Additive Manufacturing, Topology Optimization and ANSYS Mechanical

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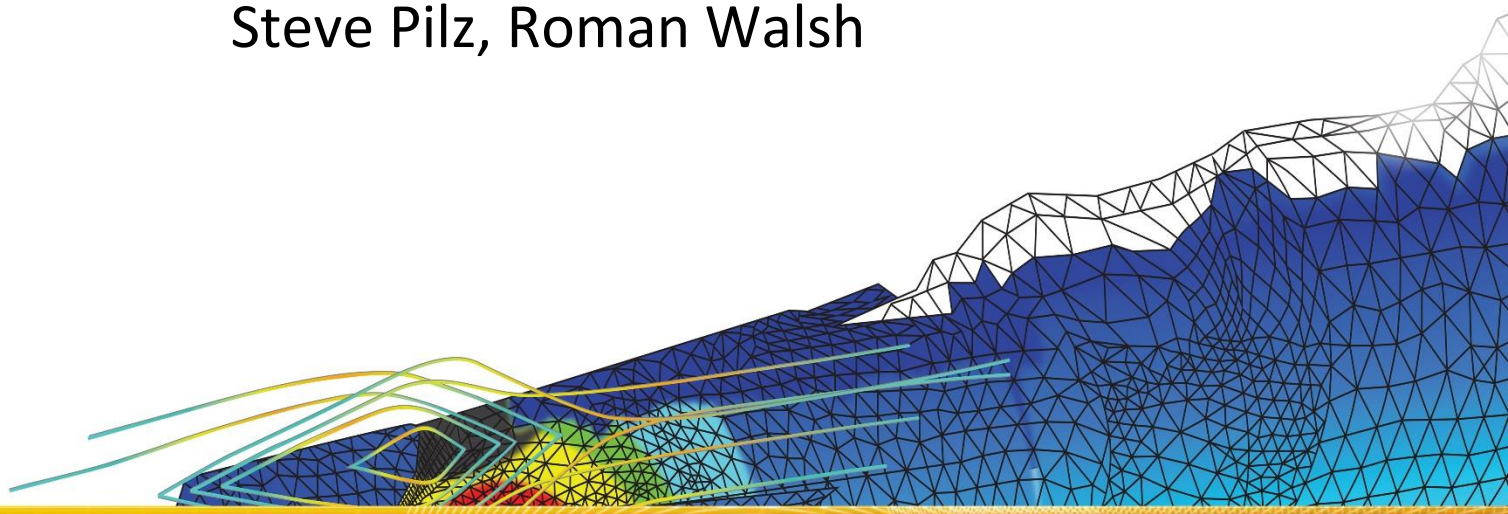
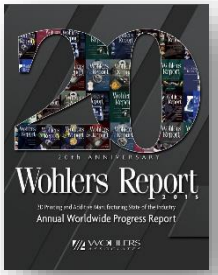


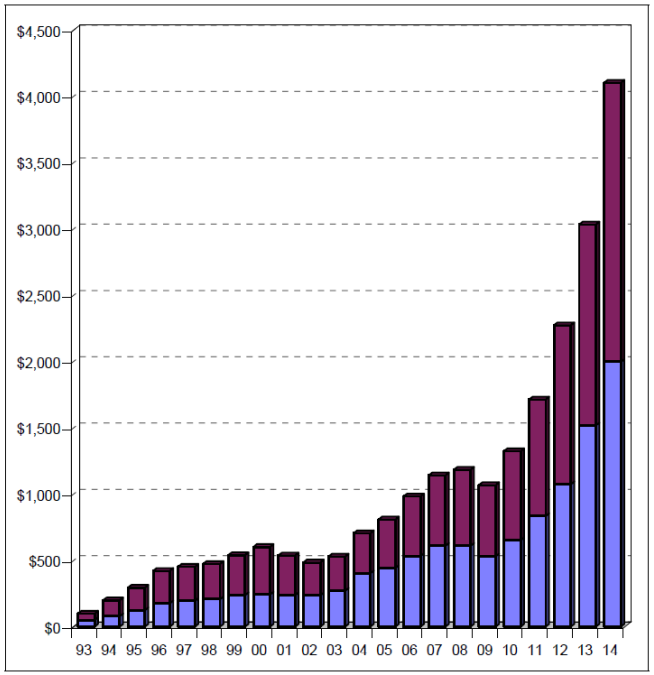
Additive Manufacturing

- What's the big deal?
- Who stands to gain the most?
- Why topological optimization?
- How do you get ANSYS Topology Optimization?

