ADDITIVE MANUFACTURING

THE EMERGENCE OF ADDITIVE MANUFACTURING

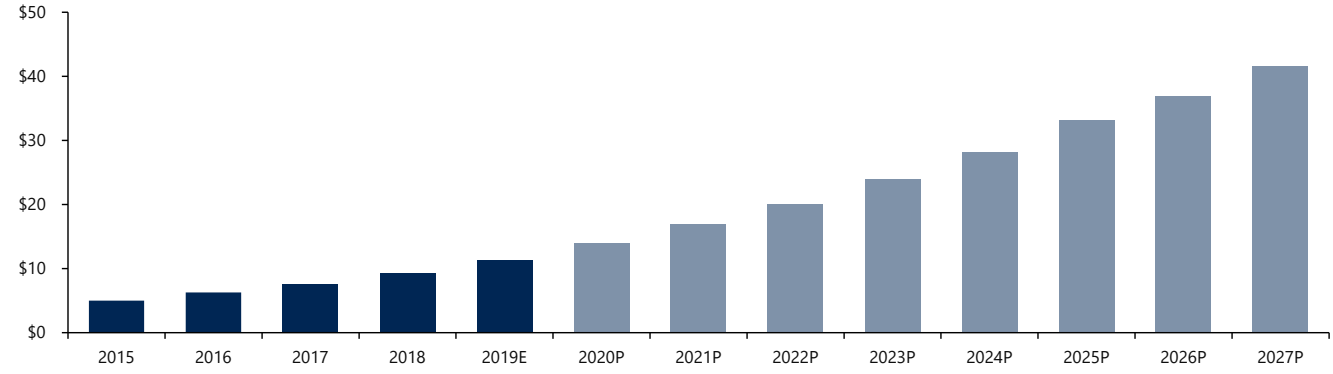
An emerging and transformative production approach, additive manufacturing is enabling the manufacture of lighter, stronger products and is experiencing rapid global adoption

ADDITIVE MANUFACTURING OVERVIEW

In direct contrast with traditional manufacturing approaches (broadly considered "subtractive" manufacturing methods) that produce a given component or system by removing material via machining, milling, and other cutting methods, additive manufacturing is a production approach that builds a three-dimensional object by using computer-aided-design ("CAD") software to precisely deposit material layer-by-layer. In an additive manufacturing process, a to-be-produced object is digitally mapped by CAD software that defines the object in the context of ultra-thin layers. The digital mapping is then used to guide the path of a print head as it sequentially deposits layers of melted or partially melted material on top of each other, which bond to the preceding layer of deposited material and fuse together as they cool. A variety of additive manufacturing processes have been developed, including material extrusion (perhaps the best-known and most widely adopted), directed energy deposition, material jetting, binder jetting, sheet lamination, vat polymerization, and powder bed fusion, as has a range of unique supporting technologies, including sintering and direct metal laser sintering technologies, direct metal laser melting and electron beam melting systems, and stereolithography systems, each of which is tailored to support specific raw material requirements and end product specifications.

Several key characteristics are enhancing additive manufacturing's viability as a production approach and driving widespread adoption. Compared to traditional manufacturing approaches, additive manufacturing oftentimes enables improved product performance, simplified production processes, and the accommodation of more complex geometries, which is driving utilization in several key industries, including aerospace and defense, automotive, and medical, among others. Originally theorized and developed several decades ago, additive manufacturing has gained significant traction in recent years as additive manufacturing systems (e.g., 3D printers) have become more cost effective. The simplified and streamlined production approach eliminates the need for costly intermediate steps, such as the creation and use of molds and dies. Additionally, increased versatility and portability is helping to facilitate wide-scale adoption. Initially, 3D printers were specifically designed to work with polymer-based materials, but today, 3D printers are capable of accommodating a significant and steadily increasing variety of raw materials, including concrete, wood, and steel, as well as a broad spectrum of metal alloys and metal-matrix composite materials. Further, given that 3D printing systems are generally smaller than traditional production systems, additive manufacturing is generally portable, allowing for production at a location that is geographically closer to customers, suppliers, and other key supply chain partners, thereby alleviating logistics burden. Additive manufacturing can also be incorporated within a traditional machining process ("hybrid machining"), providing traditional machining operations with more control and flexibility over their production processes and products.

