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

MB74-10
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## Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Slide Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Executive Summary</td>
<td>3</td>
</tr>
<tr>
<td>Internet of Industrial Things—A Research Perspective</td>
<td>5</td>
</tr>
<tr>
<td>Overview of Additive Manufacturing</td>
<td>10</td>
</tr>
<tr>
<td>Opportunities Across Regions and Industry Verticals</td>
<td>18</td>
</tr>
<tr>
<td>Future of Additive Manufacturing—Growth Strategies</td>
<td>30</td>
</tr>
<tr>
<td>Company Profiles</td>
<td>39</td>
</tr>
<tr>
<td>Conclusion</td>
<td>48</td>
</tr>
<tr>
<td>Appendix</td>
<td>52</td>
</tr>
<tr>
<td>The Frost &amp; Sullivan Story</td>
<td>54</td>
</tr>
</tbody>
</table>
Executive Summary
Key Findings

1. Additive manufacturing is poised to grow at a rate of 15.0% (CAGR, 2015–2025)

2. Global 3D printing revenues in automotive industry will grow at a CAGR of 34% between 2015–2020.

3. Aerospace, Automotive and Medical industries are expected to account for 51% of the 3D printing market by 2025.

4. 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.

5. Graphene-based 3D printing through Fused Filament Fabrication (FFF) will be next big innovation in additive manufacturing market.

6. Additive manufacturing in the aerospace and defense industry is poised to grow at a 26% CAGR (2015–2025)

7. 3D printing in medical devices vertical is expecting a growth of 23% between 2015 and 2025

8. Graphene in 3D printing

9. Very high potential of product differentiation and supporting demand for unique products will reduce commoditisation of 3D printing.

Source: Frost & Sullivan
Internet of Industrial Things—A Research Perspective
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 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.

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 value-chain networks in the future.

The advent of advanced ICT technologies will promote new inter-relationships 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
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
## Future of Additive Manufacturing: Key Questions This Study Will Answer, Global, 2015

<table>
<thead>
<tr>
<th>Question</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>What are key technologies driving additive manufacturing? What is the impact of 3D printing across different regions?</td>
<td></td>
</tr>
<tr>
<td>What are the key impact modules in the additive manufacturing value chain? What is the effect of commoditization in the additive manufacturing market?</td>
<td></td>
</tr>
<tr>
<td>What are strategies employed in the APAC region to enable the growth of additive manufacturing?</td>
<td></td>
</tr>
<tr>
<td>What are some of the key application of 3D printing in the automotive, aerospace, and defense sectors?</td>
<td></td>
</tr>
<tr>
<td>What are future growth strategies in additive manufacturing market? What will be the scenarios for new market entrants?</td>
<td></td>
</tr>
</tbody>
</table>

Source: Frost & Sullivan
Overview of Additive Manufacturing
3D Printing—The Broad Outlook

**Trends**
- An increasing trend toward cost-effective manufacturing and rapid production is leading to favorable growth for this technology.
- There has been an increase in its popularity with the development of heterogeneous material manufacturing capability.

**Potential**
- 3D printing has a growing market capability in the aerospace, automotive, healthcare, and consumer products sectors.
- 3D printing is expected to increase its market share by 2X times by 2018.

**Impact**
- 3D printing is expected to see wider usage in automotive and aerospace applications and customised manufacturing.
- With 3D printing, it becomes possible to develop an agile manufacturing environment, which may reduce the lead time from conception to the production stage by 70% or more, depending on the type of manufacturing desired.

Source: Frost & Sullivan
3D Printing—The Process Flow Exhibit


Design and Development
Computer aided design (CAD), computer aided engineering (CAE) software

Software
STL file conversion software

Raw Materials
Metal or plastic granules and powder

Key Companies:
- Erasteel
- Sandvik

3D Printers

Key Companies:
- Autodesk
- Dassault Systèmes
- Pro/ENGINEER
- Ansys
- HyperMesh
- Altair
- Unigraphics

Key Companies:
- Materialise
- Netfabb

3D Printers

Key Companies:
The ExOne Company
Arcam
Stratasys
3D Systems
Renishaw
EnvisionTEC

Key Companies:
DMG Mori
Mazak
Matsuura

Finished Product

Inspection
Conventional
Machine

Key Companies:
Sigma Lab

Source: Frost & Sullivan
A focused beam of high-energy electrons is used to melt the metal powder layer by layer in the vacuum as per the pre-defined dimensions.