Revenue from AM worldwide

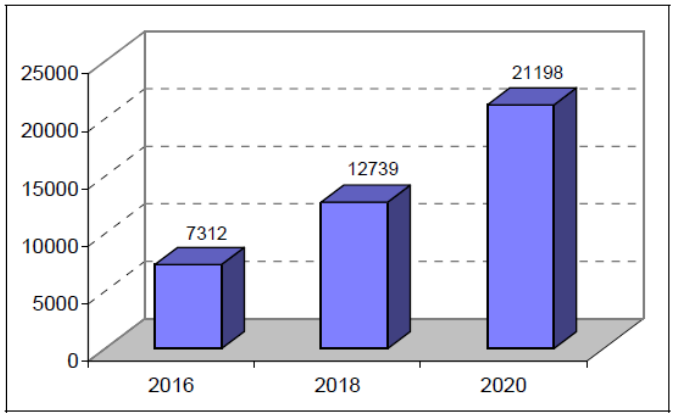


In 2010, the AM (products and services) grew 24.1%.
In 2011, the AM (products and services) grew 29.4%.
In 2012, the AM (products and services) grew 32.7%.
In 2013, the AM (products and services) grew 33.4% to $3.033 billion.
In 2014, the AM (products and services) grew 35.2% to $4.103 billion.



Source: Wohlers Associates, Inc.

