

# The Additive Manufacturing Gold Rush

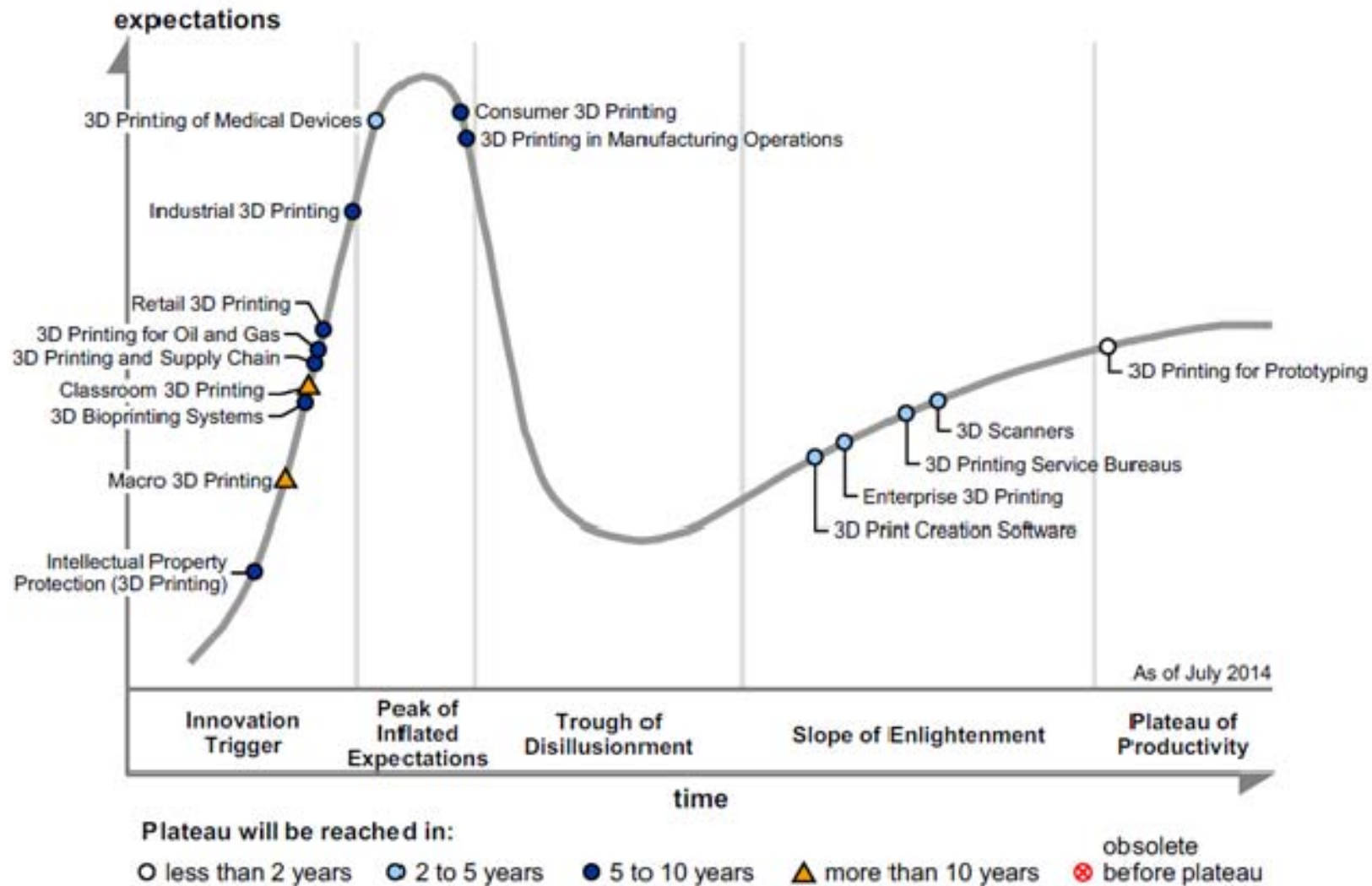
Dream or Reality?



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# Where's the Rush?

Figure 1. Hype Cycle for 3D Printing, 2014



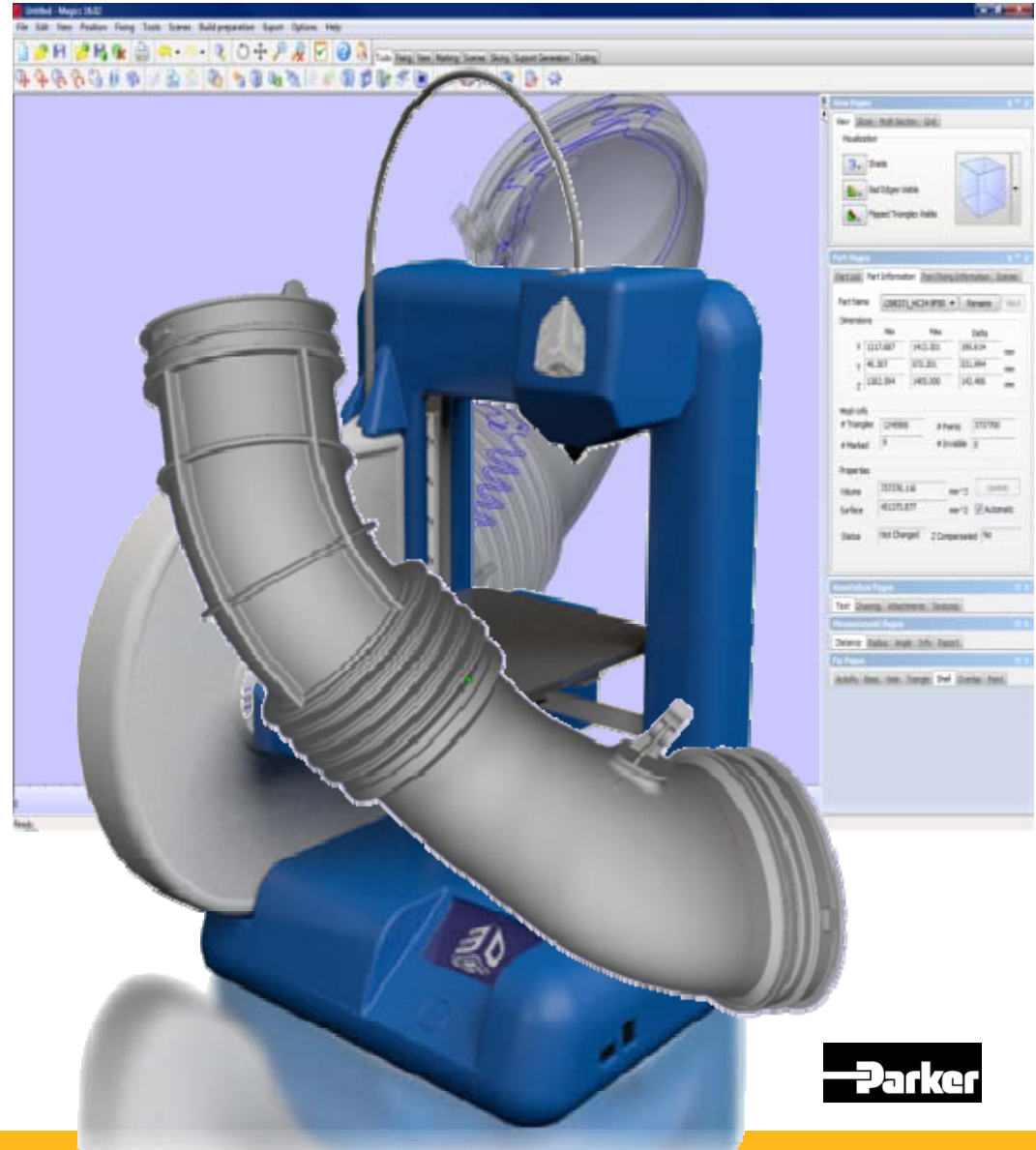
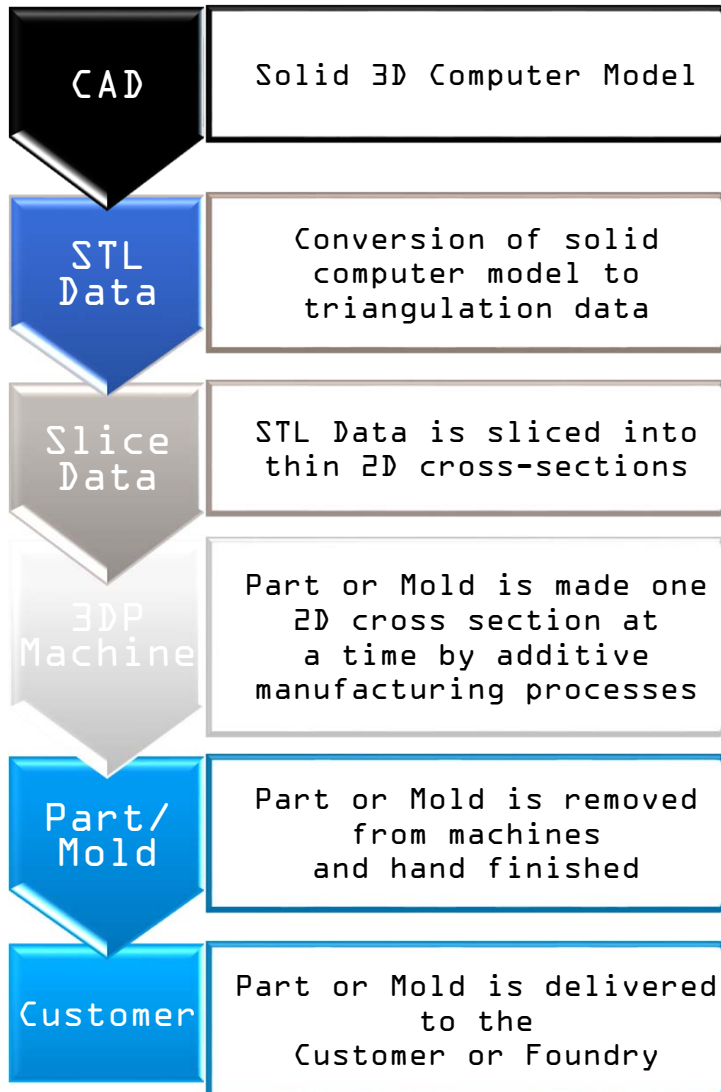
# The Additive Manufacturing Gold Rush

