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# Cloud Manufacturing Creating a more sustainable future



# Contents

Executive summary	3
Introduction	4
1. Materials and design	8
Reduction of waste materials with additive manufacturing	
Lightweighting	
More sustainable prototyping	
2. Factory operations	11
Hyper-efficient micro-factories	
Part consolidation with additive manufacturing	
3. Supply chain	13
Reduce transportation emissions	
Carbon footprint assessment of cloud manufacturing: Transport implications	
Eliminate waste from obsolete parts	
Reimagine warehousing	
Conclusion	17
	4.5
Selected citations and references	18



# **Executive summary**

Sustainability is one of the most important issues that manufacturers face today. More than ever, manufacturers want to make and move goods more sustainably, but finding solutions for environmentally responsible manufacturing can be challenging.

The Cloud Manufacturing Platform<sup>™</sup> from Fast Radius gives individuals and organizations options for more sustainable production throughout the entire product lifecycle. Over the life of a product, cloud manufacturing can lead to a total emissions reduction of 19%.

This white paper outlines how cloud manufacturing enables sustainability in three ways:

- O1 Empowers customers to make choices about design and materials that can lead to more sustainable parts and products.
- O2 Makes **factory operations** more effective and efficient by constantly learning, optimizing, and adjusting processes.
- 03 Makes **supply chains** shorter, reducing greenhouse gas emissions and the overall environmental footprint associated with warehousing and obsolescence.

19%

of manufacturing emissions can be reduced with cloud manufacturing

## Introduction

Every manufactured product — from cars to cell phones – has an impact on the environment. The environmental footprint is the sum of the ways a product interacts with and affects the natural environment, and it's determined by the decisions that are made about its design, material, manufacturing, and transportation to its end use destination.

To understand the environmental impact of a manufactured part, start by considering the energy used in every step of the production process. Raw materials must be extracted and converted into a usable form by processes that use energy. There are emissions associated with transporting those materials to factories where they'll be made into parts. Then those parts make environmental impacts as they move through the supply chain to be assembled and packaged before they end up in the hands of the end consumer. Myriad decisions come into play as manufactured goods move through the product lifecycle. From the origin of the raw materials to the source of electricity used in the factory to the shipping method used to get a product to its destination, the cumulative environmental impact of these decisions is massive. Research from The World Resources Institute shows that industrial activity, which includes manufacturing, accounts for 24% of global greenhouse gas emissions.

In addition to their carbon emissions, industrial processes create a significant waste footprint, with consequential impacts for society and the environment. In the US alone, the <u>EPA has estimated</u> that approximately 7.6 billion tons of industrial solid waste is disposed of every year.

Across the world, companies are taking steps to reduce their environmental impacts. The UN Sustainable Development Goals (SDGs) make clear that responsible consumption and production are integral to sustainable business practices, providing greater value to society with less material input. To support achievement of the SDGs, more than 20% of the world's 2,000 largest public companies <u>have pledged</u> to meet net-zero carbon emissions targets. More than ever, the way we make goods needs to be reimagined to be more efficient and sustainable.

Fast Radius is excited to introduce our <u>Cloud Manufacturing Platform</u>, an innovative solution that can dramatically improve the sustainability of manufacturing. Fast Radius' Cloud Manufacturing Platform is an end-to-end solution that integrates design, production, and fulfillment operations through a common physical and digital infrastructure.

The Fast Radius Cloud Manufacturing Platform is an innovative solution that can dramatically improve the sustainability of manufacturing.

# The Cloud Manufacturing Platform<sup>™</sup> has four components:

#### 1. Applications and services

Specific solutions that help our customers to design, manufacture, and fulfill their goods.

### 2. Digital thread and learning engine

A learning engine that analyzes the data we collect about every part we make, allowing us to continuously improve operations and make better parts.

#### 3. Operating system

Software that orchestrates the customer experience and our internal workflows.

### 4. Physical and digital infrastructure

Micro-factories around the world that make parts and collect data.



Cloud manufacturing enables faster, more transparent, and more costeffective ways to manufacture goods in prototyping and production. With the tools of our Cloud Manufacturing Platform, customers can make sustainable choices and see the impact of their choices.

The impact of cloud manufacturing can be significant for the environment and for those individuals and organizations that choose to reduce carbon emissions and waste. By using our Cloud Manufacturing Platform, organizations will have the power to quantify the environmental impact of their manufacturing activity and make choices that help them to meet internal goals and external regulations.

