

## Additive Manufacturing Ecosystem

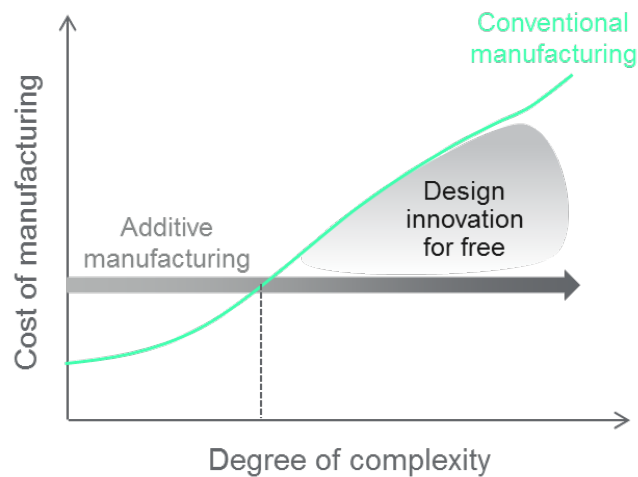
Luana Iorio,

Materials Leader

GE Additive, Cincinnati, Ohio

Additive Manufacturing is in the process of disrupting the manufacturing industry. Additive Manufacturing (AM) will change and simplify industrial supply chain and also enables fundamental changes in the product development process. This transformative manufacturing technology allows for much more concurrent innovation of product design, materials and manufacturing than has ever been possible before. AM completely disrupts the current design-manufacturing paradigm that couples increased design complexity with increased manufacturing cost, as illustrated in Figure 1.

Additive manufacturing processes build components one layer at a time, most typically starting with a powder and applying an energy source in the form of a laser or electron beam to achieve consolidation. By avoiding the need for tooling that many manufacturing processes such as casting and forging require, lead times are significantly reduced and flexibility in design is greatly enhanced. While additive manufacturing started out as a prototyping technology, it is now clear that applications for high-volume production are not only achievable but highly advantageous.



*Figure 1: Changing the Cost-Product Design Complexity Paradigm:  
Additive manufacturing enables more complex systems without incremental cost.*

A growing number of use cases support these bold statements. Perhaps the most widely recognized example is the fuel nozzle for CFM International's<sup>1</sup> LEAP engine, introduced into service in 2016. Direct Metal Laser Melting (DMLM) technology was used to build the fuel nozzle tip and in so doing the design team was able to increase the durability of the part by a factor of 5, reduce the weight by 25% and reduce the part count from 20 to one. These are tremendous product performance and supply chain simplification achievements. GE has built a brand new facility in Auburn, Alabama which will produce over 200,000 of these fuel nozzle tips over the life of the program. The learning from this development translated into several larger-scale programs to use additively-produced components more broadly. A demonstrator engine was designed to be 35% additive and was produced and tested in just 18 months.

While applications in the aerospace industry are a natural fit for additive components due to the importance of lightweight structures, the application spaces for additive-enabled systems are growing rapidly and include orthopedic structures, industrial equipment, heat exchangers, inspection technologies and many others. Examples from these industries will be shared along with the remaining challenges and ecosystem gaps that need to be addressed to further accelerate the adoption of additive manufacturing.

1 - CFM International is a 50/50 joint company between GE and Safran Aircraft Engines