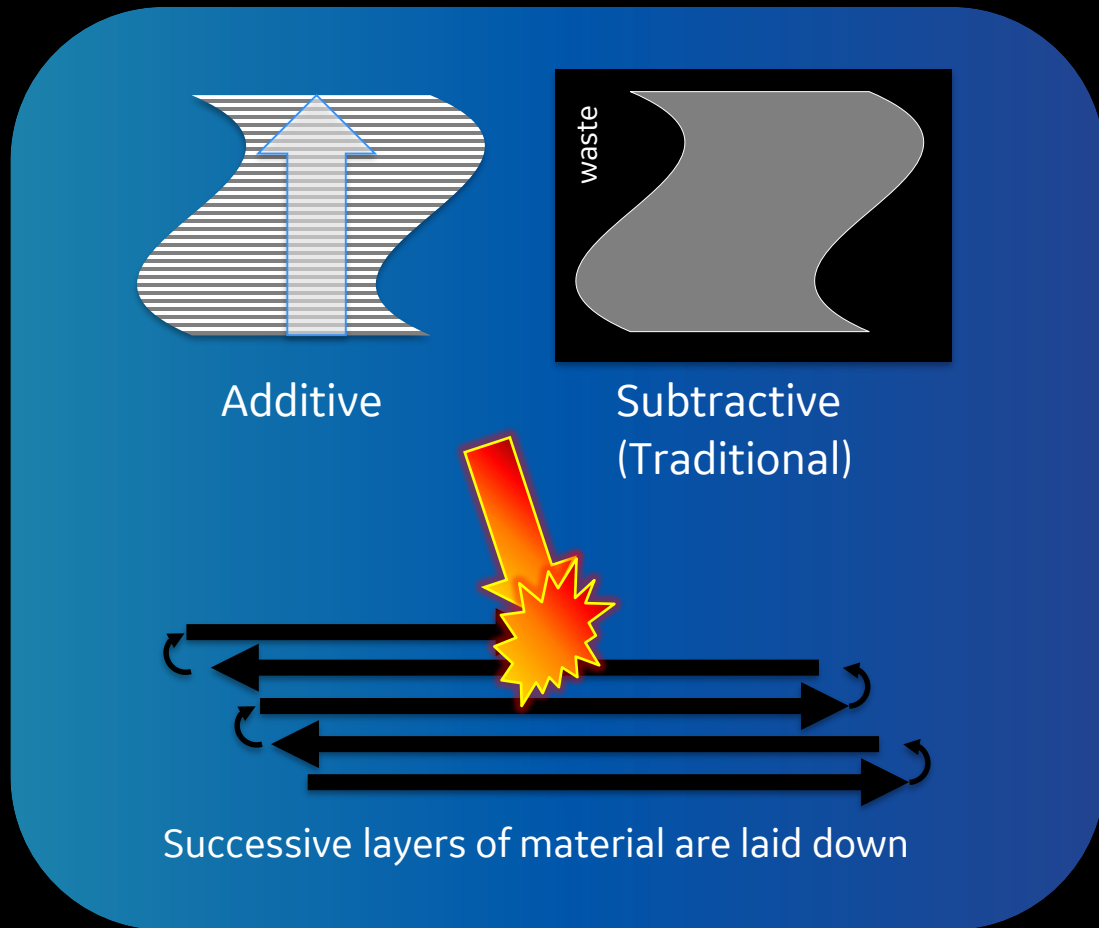




# Technologies of the Future Additive Manufacturing

Marian Lubieniecki  
EDC, GE Aviation  
3 October 2017

# What is Additive Manufacture (a.k.a. 3D Printing)



## 3D printing or additive manufacturing (AM)

is any of various processes for making a three-dimensional object of almost any shape from a 3D model or other electronic data source primarily through additive processes in which successive layers of material are laid down under computer control.

- Wikipedia



# A Brief History of Additive

~2300 BC - Early examples of layered additive manufacturing, the Giza Pyramids, constructed

1971 - Pierre Ciraud patents method for manufacturing parts by using a laser and metal powder

2012-2016 - Qualification and Transition of AM from Rapid Prototyping to **Rapid Production for the Aerospace Industry**

1986 - Chuck Hull patents **Stereolithography** process; **modern rapid prototyping is born**

2011 - EOS introduces the M280, featuring a **400 watt Fiber Laser for increased productivity**

1986 - University of Texas patents **computer controller laser beam scanning** for selective solidification of metal powder

2007 - Arcam introduces the A2 **Electron Beam Melting (EBM)** machine

1992 - DTM releases Sinterstation 2000, first commercial **plastic powder Selective Laser Sintering (SLS)**

2004 - EOS introduces the M270 machine with **200 W Fiber Laser**, allowing the processing of Super Alloys