## Tools of the Trade



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# Additive Manufacturing (AM) Basics



# Standardized AM Categories

Binder Jetting

Directed Energy  
Deposition

Material Extrusion

Material Jetting

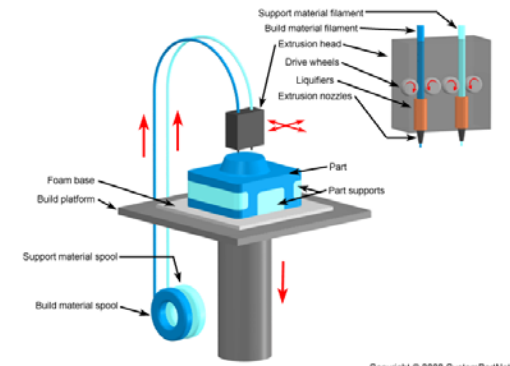
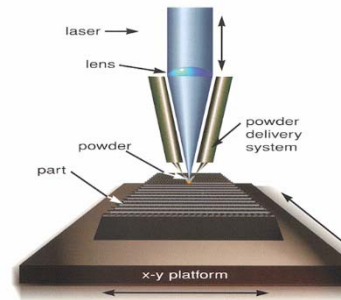
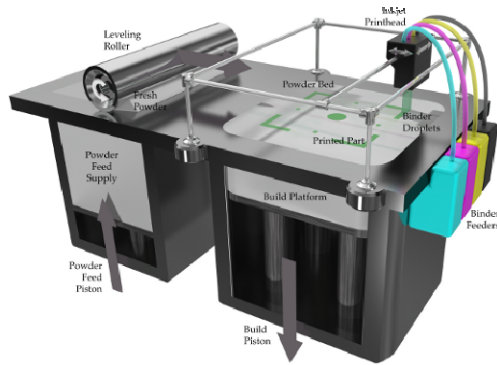
Powder Bed Fusion

Sheet Lamination

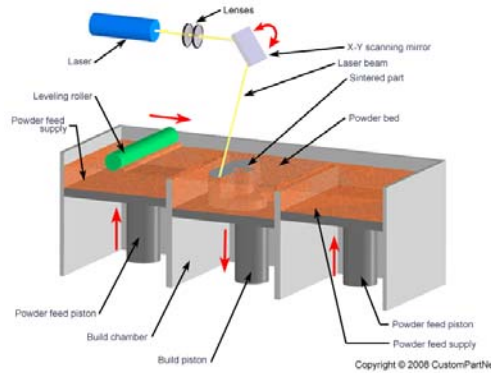
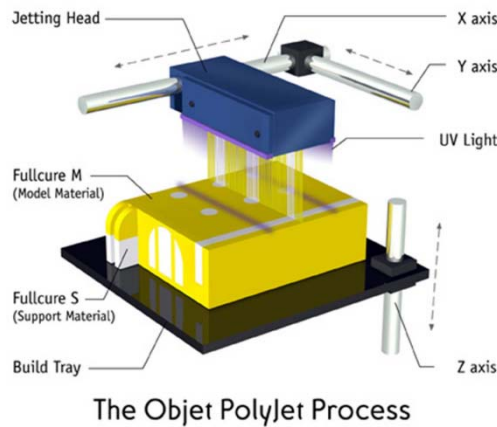
Vat  
Photopolymerization



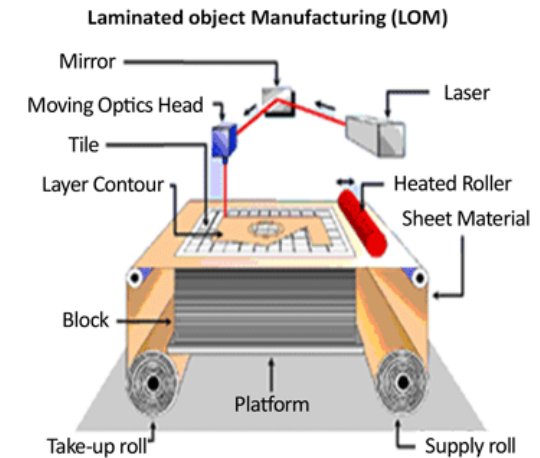
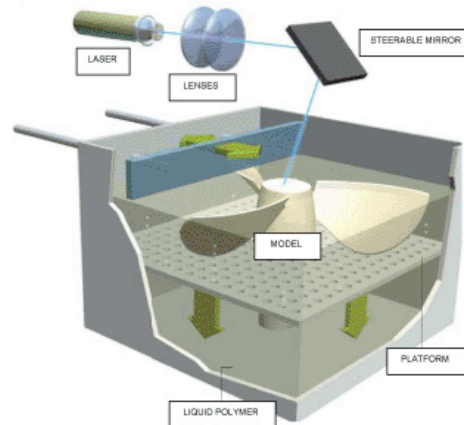
# Standardized AM Categories



Copyright © 2008 CustomPartNet



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# Binder Jetting



Image Source ExOne  
([www.exone.com](http://www.exone.com))

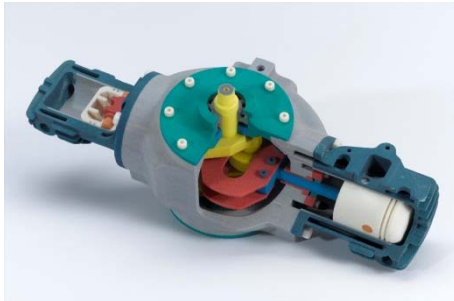
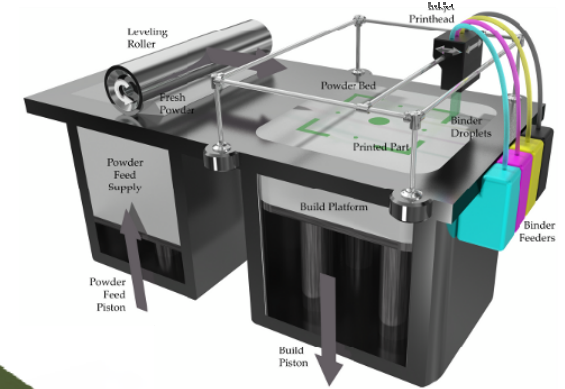
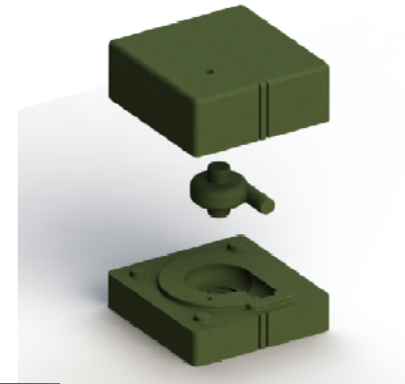


Image Source Ford Motor Company



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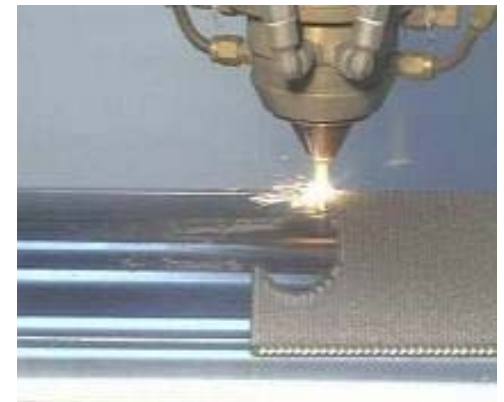
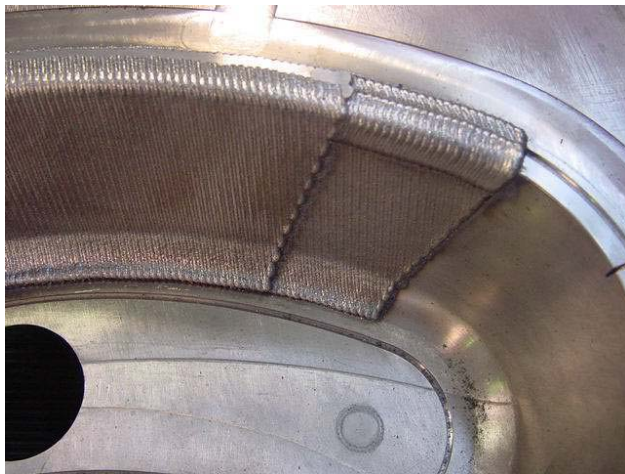
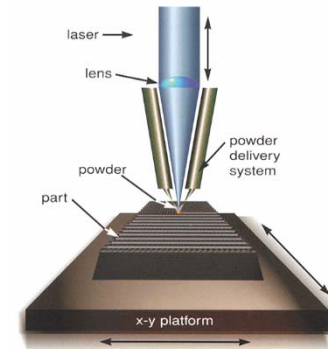
Process: Liquid bonding agent is selectively deposited to join powder materials

