GE Additive

Lessons Learned from Commercial Aviation Certification

Presenter: Mark Shaw

October 17, 2019

The a-CT7 engine mid frame – an example of additive

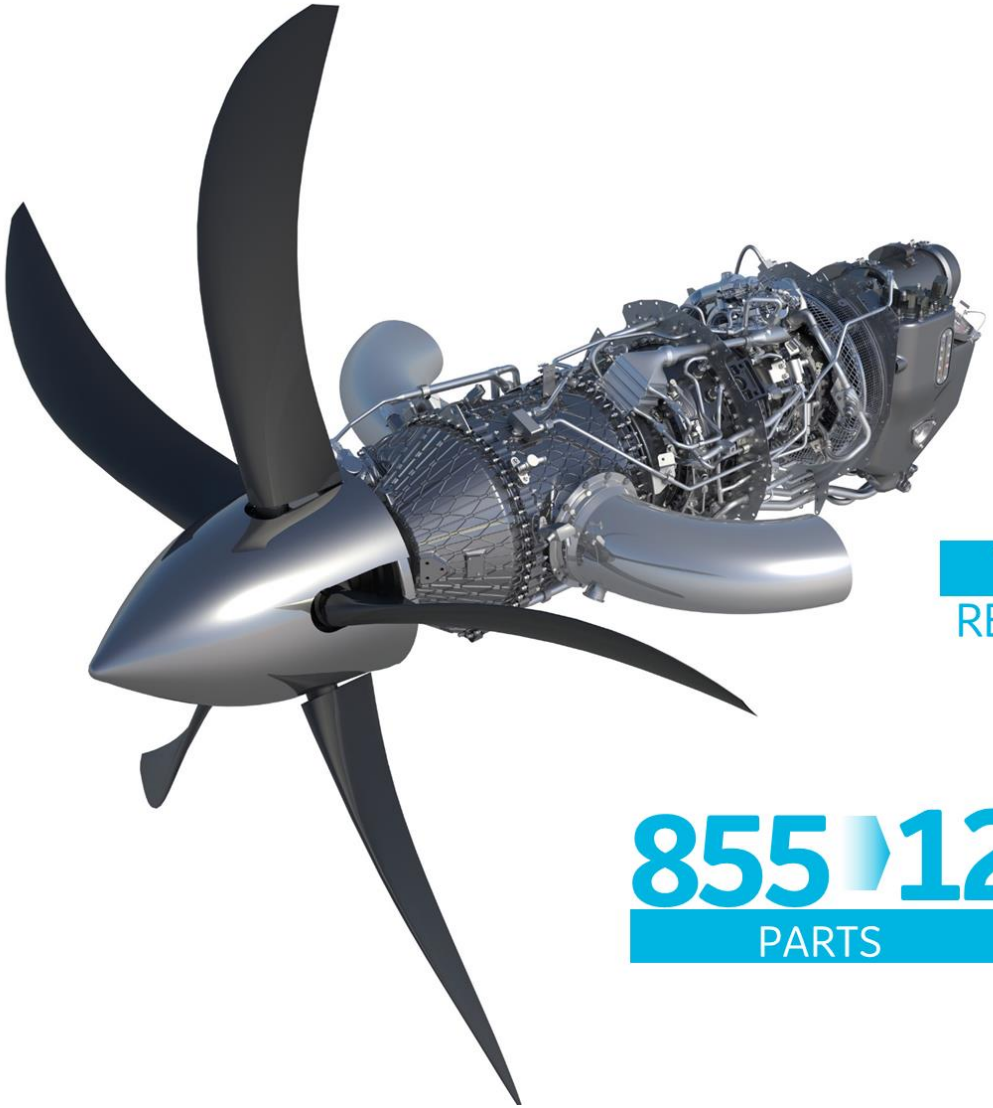
~300 1

Mid-Frame
Super Structure

7 assemblies to 1
~300 parts to 1
>10 lbm weight reduction

The GE Catalyst engine

Combustor test schedule reduced from **12 months** to **6 months**

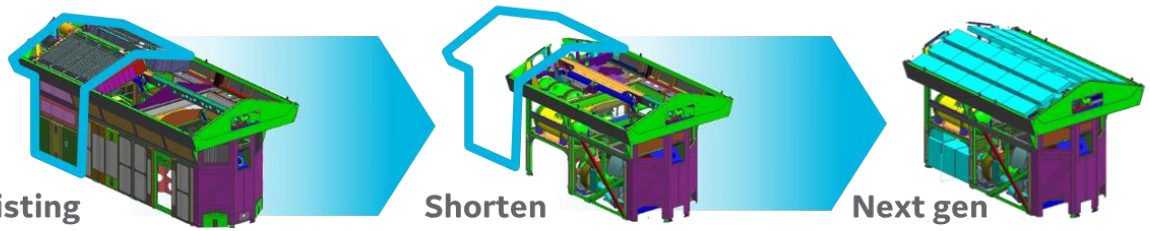


20% LOWER FUEL BURN

5% WEIGHT REDUCTION

855 > 12 PARTS

GE locomotive heat exchanger



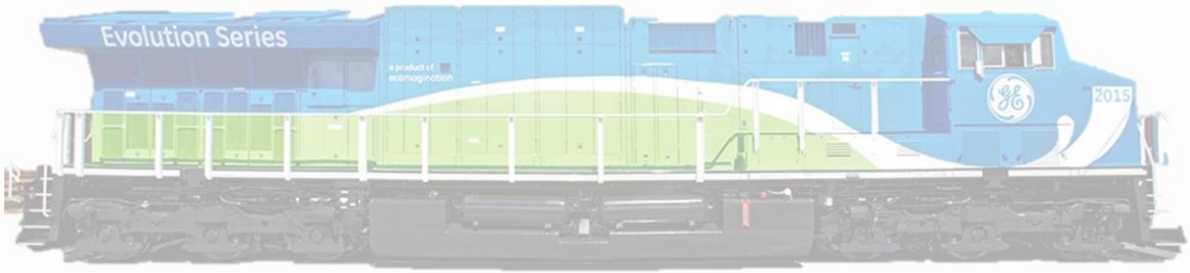
Existing
Rad Cab

Shorten
Rad Cab by ~ 80”

Next gen
Rad Cab

2000 1
PARTS

70%
SMALLER



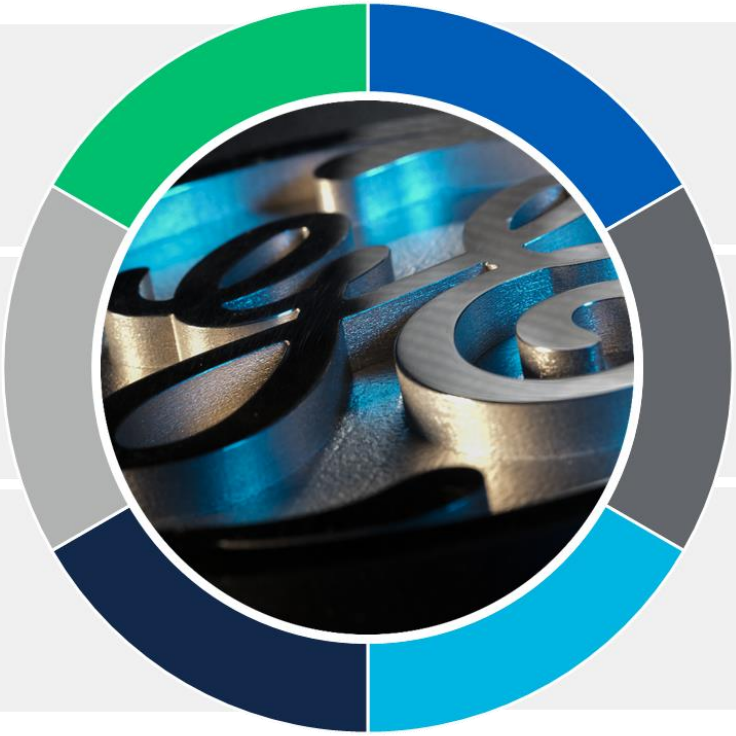
TIER IV EGR
COOLER

GE Additive Ecosystem

Machine modalities
- **Concept Laser**, Direct metal laser melting
- **Arcam EBM**, Electron beam melting
- **GE Additive,** Binderjet

AP&C Materials
- Advanced materials
- Powder supply
- Tested and validated

Consultancy solutions
- AddWorks Materials Solutions