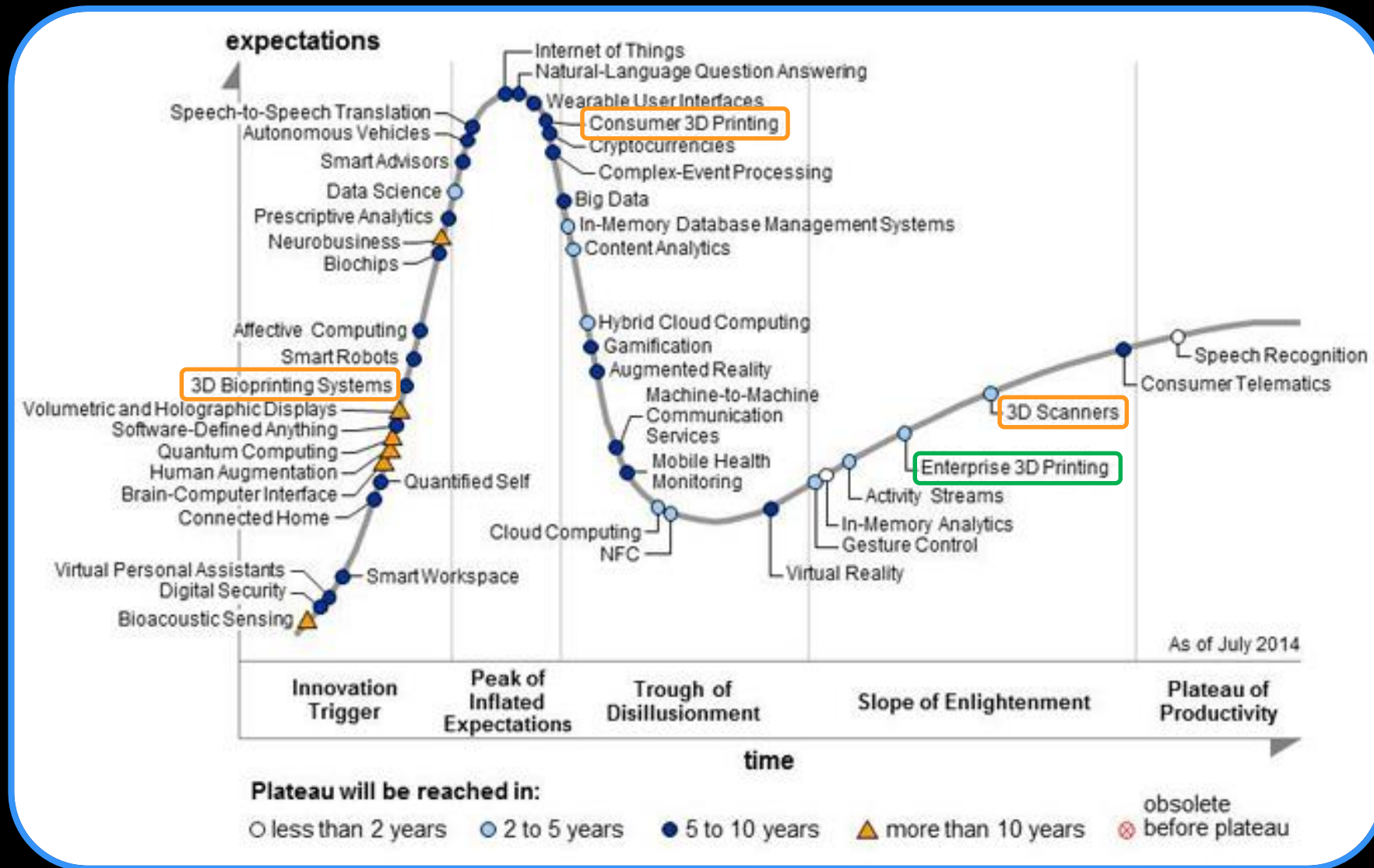
1995 - EOS patents **powder bed technology** and releases first commercial **Direct Metal Laser Sintering (DMLS)** machine (M250)

2003 - **First North American DMLS machine** installed at **Morris Technologies, Inc.** GE began work on **DMLM fuel nozzles**

2002 - First commercial **Electron Beam Melting (EBM)** machine (S12) introduced by Arcam