Technologies: Varies by binding material

Materials: Plastic, Ceramic, Metal, Sand, PMMA



# Directed Energy Deposition



Process: Focused thermal energy melts material as it is deposited

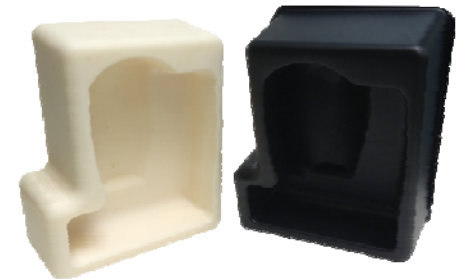
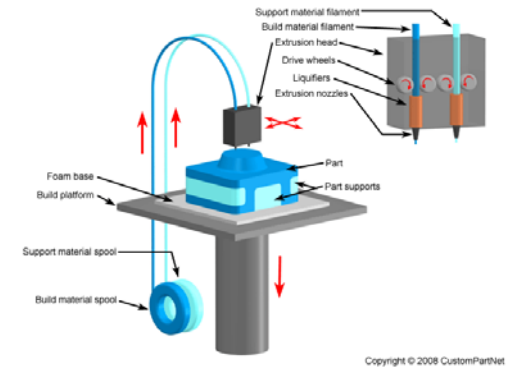
Technologies: LENS, EBF, DMD

Materials: Metals (wire or powder)





# Material Extrusion



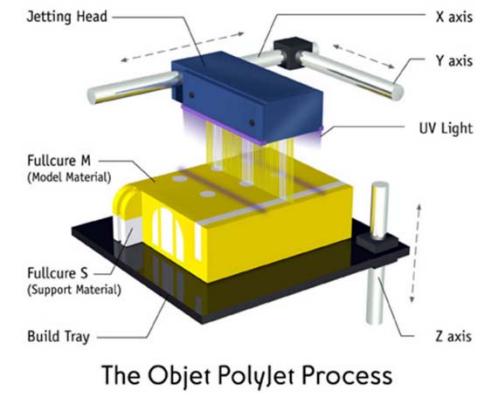
Process: Material is selectively dispensed through a nozzle

Technologies: FDM, FFF

Materials: ABS, Polycarbonate, PLA, Nylon, Ultem



# Material Jetting



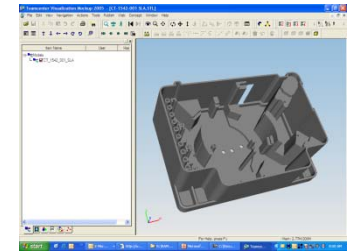
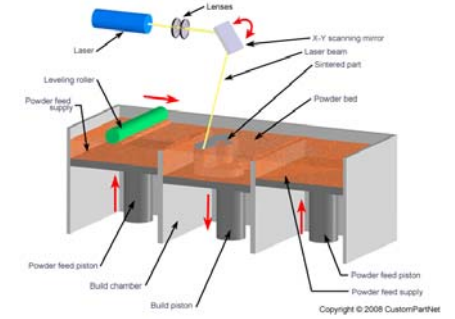
Process: Droplets of build material are selectively deposited

Technologies: CS, DOD

Materials: Wax, Photopolymers



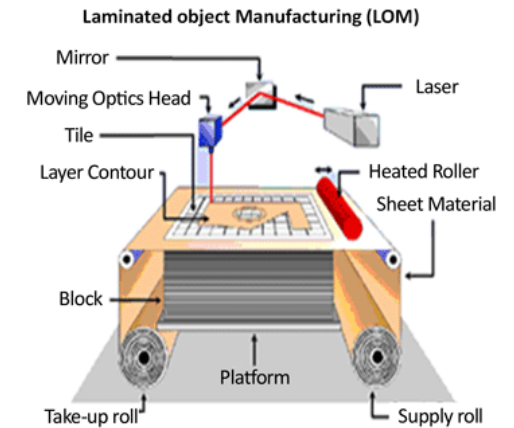
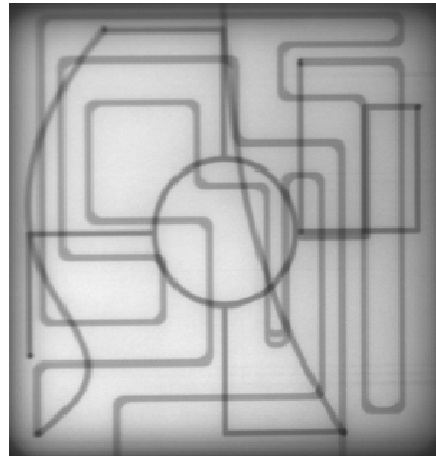
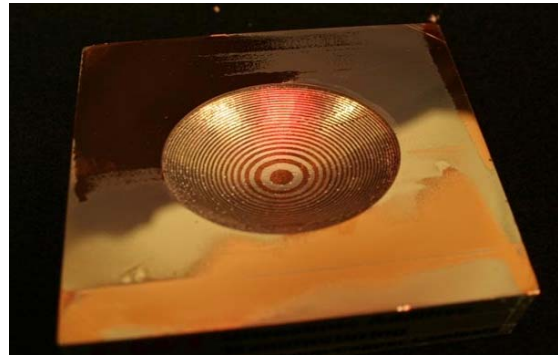
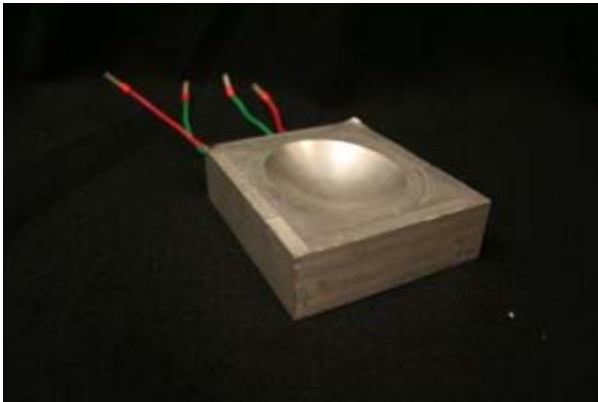
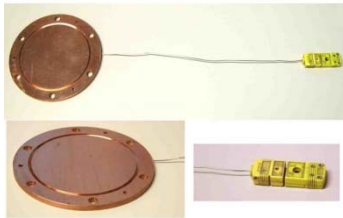
# Powder Bed Fusion



Process: Thermal energy selectively fuses regions of a powder bed  
Technologies: SLS, DMLS, EBM, SHS, SLM  
Materials: Powdered Metals, Polymers, Composites, and Ceramics



# Sheet Lamination



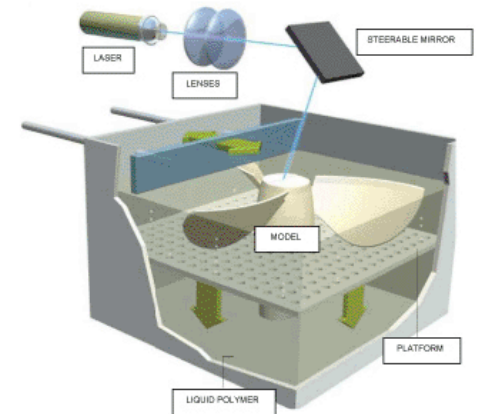
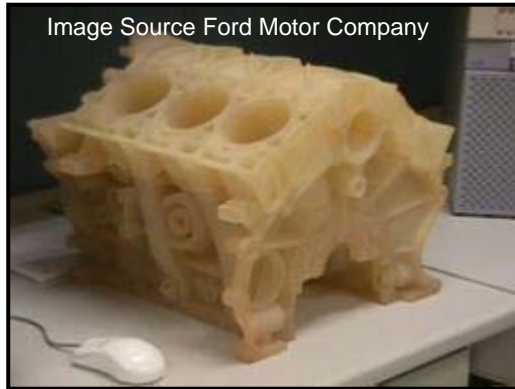
Process: Sheets of material are bonded to form an object

Technologies: UAM, LOM

Materials: Foil of Metal, Plastic or Paper



# Vat Photo Polymerization



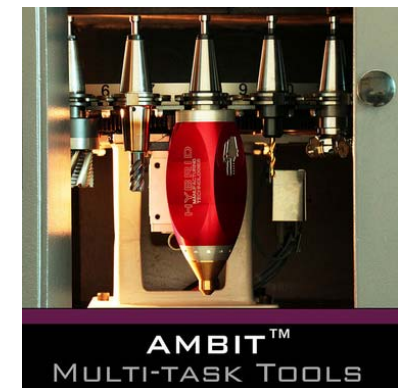
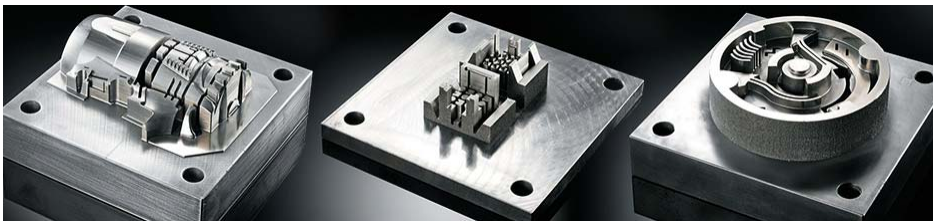
Process: Liquid photopolymers selectively cured by light polymerization

