Troika Solutions LLC

Advocating 3D Printing in the DoD

Employing a Business Case Analysis

2016

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3D Printing Basics

"3D Printing Will Rock the World"

-John Hornick

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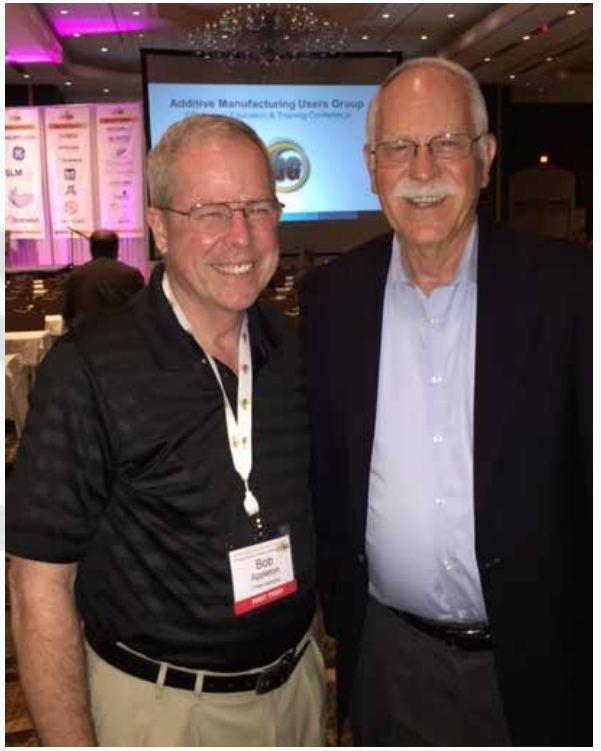
What is 3D Printing?

- Definition…the process of joining materials to make objects from 3D model data, usually layer upon layer

  – ASTM International, Committee F42

- Over 30 Years old
- Many uses; Many materials
- Rapidly advancing technology
- Family of loosely related technologies



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Seven Overall Technology Categories

Technology	Description
Binder Jetting	Liquid bonding agent selectively deposited to join powder
Material Jetting	Droplets of build material selectively deposited
Powder Bed Fusion	Thermal energy selectively fuse regions of powder bed
Directed Energy Deposition	Focused thermal energy melts materials as deposited
Sheet Lamination	Sheet of material bonded together
Vat Photopolymerization	Liquid photopolymer selectively cured by light activation
Material Extrusion	Material selectively dispensed through a nozzle or orifice

Simplified by Hod Lipson in his book “Fabricated”

1. Printers that squirt, squeeze or spray and 2. Printers the fuse, bind or glue.

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Why 3D Printing?

"What would you make if you had a machine that could make anything?" Hod Lipson, *Fabricated*

- Weight saving
- Speed
- Lifecycle Cost
- Simplify Complexity
- Otherwise impossible designs
- Digital
  - Design to production