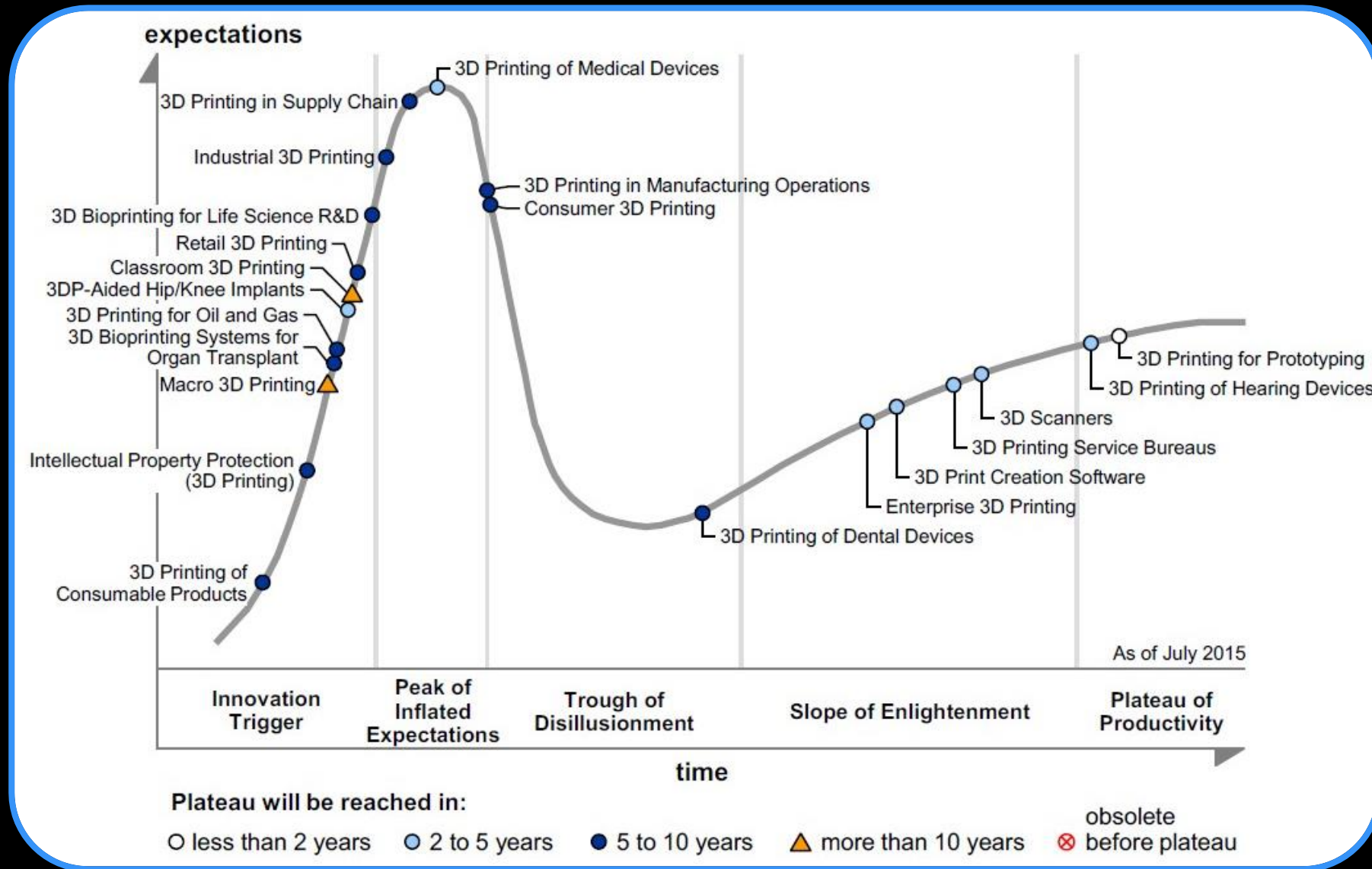


# Gartner's Hype Cycle for Emerging Technologies

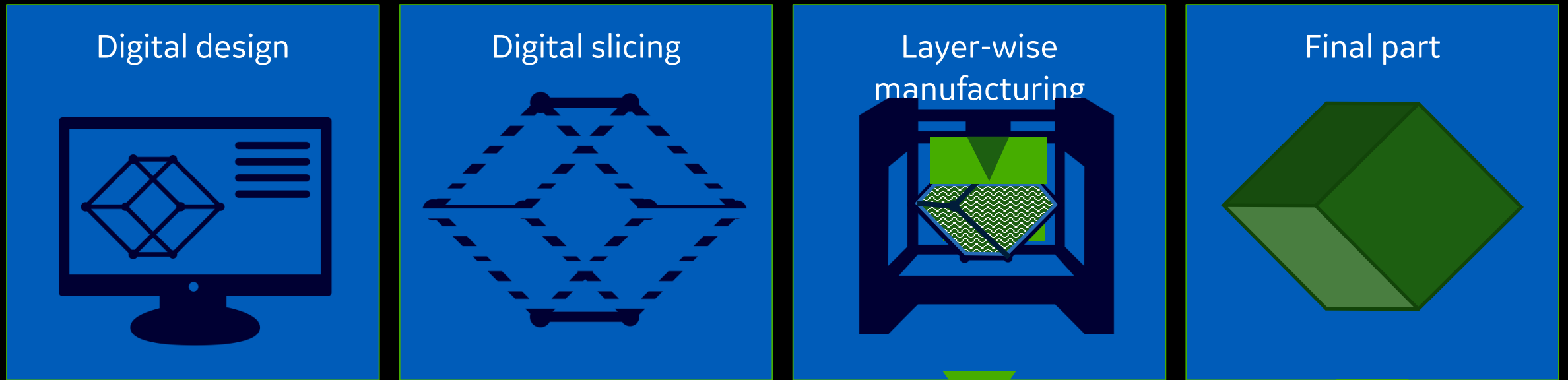




# Gartner's Hype Cycle for 3D Printing



# Additive Manufacturing .. a 4 step process



1

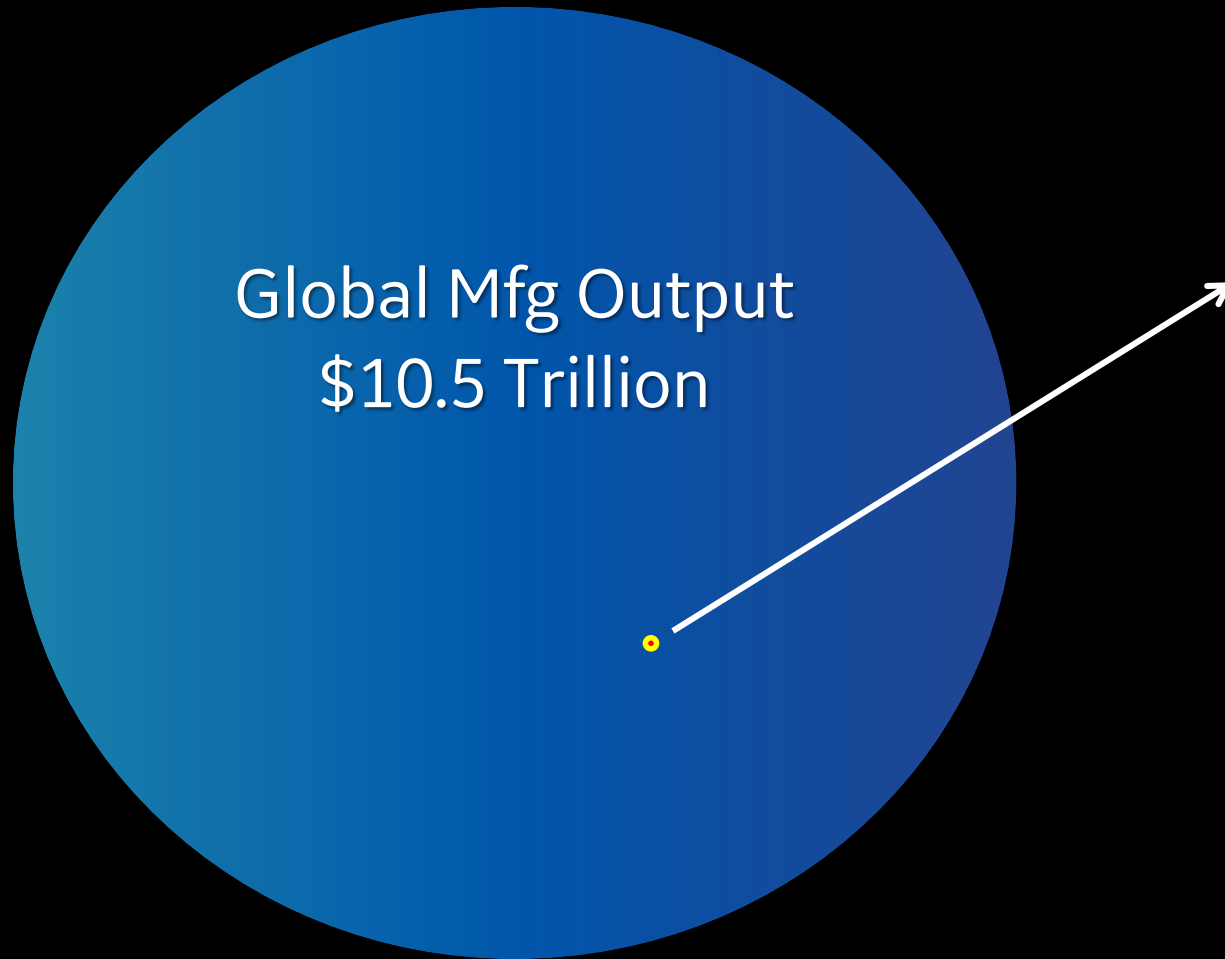