# The Fast Radius Cloud Manufacturing Platform<sup>™</sup> enables sustainability across the manufacturing lifecycle:

#### Materials and design

Cloud manufacturing enables customers to make well-informed choices about materials and create designs that reduce waste, leading to more sustainable parts and products.



Our Cloud Manufacturing Platform was built to be more effective and efficient than traditional large-scale manufacturing. Our systems are constantly learning to optimize operations.



#### Supply chain

Cloud manufacturing makes supply chains shorter, reducing the carbon emissions associated with transportation, eliminating the need for physical warehousing, and reducing the potential for obsolete parts.



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## 1. Materials and design

Our Cloud Manufacturing Platform enables customers to make choices about designs and materials that can lead to more sustainable parts.

# Reduction of waste materials with additive manufacturing

As its name suggests, additive manufacturing (AM) builds a part by adding material whereas subtractive methods like computer numerical control (CNC) machining make parts by removing material from a larger piece. In each manufacturing process, leftover material is typically scrapped. The aerospace industry calls this the buy-to-fly ratio, defined as the ratio of how much extra material they have to buy to make a specific part. With traditional CNC milling, the ratio could be as high as 10:1, meaning it requires 10 kg of raw material to make a one kg part, but with metal <u>additive manufacturing</u>, aerospace manufacturers have gotten the buy-to-fly ratio as low as 2:1.

There are multiple applications where customers can leverage additive manufacturing capabilities to provide significant reductions in material input, ultimately reducing the environmental footprint of a product due to more efficient use of raw materials and energy.

## Technologies like HP Multi Jet Fusion (MJF) enable us to reuse leftover materials during additive manufacturing

The polymer powder used to create products through additive manufacturing is sometimes wasted because the chemical and physical properties are destabilized during the process. With only a small amount of powder being fused into a component, large volumes of powder are often rendered unsuitable for reuse.

Fast Radius uses <u>HP MJF</u> technology to minimize powder waste and reduce costs. MJF has the capability to automatically mix fresh and recycled powder in the additive manufacturing process, lowering the ratio of material purchased to material used. Fast Radius continues to explore partnerships and research to improve the resource efficiency of additive manufacturing.

### Lightweighting

Fast Radius gives customers access to manufacturing processes that can create lighter parts, which has sustainability impacts across production and fulfillment, and in the part's performance. Digital design tools like <u>generative</u> <u>design</u> and <u>topology optimization</u> allow engineers to make lighter parts by placing material only where needed to achieve the desired performance, thus reducing the raw and recycled material inputs.

Lighter parts can also be used in transport applications like cars and planes to save fuel, and consequently emissions. <u>The US Department of Energy</u> found that a 10% reduction in weight can amount to a 6-8% fuel economy improvement in automobiles, and a 20% reduction in weight can lead to a <u>10-12%</u> <u>improvement in fuel efficiency</u> in aircraft.

Our Cloud Manufacturing Platform allows customers to make lighter parts both through design and by presenting a wide range of material options. Increasingly, we are finding that advancements in materials engineering have made it possible to <u>transition legacy metal parts</u> to lighter plastics. In these cases, plastics make for lighter, more sustainable products that are often less expensive.

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### More sustainable product development

Cloud manufacturing enables both fast prototyping and scalable production on a single manufacturing technology platform, which ultimately reduces waste from testing prototypes and creating additional tooling.

The learning engine that powers our Cloud Manufacturing Platform allows us to learn from the production of millions of parts. These data allow us to anticipate and fix design and production issues, making prototypes more efficient and ultimately eliminating several rounds of prototyping. Fewer rounds of prototyping reduce material input, energy use, transportation, and parts to landfill.

With our Cloud Manufacturing Platform, manufacturers are no longer tied to minimum order quantities in the thousands when they only need to test a few units. This avoids the creation of extra prototypes that may end up in storage indefinitely or in a landfill.

Traditionally, moving from prototyping to production requires changes in manufacturing processes, materials, and designs. These changes lead to waste like excess tooling, and trial production runs are discarded once volume production starts. Making parts in Fast Radius' additive manufacturing micro-factories means you're prototyping on the same equipment you'll use for production, which allows parts to move seamlessly into production without generating this waste.