GLOBAL ADDITIVE MANUFACTURING DEMAND
For the Years Ended & Ending December 31, 2015 – 2027P
$ in billions



Sources: Capital IQ, Congressional Research Service, Formlabs, Globe Newswire, IBISWorld, SmarTech Publishing

ADDITIVE MANUFACTURING, *CONTINUED*

ADOPTION, APPLICATION & GROWTH OUTLOOK

Today, additive manufacturing has been broadly accepted as a valuable prototyping technique due to its ability to quickly produce a 3D object from a design, and additive manufacturing has also fast become a highly reliable production approach, with the evolution of the technology contributing to the approach's ascendancy. Numerous additive manufacturing "firsts" were achieved in the last decade, including the first food-focused 3D printer (2011), unmanned aircraft (2011), firearm (2013), and athletic shoes (2015). Today, additive manufacturing is leveraged most often in end markets in which products require complex designs and high strength-to-weight ratios, such as aerospace and defense, automotive, and medical, and several key milestones have been recently realized in each of these key end markets:

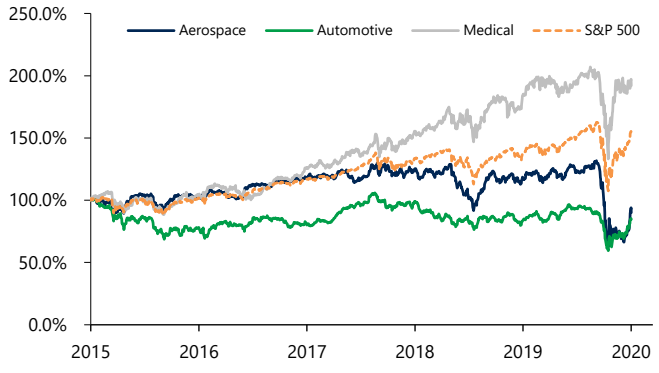
- AEROSPACE & DEFENSE: CFM International's LEAP engine, which supports the Boeing 737 MAX and Airbus 320neo aircraft, features 19 fuel nozzles with 3D-printed parts
- AUTOMOTIVE: McLaren's Formula 1 racing team regularly utilizes 3D-printed parts, and automotive OEMs are actively producing 3D-printed aluminum and plastic exhaust pipes, pump parts, and bumpers
- MEDICAL: At the New York University School of Medicine, a clinical study is evaluating the efficacy of kidney cancer models using additive manufacturing, and medical device OEM Stryker is funding a research project that will use additive manufacturing technology to produce on-demand surgical implants for bone cancer patients

Widescale adoption of additive manufacturing is driving explosive growth in a market that generated an estimated $11.2 billion of demand in 2019E, which represents 22.4% year-over-year growth since 2015. By 2027P, the global additive manufacturing market is expected to grow to $41.6 billion, representing a 17.8% Compound Annual Growth Rate ("CAGR") over 2019E. Developed economies (e.g., the United States and Western Europe) have historically been key generators of market demand and represented nearly three-fourths of total 2018 demand; however, key Asian economies, and most notably China, continue to expand their use of additive manufacturing, with Asian demand expected to grow by up to ~18% per year through 2027P. Meanwhile, the medical end market, which relies on 3D-printed materials to create tissues and organoids, prosthetics, surgical tools, and patient-specific surgical models, is expected to represent the fastest-growing additive manufacturing end market, with ~16% annual growth anticipated, and by 2027P, the medical end market is expected to generate ~33% of total global additive manufacturing demand.

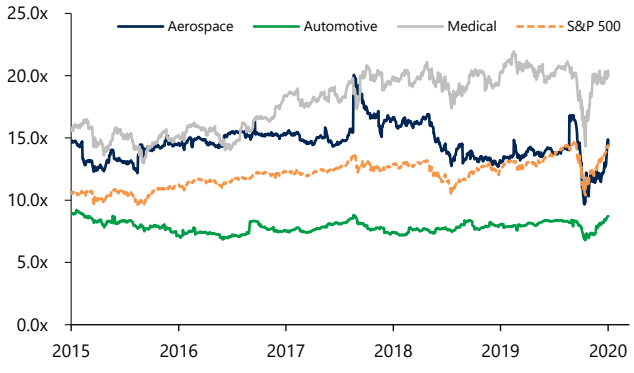
ADDITIVE MANUFACTURING BY THE NUMBERS...

$11.2B	22.4%	17.8%	130+
Aggregate global demand for additive manufacturing in 2019E	Aggregate global demand CAGR from 2015 to 2019E (developed economy-driven)	Aggregate global demand CAGR from 2019E to 2027P (developing economy-driven)	Total number of active outsourced additive manufacturers in the United States in 2020

STOCK PRICES: KEY OEM MARKETS VS. S&P 500
For the Five-Years Ended June 10, 2020
% change in share price



TEV / EBITDA VALUATIONS: KEY OEM MARKETS VS. S&P 500
For the Five-Years Ended June 10, 2020



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