2

3

4



# Additive Potential



- \$2.2 billion professional industrial additive market
- 0.02% of total global manufacturing output
- What if it was just 1%?  
= \$100B!



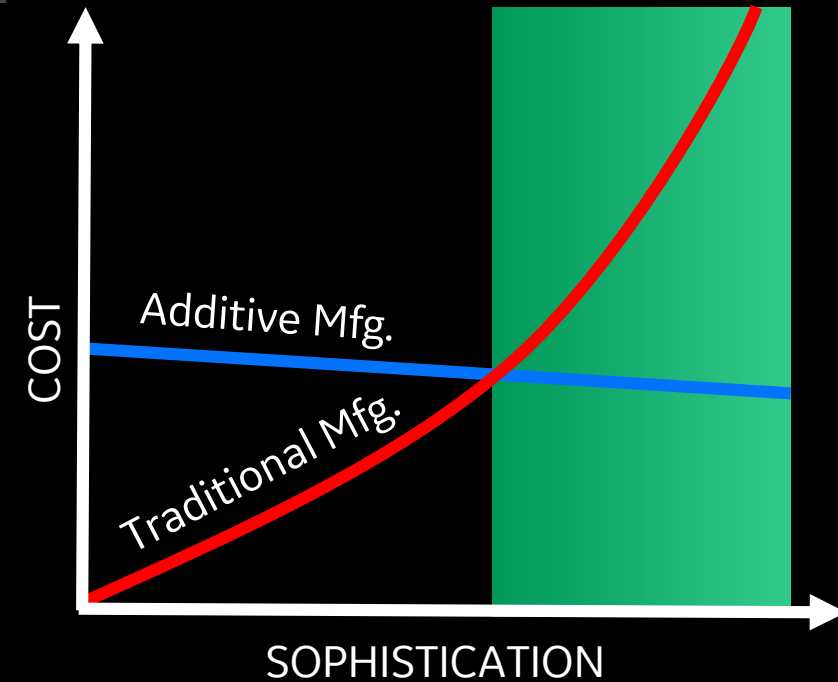
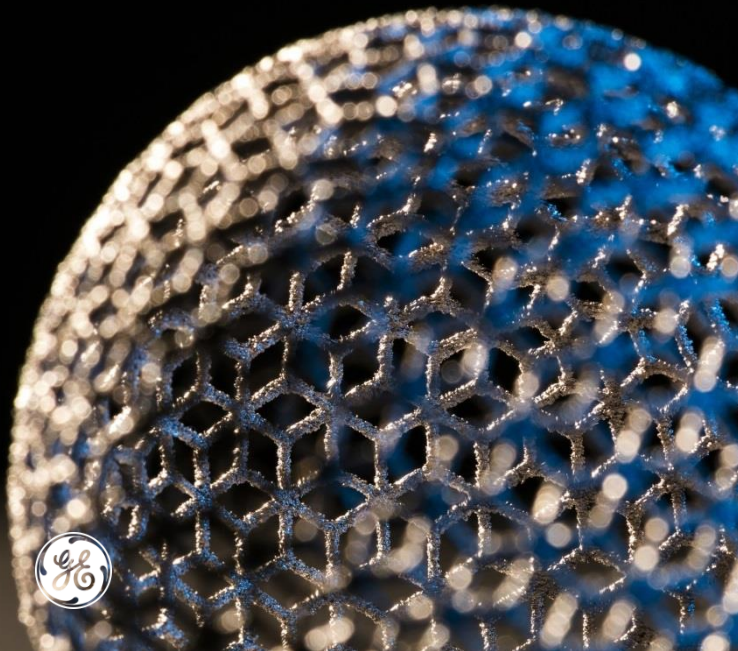
Why Additive?

