BUSINESS OPPORTUNITIES AND FUTURE DIRECTIONS OF ADDITIVE MANUFACTURING

1. Additive software innovation will play catch-up

Software has long been a bottleneck in the evolution of 3D printing. There has been a gap between hardware capability and software enablement, which became only more apparent as 3D printing started to mature as a production method.

Software links every crucial step in the AM workflow, from ordering, part design, build preparation, production planning and monitoring, and delivery. But until recently software solutions haven't been optimized to unique aspects of 3D printing.

As a result, many processes were manual or inefficient, because companies used the technologies poorly equipped for AM.

Over the last few years, the industry has been working towards closing the existing gap but there is still room for improvement.

In 2021, the progress will continue, with software companies large and small focusing on software solutions to meet the requirements of additive technologies. This evolution will fuel the next generation of software tools which will drive AM forward into industrialization.

2. Increased focus on machine connectivity

One of the biggest AM trends we expect to progress in 2021 is making AM solutions (both software and hardware) easier to integrate and connect with the production floor.

Closed, or proprietary, AM systems have long dominated the AM hardware market. Such systems typically work with materials and software provided or approved by the machine OEM and are not easily integrated with third-party solutions.

While the closed systems approach may be great for ensuring process reliability, it's often viewed as limiting the collaboration and connectivity.

As companies are ramping up their AM operations, they will require the ability to seamlessly connect their machines and software to their production environments. Using siloed solutions for the technology which thrives on connectivity is a road to nowhere for additive manufacturing.

Importantly, we witness that hardware manufacturers increasingly shift their focus to systems, which are open for integration with the factory floor.

This trend has already been strong in 2020: for example, we recently announced the collaboration with HP, which enables HP AM systems to be integrated with our additive MES software.

Another example supporting the trend comes from the 3D printing industry's mainstay, Stratasys. In December, the company announced the expansion of the connectivity capabilities for its historically closed machines.

This means that it will now be easier to connect Stratasys' systems with third-party software, giving users the power to integrate and manage their additive production using software applications of their choice.

System connectivity is no longer an option, but a necessity, for AM facilities. It's all the more encouraging to see the AM industry players begin to recognise and address this need.

3. The continued convergence of AM and AI

Artificial intelligence and machine learning are becoming integral parts of AM growth. Almost all parts of the AM value chain can benefit from AI, from material development, machine set up, part design and workflow automation.

That's why we expect that in 2021 we'll see greater integration between AI and the AM technology.

In the hardware space, AI will be paired with AM systems to enable greater process control and repeatability. For example, Inkbit is now developing an AI-based vision system integrated into a polymer system. This system will be able to scan each of the 3D printing layers and predict material behaviour during the print process.

Already widely recognised as a major digital innovation in AM, generative design also has the potential to greatly benefit from AI and machine learning.

To date, generative design has mostly been used to optimise load paths where strength and stiffness dominate. It can also be used in thermal or vibration optimisation scenarios.

AI and machine learning will take generative design to the next level, opening the door for new designs to be fully adapted to the AM process.

While we may be a few years away from the fully developed ability to adapt designs to the process automatically, we expect key advancements to take place this year, getting us closer to this goal.

Another great opportunity to put AI to work within the AM industry is by integrating it with manufacturing execution systems. At AMFG, for example, artificial intelligence powers our additive MES software to automate manual tasks such as data collection.

In future, machine analytics capabilities can be applied to analyse the collected data and suggest where improvements to the production operations could be made. Ultimately, it will provide greater visibility into where key bottlenecks are and how to optimise the process to make the most out of AM.

Ultimately, the need for smarter, more autonomous AM suggests that AI capabilities within AM hardware and software are only set to advance.

4. AM will drive distributed manufacturing

As organisations look to future-proof their supply chains, many of them are opening up to new supply chain models and technologies that will allow them to lower costs or switch more flexibly among the products they manufacture.

This need for greater flexibility and agility will give rise to a distributed, localised manufacturing, driven by additive manufacturing.