Technologies: SLA, CLIP, DLP

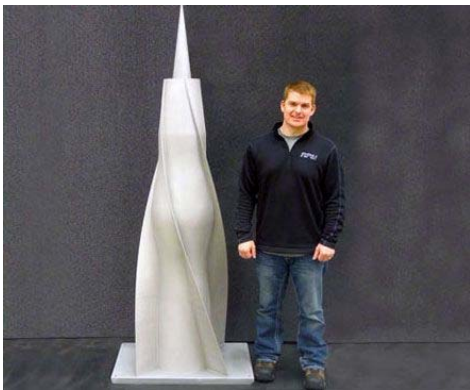
Materials: UV-Curable Photopolymers

# And More...

- Hybrid technologies
  - DMG Mori Sieki
  - MC Machinery
  - Optimec (add-on)
  - AMBIT (add-on)



# And Bigger...



# The Additive Manufacturing Gold Rush

## Finding Gold



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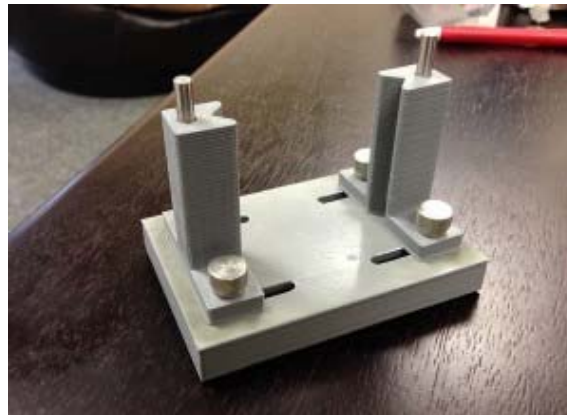
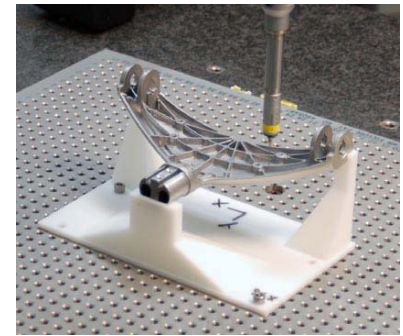
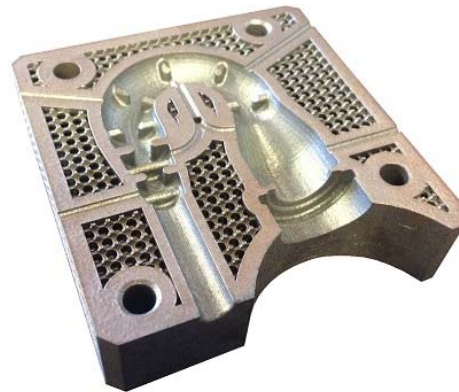
# Prototype

- Visualization
- Flow Testing
- Performance Testing
- Verification of design intent / fit / form
- Optimization of assembly sequence / methods
- Functional Prototypes



# Indirect Manufacturing

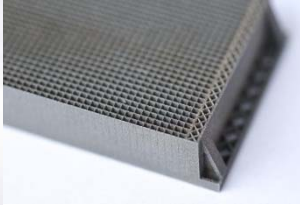
- Tooling, Fixtures, Gauges



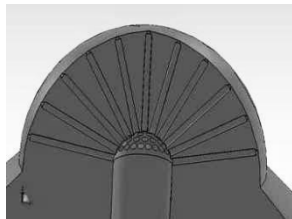
# Direct Manufacturing



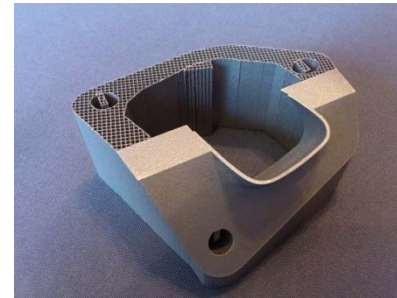
Tungsten



Heat Exchanger



Fuel Nozzle



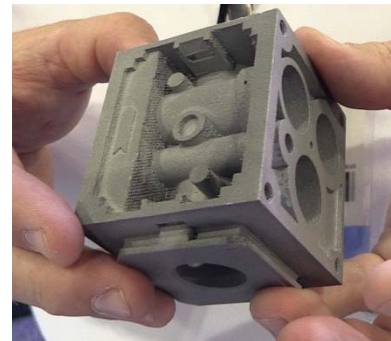
Light Weighting /  
Thermal Management



Light Weighting

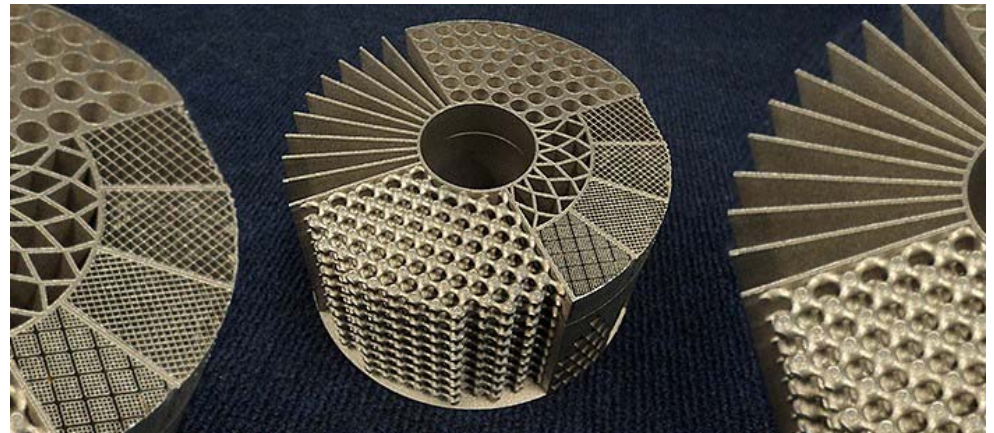
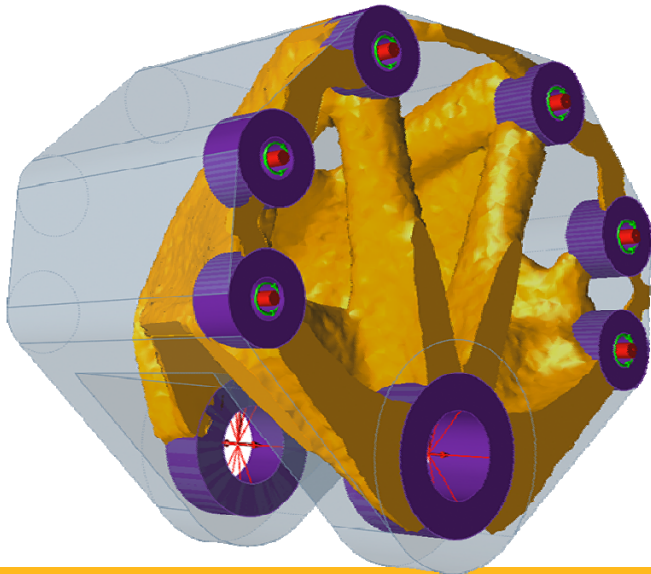
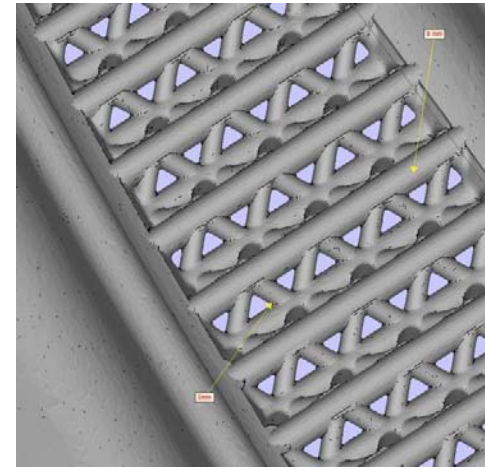
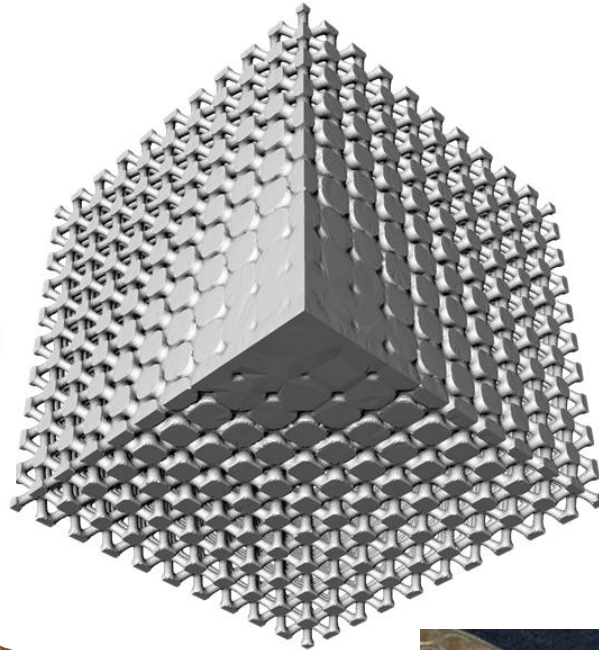


