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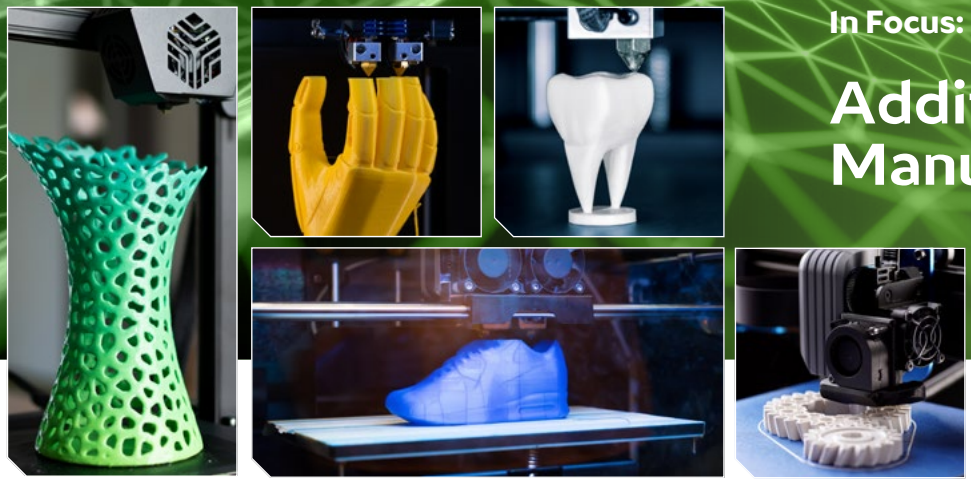
In Focus:

Additive Manufacturing



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Introduction

Additive Manufacturing (AM), also known as 3D Printing, is the technique of creating objects by joining materials based on 3D model data. Unlike subtractive manufacturing methods like CNC, where material is removed to shape an object, AM builds objects layer by layer. Over the past four decades, AM technology has undergone significant advancements, including various sub-technologies that have brought about improvements in speed, quality, and commercial viability.

The AM market has accelerated its development in the last 10 years demonstrating 24% Year-On-Year (YOY) growth and totaling ~15.3 Bn USD market size in 2021.(1) The market size is projected to be 363.6 Bn USD by year 2040 registering an annual growth of 18% on an average.(2)

Growth was the motive for the innovaiton and development of additive manufacturing technology, which resulted in joining of a number of companies, and the increae of retail market for this technology in the chain value of the AM.

It is worth mentioning that Additive Industry can be categorized into 4 segments, primarily the materials, equipment, services, and software. The industry experts have sub-categorized these segments and then classified by industry usage. However, for the uniformity of this report, we have emphasized on the 4 main segments.

History

The first additive manufacturing system can be traced back to the work of Dr. Hideo Kodama in the 1980s, from there, additive manufacturing has taken off, branching out into several different types of technologies. In 1984, Charles Hull patent the first 3D printing technology known as SLA. Thus, commercialized availability of additive manufacturing and 3D printing for manufacturers was born. Following the release of the first 3D printer, inventors and creators began researching new methods and techniques such as SLS and SLM in the early 1990s.

(1) Source: Wohlers Report, 2022
(2) Source: Additive Manufacturing Study, McKinsey & Co 2022

Global Supply & Demand

The global Additive Manufacturing supply chain includes players:

17% Materials

22% Systems

54% Services

7% Software

While the majority of users primarily utilize additive manufacturing for prototyping purposes, a significant trend is emerging. Over 18% of companies are now employing AM for direct manufacturing, including the production of end products and components. This growing adoption indicates the increasing acceptance and maturation of the technology.

Presently, Additive Manufacturing encompasses five major sectors: healthcare, aerospace, consumer products, oil & gas and power, and automotive. These industries have shown remarkable progress in adopting AM technology, with a multitude of applications. According to the technology adoption cycle, AM is projected to enter the phase of commercial scaling in the coming years, and its growth is anticipated to accelerate compared to previous phases, eventually reaching its plateau of productivity around 2040.

