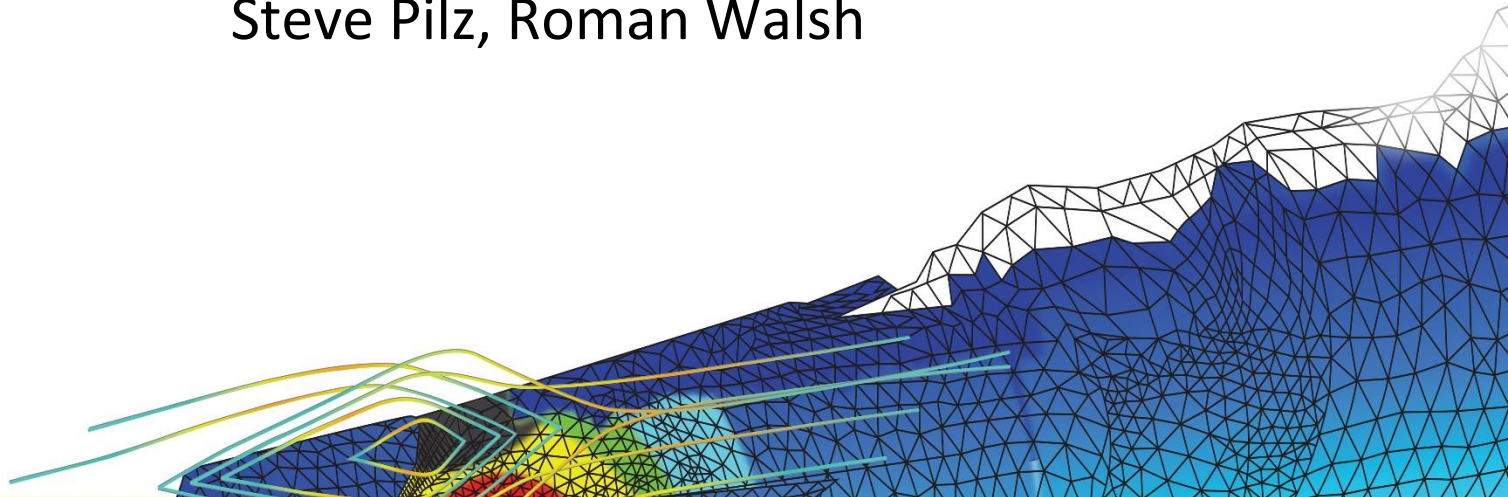


**ANSYS®**

# **Additive Manufacturing, Topology Optimization and ANSYS Mechanical**

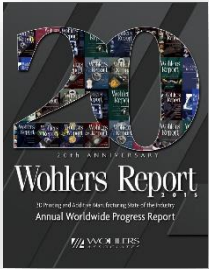
Steve Pilz, Roman Walsh



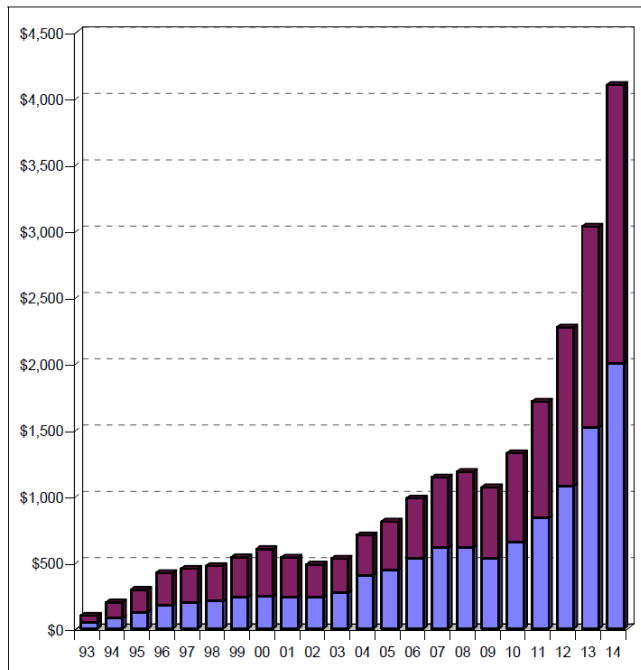
# Additive Manufacturing

- **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

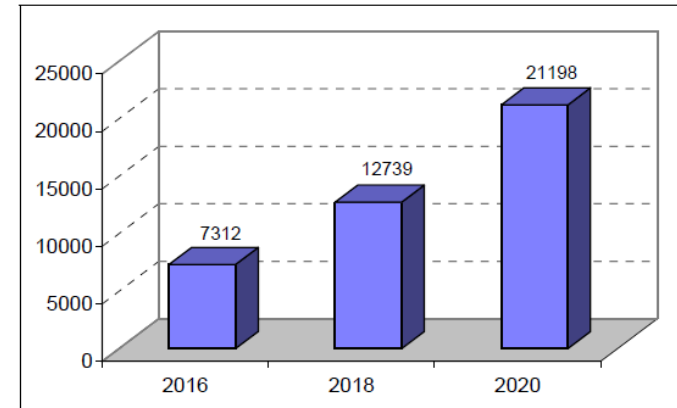


In 2010, the AM (products and services) grew 24.1%.  
