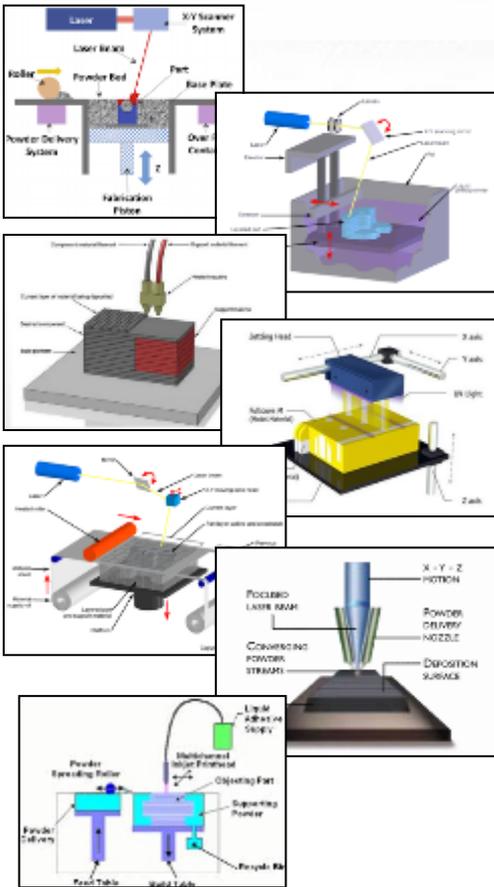


What is Additive Manufacturing?

7 Different Processes:



Seemingly infinite number of materials:



Polymer

Metal



Glass



Sand



Ceramic



Concrete



Food

Multiple Applications:

- Tooling
- Fixtures
- Molds
- Prototyping
- Training Aids
- Medical Implants
- Surgical Tools
- Decoys
- End use Parts
- Platforms



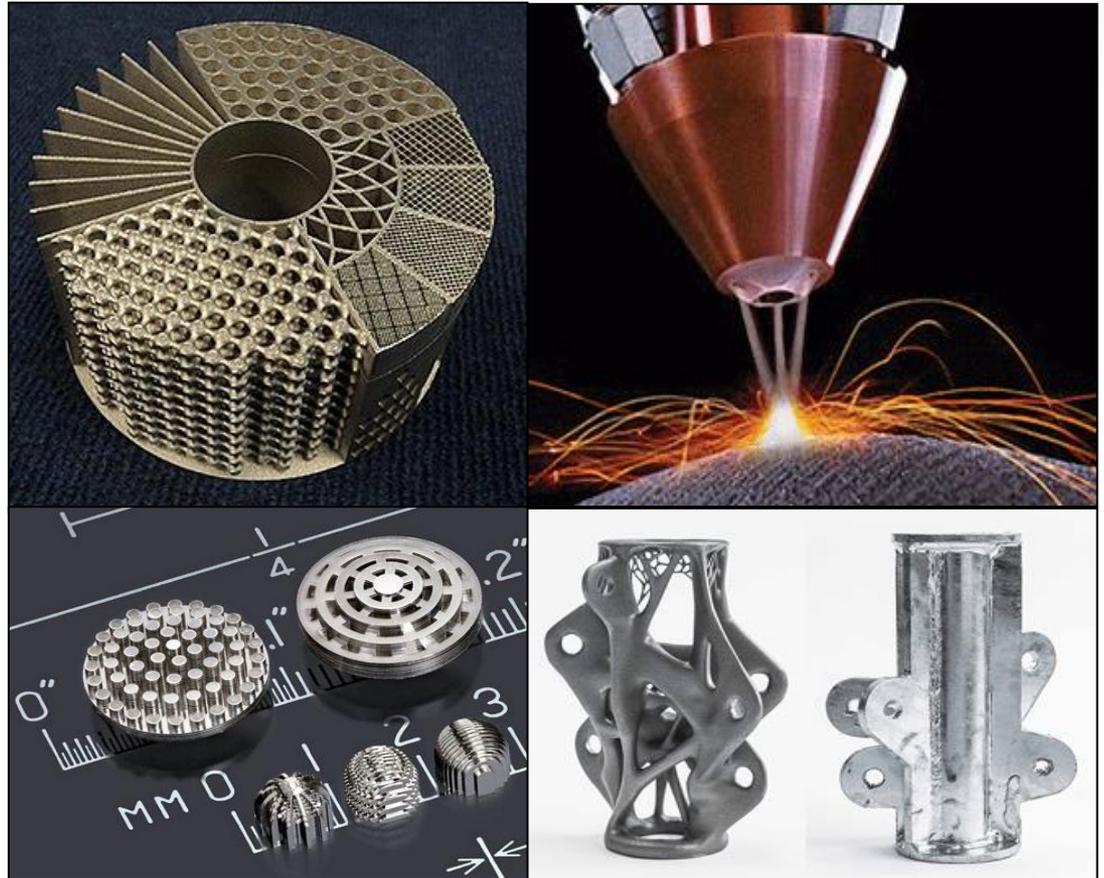
What is Additive Manufacturing?

Additive manufacturing (AM) describes a series of part manufacturing technologies that fundamentally differ from conventional subtractive machining processes. The different additive processes each possess unique advantages in materials and applications. The processes can broadly be categorized into the following eight groups:

- **Binder Jetting**
- **Directed Energy Deposition**
- **Direct Write**
- **Material Extrusion**
- **Material Jetting**
- **Powder Bed Fusion**
- **Sheet Lamination**
- **Hybrid Technologies**

“The process of joining materials to make objects from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing methodologies.”

