The Key to Transforming Additive Manufacturing

How an additive manufacturing software platform is the key to transforming the additive manufacturing industry.

Over the past few decades, additive manufacturing technologies have become widely used across various industries such as automotive, medical, aerospace, and commercial goods. Its adoption has primarily been associated with prototyping due to its ability to rapidly produce multiple iterations of complex geometric shapes that are either more expensive or are near impossible to produce with traditional manufacturing technologies.

Now, thanks to advancements in material sciences and printer hardware, additive is able to rapidly produce customized high-quality production-grade end use parts.

This has allowed additive to become a viable option for companies to include in their manufacturing process to allow for more agile production. However, the move of additive manufacturing from prototyping to large scale end-use part manufacturing will require a software platform to address the unique needs and workflows.

> Additive technology will only continue to advance, and it's adoption will continue to grow.

The Current State of Additive Manufacturing

Additive manufacturing has been in a constant state of growth and development for nearly thirty years. The most common method of additive manufacturing has been Fused Deposition Modeling (FDM). This technology is what propelled additive manufacturing into its current role of rapid prototyping.

There are now eight standardized additive manufacturing processes, each with their own respective strengths and weaknesses. The following polymer technologies are considered the gold standard for creating high quality production parts:

- Selective Absorption Fusion (SAF)
- Fusion Deposition Modeling (FDM)
- PolyJet (PJ)
- Stereolithography (SLA)
- Programmable Photo-Polymerization (PPP)

Figure 1: Production grade FDM parts printed using the Stratasys Fortus380mc

Additive manufacturing has also been able to leverage new materials such as Ultem™, carbon fiber, and other thermoplastics to produce high strength end use parts. With these new technologies and materials, additive manufacturing has started to shed its old role of only producing prototypes, and has begun to shift into production of end use parts which has contributed to the overall growth of the global additive manufacturing (AM) market.

By the end of 2022, the global AM market is expected to be valued at 25.9 billion dollars. The market is expected to continue to expand at a compound annual growth rate (CAGR) of 6.30% from 2022 to 2028 according to Persistence Market Research.

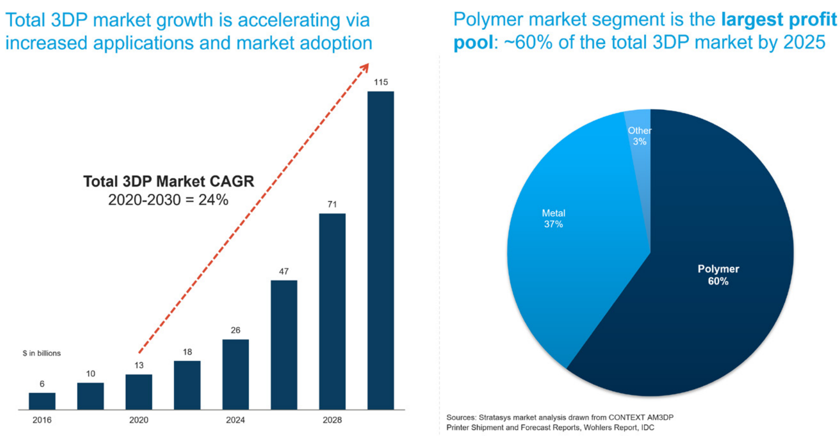


Figure 2: Stratasys market analysis drawn from CONTEXT AM3DP Printer Shipment and Forecast Reports, Wohlers Report, IDC

Why are companies adopting Additive Manufacturing?

Machine capabilities and materials have helped pave the way for additive's growth in companies applications, but there have also been specific benefits that only additive can add to a company's manufacturing process.

First, is its ability to quickly produce complex geometries. Additive has always been utilized for prototyping complex geometries, but as the technologies and materials have improved, so has the possibilities of producing complex end use parts.

As an example, companies can now produce complex parts in a single AM job, rather than the traditional method of making multiple parts and assembling them once all parts have been produced. This example leads into our second major benefit additive brings to manufacturers - Shortened supply chains.

The second major benefit of additive manufacturing is its ability to shorten supply chains. A single additive machine can produce a multitude of different parts in a single job, within the factory floor, in a matter of hours or days.

Traditional manufacturing on the other hand, typically requires a specialized mold or tool, custom built for a specific machine. This is effective at producing large quantities of the same part.

However, it also means that if a company needs to change a machine to produce a different part, it can take weeks or even months to get a new mold designed, created, and shipped to the factory with the machine.