Complex Geometry



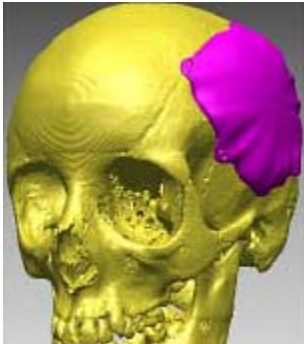


# Complex Structures





# Medical



Affordable  
Customization



# Fashion

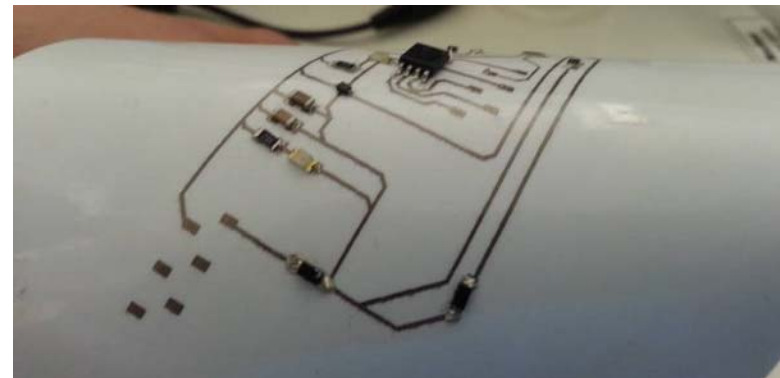


# Food



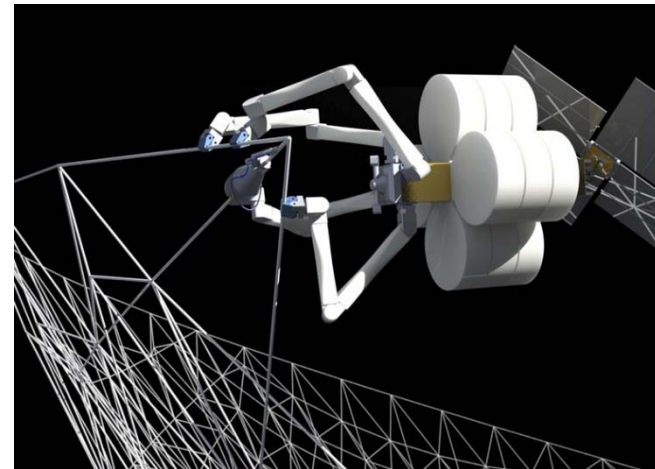
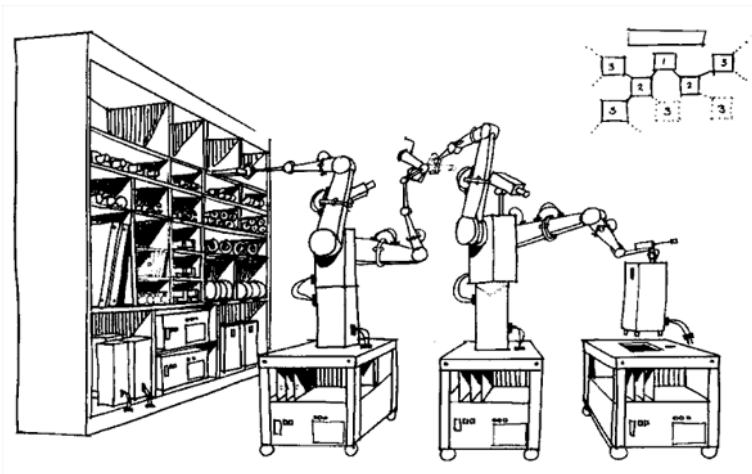
# Manufacturing

