parts and collect data

How Industry 4.0 technologies fuel Cloud Manufacturing

Industry 4.0 refers to digital tools that orchestrate and streamline the operations of industry. In manufacturing, this includes software for digital design and simulation, digital metrology, factory monitoring and control, logistics software, and more. These are the key Industry 4.0 concepts fuelling Cloud Manufacturing:

Digital manufacturing: Manufacturing methods like additive manufacturing and computer numerical control (CNC) machining create physical parts directly from digital designs.

Cloud computing: Cloud Manufacturing applications are built on cloud services so that users can access them anywhere, allowing manufacturing work outside the factory floor.

The Industrial Internet of Things (IIoT): The lifecycle of every part is fully traceable with data collected from digital manufacturing equipment and external sensors.

Artificial intelligence (AI): Systems analyze data and outcomes to discover patterns and implement changes that continuously make processes smarter and more effective.

Vision

Cloud Manufacturing with Fast Radius

In the next decade, Cloud Manufacturing will have as profound an impact on the way we make and transport physical goods as cloud computing has had on the way we access and analyze information.

We're building a first-of-its-kind Cloud Manufacturing platform that will democratize access to new technology, coordinate and unify disparate operational systems, and create transparency for users.

The Fast Radius Cloud Manufacturing Platform

Platform structure

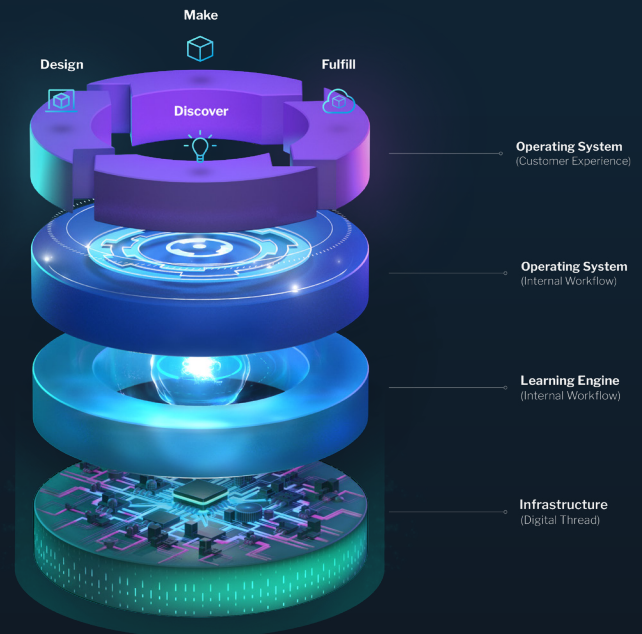
The Fast Radius Cloud Manufacturing Platform is built on four components that collect, organize, and analyze data from every step of the product lifecycle. The graphic below illustrates how our platform is structured.

Applications and Services: Our platform provides specific solutions for external users and internal operations.

Operating System: Our software links all the components of the production process and presents a transparent view across the life of a part.

Digital Thread and Learning Engine: Our learning engine analyzes the data we collect about every part we make, allowing us to continuously improve operations and make better parts.

Physical and Digital Infrastructure: Our production centers around the world make parts and collect data throughout the manufacturing process.



Cloud Manufacturing

Current Fast Radius Cloud Manufacturing solutions

We are continuously improving and expanding our platform, and today our customers can access three solutions powered by Cloud Manufacturing.

SOLUTION	DEFINITION	EXAMPLE
Additive Launch	Use the most advanced additive manufacturing platform in the world to discover, design, and make production parts.	We make serial parts that meet strict industry regulations for Aptiv and Ford in our world-renowned additive factory. Our tool-free approach saved 20 weeks of product development time over injection molding.
Virtual Warehouse™	Store design and production specifications digitally and produce parts only as needed for true just-in-time fulfillment.	Satair worked with us to redesign existing tools for additive manufacturing. The resulting parts are lighter, stronger, and can be manufactured and fulfilled in only 48 hours instead of months.
On-demand manufacturing	Upload designs, evaluate manufacturing options, and order parts from our secure interface.	We worked with Cobalt Robotics to improve the way they made multiple parts, saving them 60% in production costs for cast urethane, 33% on additive parts, and 90% on painting and finishing. By managing logistics, we also cut two weeks of project time from each part produced.