Lighter
Stronger
Cheaper
Faster
Better

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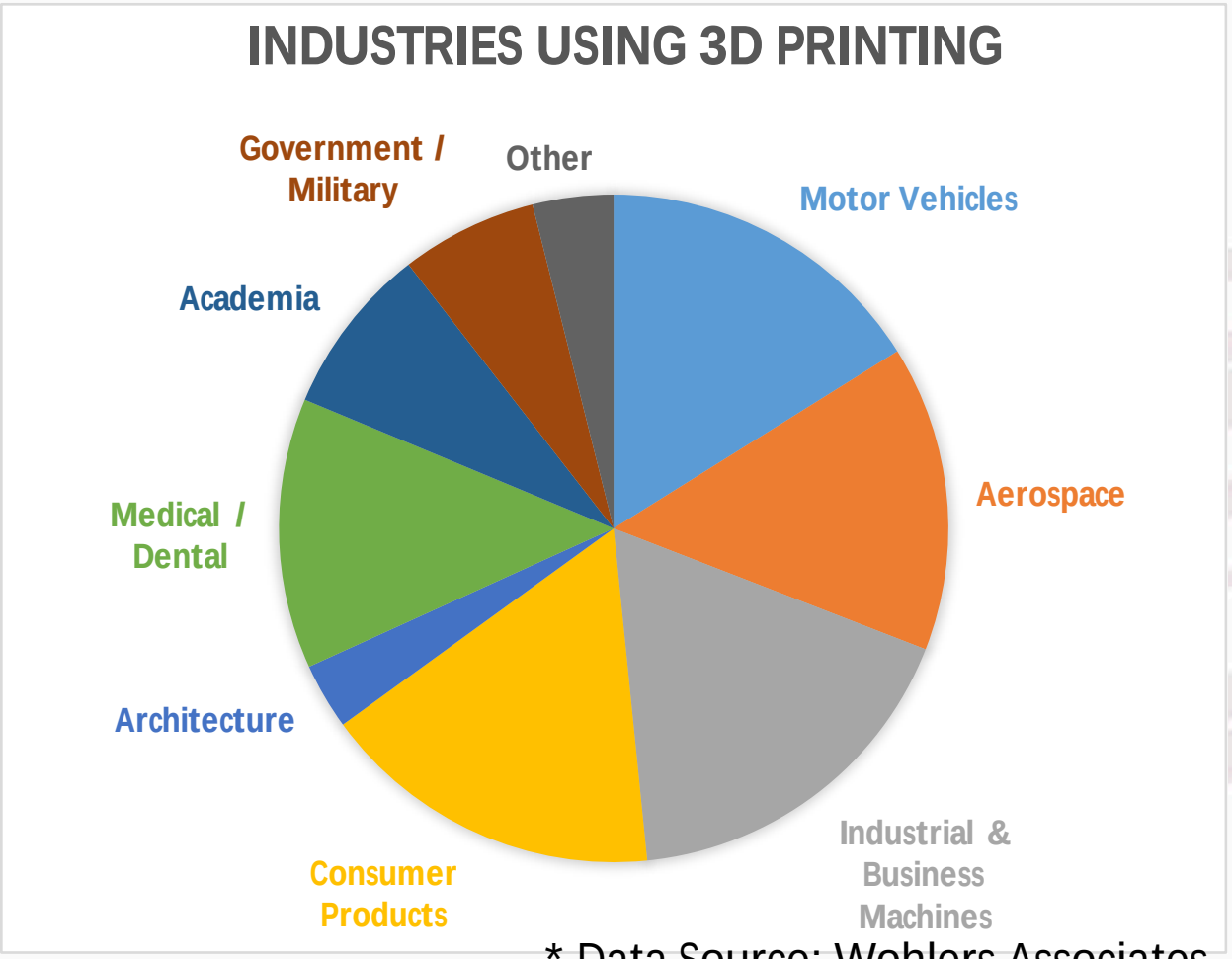
Is Anybody Using it Now?



* Data Source: Wohlers Associates

SHORT LIST

- Boeing
- Airbus
- Stryker
- Invisalign
- NASA
- Lockheed-Martin
- Space X
- Oak Ridge National Labs
- Ford
- Delta Airlines
- General Electric