 In 2011, the AM (products and services) grew 29.4%.  
 In 2012, the AM (products and services) grew 32.7%.  
 In 2013, the AM (products and services) grew 33.4% to \$3.033 billion.  
 In 2014, the AM (products and services) grew 35.2% to \$4.103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



Source: Wohlers Associates, Inc.

Grew 34% to \$5.5 billion this year

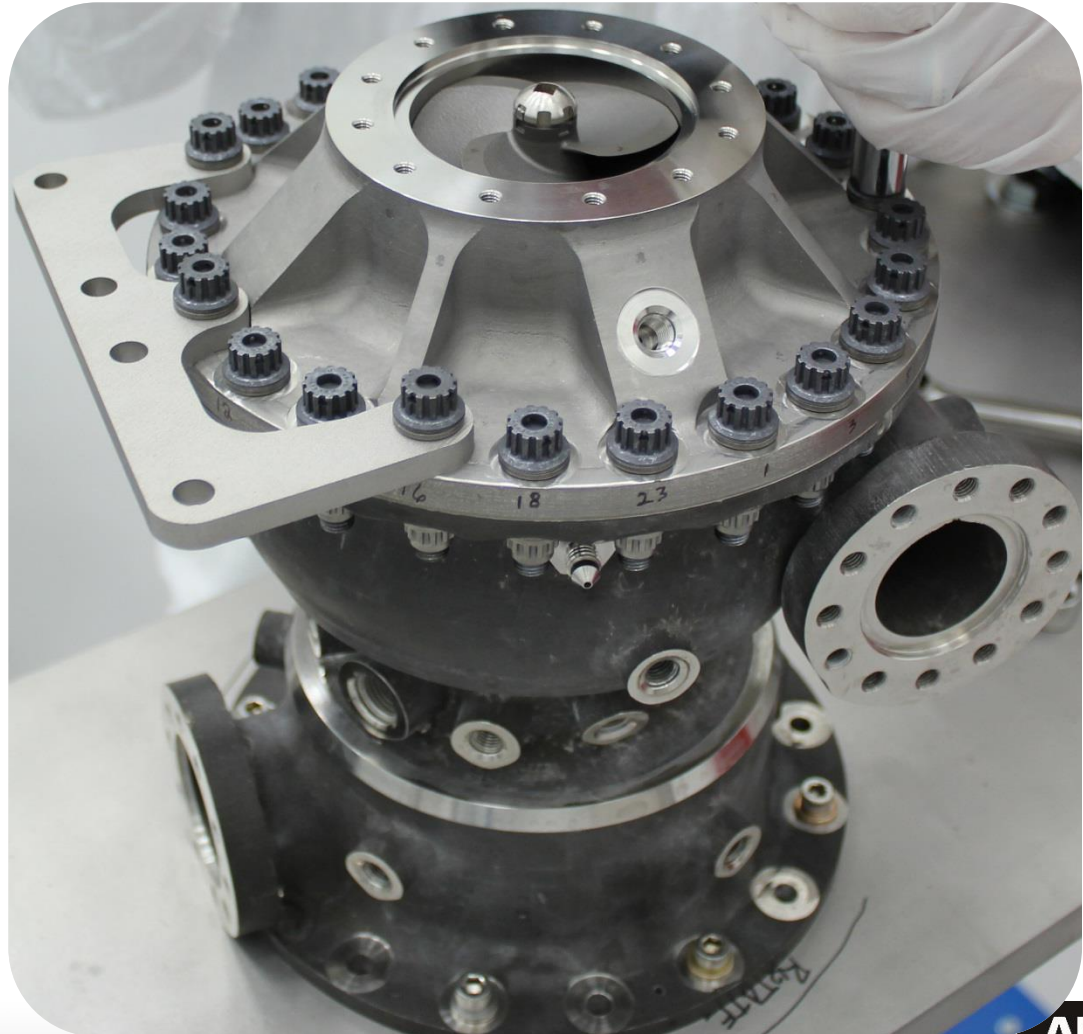


Source: Wohlers Associates, Inc.