The system uses thermoplastic material, which is melted to a semi-liquid state and extruded according to computer-controlled paths.

Small particles of plastic, glass, or ceramics are fused together from a high-powered laser to form a solid 3D object.

An economic process in which layers of adhesive-laminated paper or plastic sheets are glued together and cut to create complex shapes.

A stereolithography apparatus uses liquid plastic, a perforated platform, and a UV laser to print 3D objects.

Similar to electron beam melting, this method creates complex objects by completely melting the metal powder using a high-powered laser beam.

Fused Deposition Modeling (FDM)
Selective Laser Sintering (SLS)
Laminated Object Manufacturing (LOM)
Selective Laser Melting (SLM)
Electron Beam Melting (EBM)
Stereolithography (SLA)
Additive Manufacturing

Source: Frost & Sullivan
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.

- 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.

- 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.

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

<table>
<thead>
<tr>
<th>TREND</th>
<th>Decreasing</th>
<th>Stable</th>
<th>Increasing</th>
</tr>
</thead>
</table>

Source: Frost & Sullivan

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

Rest of the World

North America
## Commoditisation in the 3D Printing Industry

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

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

Source: Frost & Sullivan
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

- On-Going Services
- Production
- Post-Production Services

Sourcing
- Design & Engineering Expertise
- Metallurgical Expertise
- Proprietary Application Development
- Production Manufacturing Development

Pre-Production Services

Production Services

Finishing
- Finishing is done mostly with conventional manufacturing techniques.

Finished Product

Source: Linear Mold & Engineering, Frost & Sullivan

- Powder obtained from LPW Technology, ATI, and Carpenter.
- Excess powder material can be sold back to the supplier.
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-to-order, 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 than 80%.

Source: Frost & Sullivan
Opportunities Across Regions and Industry Verticals
Regional Additive Manufacturing Market


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.

Source: Frost & Sullivan
## Comparative Analysis of 3D Printing Technologies

### Future of Additive Manufacturing: Comparative Analysis of Major 3D Printing Technologies, Global, 2015

<table>
<thead>
<tr>
<th>Technology</th>
<th>Stereolithography</th>
<th>Fused Deposition Modeling</th>
<th>Selective Laser Sintering</th>
<th>Electron Beam Melting</th>
<th>Laminated Object Manufacturing</th>
<th>Selective Laser Melting</th>
</tr>
</thead>
<tbody>
<tr>
<td>North America</td>
<td>High</td>
<td>High</td>
<td>Medium</td>
<td>High</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>APAC</td>
<td>Medium</td>
<td>High</td>
<td>Medium</td>
<td>Medium</td>
<td>Low/Nil</td>
<td>Medium</td>
</tr>
<tr>
<td>EME</td>
<td>High</td>
<td>Medium</td>
<td>High</td>
<td>High</td>
<td>Low/Nil</td>
<td>High</td>
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<tr>
<td>ROW</td>
<td>Medium</td>
<td>Medium</td>
<td>Low/Nil</td>
<td>Medium</td>
<td>Low/Nil</td>
<td>Medium</td>
</tr>
</tbody>
</table>

### Future of Additive Manufacturing: Market Share Percent of Key Countries, Global, 2015

- **USA**: 32.5%
- **China**: 23.7%
- **Germany**: 13.0%
- **Japan**: 9.2%
- **United Kingdom**: 11.2%
- **France**: 5.1%
- **Others***: 5.3%

- **North America and Europe** being early adopters of CAD and CAE, have the highest market shares in the additive manufacturing market.
- **The APAC countries**, particularly China, is poised to see large-scale adoption of additive manufacturing in consumer electronics and retail markets.

*Other include India, Latin America, Russia, Australia, Italy, Sweden, Belgium, Spain, Netherlands

Source: Frost & Sullivan
Strong Support for 3D Printing within the APAC Region


- 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.