The global Additive Manufacturing supply chain includes players that supply materials (17% market share), systems (22% market share), services (54% market share), and software (7% market share).[4] However, most of the main players are covering multiple elements of supply, and the trend is to further enhance integrated offerings in order to capture a larger market share.

To support the 2040 market size, supply will need to scale at the appropriate cost and quality.

Description	Materials	Equipment	Services	Software	Total
Demand (Bn USD)	58.2	64.4	205.8	21.6	350
Supply (Bn USD)	60.5	66.9	213.8	22.4	363.6
Gap/Surplus (Bn USD)	2.3	2.5	8.0	0.8	13.6
Growth (P.A)	18%	17%	19%	18%	18%

Materials

The anticipated growth rate is projected to be 18% CAGR(4), primarily driven by the increased utilization of larger scale final production and the adoption of advanced high-end products.

Equipment

growth is expected to be at 17% CAGR[4], smaller base of potential first time buyers. Strongest demand is expected in industrial scale machines.

Services

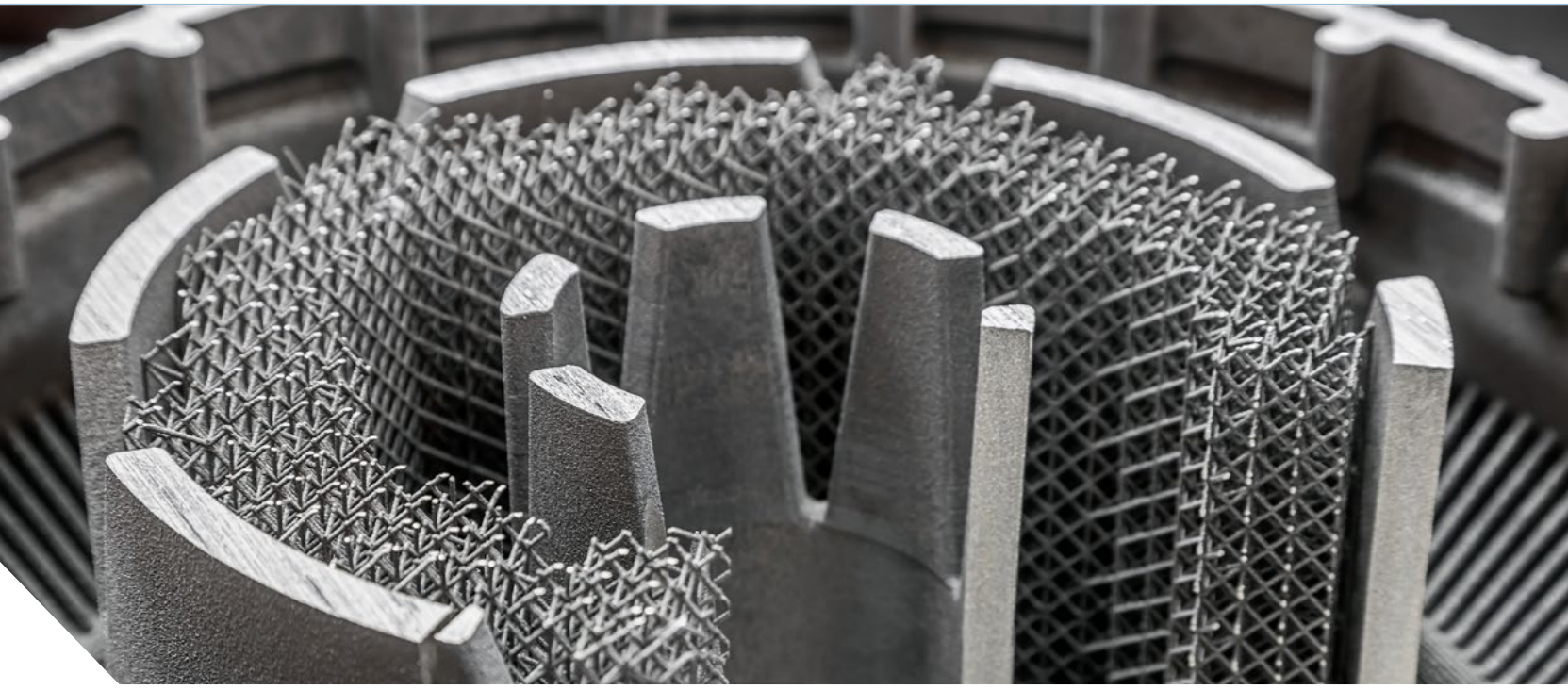
growth is expected to be at 18% CAGR[4], growth in larger scale final production and demand for outsourced service (avoid capex) growing share of services.