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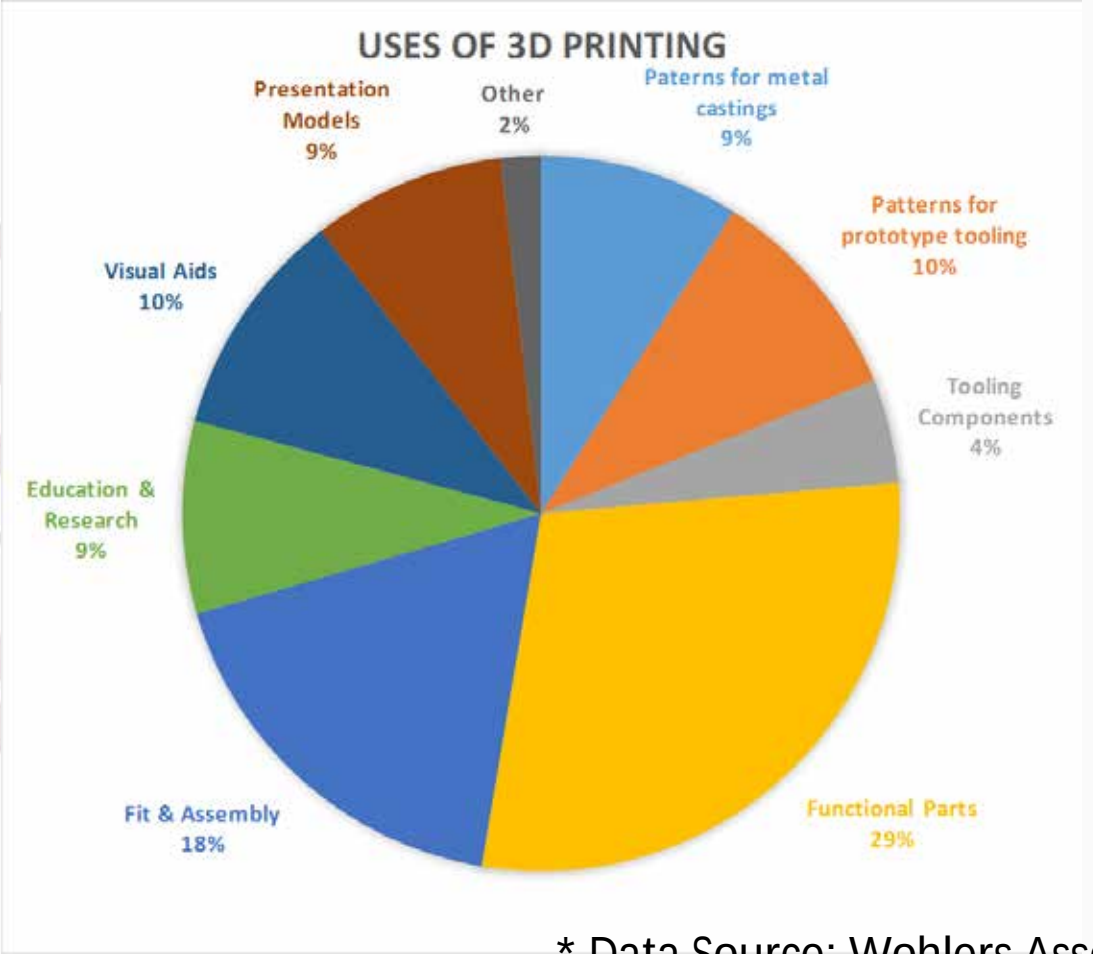
What is it used for?

- Rapid Prototyping
- Aerospace
- Medical / Dental
- Automotive
- Art
- Archeology/Paleontology



* Data Source: Wohlers Associates

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How Could the DoD Use 3D?

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Expeditionary Logistics

Military supply, transportation and repair face unique challenges

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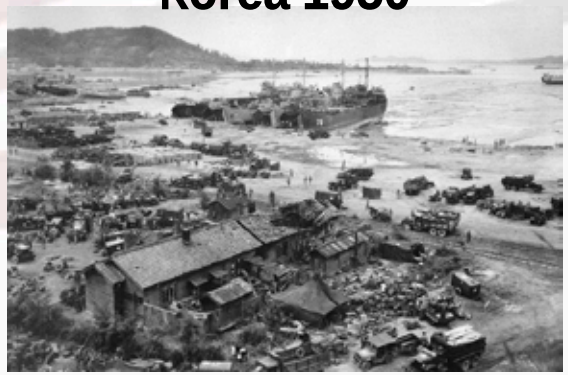
Virtual Inventory