Legend: Labour intensity | Low | High

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)

Future of Additive Manufacturing: Governmental Support and University Initiatives, Singapore, 2015

- Singapore’s Economic Development Board has set aside $500 Million to nurture the country’s growing additive manufacturing sector over the next 5 years.
- Nanyang Technological University has spent $30 Million to construct an additive manufacturing centre and have also developed 3D printing driven startups.
- These efforts will be part of the National Additive Manufacturing Innovation Cluster, an initiative to implement 3D printing technology into Singapore-based businesses and startups.


- Developed a new technology 400 times faster than existing DLP technologies
  - Carima (South Korea)
  - Ultra Clean Asia Pacific (Japan)
  - Drona (India)
  - Sentrol (South Korea)
  - Addwii (Taiwan)

- Launch of a gigantic 3D printing facility in Singapore
- Botzlab’s Drona has been developed to provide competition for FDM printers
- Low cost 3D printer based on a very similar binder jetting technology, partnership with an inkjet cartridges manufacturer.

Note: DLP – Digital Light Processing Source: Frost & Sullivan
The aerospace, automotive, and medical industries are expected to account for 51% of the 3D printing market by 2025.
3D Printing Across Industry Verticals

Future of Additive Manufacturing: Schematic Adoption Rate of 3D Printing Across Industry Verticals, Global, 2015–2025

Scale: 0 means limited adoption of 3D printing
5 means maximum adoption of 3D printing

1) Prototyping, pre production, and actual production jobs are taken in consideration for analysis.
2) Metal and plastic 3D printing have been included

Source: Frost & Sullivan
3D Printing in the Automotive Industry

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

Mega Trends impacting the automotive industry…

- Changing Patterns of Demand
- Increased Customisation
- E-mobility
- Focus on Sustainability

...are driving a transformational shift to AM…

- Cost-effective short-series production
- Time-to-market as key differentiator
- Lightweight parts and efficient use of materials

... which evolves from prototyping to direct manufacturing…

- Direct Digital Manufacturing
- Short production runs
- Additively manufactured moulds
- Prototype parts manufacturing

... generating growth opportunities for AM.


$0.53B

CAGR: 23.2% $4.30B

Revenue

2015 2025

IioT and the supplier transformation are catalysts for growth in the additive manufacturing sector in the automotive industry

Technology Convergence:
Infusion of IT into the OT layers

The Diversification of the IioT Business Ecosystem:
Expanding strength of service providers

New Service Models:
- Contract manufacturing model
- Additive manufacturing as a service

Supply Chain Evolution:
- Adaptable supply chain
- Full visibility of flow of materials and process cycle times

Source: Frost & Sullivan
The Shift in Applications


- **Visualisation:** Communication of concept and design
  - Advances in precision manufacturing

- **Rapid prototyping:**
  - Parts and assemblies: Models that are in fit, function and supply form

- **Advances in subsurface engineering and multimaterial joining**

- **Production:** Direct parts and assembly production
  - Advances in self assembly and integration of different techniques

Past | Present | Future
--- | --- | ---
Customisation and Prototyping | Volume, Scale, and Availability


- **Automotive Industry**
  - Design and prototypes
  - Aftermarket customisation
  - Specialised and lightweight components
  - Crowdsourced design and manufacture
  - Innovative vehicle printing

Source: Frost & Sullivan
A Print, Assemble, Drive Scenario?


1. **Strati**
   - 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%.

2. **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.

2. **BMW**
   - 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
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
Strategies to Acquire Advanced Additive Manufacturing Capabilities to Achieve Sustainable Growth

Organic Growth

- Increase Capacity
- Customer Base Expansion
- New Product Development

Inorganic Growth

- Mergers and Acquisition

- While automotive, aerospace, and medical are the top 3 industry verticals, process industries are slowly gaining prominence.
- While North America and Europe continue to grow their additive manufacturing capabilities, the Middle East and APAC regions are slowly expanding their reach.

Currently companies are selective in terms of the orders they can accommodate due to the capacity availability.
Companies will have to cater to the increasing demand.