# 2. Factory operations

Our Cloud Manufacturing Platform is built to be more effective and efficient, and our systems are constantly learning to optimize operations.

### Hyper-efficient micro-factories

According to the <u>International Energy Agency</u>, the industrial sector uses 37% of global energy and produces about 24% of global emissions. Most environmental pollution is found to have its origins in industrial processes, with manufacturing alone accounting for 77% of industrial energy consumption.

Parts manufacturers can decrease their emissions by switching from centralized megafactories to micro-factories where software improves efficiency through visibility and coordination of all the people, machinery, and logistics involved in production. Our micro-factories are digitally connected and software controlled, which gives us full visibility into every aspect of production and fulfillment. With this visibility, we can proactively identify and eliminate

### WØRLD ECONOMIC FORUM

In 2018, The World Economic Forum recognized Fast Radius as one of the most advanced factories in the world. WEF gave us this accolade for our visionary micro-factory model and Cloud Manufacturing Platform. These innovations have the potential to create major sustainability impacts.

waste, such as excess energy consumption and idle time. When evaluating different manufacturing processes, designs, and materials, we can calculate the emissions impact of different choices giving the customer insights to make more sustainable decisions in product design and manufacturing. Using data from our micro-factories, we are building a learning engine that uses artificial intelligence to suggest the most effective ways to make and process parts and flag any causes for concern during the scale up to production. As a result, parts are less likely to fail and end up as scrap, creating an optimal production plan with fewer iterations and less waste.

Our Cloud Manufacturing Platform allows us to optimize factory operations to make sure our machinery is utilized as much as possible. Our software is capable of organizing our factory workflows so that every machine runs at a near-full schedule. Smaller shops typically do not see this kind of efficiency since they do not have the volume of smaller orders to keep machines busy.

### Part consolidation with additive manufacturing

Additive manufacturing allows us to consolidate multiple components into one because additive is uniquely capable of producing complex geometries that cannot be manufactured or are cost prohibitive using traditional manufacturing methods.

Part consolidation starts with a traditional design, for which multiple components would be manufactured separately and then assembled into a single unit. Using additive manufacturing, you can often print complex assemblies like hinges or chain links — as a single component. Consolidated parts eliminate the environmental impacts of manufacturing each component separately. <u>Part consolidation</u> also eliminates the need to ship components to a common location for assembly, reducing the labor needed to produce the part and the emissions associated with transportation. Parts can also be smaller and lighter due to the removal of joining and interface features.



#### The Steelcase SILQ chair armrest

The <u>Steelcase SILQ chair armrest</u> used to be assembled using three separate pieces, but thanks to additive manufacturing and complex latticed geometries, it is now printed as one piece. This removed manufacturing steps and allowed Steelcase to reduce material usage by 70%. With additive manufacturing, part consolidation allows for lower overall projection costs, less material, less risk, and better performance.

# 3. Supply chain

Cloud manufacturing makes supply chains shorter, reducing not only carbon emissions but also the environmental footprint of warehousing and obsolete parts.

### **Reduce transportation emissions**

The transportation sector is responsible for 30% of greenhouse gas emissions in the US, with freight accounting for 40% of that total, according to reporting from McKinsey. Since nearly a quarter of a part's carbon footprint is attributed to transportation, reducing the distance a part must travel can have a major impact. A study from the World Economic Forum found that air transport creates emissions 11x larger than truck transport and 31x larger than rail transport (per km/per ton). Building our micro-factories in locations that are accessible by truck or train to our largest customer bases minimizes the need for air freight and the associated environmental impact.

Fast Radius is constructing micro-factories at strategic locations around the globe to reduce the distance products need to travel to get to the end consumer. Centralized manufacturing in remote megafactories has historically been seen as a cost-effective solution, but it generates significant emissions. Cloud manufacturing offers improvements over centralized manufacturing. The modeling below, conducted by ERM, shows how cloud manufacturing can enable an 83% reduction in transportation emissions by shifting production from a single central location to distributed micro-factories around the world. Using distributed manufacturing, transportation can account for as little as 5% of a product's carbon footprint, down from 25%.



### Carbon footprint assessment of cloud manufacturing: **Transport** implications

Fast Radius' Cloud Manufacturing Platform, with distributed micro-factories, presents customers with the opportunity to achieve significant sustainability benefits compared to more conventional, centralized manufacturing.