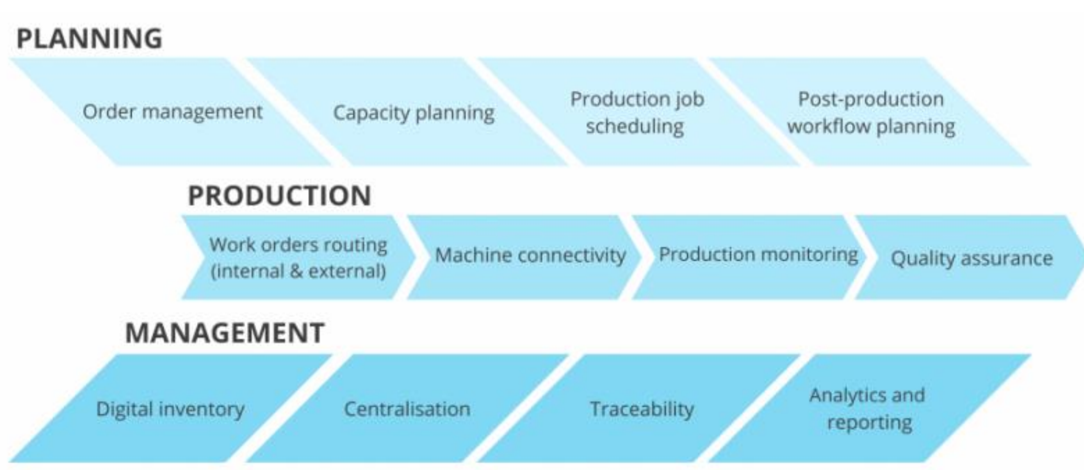
AM can dramatically reduce the number of steps required to make complex metal or polymer shapes, accelerate lead times and facilitate the shift to digital inventories. These benefits make it particularly attractive for the distributed model of manufacturing.

We believe that 2021 will mark the year when more companies begin to seriously investigate distributed manufacturing with AM. This trend is supported by a recent survey by HP, stating that 59 per cent of companies are currently evaluating hybrid models and 52 per cent are looking into localised digital manufacturing.

5. The next wave of growth in additive MES

The adoption of digital manufacturing technologies like AM will ultimately require a software foundation, which can support the growth and scalability of AM across the organisation.

That's why we're seeing an increased interest in Manufacturing Execution Systems (MES) for additive manufacturing. MES software has been designed to make the AM workflow more easily manageable, by automating key processes like order management, production scheduling and monitoring.



Advanced additive MES helps to organises teams, data and processes

MES projects have a proven track record of benefits and are now viewed as a strategic level of importance alongside AM adoption.

To get to this level, however, required a years-long evolution of additive MES software, which has had to be developed to meet the unique needs of AM.

Although today’s MES capabilities are wide-reaching, there are still a lot of new exciting developments on the horizon. Tighter convergence with machine learning, advanced connectivity with hardware, greater interoperability – all of this is already in the works today, getting ready to fuel the next wave of growth in AM in 2021 and beyond.

CASE STUDY – IN AUTOMOBILE

ROUSH SAVES 35% IN COSTS AND MEETS DELIVERY SCHEDULE WITH 3D PRINTING FROM STRATASYS DIRECT

Roush Performance Products is an American automotive company that develops and manufactures high-performance components for street and competitive racing applications. The company develops a wide range of vehicles for customers, from Ford F150s to Mustangs

The Challenge

Due to an issue with the Advanced Driver Assistance System (ADAS), a late-stage design change became necessary for the front grill camera on the Roush F-150 pick-up truck. To address the problem, Roush needed to either redesign the grille or redesign the camera mount.

Roush’s traditional approach to this issue would have been to create an injection-molded tool, adding up to an additional 16 weeks, plus time for testing, painting, and assembly trials. However, with trucks already in the facility waiting to be built, Roush needed a faster solution and approached Stratasys

Roush Turns to Stratasys

Roush needed the camera mounts to be dimensionally accurate, high-impact resistant, and ductile so they could be mounted with multiple parts together. Stratasys recommended using PA11 material using Selective Absorption Fusion (SAF™) technology on the H350 printer. Designed specifically for production projects, SAF is a powder bed fusion technology that provides enough throughput to make several thousand parts for the entire production run of F-150 vehicles.

After prototyping a new design using SAF, Roush engineers discovered the parts performed exceptionally well during rigorous testing, were more effective than injection molding, and could be produced with a much faster turnaround.

Roush Contracts Stratasys Direct for Production

With a newly designed camera mount in hand, Roush still faced the challenge of manufacturing enough components to equip an entire fleet of F150 trucks. Although Roush had been using 3D printing for several years, they had never utilized additive manufacturing for end-use parts. Until recently, 3D-printed parts for automotive companies focused primarily on low-volume components – jigs, fixtures, tooling, and other prototypes. With the introduction of SAF technology, a production solution was available to manufacture end-use components quickly, efficiently, and affordably.

