Global Additive Manufacturing Market, Forecast to 2025

Connected Supply Chains of the Future Take Shape as Change is Unleashed from Concept to Production

Frost & Sullivan's Global 360° Research Team

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Contents	
Section	Slide Number
Executive Summary	3
Internet of Industrial Things—A Research Perspective	5
Overview of Additive Manufacturing	10
Opportunities Across Regions and Industry Verticals	18
Future of Additive Manufacturing—Growth Strategies	30
Company Profiles	39
Conclusion	48
Appendix	52
The Frost & Sullivan Story	54

Executive Summary

Return to contents

Key Findings

Additive manufacturing is poised to grow at a rate of 15.0% (CAGR, 2015–2025)	Global 3D printing automotive indust CAGR of 34% be 2020.	try will grow at a	Aerospace, Automotive and Medical industries are expected to account for 51% of the 3D printing market by 2025.
15.0% Additive manufacturing growth	34% A 3D in aut	printing growth	51% Aerospace, automotive, and medical industries
Additive manufacturing in APAC region is set to grow at a rate of 18.6% (CAGR 2015–2025) with China making more than 70% of the business.			
China's market share >70 in APAC market	%	Graphene in 3D printing	
3D printing in medical devices vertical is expecting a growth of 23% between 2015 and 2025	Additive manufac aerospace and de poised to grow at (2015–2025)	efense industry is	Very high potential of product differentiation and supporting demand for unique products will reduce commoditisation of 3D printing
23% Medical devices growth rate	26% Aero defe	space and nse growth rate	Low commoditisation
			Source: Frost & Sullivan

Internet of Industrial Things—A Research Perspective

Return to contents

Internet of Industrial Things—The 4 Functional Facets



Industry Convergence: IT-OT

The cross-pollination of ideas, technologies, and processes between the worlds of information technology and operations technology will form the crux of the fourth industrial revolution.



Services 2.0

Services 2.0 explores newer avenues for service innovations, such as cloud-based service platforms and evaluating potential for new profit centers. Opportunity analysis is conducted for ICT in manufacturing services.



Supply Chain Evolution

The emergence of the factory of the future is set to disrupt existing supply chain networks.

Digitalisation and increased connectivity are set to disrupt and realign existing valuechain networks in the future.



The Industry 4.0 Business Ecosystem

The advent of advanced ICT technologies will promote new interrelationships and interdependencies, giving way to unexpected business collaborations and partnerships in the future.

> Image Source:Thinkstock Source: Frost & Sullivan

Frost & Sullivan's Offering

2015–2016 Research Portfolio

- 1. Internet of Industrial Things: The Vision and the Realities
- 2. Investing in the Currency of the Future: Big Data for the Manufacturing Domain
- 3. The Safety-Security Argument: Expanding Needs in a Connected Enterprise
- 4. Services 2.0: The New Business Frontier for Profitability
- 5. The Industrie 4.0 Business Ecosystem: Decoding the New Normal

6. Concept to Production: Future of Additive Manufacturing

- 7. Internet of Industrial Things: A Case for Global Venture Capital Investments
- 8. Evolution of Robotics: Growth Opportunities in the Age of Industrie 4.0
- 9. Supply Chain Evolution: Tectonic Shifts in the Value-Chain
- 10. Anatomy of a Digital Factory: A Deep Dive into IT-OT Convergence

Image Source: Thinkstock Source: Frost & Sullivan

Research Scope and Objective

Future of Additive Manufacturing: Research Scope and Objective, Global, 2015			
Objective	The aim of this study is to analyse the future of additive manufacturing and investigate the adoption of additive manufacturing in actual production across different industry verticals. Furthermore, the study evaluates the new lucrative business models that are being developed in the additive manufacturing market.		
Base Year	2015		
Forecast Period	2016-2025		
Geographical Scope	 North America (NA): United States of America and Canada. Europe and the Middle East (EME): Key countries: Germany, United Kingdom, France, United Arab Emirates, Netherlands, Norway, Sweden, Finland. Asia Pacific (APAC): Key countries: China, Japan, India, Australia, South Korea. Rest of the World (ROW): Key regions - Latin America, Africa, and Russia. 		

