Meeting with Boeing NCMS Next Generation Surface Engineering Tech - Workshop

Presented by

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Be Curious℠

Our business units

"UTRC is where you bring your toughest problems."

UTC Aerospace Systems

United Technologies
Climate | Controls | Security

Pratt & Whitney
A United Technologies Company

Otis
A United Technologies Company

UTRC is UTC's

innovation engine

Defining what's next:

Define new frontiers

Co-develop new technologies

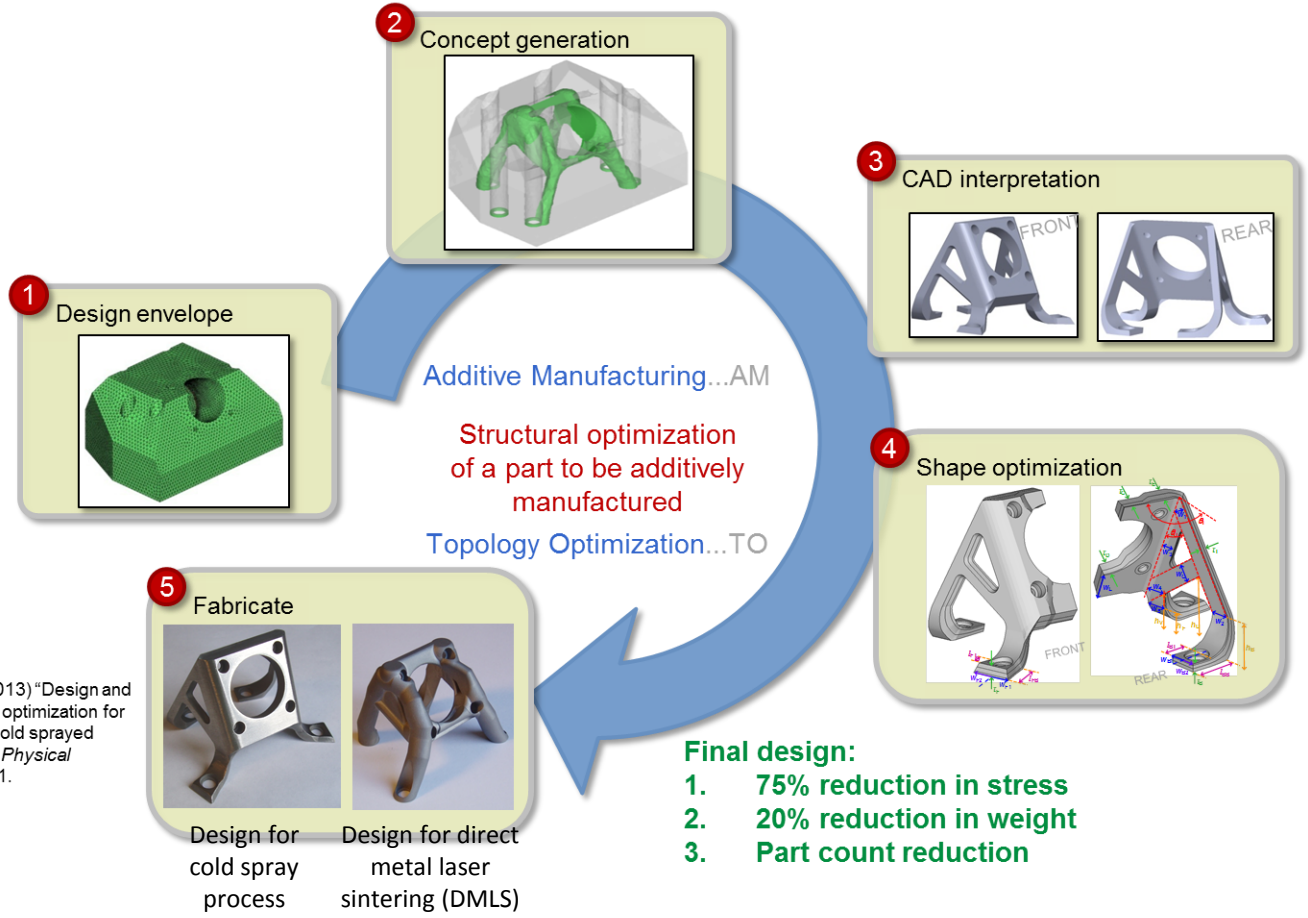
Solve tough problems

Serve as hub for technical interchange

Leverage global network of innovation

Monetize UTC intellectual property

Additive Topology Optimized Manufacturing (ATOM)