Grew 34% to $5.5 billion this year

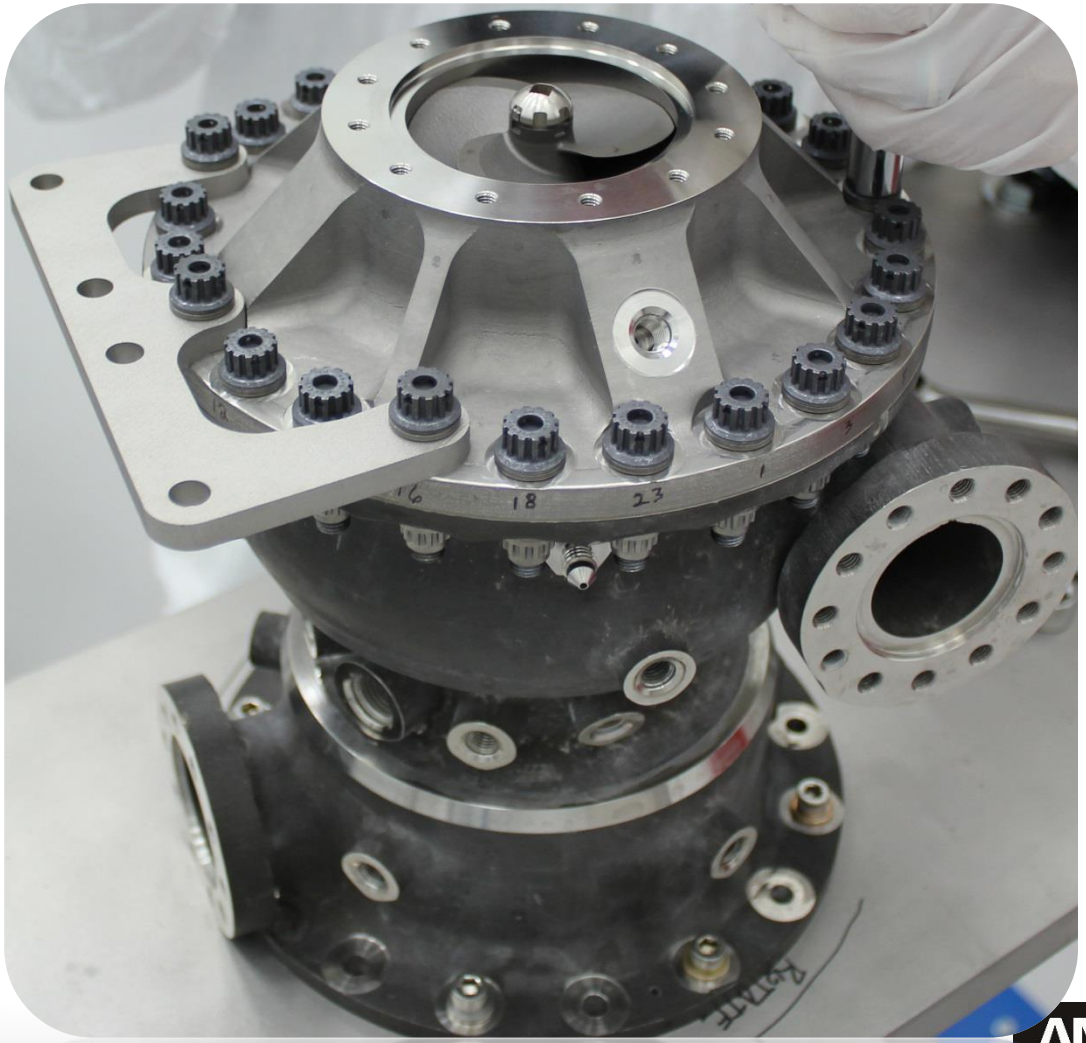


Source: Wohlers Associates, Inc.

Fewer Parts, Less Cost, Better Reliability

NASA turbopump:

- **45% fewer parts**
- Runs at 90,000 rpm, and creates 2,000 hp
- **$220,000** each using conventional methods
- NASA can 3D print 2 of them in Inconel for **$20,000**



Fewer Parts, Less Cost, Better Reliability, Better Performance

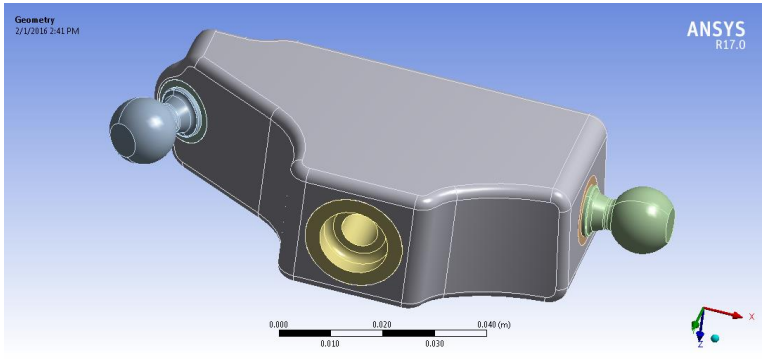
GE Aviation fuel nozzles:

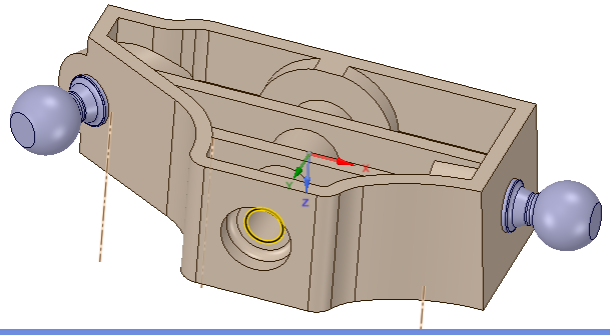
- The new design is **25% lighter**
- **5 times more durable** than the previous design
- the previous design took 20 different parts to assemble to make one fuel nozzle.

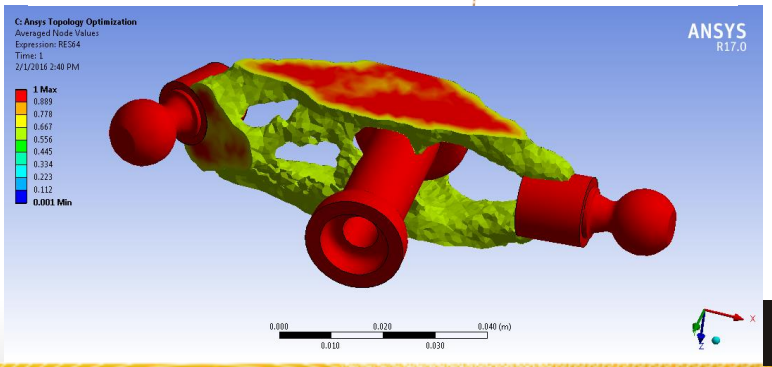
- Automotive, Biomedical, Energy, Military, Dental, Tooling, Prototyping, Patterns etc.
- LIGHTER, CHEAPER, FASTER, BETTER

In the Additive Manufacturing Age, Who Does Design?