- Multi-Material
- Surface Treatment
- Embedding
- Repairs





# In Situ Manufacturing



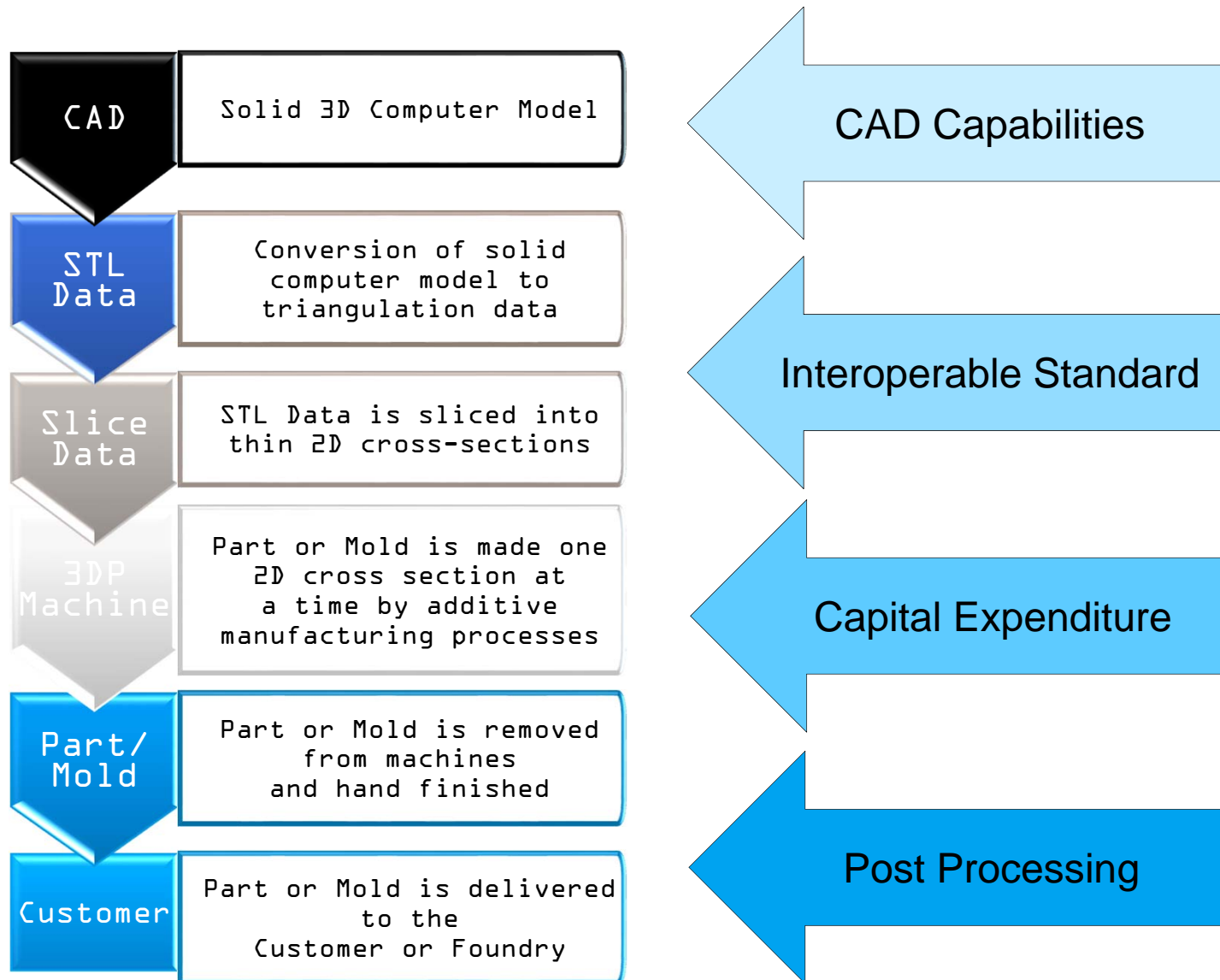
# The Additive Manufacturing Gold Rush

## The Hard Reality

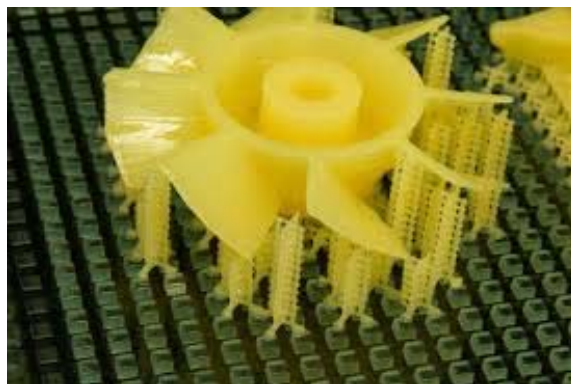
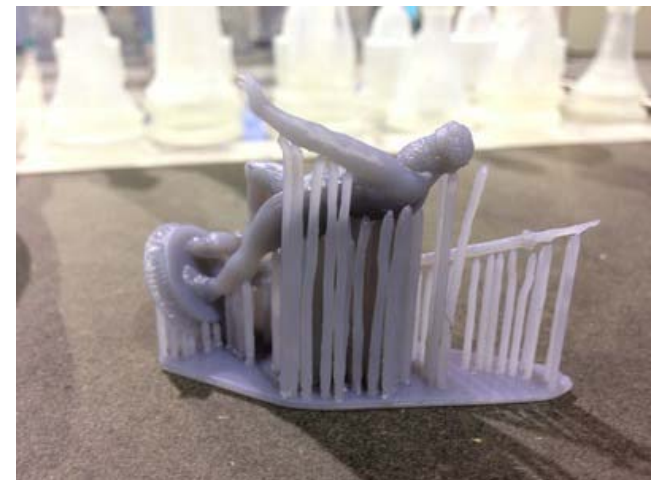
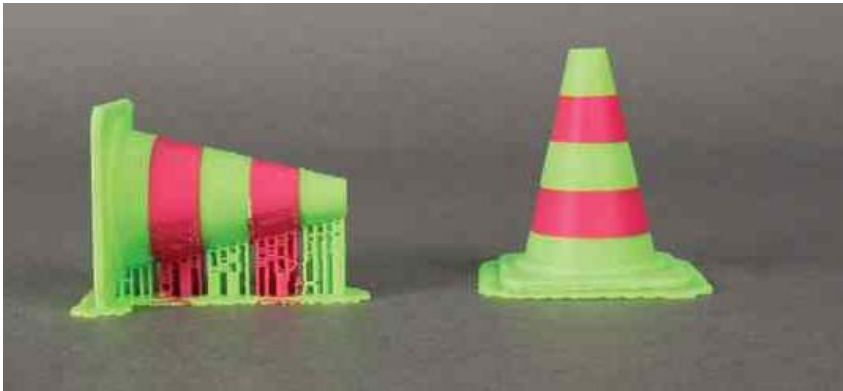


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# Additive Manufacturing (AM) Basics