with  
**ADDITIVE  
MANUFACTURING**



manufacturing cost  
**DECREASES**

design  
sophistication  
**INCREASES**



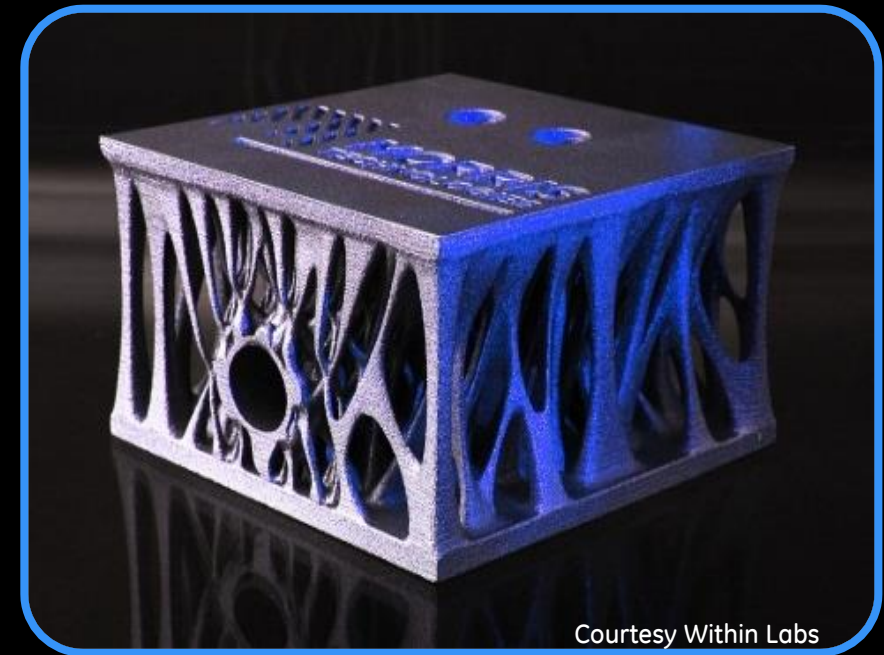
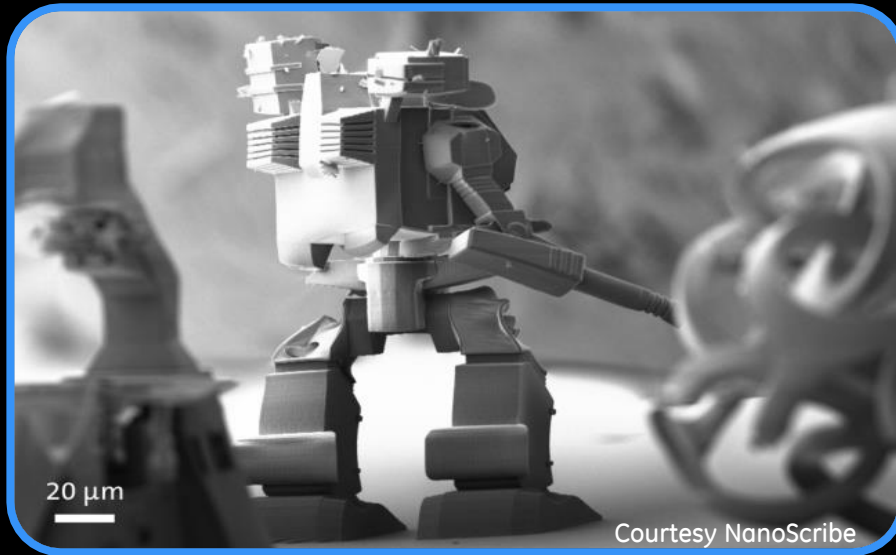