What if we had a digital library with print files for the material we need

Philippines 1897

Korea 1950



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Challenge of Transportation

US Marines in Siberia 1918

Afghanistan Today

Little has changed

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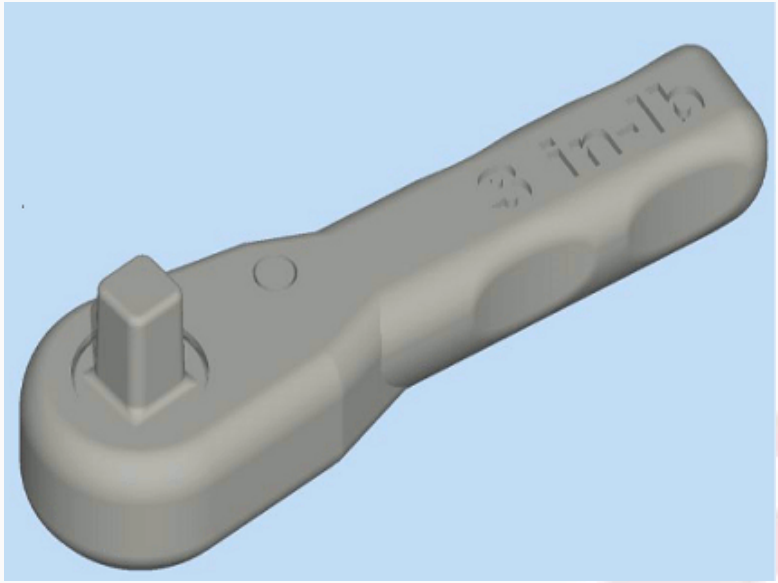
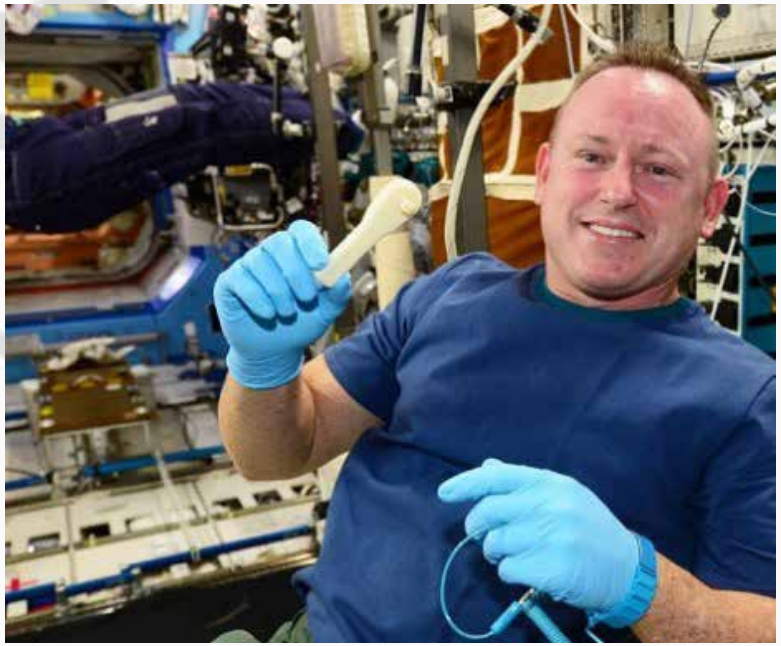
Ease of Transportation

What if we could just email the needed stuff to where it's needed?





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Obsolescence Replacement

We have a lot of old stuff

Entered Service

1970's

1950's

1980's

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But Wait; There's More

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Would it be Worth It?

- Field repairs often done with duct tape and wire
- GSA reports that DoD has $7 Billion in excess inventory
- Expedited transportation to remote locations is costly
- The cost of short production runs or reverse engineering to address obsolescence is high and slow