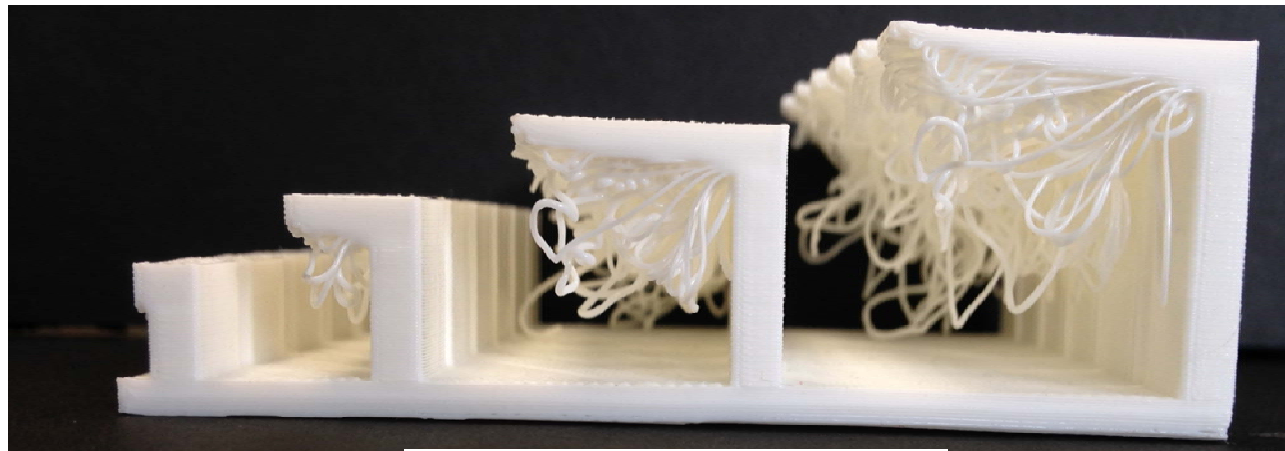


# It's Always Better In The Demo

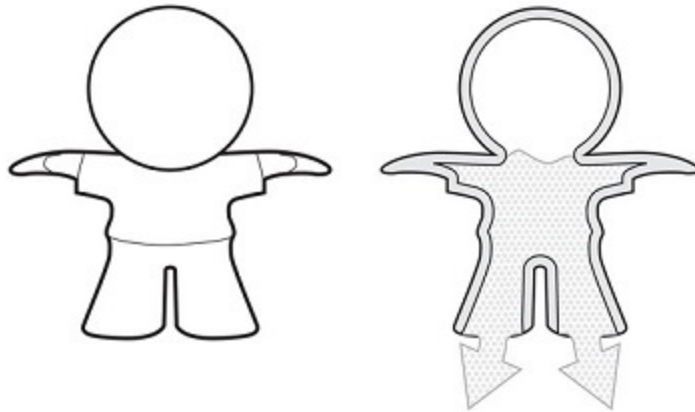




# The Bin of Broken Dreams



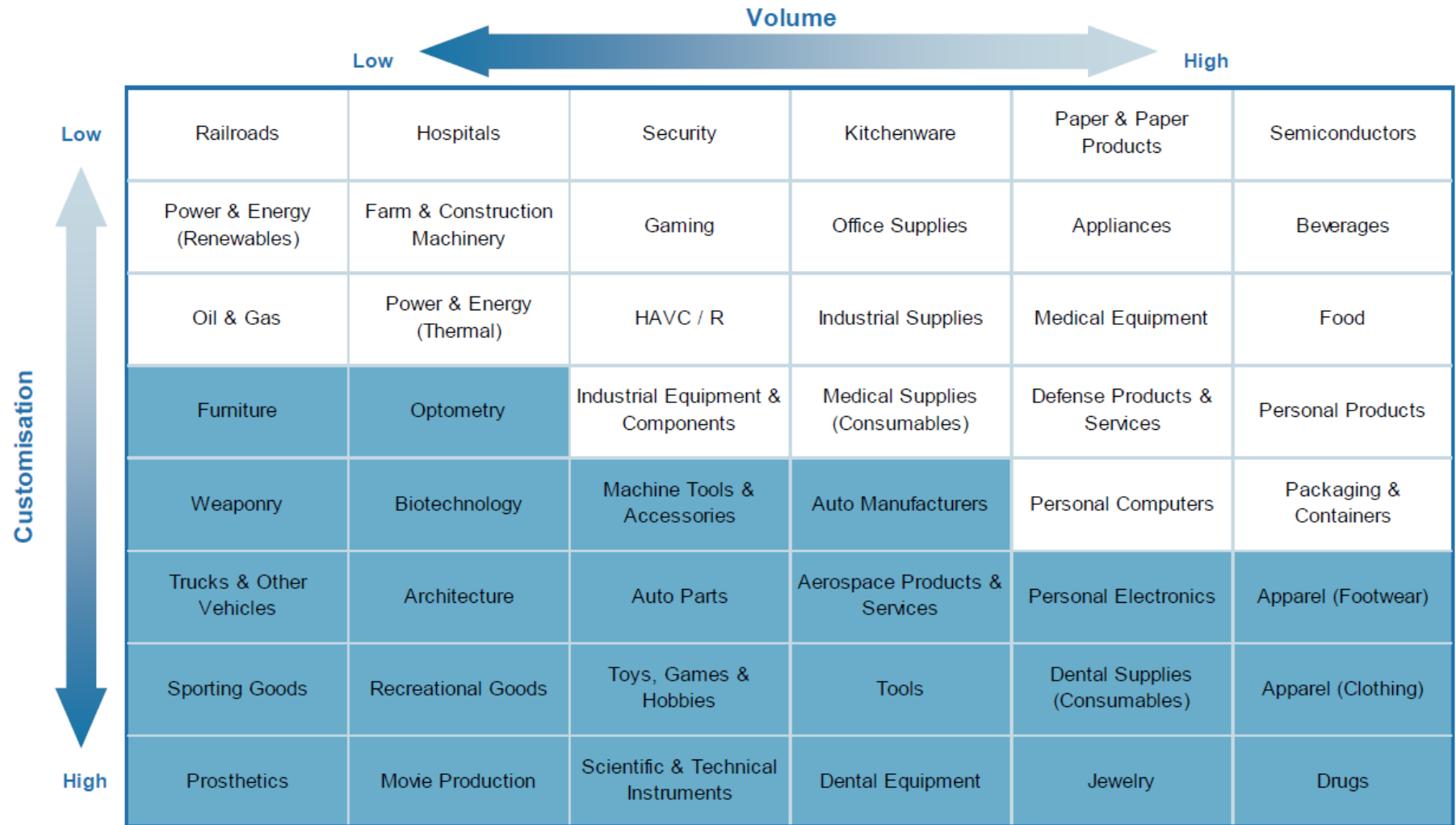
# Just Add Powder



# Where Is The Gold?



# Where Is The Gold?



Source: Morgan Stanley Research





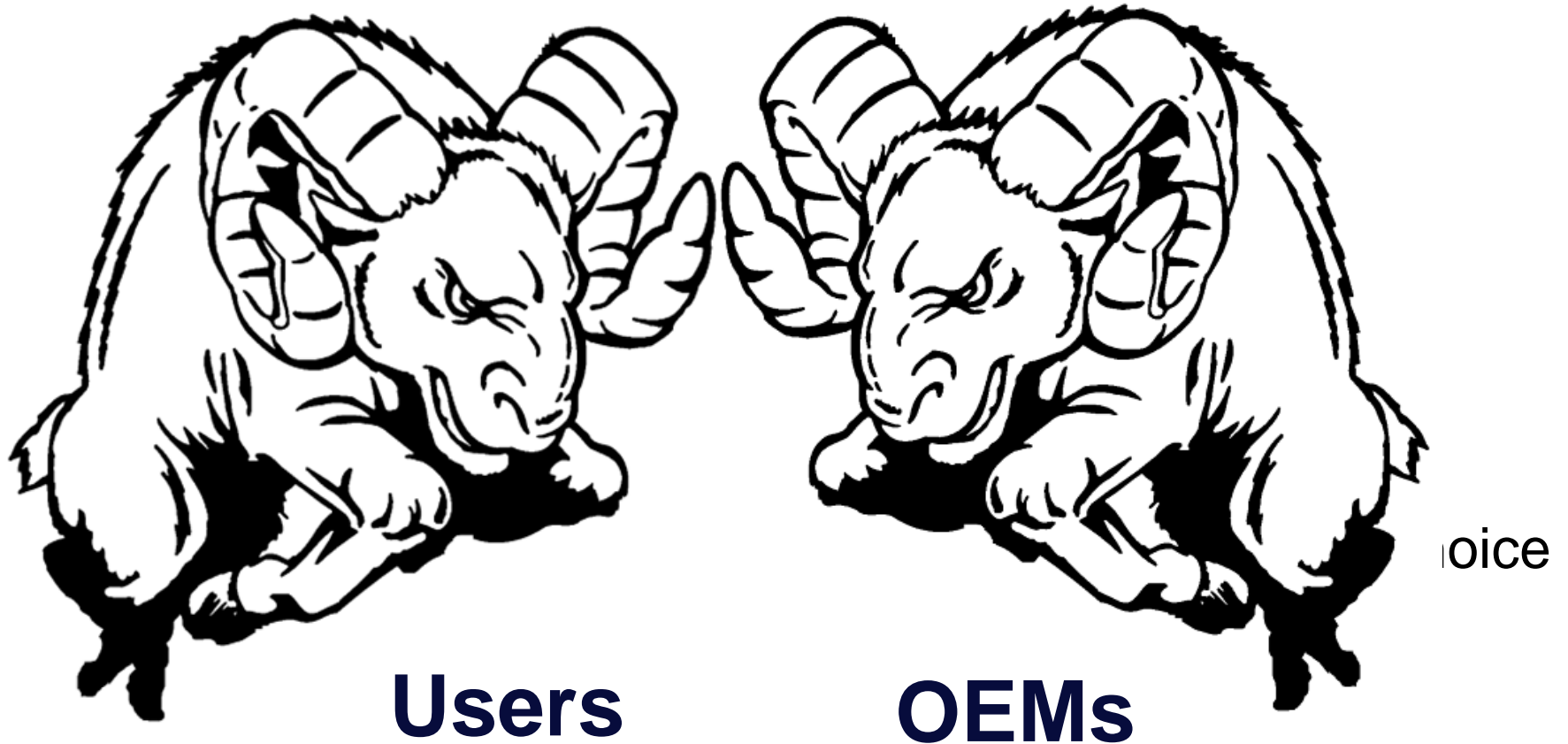
# Standards – Material And Process



**The Wild Wild West**



# Need For Standardization



# Need For Standardization



Quality control

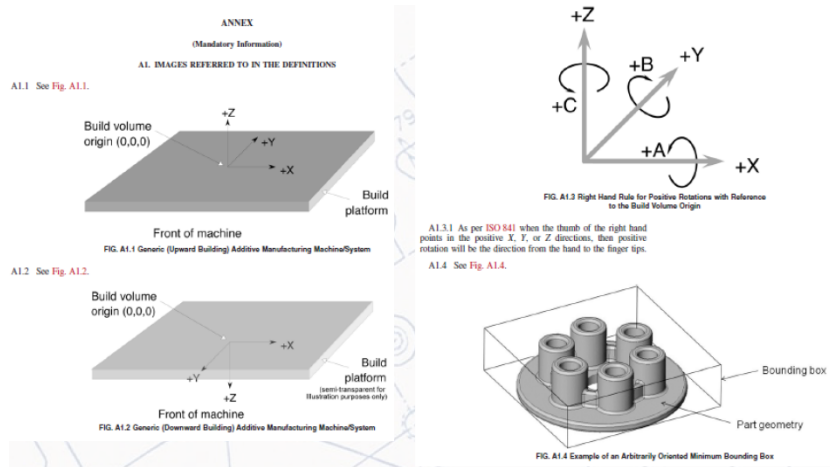


Repeatability



Parameters,  
Materials, Process

# Standards – File Format



- ASTM F42
- ISO TC 261
- STL “file format”
- AMF “file format”

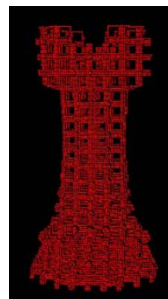
**Multiple Materials**



**Graded Materials**



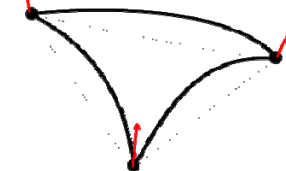
**Microstructure**



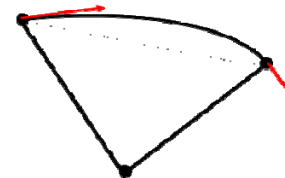
**Curved patches**



**CURVED PATCH**  
(Curved using vertex normals)



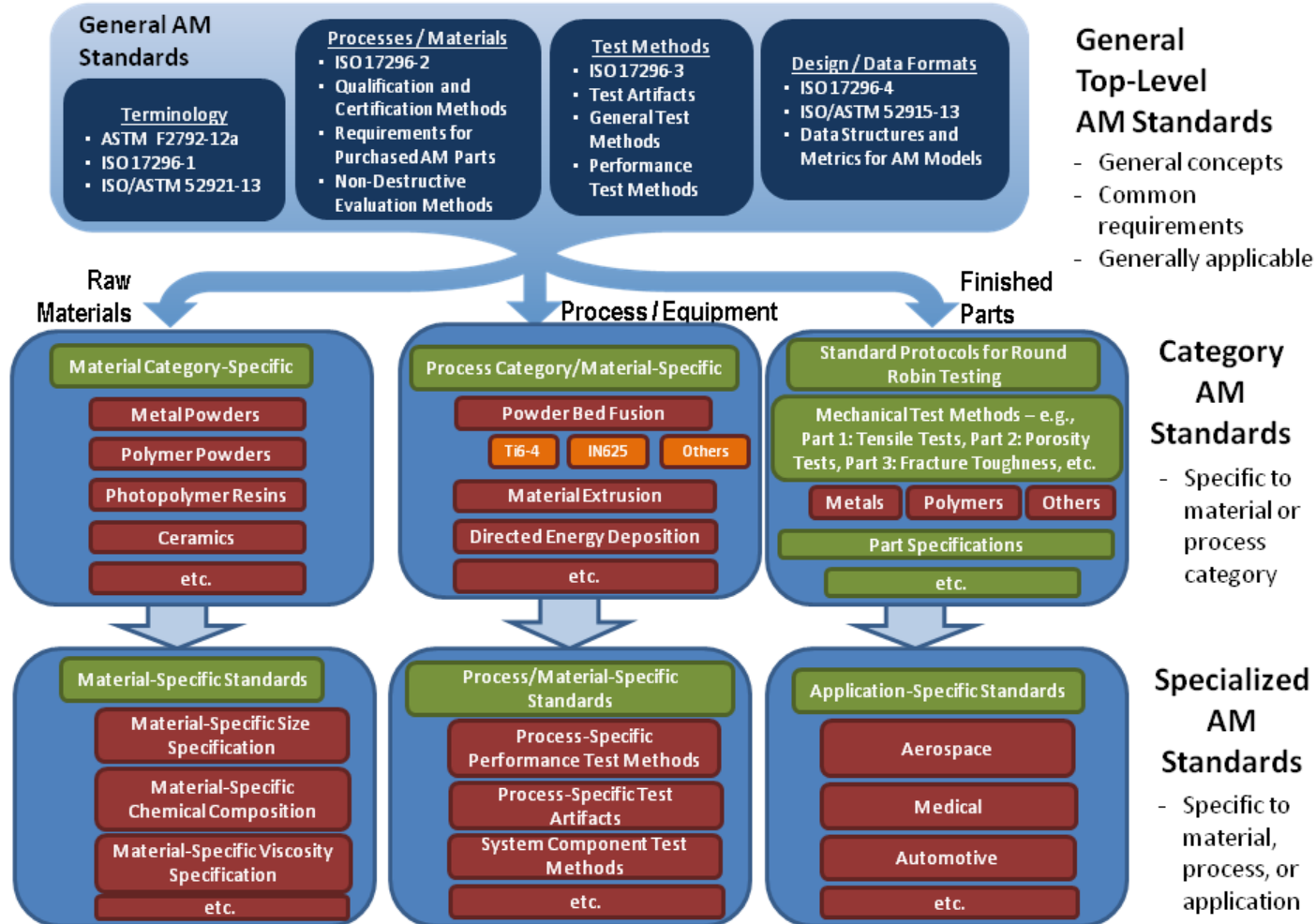
**CURVED PATCH**  
(or curved using edge tangents)





# Standards

## Structure of AM Standards



# The Additive Manufacturing Gold Rush

## The Good, The Bad and The Ugly



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# Intellectual Property – The Good