# Typical Types of Additive

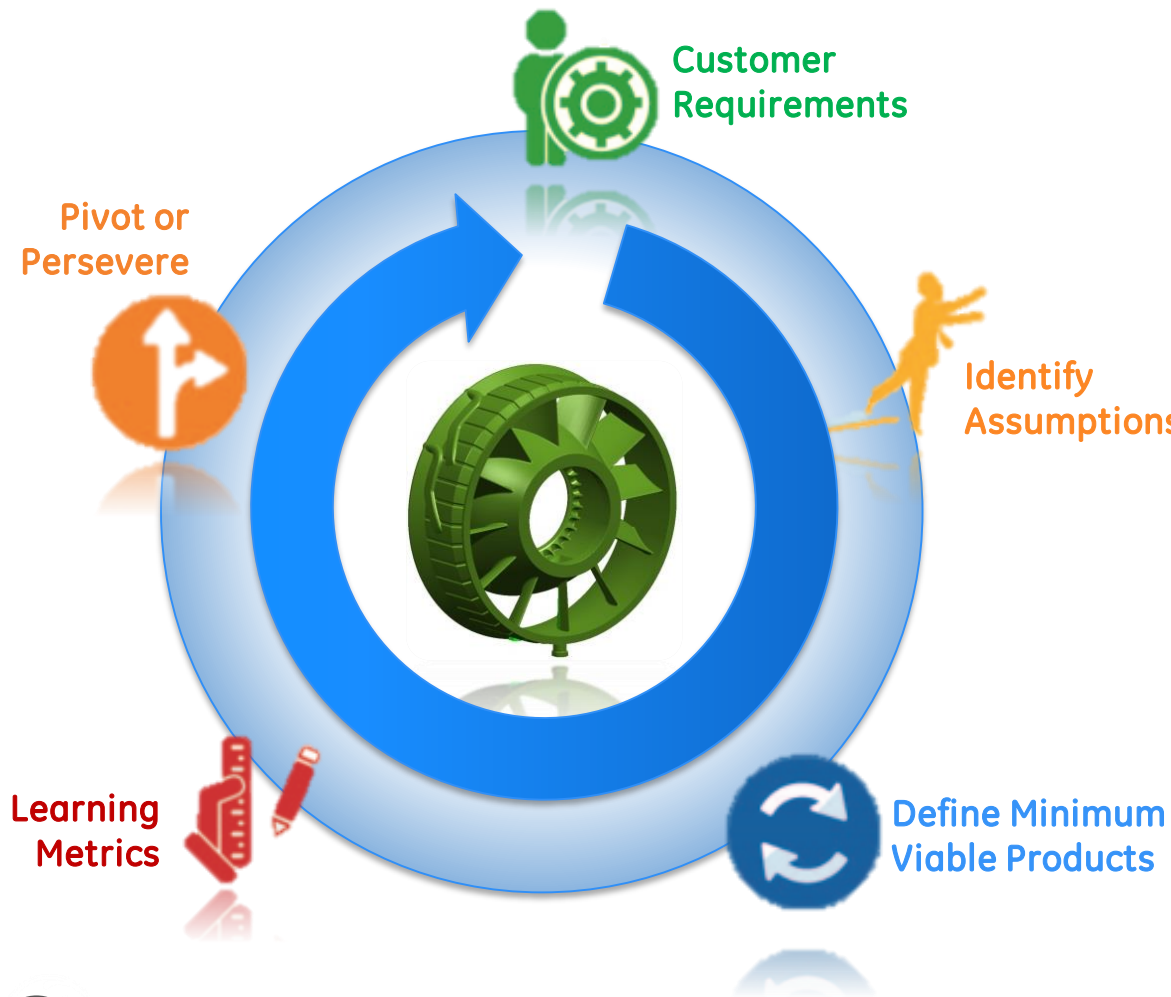
**Polymers** – SLA, SLS, FDM, PolyJet, DLP, etc...