Source: Frost & Sullivan
Organic vs Inorganic Growth


Growth Strategies

Organic
- Entering new verticals
- Core talent development
- Supply chain optimisation

Inorganic
- R&D
- Acquisition / Takeover
- Joint venture
- Strategic alliance

Advantages
<table>
<thead>
<tr>
<th>Organic</th>
<th>Inorganic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Can control rate of growth</td>
<td>Increase in market share and assets</td>
</tr>
<tr>
<td>Less cultural and integration challenges</td>
<td>New skills and knowledge become available</td>
</tr>
<tr>
<td></td>
<td>Access to capital and new markets may be easier.</td>
</tr>
</tbody>
</table>

Disadvantages
<table>
<thead>
<tr>
<th>Organic</th>
<th>Inorganic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strain on capital</td>
<td>Management challenges due to the increased size and complexities</td>
</tr>
<tr>
<td>Diverts focus from the business’ core mission</td>
<td>Integration and execution challenges</td>
</tr>
<tr>
<td></td>
<td>Systems, sales, and support capabilities must be scaled</td>
</tr>
</tbody>
</table>

Source: Frost & Sullivan
# Inorganic Growth Opportunities


<table>
<thead>
<tr>
<th>Opportunity</th>
<th>Partner with a 3D printing company</th>
<th>Partner with an R&amp;D institution</th>
<th>Partner with a customer who utilizes 3D printing</th>
<th>Partner with a niche solution provider</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Acquire the in-house capability as well as the infrastructure to manufacture components using 3D printing technology</strong></td>
<td>Acquire the in-house capability as well as the infrastructure to manufacture components using 3D printing technology</td>
<td>Develop in-house expertise by working with a well-renowned research institute.</td>
<td>Develop contracts with a firm to manufacture components using 3D manufacturing - an outsourcing model</td>
<td>Partner with a solution provider that has strong capabilities in niche solutions such as software or value engineering</td>
</tr>
<tr>
<td><strong>Advantage:</strong></td>
<td>Strengthened R&amp;D capabilities for new material and technology development</td>
<td><strong>Advantage:</strong> Low upfront investment</td>
<td><strong>Advantage:</strong> Acquire specialised capabilities</td>
<td><strong>Advantage:</strong> Acquire specialised capabilities</td>
</tr>
<tr>
<td><strong>Disadvantage:</strong></td>
<td>Scaling / commercialisation may be difficult</td>
<td><strong>Disadvantage:</strong> Upfront investment maybe high</td>
<td><strong>Disadvantage:</strong> Upfront investment maybe high</td>
<td><strong>Disadvantage:</strong> Upfront investment maybe high</td>
</tr>
</tbody>
</table>

### 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**

Source: Frost & Sullivan
### Strategic Explanation

<table>
<thead>
<tr>
<th>3D Company</th>
<th>R&amp;D Institute</th>
<th>3D Customer</th>
<th>Niche solution provider</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Time to Setup</strong></td>
<td>Match capabilities with company’s portfolio (6–18 months)</td>
<td>Align with the disruptive market trends. (6–12 months)</td>
<td>Establish customers faith (1–3 years)</td>
</tr>
<tr>
<td><strong>Level of Investment</strong></td>
<td>Very high: Purchase of company</td>
<td>Low: Nominal investment due to collaboration with R&amp;D institute</td>
<td>Medium: Attract customers and build brand value</td>
</tr>
<tr>
<td><strong>Ease of Implementation</strong></td>
<td>Difficult to merge company culture and best practices</td>
<td>Easier to tune the research activity to the company requirements</td>
<td>Difficult because value has to be provided right from the start</td>
</tr>
<tr>
<td><strong>Complexity of Supply Chain</strong></td>
<td>Access to a well-established supply chain</td>
<td>Difficult because of evolving requirements</td>
<td>Depends on the company</td>
</tr>
</tbody>
</table>

Source: Frost & Sullivan
## Case Example: Strategic Application in the Automotive Industry

### Focus Area

<table>
<thead>
<tr>
<th></th>
<th>Reasoning</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Aggressive targets to obtain a diverse set of technologies</td>
</tr>
<tr>
<td>2</td>
<td>Acute focus towards niche and emerging Tier II and Tier III OEMs who are looking for low-volume manufacturing</td>
</tr>
<tr>
<td>3</td>
<td>Create a blue ocean market</td>
</tr>
</tbody>
</table>

90% of the 3D printing applications in the automotive industry are for prototyping and 10% for production.

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.

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.