Source: Frost & Sullivan

Key Questions this Study will Answer

Future of Additive Manufacturing: Key Questions This Study Will Answer, Global, 2015

What are key technologies driving additive manufacturing? What is the impact of 3D printing across different regions?

What are the key impact modules in the additive manufacturing value chain? What is the effect of commoditization in the additive manufacturing market?

What are strategies employed in the APAC region to enable the growth of additive manufacturing?

What are some of the key application of 3D printing in the automotive, aerospace, and defense sectors?

What are future growth strategies in additive manufacturing market? What will be the scenarios for new market entrants?

Source: Frost & Sullivan

Overview of Additive Manufacturing

Return to contents

3D Printing—The Broad Outlook



3D Printing—The Process Flow Exhibit Future of Additive Manufacturing: Process Flow Exhibit, Global, 2015 **Design and Development** Computer aided design **Finished Product Raw Materials** Key Companies: (CAD), computer aided Metal or plastic Erasteel engineering (CAE) software granules and powder Sandvik Software STL file conversion Inspection and Testing software Finishing Conventional **3D Printers** Machine Key Companies: Autodesk **Key Companies: Dassault Systèmes** Key Companies: Sigma Lab Key Companies: **Pro/ENGINEER** Materialise DMG Mori Ansys Netfabb Key Companies: **HyperMesh** Mazak The ExOne Company Altair Matsuura Arcam Unigraphics Stratasys **3D Systems** Renishaw EnvisionTEC Source: Frost & Sullivan

Technology Classification

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State of Today's 3D Printing Industry

Future of Additive Manufacturing: Global 3D Printing Footprint, Global, 2015

- Main focus areas include the advanced aerospace and defence sectors, automotive, and 3D printed metal parts.
- A growing number of start ups such as Shapeways and Makerbot are offering low-cost 3D printing services and products.

North America

Rest of

the World

- Crowd funding initiatives, such as SULI LAB in Chile, are developing open source, 3D printable solar modules.
- 3D Systems has acquired Robtec, creating 3D Systems Latin America, in Brazil.

Note: Rest of the world includes Latin America, Africa, and Russia

TOFUE	Decreasing	Stable	Increasing
TREND		•	

- China aims to develop 3D printing for mass manufacturing of aerospace components.
- Mostly reliant on mass manufacturing; as the cost of the technology reduces in the future, the adoption is likely to be higher.

Europe and Middle East Asia Pacific

- The rate of adoption is slow, compared to the North American region.
- Efforts mainly focused on multi-material 3D printing and laser-based additive manufacturing and its applications for naval and industrial parts manufacturing, and so on.
- Marked increase in funding for 3D printing by automotive companies; a major funding source is the European Union Seventh Framework Programme for research and technological development.

Source: Frost & Sullivan

Commoditisation in the 3D Printing Industry

Future of Additive Manufacturing: Commoditisation Scenarios and Impact on 3D Printing, Global, 2015

Levels of commoditisation	3D printing industry perspective	Threat of 3D printing commoditisation	
Low level of innovation	Accelerated pace of innovation along value chain	Very low: Participants not capable of being active in many fields	
Not much product differentiation, high level of standardisation	Very high potential of product differentiation and supporting demand for unique products	iation Very low: Long-term advantage	
Competition with comparable, substitutable products / services	Overall lack of sufficient production capacity, participants serving various niches	Low: Medium-term advantage	
High price transparency for customers-buyers' market	Low price transparency in the middle to high-end market	Low in the middle and high-end market; High in the low-end market: Long-term advantage in the high-end market	
Increasing price and margin pressure	Margin pressure mainly due to process inefficiencies. Price pressure in the low-end market	Low in the middle and high-end markets; margins expected to improve. High in the low-end market	
New market participants and production over-capacities	Demand significantly outpaces capacity, high level of investment in production capabilities to continue	Low: Long term advantage in the middle and high-end market segment	
		Source: Frost & Sullivan	