Figure 3 – 3D Printed Jig being used for an automotive part.

Additive's ability to produce a multitude of different parts from the same printer without tooling, mold, or change over results in a streamlined supply chain that can save a company valuable time and money.

The third reason manufacturers are adopting additive is due to its sustainability and material usage. Additive manufacturing allows for a company to use the minimal amount of material possible to produce a part. This is done by a part being built up layer-by-layer, as opposed to the traditional subtractive method which cuts the part out of a block of material. This means that the additive process can help a customer's manufacturing process save on material purchases, storage/inventory, and waste.

For these reasons additive is being adopted and sought after as the solution to accompany their current manufacturing process into the factory of the future. However, before they can fully integrate additive into their manufacturing process there is still some work to do.

What is Holding Additive Manufacturing Back

While Additive Manufacturing is growing in adoption and popularity as a component of the factory of the future, it is still a young model of production. Additive currently does not yet have the same established software infrastructure as traditional manufacturing. Some of the noteworthy challenges include:

- Integrating with existing manufacturing IT and OT infrastructures.
- Managing large fleets of 3D printers efficiently in a local or remote factory floor setting.
- Efficiently managing inventory, which is required in any manufacturing forecasting.
- Traceability for every step an additive-produced production part takes in its manufacturing process to ensure proper quality and compliance protocols
- Fine monitoring and quality control of parts produced.

Overall additive manufacturing has been lacking the software-driven operational capabilities to address these issues effectively in a factory environment. This is holding AM back from achieving it's full potential as a part of the factory of the future.

In order to integrate into a factory floor environment AM needs robust manufacturing execution solutions. Manufacturing execution however is not a new topic. In fact today, manufacturing execution software (MES) is used to manage established manufacturing workflows. Unfortunately, these current MES solutions are ill-equipped to handle the unique manufacturing capabilities and workflows that additive manufacturing entails.

Illustrated below are some of the key ways in which traditional and additive manufacturing technologies differ.

Traditional	Additive
CNC's, hard tooling	Smart, connected 3D printers and supporting devices
1 SKU = 10,000's parts	100's work orders = 1 job Make anywhere
ERP Master Schedule	Elastic, on demand scheduling Short Lead
Quality = post mortem inspection, statistics	Layer x Layer quality Machine learning Closed loop feedback
Commodity raw materials	Specialized materials Licensing models

What is Holding Additive Manufacturing Back (Cont.)

Material usage and Production

Traditional: Relies on industrial machines and common raw materials to create large quantities of parts. It also requires parts to be printed individually then assembled.

Additive: Uses multiple highly specialized materials for smaller scale production of parts. AM can also print full moving assemblies rather than having to produce individual parts to assemble after production.

Quality Control & Validation

Traditional: Parts that are created traditionally are inspected and quality assured at the end of the manufacturing process.

Additive: Has the built-in capability to check the quality of a part on a layer-by-layer basis during the manufacturing process.

Connectivity & Data

Traditional: Certain methods of traditional fabrication lack connectivity and data analysis. Due to not being able to connect to a wider factory floor network or fellow machines, traditional manufacturing reaches a limit on how data can be leveraged to improve efficiency.

Additive: 3D printers are natively smart and connected. This means that every printer can produce machine and part data that can be used to improve the manufacturing processes and prevent future problems through preventative maintenance. Parts created via additive manufacturing are also able to take full advantage of machine learning to improve quality, reduce the amount of design iterations, and decrease material usage.

Elasticity and Production Sizes

Traditional: One SKU represents a part or product that is made the same way tens of thousands of times. Due to the inflexibility of the large SKU sizes, traditional manufacturing may also take months to plan, verify, and build.

Additive: Additive Manufacturing production runs in much smaller batch sizes. Typically consisting of a few dozen or a hundred parts. Due to the low volume of parts per batch, the time it takes to plan, verify, and build an additive-produced batch of parts is a matter of hours or days.

With how different additive manufacturing processes are from traditional, the current MES software that is used for traditional manufacturing is not compatible with additive manufacturing's unique workflow. A new kind of solution is needed.