Software

growth is expected to be at 19% CAGR[4], in line with industry. Growth potential in integrated software offering.

(3) Source: Based on McKinsey & Co. 900 Companies Surveys, 2019

(4) Source: Markets&Markets, Wohlers Report, 2022



The future of Additive Manufacturing in the Kingdom of Saudi Arabia

In line with Vision 2030, the National Industry Strategy (NIS)(5) and the objectives of the National Industrial Development and Logistics Program (NIDLP), the Ministry of Industry and Mineral Resources (MIMR) aims to develop an additive manufacturing (AM) ecosystem that will enable the establishment of additive manufacturing businesses within the Kingdom's expanding existing players to generate more avenues within the Kingdom to foster the growth of the domestic market and create additional opportunities.

In the Kingdom of Saudi Arabia, the supply market predominantly revolves around service providers, while the presence of material supply and equipment is relatively limited, there are ample prospects for KSA to broaden its value chain and cater to both the domestic and international markets, thereby capitalizing on the potential within the services sector.

(5) Source: National Industry Strategy (NIS)

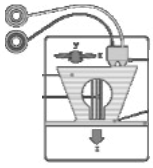
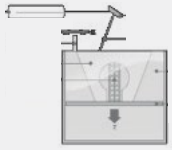
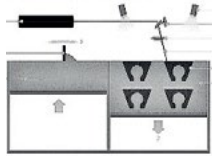
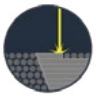
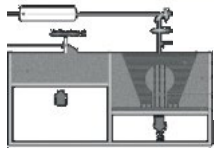
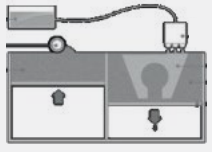
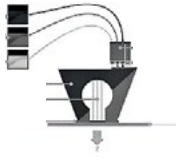
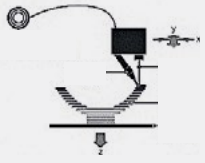
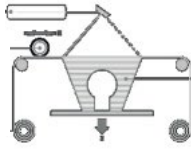
Types & Processes

Based on the printed material; being liqued, powder or connected filament, the Additive Manufacturing can be categorized into seven types/processes.

Selecting the right process comes down to aligning the advantages and limitations of each technology to the application's most important requirements. Properly utilizing the available 3D printing technologies will reduce design risk and, ultimately, result in better products.

Process		Acronyms	Feedstock	Polymer	Metal
	Extrusion	FFF, FDM, BMD	Filament, rod, pallets	✓	✓
	Photopolymerization	SLA, DLP, CLIP	Liquid	✓	✓
	Powder Bed Fusion (Polymer)	SLS, HSS, MJF	Powder	✓	
	Powder Bed Fusion (Metal)	SLM, DMLS, EBM	Powder		✓
	Binder Jetting	BJ, 3DP	Powder		✓
	Material Jetting	MJ, Polyjet, Multijet	Liquid	✓	✓
	Directed Energy Deposition	DED, LENS, EBAM	Wire, powder		✓
	Sheet Lamination	LOM, UAM	Sheet	✓	✓

Source: MIT, AM Process Comparisons, 2021

Process	Explanation	Machine
 Extrusion	Material is selectively dispensed through a nozzle or orifice, where is typically heated to soften or melt the material.	
 Photopolymerization	Liquid photopolymer in a vat is selectively cured by light-activated photopolymerization.	
 Powder Bed Fusion (Polymer)	Focused thermal energy selectively fuses regions of a powder polymer bed.	
 Powder Bed Fusion (Metal)	Focused thermal energy selectively fuses regions of a powder metal bed.	
 Binder Jetting	Droplets of build material are selectively deposited.	
 Material Jetting	A liquid bonding agent is selectively deposited to bind powder materials, typically followed by sintering to densify the bound powder.	
 Directed Energy Deposition	Focused thermal energy is used to fuse materials by melting as they are being deposited.	
 Sheet Lamination	Sheets of material are bonded to join consecutive layers of a part.	