Forbes / Games

5 Billionaire-Owned Energy Stocks With Triple Digit I

JAN 29, 2014 @ 04:55 PM 118,958 VIEWS

## Massive 'EVE Online' Battle Could Cost \$300,000 In Real Money [Update]



**Erik Kain,** CONTRIBUTOR

*I write about the intersection of entertainment and technology.*

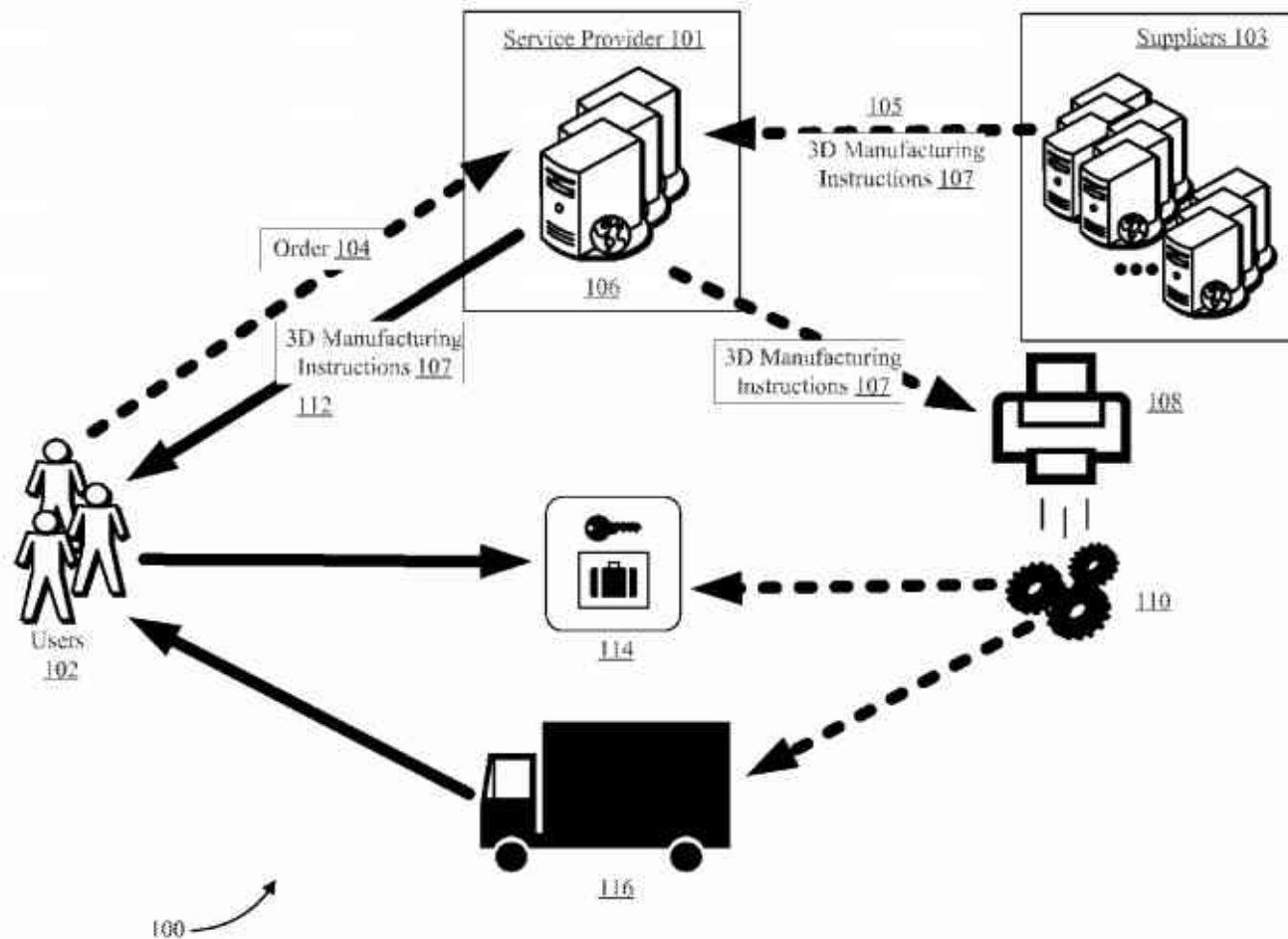
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# Intellectual Property – The Good



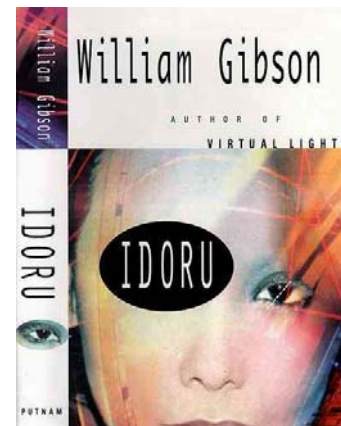


# Intellectual Property – The Bad

Remember Napster?



What if you could  
make an exact copy  
of any object?



# Intellectual Property - The Ugly



# The Additive Manufacturing Gold Rush

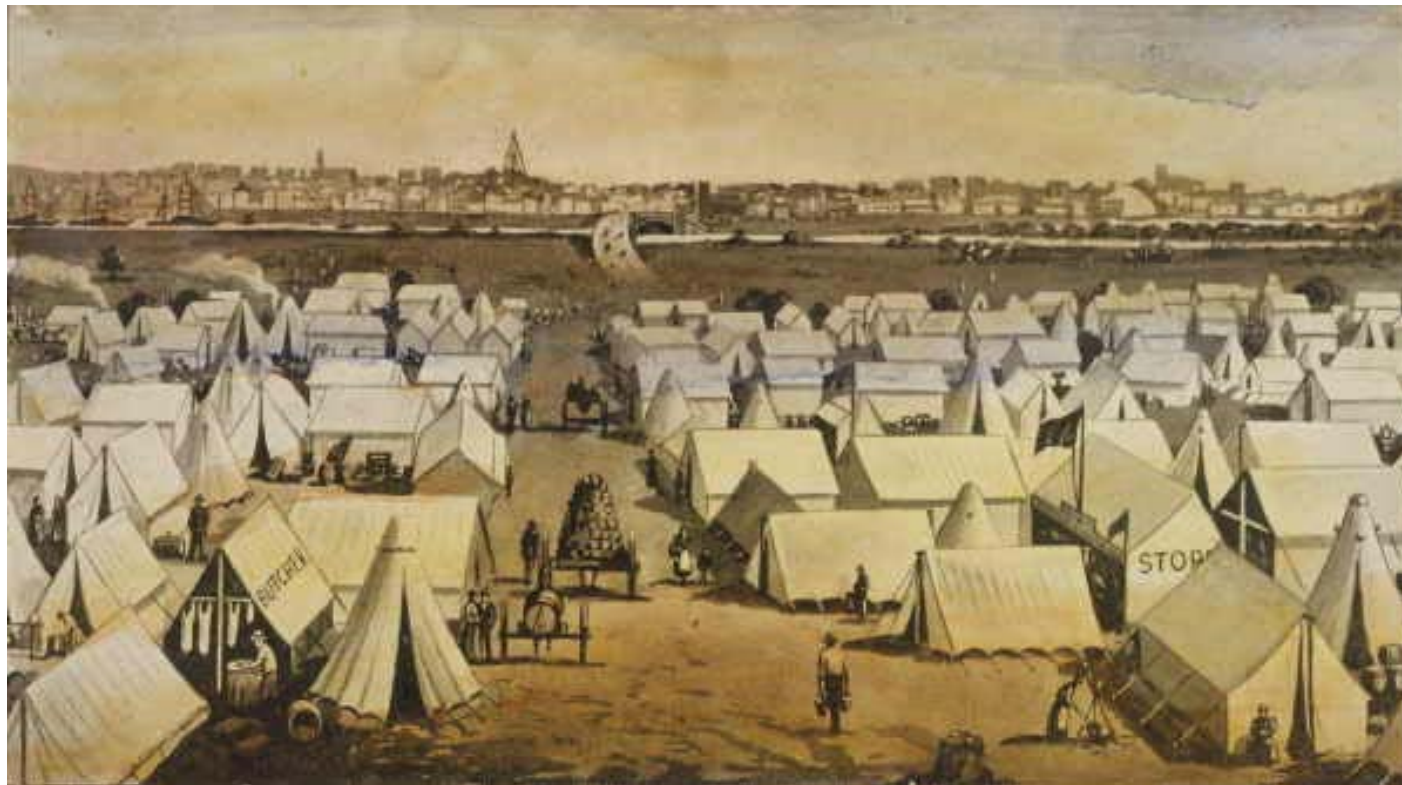
**Dream or Reality?**



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# The California Gold Rush

## The Dream and the Legacy





# The AM Gold Rush

- Variety of technologies
- Continuous Innovation
- Significant Investment



# The AM Gold Rush

- Traditional manufacturing will not disappear
- Evolution more than Revolution
- New applications “discovered” every day
- IP challenges
- Standards



# The AM Gold Rush

- New Business Opportunities and Models
- Consolidation
- Cross-Pollination
- Still many Dreams to be brought to reality





## **A NEW MAGNIFICENT MANUFACTURING METHOD**

**COME AND TEST YOUR LUCK. RAPID TURN AROUND TIME. PARTS READY AS BUILT. SUCCESS FOR ALL  
TECHNOLOGY CHANGING BY THE HOUR. HARNESS THE POWER OF 3D. DON'T WAIT, JUMP ON BOARD NOW!**



## **ADDITIVE MANUFACTURING**

### **GOLD RUSH**