Across the lifecycle of a product, in both centralized and distributed manufacturing, the greatest contribution to emissions comes from the materials used, followed by transportation and energy to manufacture the product at a factory. These two types of manufacturing differ in their impact on emissions associated with supply chain transportation. We projected that distributed manufacturing reduces transportation emissions by 83% over centralized manufacturing since distributed micro-factories are built closer to source materials, transportation hubs, and the end customer.



Materials



#### Carbon emissions across the lifecycle of a product

Across the lifecycle of a product, cloud manufacturing leads to a significant total emissions reduction of 19%. By using cloud manufacturing and making sustainable design choices, users can lower the carbon footprint at various points in the lifecycle of a product, thus minimizing overall climate impacts.

### Eliminate waste from obsolete parts

Manufacturers frequently order more parts than they need to meet minimum order quantities dictated by their suppliers or the need to create a reasonable cost basis for their parts. Excess parts collect dust in warehouses until they become obsolete, at which point they end up in a landfill. For instance, each year an average of 3,000 parts become obsolete on every car model on the road. The Cloud Manufacturing Platform enables customers to store designs in our Virtual Warehouse<sup>™</sup> and order only as many parts as needed throughout a product's lifecycle. Spare parts can be produced in small quantities as needed so warehousing excess parts becomes unnecessary.

Managing spare parts with the Virtual Warehouse has the added benefit of being able to extend a product's life. Typically, companies stop supporting a product after a certain period, at which point customers must dispose of the product entirely if a crucial part breaks.

With cloud manufacturing, all design and production information is stored in the cloud. If the part can be made with additive manufacturing, it can be printed on demand as needed - and in quantities as small as one. Crucial parts of a product can be replaced individually, instead of replacing full assemblies or disposing of the product entirely. This enhances the sustainability of the product by extending the useful life. In fact, the <u>US Air Force</u> is using 3D printing to manufacture the spare parts needed to keep some of its aircraft in the air.

#### Enhanced customer experience and costing savings: Eliminating waste from obsolete parts and reimagined warehousing

To enhance the sustainability of its products, <u>Husqvarna Group</u>, a global leader in outdoor power products for forest, park, and garden care, hosts parts the Fast Radius Virtual Warehouse. Upon request, Fast Radius can produce and deliver parts in a matter of days. With the Virtual Warehouse, parts are never out of stock, and Husqvarna does not have to physically store excess parts in warehouses.



### Reimagine warehousing

Logistic activities in global supply chains are a major contributor to industrial emissions and environmental pollution. A major component of the overall footprint of a product comes from storage and material handling processes in warehouses. These warehouses are often inefficient, holding thousands of parts and tools for outdated processes and products. For instance, a report from the <u>City University of London</u> references an interiors supplier that uses a 120,000-square-foot building to store more than 4,000 obsolete large injection-molding tools that date back to the 1950s. The environmental footprint associated with conventional warehouses can be eliminated by using the Cloud Manufacturing Platform and virtual warehousing.

By storing parts and manufacturing instructions on a virtual platform, customers can produce parts on demand and ship them directly to their destination. Eliminating or reducing the need for warehouses saves the resources needed to build and run warehouses themselves. The electricity, water, and HVAC needed for these facilities have a large environmental impact that can be reduced dramatically through virtual warehousing.

Beyond the environmental costs of running warehouses, eliminating warehousing reduces the need for transportation throughout the supply chain. Parts typically go from factory to warehouse to end customer. By eliminating the warehousing step, you eliminate an entire carbon-producing leg of that part's fulfillment journey.

## Conclusion

Every product has an environmental footprint built on numerous choices made during the design and production processes. Despite the best intentions, most product developers haven't been able to control most of the factors contributing to that footprint. Fast Radius' Cloud Manufacturing Platform finally empowers customers to make more sustainable choices.

Going forward, Fast Radius continues to explore ways our services can support the development of more sustainable products, such as greener options for end-of-life and packaging, which add minimally to carbon emissions, but are critical to consider when minimizing waste impacts.

Fast Radius has an ambitious plan to grow our Cloud Manufacturing Platform with sustainability infused into everything we build. As we develop our global network of micro-factories, and expand our software platform, our customers will be able to increasingly benefit from sustainable manufacturing.

#### Want to learn more?

<u>Contact us</u> to see how the Fast Radius Cloud Manufacturing Platform can help meet your sustainability goals. Cloud Manufacturing: Creating a more sustainable future

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