An Additive Centric Software Platform

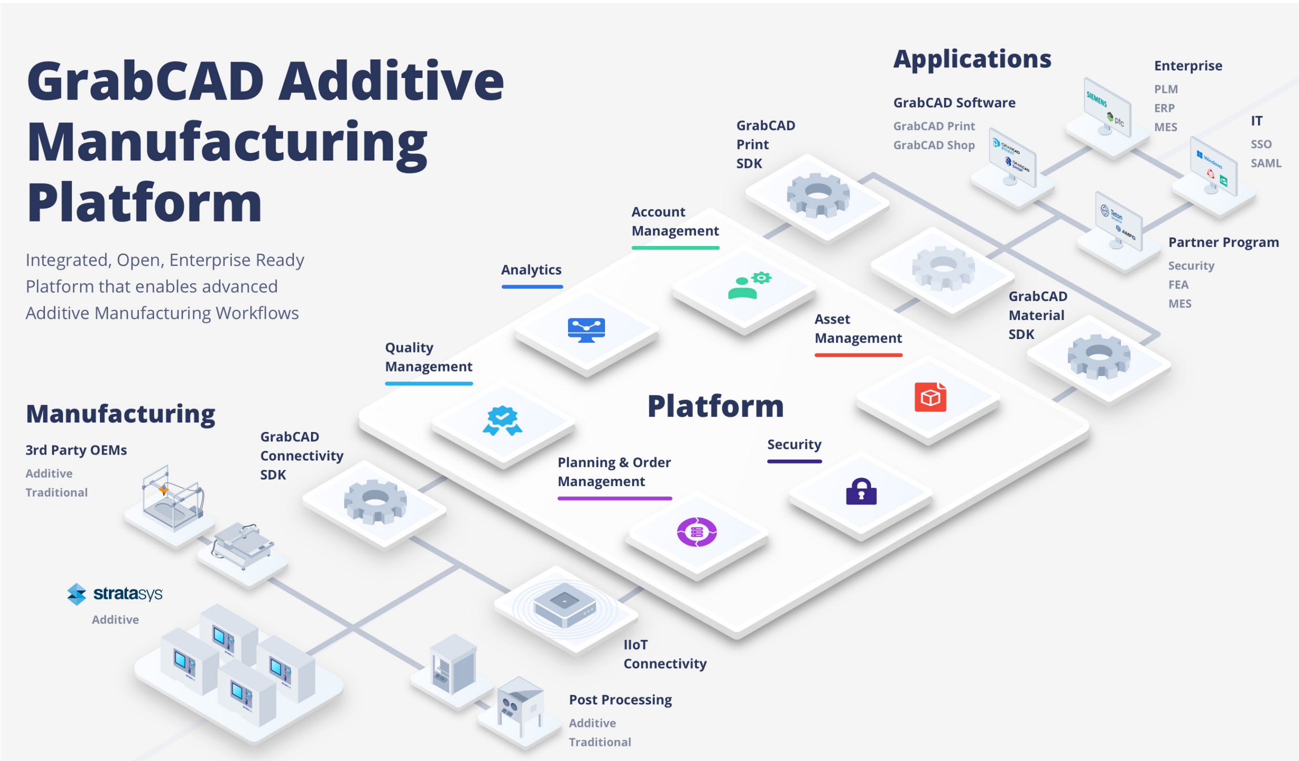
Additive manufacturing centric software solutions are needed to enable additive manufacturing to reach its maximum potential and fill the gaps that traditional manufacturing software cannot fill. However, there is currently no single software solution to meet additive manufacturing's every need, which is why a number of software solutions need to be integrated via an open multifaceted platform.

This additive manufacturing platform's digitally centric workflow needs to play to additive manufacturing's strengths while addressing the issues previously stated by solving these key areas:

- **Quality Management:** The capability to find potential flaws in a part during the design or printing process and ensuring that when a part is finished printing, it is production ready.
- **Asset Management:** The ability to effectively manage machines, materials, post-processing equipment, physical, and digital inventory.
- **Account Management:** Flexibility to set different user access permissions as per a company's requirements.
- **Planning & Order Management:** Easily handle any plans to scale additive operations, whether that is in the form of an increase in additional hardware, an increase in the volume of parts produced, or an increase in the number of orders being placed.
- **Analytics:** In depth business intelligence that can help companies gain deeper insight into their additive manufacturing process and drive new business value.
- **Security:** Traceability and protection along the whole additive manufacturing process.

All of this would enable additive manufacturing to fully shift into manufacturing at scale. An AM software platform designed specifically for AM workflows.

Since no platform existed in the market that could solve all of these issues, Stratasys has developed its own open and connect platform: The GrabCAD Additive Manufacturing Platform.