As a high-performance Original Equipment Manufacturer (OEM) Roush had rigorous testing and quality requirements that every part had to meet. Roush needed to ensure their components would be consistent, repeatable, and meet PPAP standards. Stratasys Direct delivered on that challenge.

Since the beginning of the project, Stratasys Direct has manufactured more than 850 components for Roush, with more scheduled for production through the end of the year. By the end of 2023, Stratasys Direct will have fabricated approximately 1500 3D-printed parts for the automaker.

CASE STUDY – IN AERO SPACE

Lufthansa Technik and Premium AEROTEC reach milestone in additive manufacturing

In their joint effort to use additive manufacturing methods for a more cost-efficient aircraft spare parts production, Lufthansa Technik and Premium AEROTEC recently reached an important milestone: A metal component developed at Lufthansa Technik's Additive Manufacturing (AM) Center for the IAE-V2500 engine's anti-icing system has now received its official aviation certification from EASA. On this basis, Premium AEROTEC will produce the so-called "A-Link" for Lufthansa Technik at its Varel (Germany) site using a 3D printer.

AboutPremiumAEROTEC

Premium AEROTEC is a global player in the aviation industry. Its core business is the development and production of aero structures made of metal and carbon fiber composites. The company has sites in Augsburg, Bremen, Hamburg, Nordenham and Varel in Germany and in Braşov, Romania. Premium AEROTEC employs a total of around 7,600 people.

A total of nine of these A-Links fix a ring-shaped hot air duct in the engine's inlet cowl, which is thus protected from ice buildup during flight operations. However, the vibrations that occur here during operation cause the A-links to wear at their mounting holes, so that after a few years they are often ripe for replacement.

As the A-Links can be exposed to temperatures of up to 300 degrees Celsius, they are made of titanium. In the original, the component is manufactured by a forging process to meet the highest requirements for material properties. In the new manufacturing solution developed by Premium

AEROTEC and Lufthansa Technik, however, it is built layer by layer in a 3D printer. This process, called Laser Power Bed Fusion (LPBF), offers the advantage over forging that no jigs or molds are needed for production. In addition, the process can save valuable material, since after 3D printing a material removal is only necessary to a very small extent on some functional surfaces.

However, the properties of the components produced in this way, for example their strength, are heavily dependent on the corresponding additive manufacturing process, the qualification of which must therefore be proven in a complex procedure. To this end, Premium AEROTEC carried out a large number of so-called “print jobs” with test specimens, with constant settings of all process-relevant parameters. This way, it was finally possible to establish a constant and reliable process and to prove that the highest requirements in terms of material properties are also achieved here. In terms of tensile strength, the additively manufactured A-Link is even superior to the original part.

As part of this certification process, Lufthansa Technik has now extended the expertise of its EASA Part 21/J development facility to include additively manufactured metal components. For Premium AEROTEC, the cooperation with Lufthansa Technik is a significant milestone in the field of additive manufacturing, as it is the first time the company has supplied a customer outside the Airbus Group with printed series components. The first A-Links from the cooperation will be used in the Lufthansa fleet, where long-term experience with the new components is to be gained beyond certification.

“Premium AEROTEC is an international pioneer and technology leader in the additive manufacturing of aerospace components. Our company has already been applying this technology in the series production of complex structural components since 2016,” said Dr. Ulrich Weber, Chief Operating Officer at Premium AEROTEC. “I am very pleased that in cooperation with Lufthansa Technik we can now once again demonstrate our comprehensive expertise in 3D printing.”

“We have been producing components for the aircraft cabin, the vast majority of which are made of plastic, using 3D printing for years. Now we are able to demonstrate that structurally relevant metal parts for use outside the cabin can also be manufactured additively and approved for flight operations,” said Soeren Stark, Chief Operating Officer of Lufthansa Technik. “In this way, we have not only achieved a cost saving for the component in question, but also defined and qualified all the necessary processes for the application of this groundbreaking manufacturing method for structurally relevant metal parts.”

However, the first aviation certification of a load-bearing metal spare part currently represents only a first step for both partners, as its geometry still largely corresponds to the original part. Future developments in the technology will also make it possible to use the advantages of additive manufacturing for targeted optimization of the geometry. Theoretically, there are no limits to the shaping of additively manufactured components, so that they can then be produced much more easily and with less material while retaining the same strength and function. Both partners intend to further develop these possibilities in the near future.