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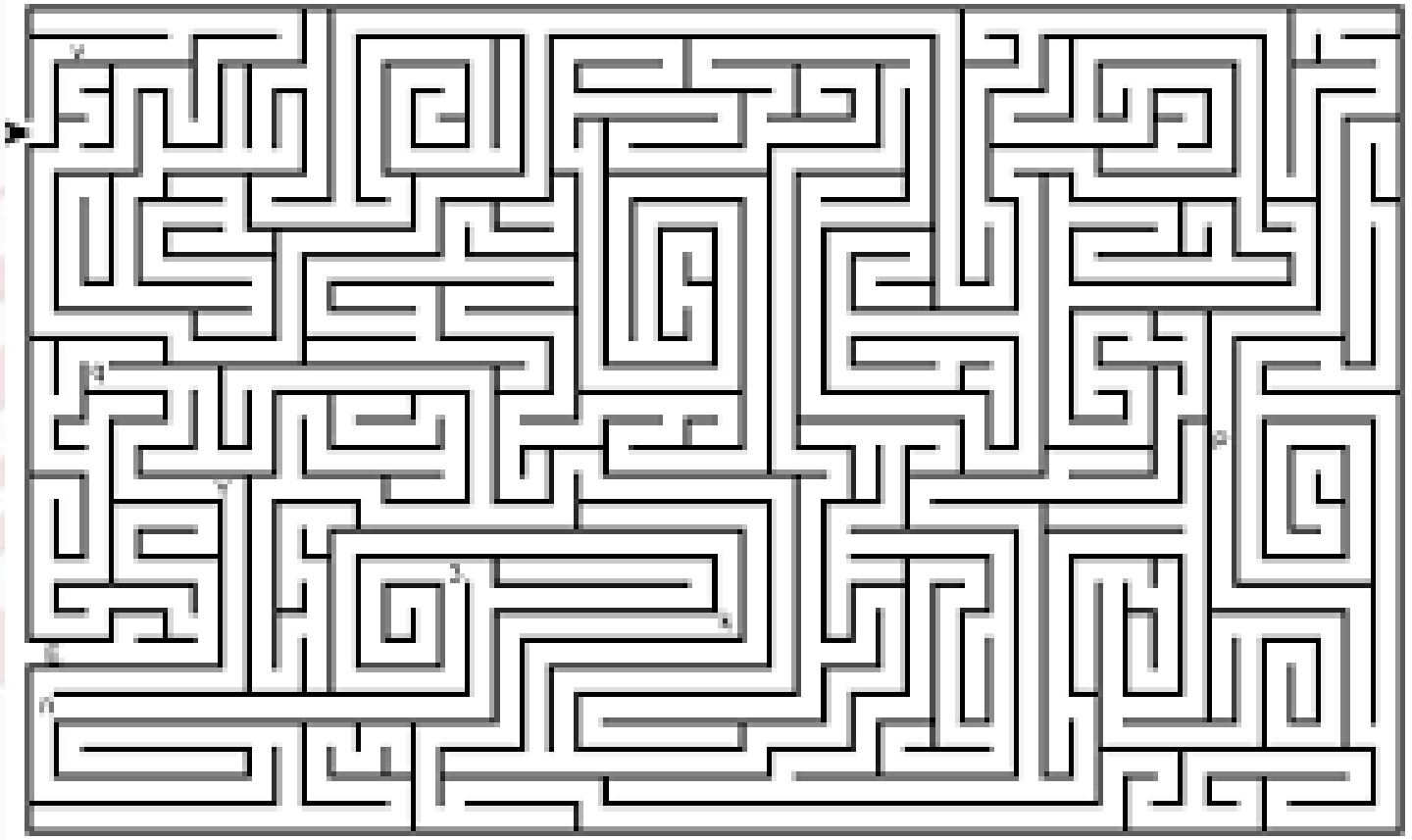
But, It's Complicated

- Data management and interoperability
- Data formats
- Data security
- Intellectual Property
- Quality control
- Standardization



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Why use a Business Case Analysis (BCA)?

- BCA is a structured methodology
- Quantify the benefits
- Study the costs and challenges
- Map the best path of implementation
- Prove the value

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BCA Methodology

- Analyze Product Lifecycle Costs
- Cost Estimating Process
- BCA Types
- Business Process Analysis
- Ground Rules and Assumptions