**Metals** – Powder Bed, Deposition, Consolidation

**Emerging Micro/Nano-Additive**



# FastWorks – Build, Measure, Learn Strategy



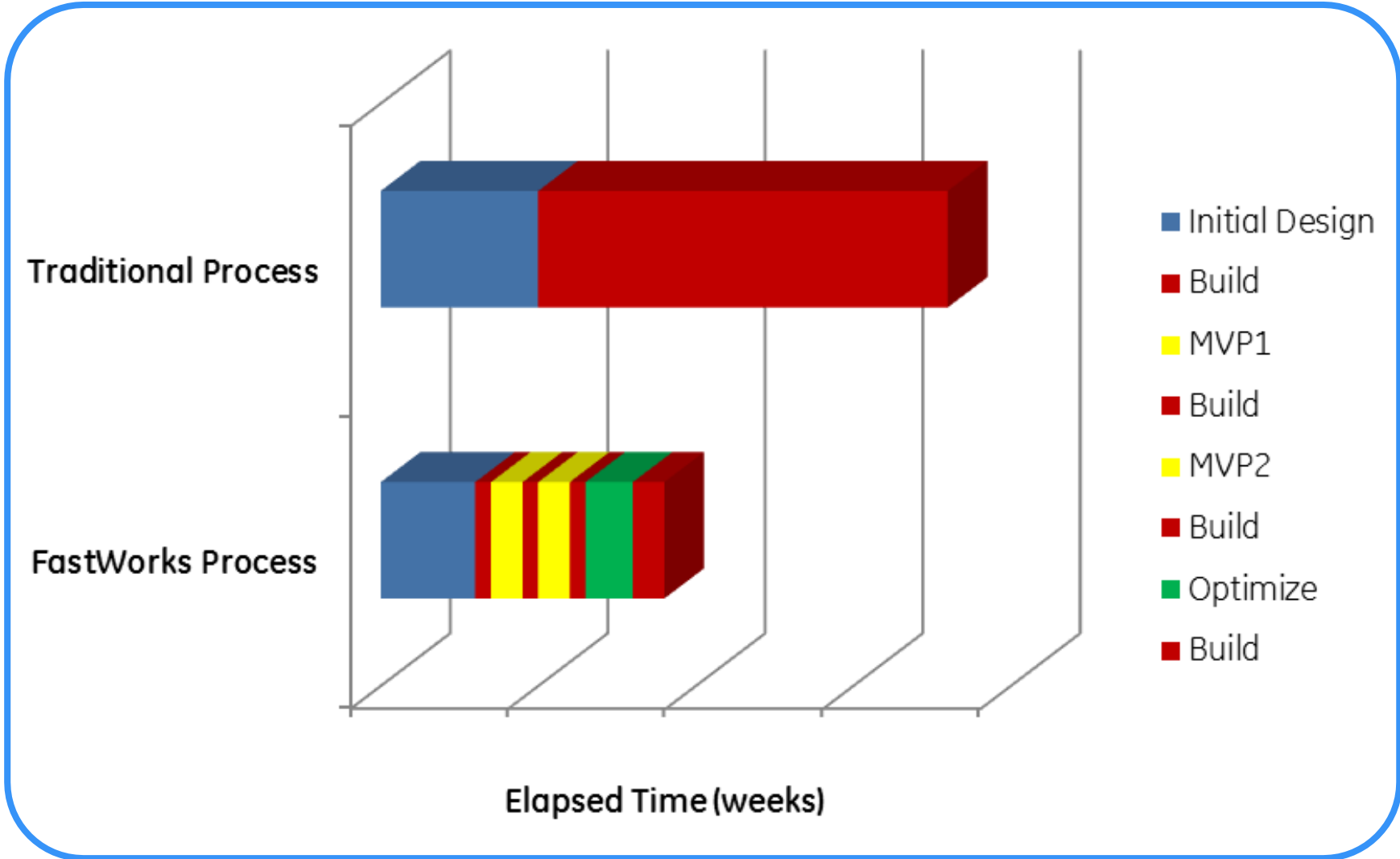
- ✓ Improves the customer experience & outcome
- ✓ Iterative approach – allows early customer engagement
- ✓ Increases empowerment & accountability
- ✓ Reduces time to implement new processes & technologies
- ✓ Increases speed to market
- ✓ Decreases risks