The next phase of Cloud Manufacturing at Fast Radius

We have an ambitious roadmap for the Fast Radius Cloud Manufacturing Platform over the next several years. Here are some key elements we are developing now:

Factory Footprint

We currently have two production centers that produce and fulfill additive and CNC-machined parts, and we work with a global network of vetted suppliers to produce injection-molded, cast urethane, and additional CNC parts. In the next 2-3 years, we will expand our factory footprint, starting with the announcement of our third production center in early 2021.

Software Development

We're developing customer-facing applications that allow engineers to compare manufacturing methods, build a business case for additive manufacturing, and share their designs with the broader community.

Design

Our design software uses machine learning to improve with every part we make (10+ million parts to date). We are capturing and codifying centuries of engineering expertise and making it available to engineers everywhere. We're also building tools to make design collaboration easier within our platform.

Manufacturing

We're building a virtual factory experience where customers can monitor their parts in our production center as if it's their own on-premise infrastructure. Expect real-time monitoring in addition to applications for order management and production scheduling.

Fulfillment

In the next few years, customers will be able to integrate their procurement and ERP systems with ours for a seamless experience.

Open Ecosystem

We have an extensive roadmap of applications we're bringing to market in the coming years, and we will soon open our ecosystem so that others can contribute to it.

Tangible Benefits of Cloud Manufacturing

Cloud Manufacturing will benefit manufacturers of all sizes by making their processes more efficient, cost-effective, and flexible. These are the key benefits we will see across industries.

01 Faster time to market for new products

- Cloud Manufacturing gives engineers access to world-class design tools and the technology to produce their ideas whenever they can access the internet.
- Digital manufacturing methods allow for faster design cycles since functional prototypes can be produced in days instead of weeks or months.

02 More flexible and resilient supply chains

- Cloud Manufacturing allows users to scale solutions to meet shifts in demand without being limited by their onsite capabilities or existing supply chains.
- Design files and production specifications can travel across the world to be produced reliably wherever there is capacity.
- Cloud Manufacturing mitigates disruptions in the supply chain that come from trade restrictions, natural disasters, and even outages in specific factories.

03 Visibility and traceability

- Cloud Manufacturing allows us to trace every part individually through the entire production process, giving us the ability to catch mistakes before they happen.
- If parts fail, we can isolate every datapoint in the production cycle to identify exactly what went wrong and take corrective action immediately.

04 Sustainability

Cloud Manufacturing will help the industry move toward sustainability:

- We can reduce carbon emissions by producing parts close to the point of consumption rather than shipping them across the globe.
- Digital design tools allow us to make stronger, lighter parts, so we can use less material and fewer resources to transport parts.
- Virtual warehousing prevents manufacturers from over-producing parts that they may end up discarding.
- More efficient factories consume less energy, waste less material, and produce less carbon.

05 Cost savings

Cloud Manufacturing can reduce costs in several ways:

- Shorter design cycles and simpler supply chain operations reduce labor costs.
- Reducing risk in supply chains means fewer unanticipated expenses.
- Advanced design tools can make parts more cost-effective by using less material and reducing assemblies.
- The Virtual Warehouse™ reduces warehousing and carrying costs by allowing users to store parts digitally and produce them only when they're needed.

How to get started with Cloud Manufacturing

Cloud Manufacturing is the future, and those organizations that embrace it early will lead the next era of manufacturing.

Fast Radius is committed to making Cloud Manufacturing a reality. We're building a first-of-its-kind Cloud Manufacturing platform that transforms the way our customers make and move parts around the world. Our software allows users to manage design, manufacturing, and fulfillment in a single accessible digital platform. We make manufacturing so smart and easy that anything is possible.

Want to join us?

We are always looking for early adopters to test our solutions before they come to market. [Contact us](#) to find out more and visit os.fastradius.com to see our software in action.