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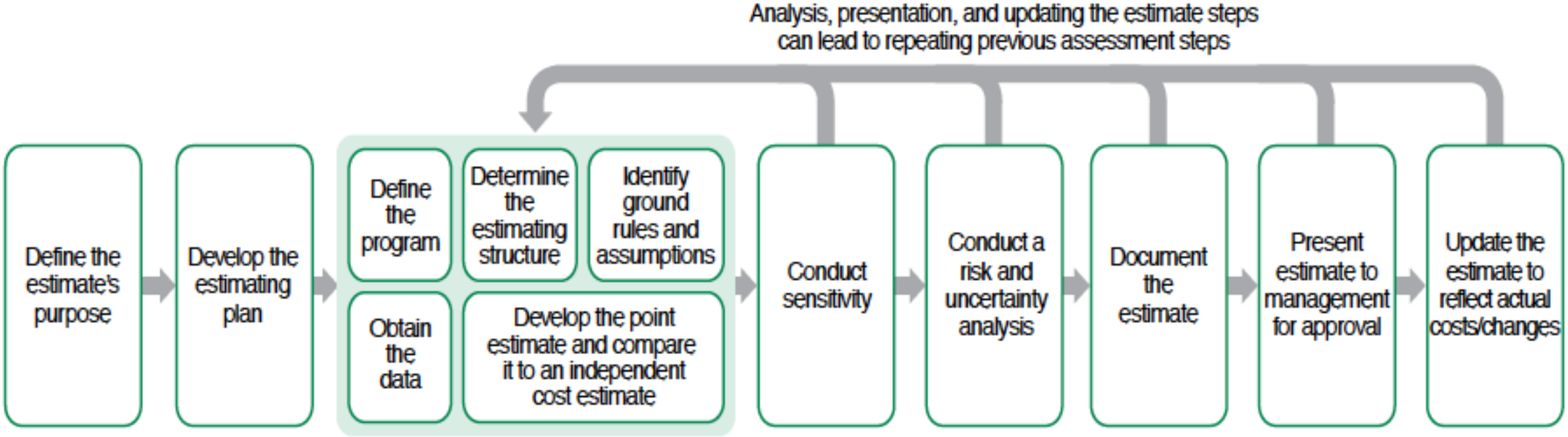
GAO Cost Analysis Methodology

Initiation and research
Your audience, what you are estimating, and why you are estimating it are of the utmost importance

Assessment
Cost assessment steps are iterative and can be accomplished in varying order or concurrently

Analysis
The confidence in the point or range of the estimate is crucial to the decision maker

Presentation
Documentation and presentation make or break a cost estimating decision outcome



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Business Case Analysis Types

- Analysis of Alternatives (AOA)
- Cost Effectiveness Analysis (CEA)
- Economic Analysis (EA) and Cost Benefit Analysis (CBA)

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Business Process Analysis

- Organizational goals and objectives drive functional requirements
- Solutions may include business process improvement, organizational change, strategic planning, and policy development.
- Business Process Re-engineering (BPR)
- Assessing process weaknesses, identifying gaps, and implementing opportunities to streamline and improve the processes