Advanced 3D Printing Value Chain

3D printing is a computer-driven additive manufacturing technology used for producing the final product from a digital model by laying down successive layers of material. Future of Additive Manufacturing: Advanced Value Chain Analysis, Global, 2015 Production Post-Production Services **On-Going Services** Design & Engineering Expertise **Pre-Production** Services Metallurgical Expertise Sourcing Finishing **Finished Product** Proprietary Powder Application obtained from Production Development Finishing is done mostly with LPW Services conventional manufacturing Technology, Production techniques. ATI, and Manufacturing Carpenter. Development Excess powder material can be sold back to the supplier Source: Linear Mold & Engineering, Frost & Sullivan

Conventional vs Additive Manufacturing Supply Chain

Future of Additive Manufacturing: Conventional vs Additive Manufacturing Supply Chain, Global, 2015

Conventional Supply Chain

- Supply is a crucial part of production and a delay in any one of the tributaries of a supply chain has a ripple effect across the production value chain.
- Logistics management is key to functionality. Large amounts of money and time are invested to ensure seamless flow of logistics to and from the production sites.
- Large-scale warehousing is crucial to ensure effective storage of raw material inventory, inflow of material from suppliers, and storage of finished goods before shipping.
- Complex systems and processes are required to handle parts from suppliers to maximize production efficiencies.
- Customisation of products is almost impossible as this requires significant adjustment in the standard supply chain paths followed.
- Lead time is very high compared to additive manufacturing.

Additive Manufacturing Supply Chain

- The existing conventional supply chain will see a complete overhaul to meet additive manufacturing requirements.
- The Number of supplier and vendors is poised to reduce.
- Logistics cost will be reduced as most of the material is supplied in powder form and the finished product is distributed locally or within the unit itself.
- The need for warehouses will reduce exponentially as most products are made-toorder, eliminating the need to store finished goods.
- Operations, with respect to tooling and maintenance of multiple machines, are completely ruled out.
- Short lead and cycle times; logistics cost to be reduced by more then 80%.

Source: Frost & Sullivan

Opportunities Across Regions and Industry Verticals

Return to contents

Regional Additive Manufacturing Market

Future of Additive Manufacturing: Schematic of Revenue Generation in Regions, Global, 2015–2025 Additive manufacturing in APAC region is set to grow at a rate of 18.6% (2015–2025) with China making more than 70.0% of the business.



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Comparative Analysis of 3D Printing Technologies



Strong Support for 3D Printing within the APAC Region Future of Additive Manufacturing: Labour Cost Advantage, APAC, 2015 3D printing is a not very labour intensive, but a considerable amount of manpower is required for ensuring seamless work flow through the value chain, with significant cost benefits for the APAC market. STL files correction Post processing **3D** printing Logistics Legend: Labour intensity High Low Future of Additive Manufacturing: Governmental Initiatives, China, 2015 The Chinese Ministry of Industry and Information Technology (MIIT), has just unveiled its National Plan for 3D printing The Chinese 3D printing industry will aim to achieve a sales revenue growth rate of more than 30% per year China will seek to establish 2-3 internationally competitive 3D printing companies. Key verticals include aviation and the medical industry. Source: Frost & Sullivan

Strong Support for 3D Printing within the APAC Region (continued)



Note: DLP - Digital Light Processing Source: Frost & Sullivan

3D Printing Market Potential

Future of Additive Manufacturing: Schematic of Revenue Generation in Manufacturing Sectors, Global, 2015–2025

The aerospace, automotive, and medical industries are expected to account for 51% of the 3D printing market by 2025.



Others include Energy, Construction, Food & Beverage, and others

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3D Printing Across Industry Verticals



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3D Printing in the Automotive Industry

Additive Manufacturing in the automotive industry is poised to become a \$4.30 Billion global business by 2025



The Shift in Applications

Future of Additive Manufacturing: Evolution of Additive Manufacturing Trends, Global, 2015



A Print, Assemble, Drive Scenario?