Additive is a Key Enabler for Speed



# FastWorks ... an additive advantage

Not Possible Without Additive



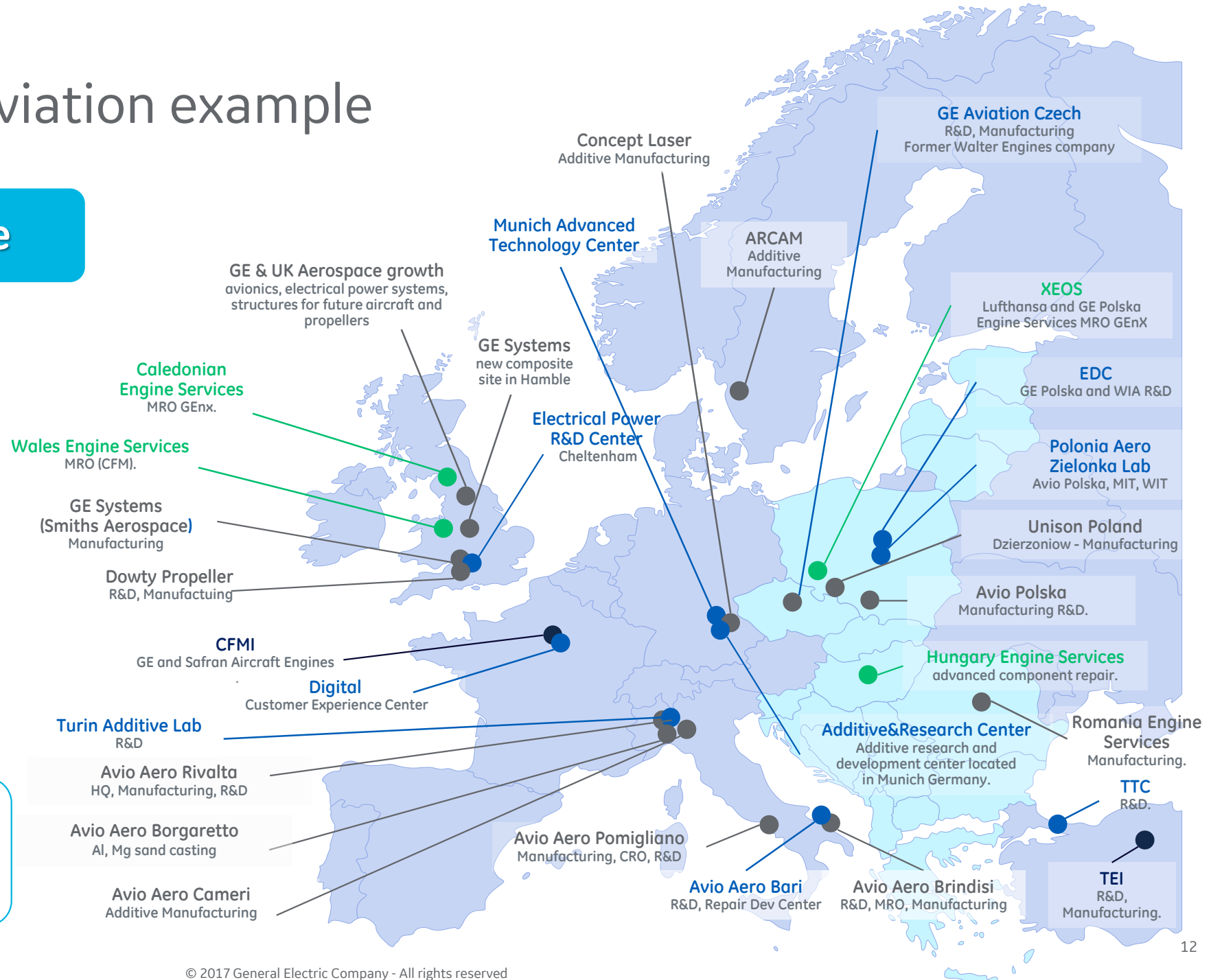
# Ecosystems – GE Aviation example

## Ecosystem advantage

- Geographical proximity
- Easy communication
- Close cooperation



- Shorter development time
- Continues product innovation
- Improved quality
- Reduced costs





# Engine Simplification: Advanced Turbo Prop

55% of major structures additively manufactured

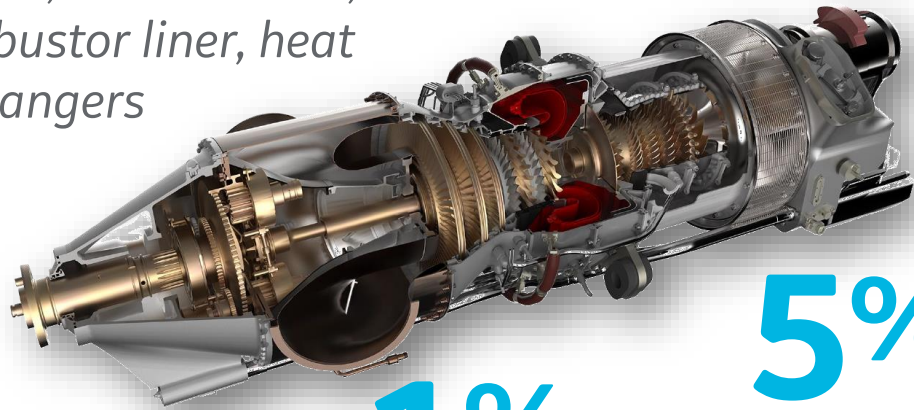
ATP engine for new Cessna aircraft - Denali

**855 → 12**  
PARTS

*Sumps, bearing housings, frames, exhaust case, combustor liner, heat exchangers*

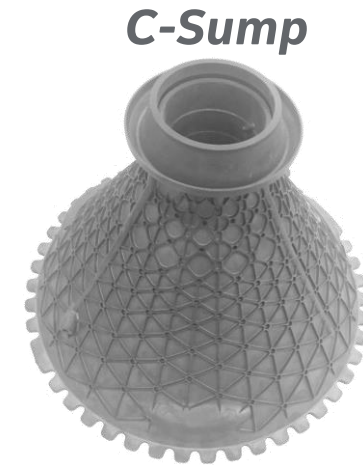
**25%**  
PART WEIGHT  
REDUCTION

**50 → 1**  
PARTS



**1%**  
FUEL BURN  
REDUCTION

**5%**  
ENGINE WEIGHT  
REDUCTION



*Each major component eliminates many sub-parts*



# A new era of design and manufacturing



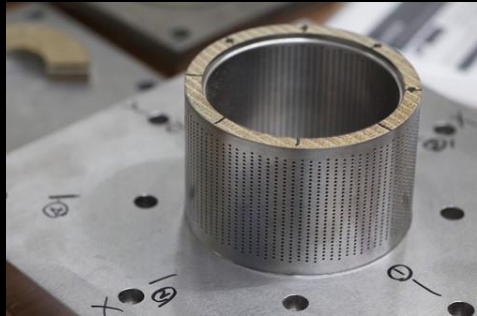
POWER



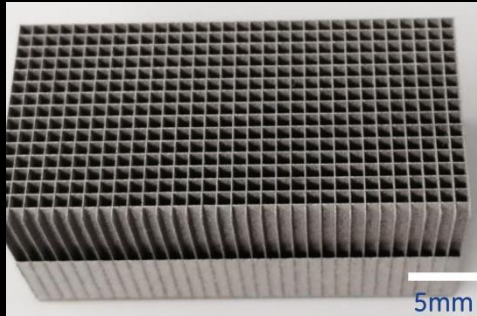
AVIATION



TRANSPORTATION



OIL & GAS



HEALTHCARE