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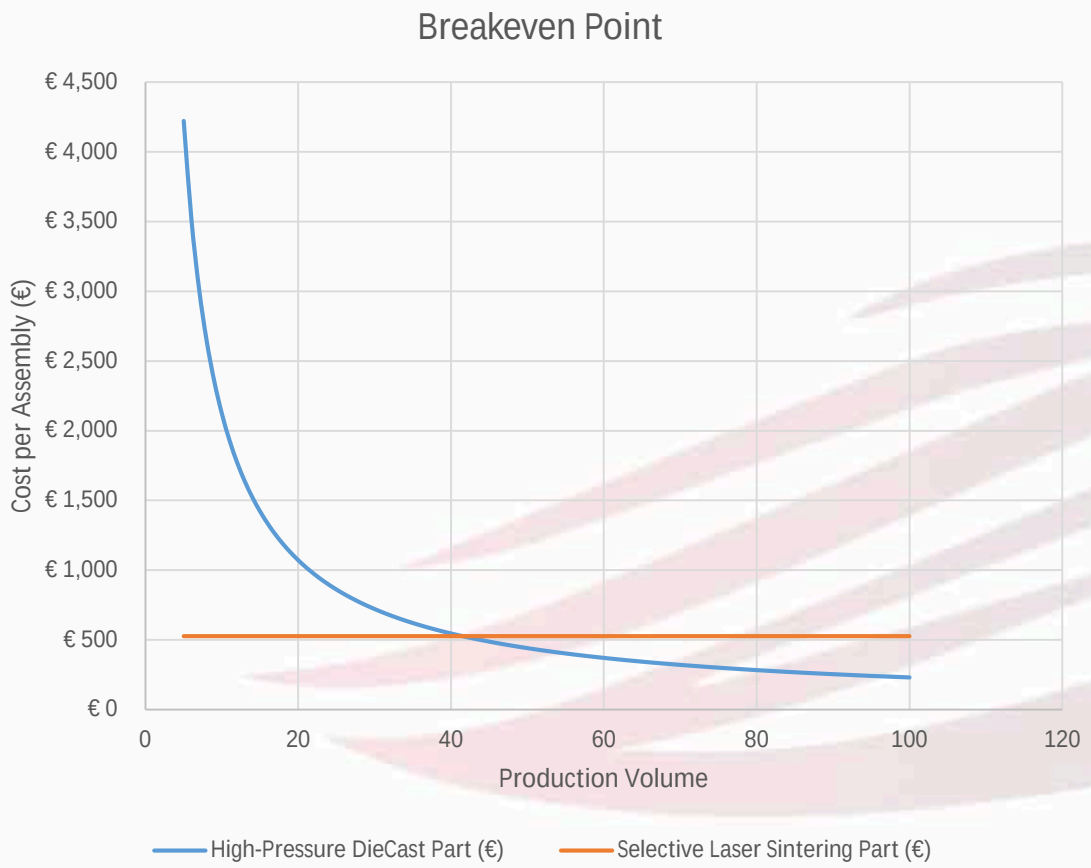
Breakeven Point Example



The breakeven point for this example occurs between the 41 and 42sn unit.	High-Pressure DieCast Part (€)	Cost for Mold	Selective Laser Sintering Part (€)
Material cost per part	€ 2.59		€ 25.81
Pre-processing cost per part	€ 0.00		€ 8.00
Processing cost per part*	€ 0.26	€ 21,000.00	€ 472.50
Post Processing Cost per part	€ 17.90		€ 20.00
Assembly	€ 0.54		€ 0.00
Total	€ 21.29		€ 526.31
First Unit cost for Traditional Manufacturing:		€ 21,021.29	
*Includes the mold for die-casting			

Breakeven Point for High-Pressure Die-Casting and Selective Laser Sintering, Atzeni and Salmi (2011)

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Ground Rules and Assumptions

- Cost estimates that are early in the product life cycle are based upon limited information and require constraints upon estimate.

- Ground Rules
  - Represent a common set of agreed upon estimating standards that provide guidance eg laws, regulations, constraints, ASME Standard etc.

- Assumptions
  - Place bounds on the scope of the estimate
  - Represent a set of judgments about past, present, or future conditions considered as true in the absence of positive proof.

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Traditional Manufacturing, In house 3D printing or Bureau 3D printing?

8 Cost Drivers

1. Engineering – parts, design complexity, printing orientation
2. Tools – molds/casting vs 3D printer
3. Material – weight, plastic vs metal, alloys
4. Manufacturing – post processing, skilled workers

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Traditional Manufacturing, In house 3D printing or Bureau 3D printing?

8 Cost Drivers

5. Quality control
6. Safety - regulations
7. Facility – factory, garrison, outer space
8. Inventory – physical vs digital

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Other Elements to Consider When Comparing 3D Printing to T/M

- The typical lead-time to acquire a part that is no longer in the supply chain is 12 to 18 months
- 3D Printing is a valuable tool for reverse engineering

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Conclusion

- Typically 3D Printing per unit cost is higher than Traditional Manufacturing
- Traditional Manufacturing up front costs can be higher than 3D Printing
- The breakeven point will drive the 3D Printing or Traditional Manufacturing decision

However……

- Readiness may be more important than cost

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QUESTIONS?