The GrabCAD Additive Manufacturing Platform Solves Additive Manufacturing Needs

The GrabCAD Additive Manufacturing Platform has purpose-built applications that provide a solution for each step of the production and distribution process, allowing it to operate alongside and in conjunction with traditional manufacturing software. With the GrabCAD Additive Manufacturing Platform, digitally aided additive manufacturing will be connected, capable, and scalable.

The platform is currently comprised of:

- GrabCAD Shop is a work order management software. It enables the visualization of printer(s) workflow via a dashboard along with allowing for the tracking of orders, and appropriate distribution of jobs per operator.
- GrabCAD Print is a 3D print preparation software. Print is able to load and print files directly from CAD. It also contains slicing software to detect errors along with the ability to modify geometry properties.
- The GrabCAD SDKs enable independent software vendors and customer developers to connect their Stratasys printers to their

Creating Levels of Connectivity

There are two primary SDKs available today that allow for different levels of connectivity:

- GrabCAD Printer Connectivity SDK is an API to allow for two-way communication between software systems and the 3D printer itself. This is an effective API to communicate machine statuses, material levels, and printer errors.
- GrabCAD Print SDK an API directly into the GrabCAD Print application. This allows for software developers and software partners to build plug-in integrations directly into the GrabCAD Print application.

Within our software ecosystem also lies the GrabCAD Partner Program. This was created to allow customers to use their preferred end-to-end additive solutions with Stratasys' 3D printer technology.

The GrabCAD Software Partners utilize the GrabCAD SDKs to connect their solutions into the Stratasys 3D printing workflow. The current line up of software providers are as follows:

- Link3D enables organizations to scale their additive manufacturing infrastructure across complex supply chains and IT environments to enable asset management, account management, planning & order management, analytics, and security. organizations to scale their additive manufacturing infrastructure across complex supply chains and IT environments.
- Identify3D technology suite enables digital manufacturing by providing usage controls, security, and traceability of design and manufacturing process data across the digital supply chain to enable asset management, account management, planning & order management, analytics, and security. suite enables digital manufacturing by providing usage controls, security, and traceability of design and manufacturing process data across the digital supply chain.

Creating Levels of Connectivity Cont.

- Vistory is a software editor that develops cybersecurity solutions to build digital trust. Mainchain is a seamless trusted third party for distributed production. Mainchain offers manufacturing customers control over risk and increases their supply chain resilience by preserving industrial property, confidentiality and trade secrets, certifying blueprint integrity, tracing industrial property throughout the digital supply chain, and automating workflows.

- Industintel, Inc. MachineScope offers a single pane of glass view into additive manufacturing operations across all Stratasys FDM printers. Using MachineScope's web browser based interface, an additive operations manager can get insights into build status, machine utilization, shift wise downtime, material consumption and daily/weekly reports.

The GrabCAD Software Partners utilize the GrabCAD SDKs to connect their solutions into the Stratasys 3D printing workflow.

- Teton Simulation develops software products to help maximize efficiency when 3D printing parts. Smartslice takes the guesswork out of optimizing a part for minimum print time and material use, while ensuring that end-use performance requirements are met. The company's hallmark is providing software that is simple to use while providing very fast reliable results

- Oqton's manufacturing operating platform automates the end-to-end workflow across and beyond the production floor. Oqton combines order tracking, latticing, build preparation, slicing, CAM, scheduling for full traceability, and data insights. It offers an intelligent combination of build prep, MES, IIoT and AI.

- Riven's cloud software accelerates product introduction and customer acceptance of high-accuracy additive manufacturing parts at scale. Riven cuts weeks from the product launch schedules with proprietary 3D reality intelligence and rich 3D visualization of as-manufactured parts, allowing manufacturers and extended end-user teams to easily validate parts, improve product accuracy and collaborate with data-driven insights.

Conclusion

With developments in printer hardware and materials, additive manufacturing is becoming more viable as a supplement to current manufacturing technologies. Companies who have started to adopt it are starting to see additive manufacturing's strengths in its ability to produce custom parts, sustainability, elasticity, and agile production. When properly integrated into current businesses, additive and traditional manufacturing can form a complete and effective factory of the future.

However, without a proper AM centric software platform, additive manufacturing could fall short. That is why Stratasys has created the GrabCAD Additive Manufacturing Platform. A single platform to solve the needs of manufacturers so that they can truly adopt additive manufacturing into their process and make it a winning solution on their new industry 4.0 connected factory floor.

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