# 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:

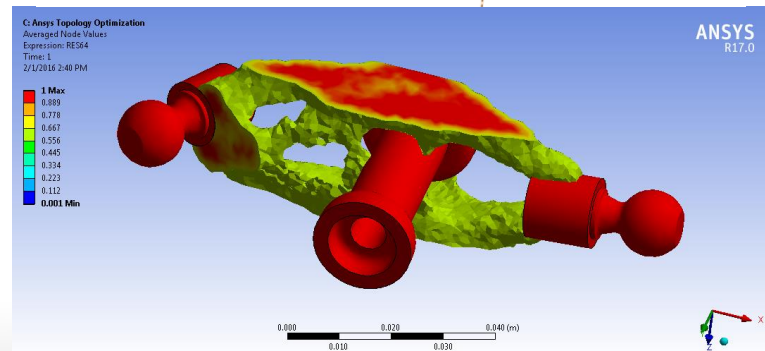
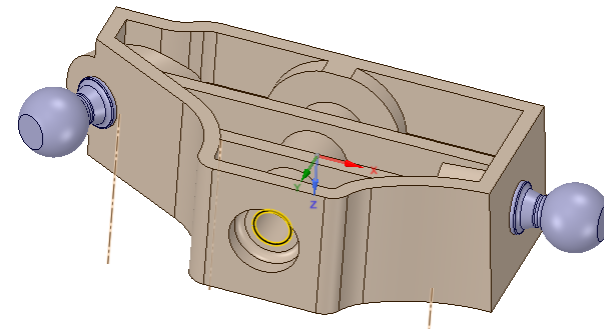
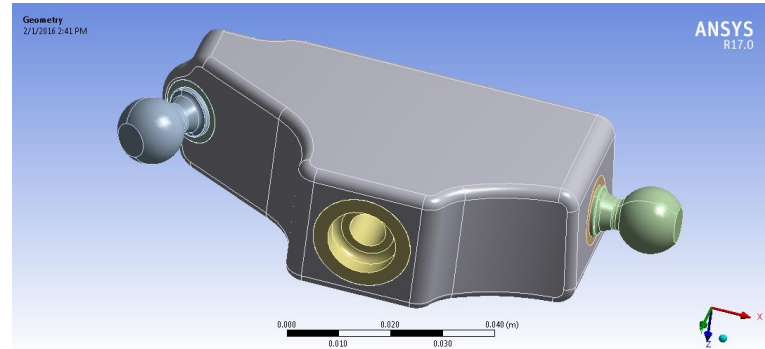
- The new design is **25% lighter**
- **5 times more durable** than the previous design
- the previous design took 20 different parts to assemble to make one fuel nozzle.
- Automotive, Biomedical, Energy, Military, Dental, Tooling, Prototyping, Patterns etc.
- **LIGHTER, CHEAPER, FASTER, BETTER**





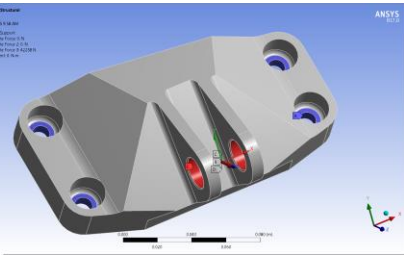
# In the Additive Manufacturing Age, Who Does Design?