Future of Additive Manufacturing: Automotive Applications, Global, 2015



- Local Motors and Cincinnati Incorporated have developed a car that is entirely manufactured through 3D printed.
- The car body comprises of carbon fibres and the body is printed over 44 hours with 212 layers.
- This enables the development of micro factories that support quick delivery times, reduces waste, and lowers distribution costs by 97%.



Ford 3D Store • Ford uses the following techniques for its 3D printing solutions - FDM, SLS, and 3D sand printing to print over 500,000 parts.



RMW



- Apart from prototyping, BMW uses 3D printing to build hand tools for automobile testing and assembly.
- Using SLS, BMW has managed to create "thumbs" for its workers to help prevent injuries and pain.

Source: Ford; Local Motors; autoblog.com; Stratasys; BMW; Frost & Sullivan

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Aerospace Industry Moving Towards Actual Production Through Additive Manufacturing

Future of Additive Manufacturing: Additive Manufacturing in Aerospace and Defence, Global, 2015



- Additive manufacturing in the aerospace and defense industry is poised to grow at 26% CAGR (2015– 2025).
- Time and cost of manufacturing can be reduced by 10 times to produce low-volume complicated parts.
- Inlet valves and nozzles are made through 3D printing for initial testing.
- The GE subsidiary, Avio Aero, has bought 10 Arcam EBM machines for manufacturing turbine blades.
- Air ducts, wing spare components, hinges, complicated jet engine part are some of key components manufactured in the aerospace industry.



- The advanced EBM technology is perfectly suitable for low volume productions in the defence industry.
- 3D printing is poised to shrink the supply chain of the component as multiple parts of a product can be printed at a single time.
- Colibri, an electromechanical components providers for unmanned aerial and ground surveillance vehicles, is using 3D printing to produce a miniature electro-optical gimbal.
- This has reduced the production time by 4 weeks and the production cost by 60%.

Source: Arcam, IDS Ingegneria Dei Sistemi; Frost & Sullivan

3D Printing in Medical Devices and Consumer Electronics

Future of Additive Manufacturing: Additive Manufacturing in Medical Devices and Consumer Electronics Industries, Global, 2015



- 3D printing in the medical devices vertical is expecting a growth of 23% between 2015 and 2025.
- China is leading the market; The China Food and Drug Administration (CFDA) has approved manufacturing of medical devices through 3D printing.
- Arcam AB has received five Q10 3D printer orders from Beijing AK Medical for manufacturing metal medical implants.
- Stratasys, 3D Systems, EnvisionTEC, Renishaw, and Materialise NV are some of the key participants in this market.



- 3D printing in the consumer electronics market is a fast growing market, generating a global revenue of \$121 Million.
- USA is poised to see double digit growth rates with revenue from 3D printing market increasing to \$171 Million by 2018.
- Product manufacturers are looking for 3D printing technologies to create flexible electronics components.
- NEC Corporation, Samsung Electronics, LG Electronics, Philips, are some of the companies which have investment in 3D printing and filed many patents in the field.

Source: Arcam AB, Consumer Technology Association, Frost & Sullivan

Future of Additive Manufacturing—Growth Strategies

Return to contents

Strategies to Acquire Advanced Additive Manufacturing Capabilities to Achieve Sustainable Growth



Organic vs Inorganic Growth



Organic	Inorganic	Organic	Inorganic
Can control rate of growth	Increase in market share and assets	Strain on capital	Management challenges due to the increased size and complexities
Less cultural and integration challenges	New skills and knowledge become available	Diverts focus from the business' core mission	Integration and execution challenges
	Access to capital and new markets may be easier.		Systems, sales, and support capabilities must be scaled
			Source: Frost & Sullivan