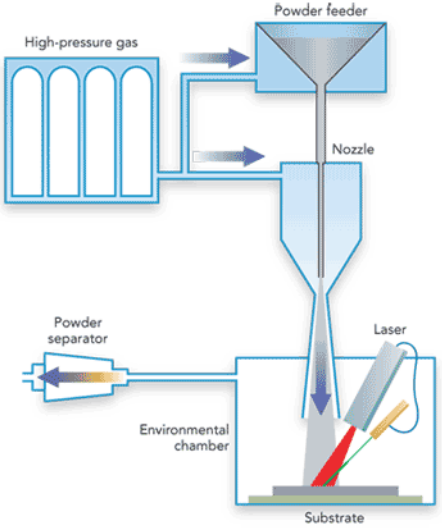
Ref: M.E. Lynch, *et al.* (2013) "Design and topology/shape structural optimization for additively manufactured cold sprayed components", *Virtual and Physical Prototyping*, 8(3), 213-231.

Final design:

1. **75% reduction in stress**
2. **20% reduction in weight**
3. **Part count reduction**

United Technologies

Hybrid Additive Manufacturing Processes



Cold Spray + Laser Heating

- Multi-material solutions fully reheat treated for optimized properties

http://www.industrial-lasers.com/articles/print/volume-23/issue-11/features/technology-report/laser-assisted-cold-spray.html

GMAW + Laser Heating

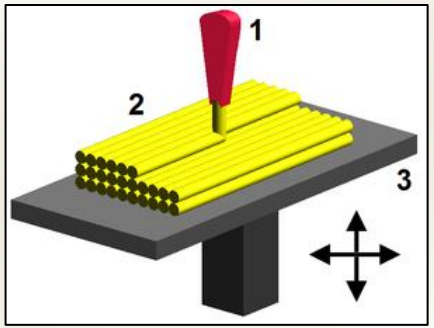
- Multi-material solutions fully reheat treated for optimized properties

http://www.industrial-lasers.com/articles/print/volume-26/issue-1/features/hybrid-laser-arc-welding-has-its-time-arrived.html

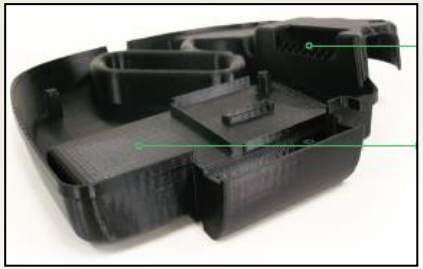
Polymer 3D Printing at UTRC

Fused Deposition

- **MakerBot 3D Printer**
- **AirWolf "reprap" style systems**
- Extrusion of polymer, layer by layer deposition
- Thermoplastic-based feedstock (neat or filled)
- Shrinkage & residual stress limits high resolution
- Capable of complex geometries and low density cores
- Multiple material deposition, limited properties



http://en.wikipedia.org/wiki/Fused_deposition_modelling



Prototype parts

Stereolithography

- **Carbon M1 CLIP 3D printer**
- **FormLabs SLA 3D printer**
- "Grandfather of 3D Printing"
- Large Area Maskless Photopolymerization
- Uses UV curing materials to build parts
- Complex geometries with good resolution
- Restricted material selection
- Resins expensive, often proprietary

Original molded part

Optimized Carbon prototype

http://www.carbon3d.com/materials/rpu-rigid-polyurethane

2-Part Resin Based Printing

- **Carbon M1 3D printer with dual cure resins**
  - Acrylate, Urethane, Epoxy, Cyanate ester
  - Duel cure chemistries: 1st to lock the geometry; 2nd to set the performance
- **Developed at UTRC: Mix-on-the-fly 3D printing**
  - Epoxies, urethanes, acrylics
  - Add fillers to print composite materials
  - Well suited for embedding of electronics