Source: Frost & Sullivan
Additive Manufacturing Market Entry Recommendations

Enter the markets providing high volume and/or high margin potential, such as automotive, aerospace, or with low threat of commoditisation, such as medical and tooling.

Focus on the **industrialisation** of the 3D printing manufacturing, through investment in large-scale production technology.

Choose leasing and the main financial mean of investing in equipment for increased profitability and flexibility.

Develop a strong sales and customer support network, which is key in creating a ‘pull’ effect on the market and has a positive effect on capacity utilisation.

Currently, high investment in R&D is focused towards development of technologies. Frost & Sullivan recommends regulated but consistent investment for development of innovative business models.

Source: Frost & Sullivan
Lucrative Business Models

- 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)

3D Printing as a Service

- 3D Printing as a Service is poised to replace traditional manufacturing business models.
- Solution providers are set to become one-stop shops through strategic partnerships or by developing in-house expertise.
- Initial investment and maintenance costs can be eliminated by product manufacturers in this model.
- The emergence of integrators providing services across the value chain will drive the mainstream adoption of 3D printers in manufacturing.

Leasing of 3D Printing Machines

- Pay as you print: No capital cost, the end user pays the 3D printer company for every product printed in the leased machine.
- In certain cases, logistics, material cost, and maintenance cost are included in the leasing model, ensuring a seamless transaction for the product manufacturers.
- Small and medium solution providers are poised to benefit from this model as it fits their low-investment criteria.

Source: Frost & Sullivan
Company Profiles
3D Systems

3D System is a 3D printing company whose offering includes 3D printers, printing services, print materials, and design and development of models. The company has established a wide customer base across the aerospace and defense, automotive, energy, healthcare, architecture, and retail industry verticals.

Year of Establishment: 1986

Employees: 5000+

2015 Revenue: $666.2M

No. of Customers: 1000+

**Key Highlights**

- The company opened a best-in-class healthcare technology to tackle the rising demands of the healthcare market.
- 3D Systems is known for the invention of SLA, Selective Laser Sintering (SLS), ColorJet Printing (CJP), MultiJet Printing (MJP), virtual surgical simulation (VSSTM), virtual surgical planning.

Source: 3D Systems; Frost & Sullivan
Stratasys has a strong foothold in additive manufacturing market across the globe. The company currently offers 3D printer material solutions, printing services, 3D printers, and strategic consulting. The company provides services across the aerospace and defense, automotive, dental, medical devices, architecture, commercial, and consumer product sectors.

- **Year of Establishment**: 1987
- **Employees**: 5000+
- **2015 Revenue**: $690 M
- **No. of Customers**: 1000+

**3D Printers**
- Idea Series
- Design Series
- Production Series
- Dental Series

**Solutions Offering**
- Rapid Prototyping
- Manufacturing & Moulding
- Consulting
- Advanced Material & Manufacturing
- Thermoplastics for FDM
- Polyjet Photopolymers

**Key Highlights**
- Stratasys acquired MakerBot as a 3D printer manufacturer in 2013 to gain market share in APAC and increase the value of 3D printing in the industry.
- Stratasys acquired GrabCAD, a CAD file sharing software company, in 2014. It also acquired Econolyst to create Stratasys Strategic Consulting.

Source: Stratasys; Frost & Sullivan
Arcam is a pioneer of the EBM process. The company has designed and built the Arcam Q20 machine, which is considered a third-generation innovation in EBM technology. The Arcam Q20 machine has been equipped with the Arcam multibeam technology that allows multiple melt pools to act simultaneously, enhancing the surface finish and increasing build rates. The machine can deliver beams at energies of 3,000 watts.

- Arcam received an exclusive order from Avio Aero, a subsidiary of General Electric, which is planning to use Arcam Q20 machine for the production of turbine blades.
- Beijing AK Medical has ordered 5 Arcam Q10 machine for manufacturing medical implants.
- Arcam has boosted its production facility with a 1,500 square metre factory in Mölndal, Sweden. This facility also includes an application and demo centre.

Source: Arcam AB, Frost & Sullivan
ExOne was founded on 1st January, 2013. It later 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.