- ASTM International F42 Committee on Additive Manufacturing Technologies, 2009



What Capabilities Does AM Investments Buy?

❖ Evolutionary Improvements In Equipment Readiness



Obsolescent Parts Manufacture
Organic capability to design and build obsolescence-challenged parts across platforms

Reduced Lead Times In Supply Chain
Enable reach-back parts printing support to Operating Forces for long-lead time parts



after Cold Spray repair

Obsolescent Parts Repair
Establish depot-level AM repair

Improved Equipment Functionality
Test & evaluate re-engineered parts for lightening, strengthening, and embedded sensors



❖ Revolutionary MAGTF Warfighter Capabilities



Expeditionary Prototyping
Build tactical innovations in-field, using printers, scanners, laser cutters, CNCs, laptops

Advanced Unmanned Systems
In-field printing of on-demand small UxS, tailored to each mission



Enhanced Munitions Effectiveness
Printed energetics and optimized frag coverage using printed frag with “pre-brittling”

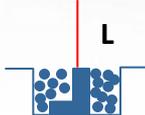
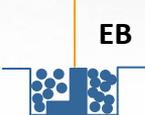
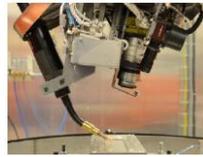
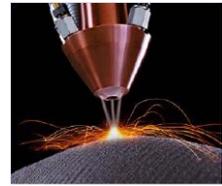
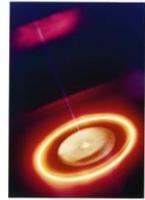
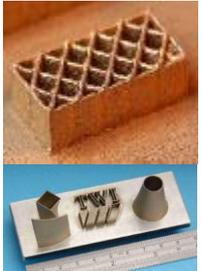
On-Demand Reinforced Shelters
On-site, C-130 capable, concrete printer to build 2400sqft shelter in 24 hours, 2 man



Types of Additive Manufacturing

Process type	Method	Materials	Market
Powder Bed Fusion	Thermal energy (Laser Or Electron Beam) selectively fuses regions of powder.	Metals, Polymers	Manufacturing & Prototyping
Directed Energy Deposition	Focused thermal energy (Laser Or Electron Beam) is used to fuse materials as deposited.	Metals	Manufacturing & Repair
Material Extrusion	Material is selectively dispensed through a nozzle and material laid down in layers.	Polymers	Manufacturing & Prototyping
Vat Photo-polymerization	Liquid photopolymer in a vat is selectively cured by light-activated polymerization.	Polymers	Prototyping
Binder Jetting	Liquid bonding agent is selectively deposited to join powder materials.	Metals, Polymers	Casting Molds, Manufacturing & Prototyping
Material Jetting	Droplets of building material are selectively deposited. (Ink-Printer)	Metals	Casting Patterns & Prototyping
Sheet Lamination	Sheets of material are bonded to form an object.	Metals	Manufacturing & Prototyping

Metal AM Process Summary

	DEPOSITION				POWDER BED		
	PLASMA (WIRE)	EB (WIRE)	LASER (WIRE)	LASER (POWDER)	LASER (POWDER)	EB (POWDER)	BINDER (POWDER)
DESIGNATED ICON							
PICTURE							
DESCRIPTION	Free deposition of wire fused using plasma arc to produce part	Deposition of wire fused using electron or laser beam in a chamber to produce part	Deposition of powder fused using laser in a chamber to produce part	Laser or electron beam selectively fuses powder on a bed in a chamber to produce part	Powder / binder system requiring down-stream consolidation		
APPLICATIONS	 <p>High material fusion rate and deposition technique enable large scale near-net shape parts or grow-outs</p>			 <p>Accurate but near-net parts and claddings</p>	 <p>High geometric complexity enables next generation small prismatic components.</p>		 <p>Net-shape parts achievable at automotive rates</p>

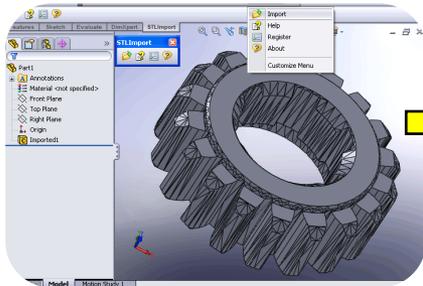
Identified Additive Manufacturing Research & Development Issues

- Cybersecurity
- 'Design for AM'
- File Database
- File Integrity
- IT Strategy
- Model and Simulation Package Development

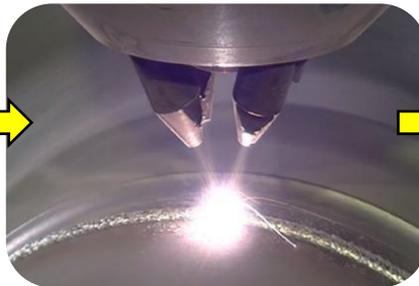
- Material Properties
- Microstructure
- Procedure Development
- Residual Stress Understanding
- Tolerances

- Closed Loop Feedback
- Improved Energy Sources
- In-situ Inspection
- Optimize Parameters
- Process Repeatability
- Sensors/Build Data
- Scalability

- Non-Destructive Evaluation/Defect Detection
- Qualification and Certification



3D Model



Print



Part



Post Process

- Material Storage
- Material Development

- Support Material Development
- Support Material Removal
- Intermediate Handling