- Human Intuition Based Design
- Physics Driven Design

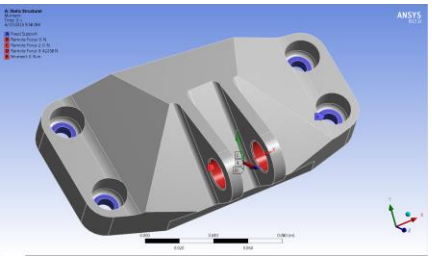




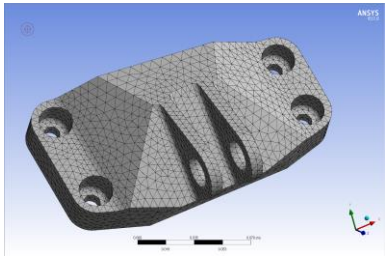


Workflow Step Example

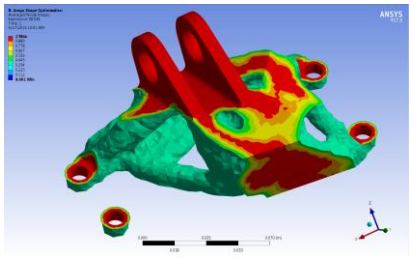
Initial Geometry Boundary Limits



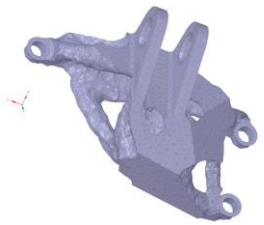
Prep for Topo Optimization



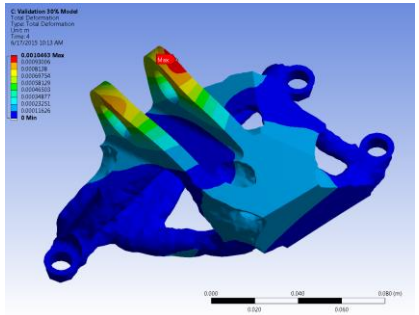
Optimized Geometry



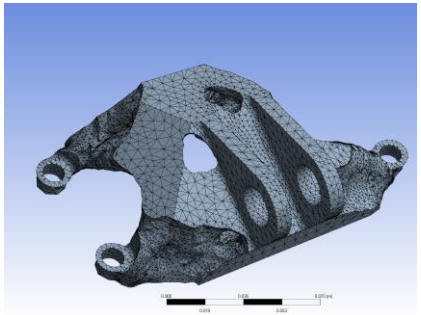
Exported STL Model in SC
Fix, Clean, Reduce, Smooth



PRINT Optimized Model

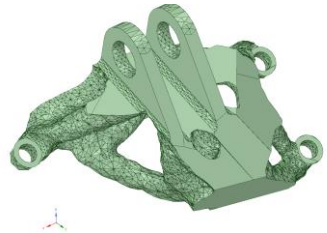


Analyze Optimized Model



Re-mesh Optimized Model

Convert to Solid in SC



ANSYS R17 Topology Optimization

- **Mechanical Physics**
  - Linear Stress
  - Steady State
  - Linear Bonded Contact
  - Solid Bodies (2D and 3D)
- **Constraint Functions**
  - Local Degree of Freedom
  - Reaction Force
  - Volume, Mass
  - Local Stress
  - Global Stress
- **Objective Functions**
  - Single and Multi Compliance
  - Local Degree of Freedom
  - Local Displacement
  - Reaction Force
  - Volume, Mass
- **Manufacturing Constraints**
  - Maximum Member Size
  - Minimum Member Size
  - Symmetry
  - Extrusion

- R17 ANSYS Topology Optimization is a free ACT Extension that can be used with any workbench based ANSYS Mechanical Solver. We plan to release commercial tested with a native workbench interface at R18

Where Do You Get ANSYS Topology Optimization?

ANSYS Customer Portal
ACT Application Store