Year of Establishment: 2003
Employees: 300-500
2014 Revenue: $43,900
No. of Customers: 100+

Product Offering
- Production Printers
- Prototyping Printers
- Contract Manufacturing

Key Highlights
- 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.
- 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 is the most renowned service bureau for additive manufacturing in North America. The company is equipped with a wide array of 3D printing and additive manufacturing equipment that serves the discrete and retail industry verticals. The company has offices in 3 buildings in Livonia, Michigan that together occupy around 67,000 square feet.

### Production Process Offering
- **Engineering**
- **Conformal Coating**
- **Tooling**
- **Traditional Manufacturing**
- **Additive Manufacturing**
- **Direct Metal Laser Sintering (DMLS)**
- **Selective Laser Sintering (SLS)**
- **Fused Deposition Modelling (FDM)**
- **Stereolithography (SLA)**

### Company Overview
- **Year of Establishment**: 2003
- **Employees**: 135 (60%-70% for AM)
- **2014 Revenue**: $20 Million
- **No. of Customers**: 1000+

Source: Linear Mold & Engineering, Frost & Sullivan
Poly-Shape (France)

Poly-Shape, started in 2007, is a French small and medium-sized enterprise that meets the needs of large industrial enterprises in various fields, such as aeronautics, medical, and automotive, on issues related to additive manufacturing. Poly-Shape tackles the evolving challenge of meeting the needs of manufacturing innovation in large groups.

Company Overview

Year of Establishment: 2007
Employees: 43
2014 Revenue: $7-$9 M
No. of Customers: 100+

Production Process Offering
Selective Laser Melting
Services
Tools Manufacturing
Lightweight Parts Manufacturing
Customised Implants

Source: Poly-Shape, Frost & Sullivan
3T RPD (UK)

3T RPD has become a leading provider of plastic and metal additive manufacturing services throughout Europe. It supplies SLS to 50% of the UK market and DMLS to 40% of the UK market.

Company Overview

Year of Establishment: 1999
Employees: 70
2014 Revenue: $5 - $10 M
No. of Customers: 100+

Production Process Offering

Metal Additive Manufacturing
Plastic Additive Manufacturing

Finishing

Additive Manufacturing Capabilities

DMLS
SLS

Source: 3T RPD, Frost & Sullivan
FIT Technology Group has specialised in innovative solutions in the field of additive manufacturing. Ranging from Rapid Prototyping to serial production, software, and hardware development, the company is able to provide all services under one roof, fast and reliably.

Additive Manufacturing Capabilities

ADM Workshops
ADM Quality
ADM Volume Manufacturing
ADM Engineering
ADM Workshop
ADM Engineering
ADM Volume Manufacturing
White Label Manufacturing
Microstructuring

Production Process Offering

FIT Prototyping
FIT Production
FIT Nord
FIT West
Netfabb

Company Overview

Year of Establishment: 2007
Employees: 43
2014 Revenue: $7-$9 M
No. of Customers: 100+

Note: ADM – Additive design and manufacturing; Source: FIT, Frost & Sullivan
• 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.

• 3D printers are going to become at least 2 times faster by 2020.
• 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.

Source: Frost & Sullivan
# 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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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
The Frost & Sullivan Story

Emerging Research
1961

Growth Partnership
1990

Visionary Innovation
Today

Source: Frost & Sullivan
Value Proposition: Future of Your Company & Career
Our 4 Services Drive Each Level of Relative Client Value

Source: Frost & Sullivan
Global Perspective
40+ Offices Monitoring for Opportunities and Challenges

Source: Frost & Sullivan
Industry Convergence
Comprehensive Industry Coverage Sparks Innovation Opportunities

Aerospace & Defense
Measurement & Instrumentation
Consumer Technologies
Information & Communication Technologies
Automotive Transportation & Logistics
Energy & Power Systems
Environment & Building Technologies
Healthcare
Minerals & Mining
Chemicals, Materials & Food
Electronics & Security
Industrial Automation & Process Control

Source: Frost & Sullivan
360° Research Perspective
Integration of 7 Research Methodologies Provides Visionary Perspective

Source: Frost & Sullivan
Implementation Excellence
Leveraging Career Best Practices to Maximize Impact

Source: Frost & Sullivan
Our Blue Ocean Strategy
Collaboration, Research and Vision Sparks Innovation

Source: Frost & Sullivan