3D Printing is *changing* the **AEROSPACE INDUSTRY**

Many materials/technologies...

- FDM
- PolyJet
- DMLS
- SLA
- SLS
- …
3D Printing is *changing* the AEROSPACE INDUSTRY

... but all work towards the same goals!

- **New** (novel) and **better** parts – more *innovation*
- **Reduced cycle times**
  - Manufacturing
  - Design
- **Reduced risk** and **cost**
  - Design
  - Manufacturing
  - End-use products
COMMERCIAL APPLICATIONS

Airbus A350 XWB flies over *1000* ULTEM 9085 parts!

- ULTEM 9085 offers high strength/weight and FAA + UL (among others) FST certified!
- Streamlined supply chain
- Overall lower manufacturing cost (as well as vastly improved lead times and quickest design iteration time)
- Approaching 1:1

BUY-TO-FLY RATIO
COMMERCIAL APPLICATIONS

Lockheed Space Systems Company uses Stratasys for 3DP’d satellite components

- Fit/function prototypes for upcoming satellites were the largest prints Stratasys Direct (RedEye) had ever done – 6.75’ x 3.8’ x 3.8’
- Printed on 6x Fortus 900MC’S in PC – 150hrs (simultaneous builds) – low “5-digit” cost
- Traditional prototyping was estimated at 6 months and $250k!
COMMERCIAL APPLICATIONS

United Launch Alliance saving $1 MILLION ANNUALLY with Stratasys 3D Printing

- 60-75% outsourced production
- Over 50%, UP TO 95% cost reduction!
- Own several FORTUS 900mc's in-house
  - Coolant nozzles in rocket, brackets, covers, ducts, etc – save weight!

ULTEM 9085 (and their AM process) is certified from pellets to final part – NO INSPECTION!
COMMERCIAL APPLICATIONS

Lockheed Space Systems Company *satellite components*

Regardless of company size or end product...

Cost savings

Time savings

... is changing the industry for the better!
NEW INSPECTION / CERTIFICATION METHODS NEEDED...

**NDE** = Non-destructive Evaluation
- Traditionally done after operations, however with AM, can be done **DURING** the build
  - Eddy-current or dye penetration don’t work well with AM’s “rough” surface
  - X-ray CT visibility of cracks limited by beam direction

**Dr. Jess Waller**, material scientist at NASA
It will be the **first of its kind** – the **standard** for AM parts – and NASA is taking the lead on that. It’s a unique opportunity we have with additive that’s not available at all with traditional methods. You can develop an NDE build record of your part that tells you what the properties of that part are, **layer by layer.**
MILITARY APPLICATIONS

Two contracts ($1M+) awarded to 3D Printing companies...

3DS, SANDIA NATIONAL LABS, LOCKHEED MARTIN, AND UNIV OF DELAWARE CENTER FOR COMPOSITE MANUFACTURING

Integrate predictive technology to dynamically monitor parts at the layer level during build

APPLIED RESEARCH LAB @ PENN STATE + HONEYWELL + NORTHROP GRUMMAN

Develop fully-dense, chemically-pure, *flight-worthy* metal parts
**Military Applications**

**America Makes RD.3 - $19M / each project!**

- **Seamless AM Design/Analysis**
  - Raytheon, GE, Altair, Ansys, Autodesk, Netfabb

- **Design Tools for AM Apps**
  - Honeywell, Ansys, Aerotech, US Army

- **Open Architecture for 3rd Party Metal AM Systems**
  - GE Aviation, RPI

- **Digital Threading for AM**
  - Boeing, Aerojet, Raytheon, Stratronics

- **Low-Cost Industrial Multi3D System for 3D Electronics Manuf.**
  - Northrup, Lockheed, Boeing, Honeywell, Draper Labs
MILITARY APPLICATIONS

Razor
University of Virginia’s drone designed to be printed anywhere

- Printed in FDM in 9 parts
- 4ft wingspan, 1.8lbs – 6lbs loaded
- Flies 40mph for 45mins! Prototype has been over 100mph
- Designed for DOD to be replaced or repaired anywhere in the world in under 24hrs, for less than $2500
Raytheon has already printed every component individually, goal is to print **ON DEMAND, IN THE FIELD**

“You can design internal features that might be impossible to machine ...We’re trying new designs for thermal improvements and lightweight structures, things we couldn’t achieve with any other manufacturing method.”

RAYTHEON AM ENGINEER TRAVIS MAYBERRY

“When we print something, we have fewer piece parts, so your supply chain becomes simpler,” she says, “Your development cycles are shorter; you’re getting parts much faster. You can get a lot more complex with your design because [you can design] angles you can’t machine into metal.”

RAYTHEON 3DP MANAGER LEAH HULL
GOENGINEER PROVIDES DESIGN AND MANUFACTURING TOOLS WITH EXPERTISE THAT ENABLES CUSTOMERS TO REDUCE THE COST, RISK AND TIME REQUIRED TO GO LIVE WITH NEW TECHNOLOGIES AND ULTIMATELY NEW PRODUCT INTRODUCTIONS.

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