Source: MIT, AM Process Comparisons, 2021

Applications

The National Industry Strategy (NIS) places emphasis on 12 key manufacturing clusters that are of high priority. Advanced Manufacturing (AM) can play a supportive role in enabling the Kingdom to achieve regional and global success. The table below summarizes the utilization of use cases across different sectors as follows:

AM prioritized sector	NIS prioritized sector	Use cases
Healthcare	Medical devices	Orthopedic & cranial implants, dental and prosthetics
	Pharmaceuticals	3D printed drug for epilepsy and personalized medications
Aerospace	Aerospace	Spare parts, tooling, clips and brackets and interior parts
Consumer	Food	Traditional food production, tooling & spare parts and 3D printed meat and confectionary
Power, energy & industrial machinery	Chemicals	Spare parts and tooling
	Renewables	Power storage battery, solar panels and wind turbines
	Machinery & Equipment	Spare parts and tooling
	Metals	Steel, Titanium, Aluminum and Cobalt Chrome alloy
Automotive	Automotive	Customized parts, electric vehicles and jigs and fixtures
Architecture & construction	Building Materials	3D printed houses
Other (non-prioritized sector)	Maritime	Spare parts
	Military	Customized parts and spare parts

Source: National Industry Strategy (NIS)

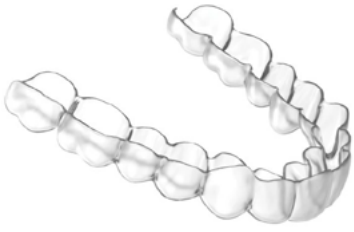
Additive Manufacturing Capability Space

These three axes--customization, complexity, and volume (quantity) inform the application potential of a manufacturing process. So, AM can be used in each of the individual points illustrated along these axes at many stages across the product lifecycle.

» Volume refers to the quantity of products (or parts) that are manufactured.

» Complexity refers to the level of complexity of the part or product.

» Customization refers to how specific the product is to the needs of the end user.



Orthodontic aligner

Artificial knee joint

Glasses frame

Optimized aerospace bracket

Sports foot support

Source: MIT, Creating a map of additive manufacturing products and services

Challenges

Industrial companies worldwide face similar hurdles when it comes to adopting Additive Manufacturing (AM). These challenges can be categorized as knowledge gaps, talent shortages, high initial costs, limited resources, and the need for standardized practices.

The following are crucial focus areas for Additive Manufacturing to tackle the obstacles to its adoption:

- Enabling AM innovation.
- Attracting the brightest national and international talent.
- Growing market awareness of Additive Manufacturing.
- Enabling full scale 3D printing industrialization.
- Developing manufacturing and non-destructive testing standards and IP.

Summary

Additive Manufacturing (AM), also known as 3D printing, is a technology that uses 3D model data to create objects by joining materials together. Over the last decade, the AM market has experienced significant growth, with an annual growth rate of 24% and a market size of around USD 15.3 billion in 2021. Projections indicate that the AM market will continue to expand, with an expected annual growth rate of 18% until 2040.

Additive mnufacturing global supply chain encompasses companies that supply materials, equipment, services, and software. In Saudi Arabia, the market primarily focuses on service providers and has a good potential to expand its offerings to both domestic and global markets, thanks to the availability of polymer and equipment suppliers. Additive manufacturing technology finds applications in various sectors such as healthcare, aviation, consumer products, oil and gas, energy, and automotive industries. However, the adoption of additive manufacturing may encounter challenges related to knowledge, skilled talent, cost, resources, and standards.