CASE STUDY – IN HEALTH CARE

3D printed patient specific Talus spacer that aid in healing a 47-year-old man

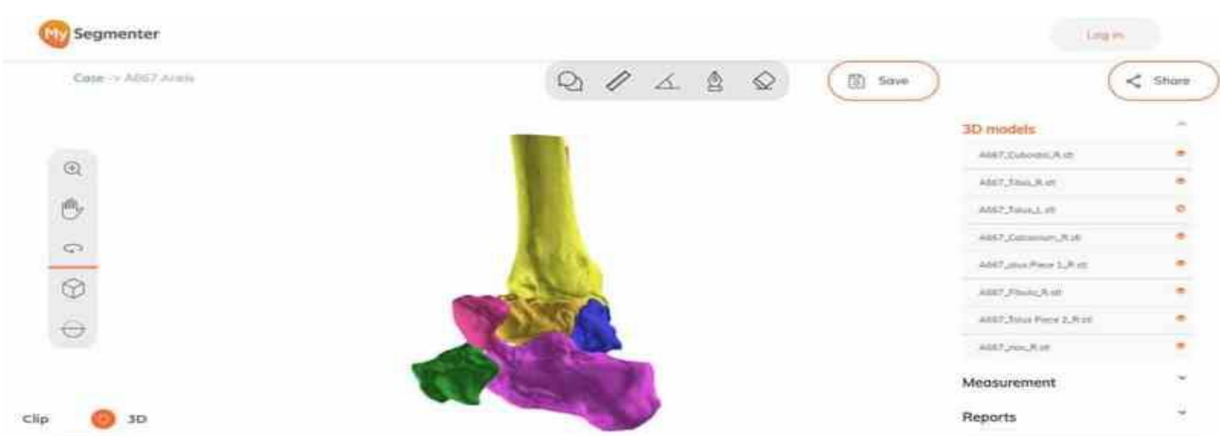
3D printing has been hailed as a revolutionary technology, and it is already generating substantial interest among the medical community. One such medical 3D printing solution provider Jajal Medical provides customized orthopedic implants. The patient-specific designs and 3D printed models can be used to create prototypes, duplicate broken parts, and even entire organs.

Jajal Medical’s custom Talus spacer could be an ideal solution for trauma cases where the neighboring joint has substantial cartilage. As a design input, bilateral ankle CT was used for 3D talus creation. The healthy side talus was mirrored and registered on the damaged talus. Considering the size variations of the talus due to soft tissue balancing, pre-op planning design proposals consisted at least five sizes (Neutral, Upsize and Downsize).

Challenge:
Talus replacement could be used in conditions like osteonecrosis and trauma. Customized talus replacement is still a rarity in foot and ankle surgeries in India. A 47yr/M was diagnosed with fractured talus in the right leg. The patient was unable to sustain the mobility of his foot.

Dr. Rajiv Shah, Head of Foot and Ankle Surgeries, Sunshine Global Hospital, Vadodara approached Jajal Medical team to provide with the patient-specific solution of 3D printed Talus spacer. The team helped to visualize, plan, and then execute.

Solution:
Detailed pre planning played a pivotal role in the outcome of the surgery. Virtual session through a digital point of care 3D printing platform Mysegmenter.com helped Dr. Rajiv Shah understand the perception and intended use. Once the requirements were clear the complete plan was proposed to the surgeon.



Key steps involved

- Contra-lateral talus was mirrored and registered with diseased talus using registration tools.
- Subsequently, we verified the conformity and location of registered talus with diseased neighboring bone. Fact that 70% of talus bone is involved in articulation, it is critical that the alignment of mirrored talus perfectly matches the articulating surface of all the adjacent bones, including tibia, navicular, calcaneus, and fibula.

- For accurate sizing prediction a 3D printed model with current position of adjacent bones was provided with existing talus gap. Five sizes -2, -1, 0 and +1, +2 were provided with as low as 10% volume difference to original.
- Range of sizes allowed surgeon to select appropriate one after intra-operative assessment of the joint.
- Considering the talus placement could be tedious and cumbersome when placed with hand during the surgery, detachable long handle was developed which was utilized for placing the talus trial and implant intraoperatively.

Outcome:

After the surgeon approval, final polished metal 3D printed talus implants were delivered non-sterile. Surgeon was happy with the customized implant quality and was able to achieve desired results with reduced intra-operative time, and faster recovery of the patient.