- Human Intuition Based Design
- Physics Driven Design

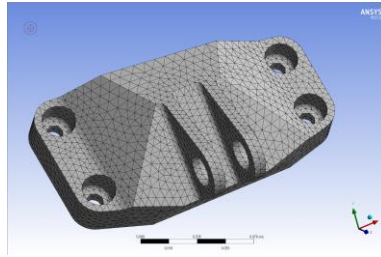


# Workflow Step Example

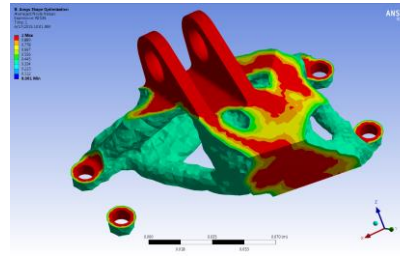
Initial Geometry Boundary Limits



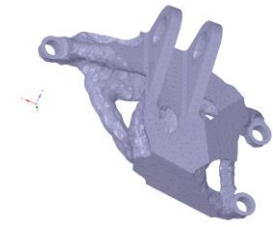
Prep for Topo Optimization



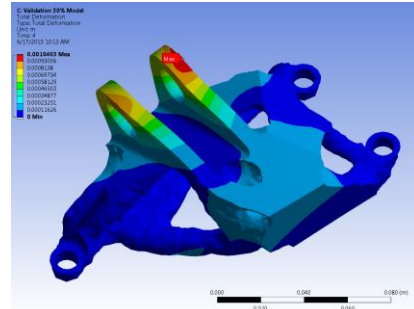
Optimized Geometry



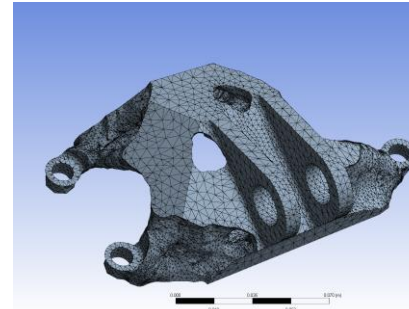
Exported STL Model in SC  
Fix, Clean, Reduce, Smooth



PRINT Optimized Model

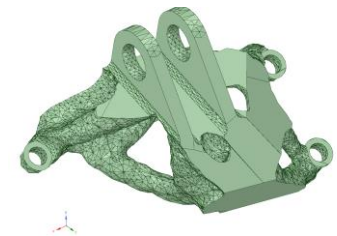


Analyze Optimized Model



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

The screenshot shows the ANSYS Customer Portal header. The navigation menu includes: Products, Training & Support, Consultancy Services, Downloads, Knowledge Resources, and Employees. The 'Downloads' menu is open, showing options: Current Release, Apache Products, Previous Releases, Installation and Licensing Help and Tutorials, ANSYS ACT Application Store, NIST REFRPROP, and Getting Started. A search bar is visible in the top right corner.

This section displays a list of 'New Items' under the heading 'My Saved Searches'. The items listed are: 'How can I simulate the melting of a solid in a closed cavity contain...', 'ANSYS AIM: Fluid-Solid Heat Transfer', 'ANSYS AIM - Generating Contacts', 'ANSYS AIM: Viewing Results', 'Shared Topology in Design Modeler', 'ANSYS Mechanical Fracture Analysis of a 2D Cracked Specimen using...', 'ANSYS Mechanical Tutorial for Nonlinear Static Structural Analysis ...', 'CFX Tutorial 5: Flow in a Process Injection Mixing Pipe R17.0', 'Icepak Tutorial 23: ANSYS Icepak - ANSYS Workbench Integration Tut...', and 'Fluent Tutorial 2: Parametric Analysis in ANSYS Workbench Using AN...'. There are also links for 'Knowledge Resources' and 'ANSYS 17.0 Now Available'.

The banner features the text: 'From FE Simulation to Knowledge-driven product development through simulation'. A quote from Cassiano A Cezario, R&D Center Simulation Leader at WEG Electric Motors, states: 'WHEN ANSYS DEVELOPED ACT, IT WAS A GIANT STEP FOR INDUSTRIES. THIS AMAZING TOOL CAN BE AN INSTRUMENT FOR SHARING INTERNAL KNOW-HOW. FOR WEG, USING ACT RESULTED IN AN INSTANTANEOUS INCREASE OF KNOWLEDGE.' The background shows a 3D simulation of a motor component.



## About ANSYS

If you've ever seen a rocket launch, flown on an airplane, driven a car, used a computer, touched a mobile device, crossed a bridge, or put on wearable technology, chances are you've used a product where ANSYS software played a critical role in its creation. ANSYS is the global leader in engineering simulation. We help the world's most innovative companies deliver radically better products to their customers. By offering the best and broadest portfolio of engineering simulation software, we help them solve the most complex design challenges and engineer products limited only by imagination.



The screenshot shows a grid of ANSYS ACT Applications for ANSYS 16, Windows only. The grid includes: 'Acoustics 16.0' (Version: 16.2), 'Acoustics 16.1' (Version: 16.2), 'Acoustics 16.2' (Version: 16.2), 'Advanced Enclosure' (Version: 5.0), 'Beam End Release' (Version: 1.2), and 'Beam to Link 16.0, 16.1, 16.2' (Version: 3.0). Each application card includes a target application, a brief description, and download options (Video, Download). The grid also features logos for CADFEM, ANSYS, and leap. On the right side, there are sections for 'Previous Releases' (listing ACT Libraries and SDK Libraries), 'ACT Templates' (listing various templates for DM, CH, and Wizard), and 'Help & Support' (listing Contact Local Support and ACT Module Doc).