Inorganic Growth Opportunities

	Future of Additive Manufacturing: Inorganic Growth Business Models, Global, 2015				
1Partner with a 3D printing company2Par R&EAcquire the in-house capability as well as the infrastructure toDevelop expertise with a we		2 Partner with an R&D institution Develop in-house expertise by working with a well-renowned research institute.	3 Partner with a customer who utilizes 3D printing Develop contracts with a firm to manufacture components using 3D manufacturing - an outsourcing model	4 Partner with a niche solution provider Partner with a solution provider that has strong capabilities in niche solutions such as software or value engineering	
	Advantage: Development of in- house 3D printing Disadvantage: Upfront investment maybe high	Advantage: Strengthened R&D capabilities for new material and technology development Disadvantage: Scaling / commercialisation may be difficult	Advantage: Low upfront investment Disadvantage: Dependence on a third- party vendor	Advantage: Acquire specialised capabilities Disadvantage: Upfront investment maybe high	
Focus areas	Aggressive targets to obtain a diverse set of technologies	Create a blue ocean market	Acute focus towards niche and emerging Tier II and Tier 3 OEMs who are looking for low volume manufacturing		

Strategic Explaination

	3D Company	R&D Institute	3D Customer	Niche solution provider
Time to Setup	Match capabilities with company's portfolio (6–18 months)	Align with the disruptive market trends. (6–12 months)	Establish customers faith (1–3 years)	Alignment with company's portfolio (1–2 years)
Level of Investment	Very high: Purchase of company	Low: Nominal investment due to collaboration with R&D institute	Medium: Attract customers and build brand value	Medium to high: Depends on the size of the company
Ease of Implementation	Difficult to merge company culture and best practices	Easier to tune the research activity to the company requirements	Difficult because value has to be provided right from the start	Easy to implement with the existing solutions with service bureaus
Complexity of Supply Chain	Access to a well- established supply chain	Difficult because of evolving requirements	Depends on the company	Less supply chain requirement as its focused on one solution

Source: Frost & Sullivan

Case Example: Strategic Application in the Automotive Industry

Focus Area	Reasoning
Aggressive targets to obtain a diverse set of technologies	90% of the 3D printing applications in the automotive industry are for prototyping and 10% for production.
2 Acute focus towards niche and emerging Tier II and Tier III OEMs who are looking for low-volume manufacturing	Emerging OEMs, such as Local Motors and Divergent Microfactories, that focus on low-volume manufacturing are using 3D printing for rapid prototyping of their vehicle structures and components.
3 Create a blue ocean market	Several educational institutions and technology partners have collaborated with automotive OEMs in using 3D printing. For example, Daimler partners with Fraunhofer Institute of Laser Technology and Concept Laser partners with BMW and Clemson University.

Additive Manufacturing Market Entry Recommendations



Source: Frost & Sullivan
Lucrative Business Models

Design to Additive Manufacturing

Closed Loop Feedback Systems

- CAD and CAE software will be designed to match the requirement of 3D printers so that the model from these software can be directly printed without any conversion and modeling correction.
- Design for additive manufacturing, that is, integration of PTC Creo and industrial 3D printers.
- The CAD software will allow the manufacturer to define the 3D printer setting and correctly position and scale model for production.
- Stratasys has released 3D printers and scanner with collaboration with Solidwork for enable direct import of data to the machines.
- Closed loop feedbacks systems are going to be new quality assurance solutions that are embedded in the 3D printers and provide real-time feedback of the production process.
- The closed loop system helps achieve higher accuracy and speeds, ultimately improving the quality of the product printed. It also helps correct any errors before the product is completely printed.
- The real-time ability of closed looped systems to monitor and detect any skipped step in the additive manufacturing process helps in making necessary changes in the programming. This makes the whole process more reliable and helps in tuning the machines' motion parameters in an aggressive manner. The overall time saved by adopting closed loop systems is estimated to be 25.0%

Source: Frost & Sullivan

Lucrative Business Models (continued)



Company Profiles

Return to contents

3D Systems



Stratasys



Arcam (Sweden)



Source: Arcam AB, Frost & Sullivan

The ExOne Company (USA)

Company Overview merged with Delaware Corporation and is now known as The ExOne Company. The company supplies 3D printing machines, 3D printed products, and 3D printing material to multiple industry verticals. ExOne is the exclusive licensee of the 3D printing process developed by the Massachusetts Institute of Technology for metal manufacturing and tooling.

ExOne was founded on 1st January, 2013. It later



Product Offering

Production Printers

Prototyping Printers

Contract Manufacturing

 ExOne has mastered the binder jetting process, which is a unique process that does not require heat for moulding. It is a process by which a binding agent is selectively deposited to fuse metal powder particles. Layers of build material are bonded together by the liquid binding agent and dropped by the printing head to form the required object. The layering and binding continues, giving rise to the finished structure.

Key Highlights

• ExOne has launched a new Design and Re-Engineering for Additive Manufacturing (DREAM) facility in its North Huntingdon unit. This will increase the virtual collaboration with the customer, helping them understand the advantage of the binding jet process across different applications.

Source: The ExOne Company, Frost & Sullivan

Linear Mold & Engineering (USA)



Poly-Shape (France)



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3T RPD (UK)



FIT Technology Group (Germany)



Conclusion

Return to contents

Key Conclusions

 Rectangular and cylindrical shapes of raw material are replaced by granules and powder according to 3D printer requirements.

• The use of carbon fibre and metal powders, such as titanium, is expected to radically improve mechanical, chemical, and thermal characteristics in multiple stringent applications, particularly for oil and gas and defence industries.

• CAD and CAE solution and software providers are poised to develop solutions to allow direct interaction with 3D printers.

 Integration of 3D printer with the modelling software will be the approach to minimise geometric errors and bring in greater accuracy.



- Business models using 3D printers will change; leasing and 3D printing as service to become the lucrative options for product manufacturing.
- The bandwidth of industrial 3D printers will increase with respect to both scale and accuracy of final product manufactured.



The Last Word: What's Next?—3 Big Predictions

Medical Applications	 3D printing of complicated body parts such as dental inserts, implants, and small section of bones Printing of a nanorobots built from DNA strands with double helical locks that are opened when the robot comes into contact with specific cancerous cells.
Self- Assembling and Programmable Materials	 Explore materials and understand reaction to external elements such that materials can be programmed to adapt and change shape in response to environmental changes. 4-D printed parts that can be sent to space and programmed to self-assemble into a given object at the desired location.
Graphene-based 3D printing	 Graphene-based 3D printing through fused filament fabrication (FFF) will be the next big innovation in the additive manufacturing market. 3D printing using graphene, which is known for its unique physical and electrical properties, can be used to manufacture filaments and printable batteries.

Source: Frost & Sullivan

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Appendix

Return to contents

Abbreviations Used

AM: Additive Manufacturing

DNA: Deoxyribonucleic Acid

ICT: Information and Communication Technology

IIoT: Industrial Internet of Things

IT: Information Technology

OEM: Original Equipment Manufacturer

OT: Operation Technology

Source: Frost & Sullivan

The Frost & Sullivan Story The Journey to Visionary Innovation

Return to contents

The Frost & Sullivan Story



Value Proposition: Future of Your Company & Career

Our 4 Services Drive Each Level of Relative Client Value



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Global Perspective

40+ Offices Monitoring for Opportunities and Challenges



Industry Convergence

Comprehensive Industry Coverage Sparks Innovation Opportunities



Aerospace & Defense



Automotive



Minerals & Mining



Measurement & Instrumentation



Transportation & Logistics





Chemicals, Materials & Food



Consumer Technologies



Environment & Building Technologies



Electronics & Security



Information & **Communication Technologies**



Healthcare



Industrial Automation & Process Control

Source: Frost & Sullivan

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360° Research Perspective

Integration of 7 Research Methodologies Provides Visionary Perspective



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Implementation Excellence

Leveraging Career Best Practices to Maximize Impact



Our Blue Ocean Strategy

Collaboration, Research and Vision Sparks Innovation



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