- AddWorks Disruptive Design Solutions
- AddWorks Industrialization



Software
- Predix
- GeonX

Customer Experience Centers
- Pittsburgh, PA
- Munich Germany

GE partner companies
- GE Capital, Financing solutions
- GE Global Research
- GE Power, Uninterrupted Power Supply (UPS)

Machines

Machine modalities

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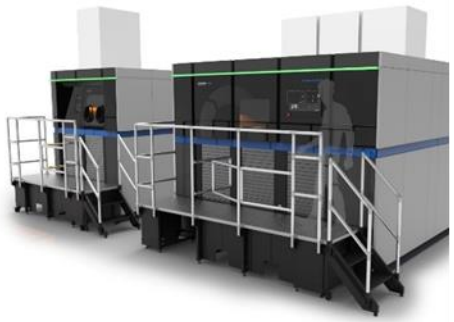

Concept Laser – Direct Metal Laser Melting

BEST DETAIL AND TOLERANCES

- ✓ Novel geometry - internal passages & thinner walls
- ✓ Covers a range of operating conditions
- ✓ Broad range of materials

Arcam EBM – Electron Beam Melting (EBM)

PRODUCE HARD TO WELD ALLOYS

- ✓ Bulkier and denser parts
- ✓ Very high heat tolerances
- ✓ Unique materials including TiAl

GE Additive – Binder Jet Technology

HIGH OUTPUT AND LOWER OVERALL COST

- ✓ Casting to Casting cost VERY competitive
- ✓ Near net shape
- ✓ Improved surface finish

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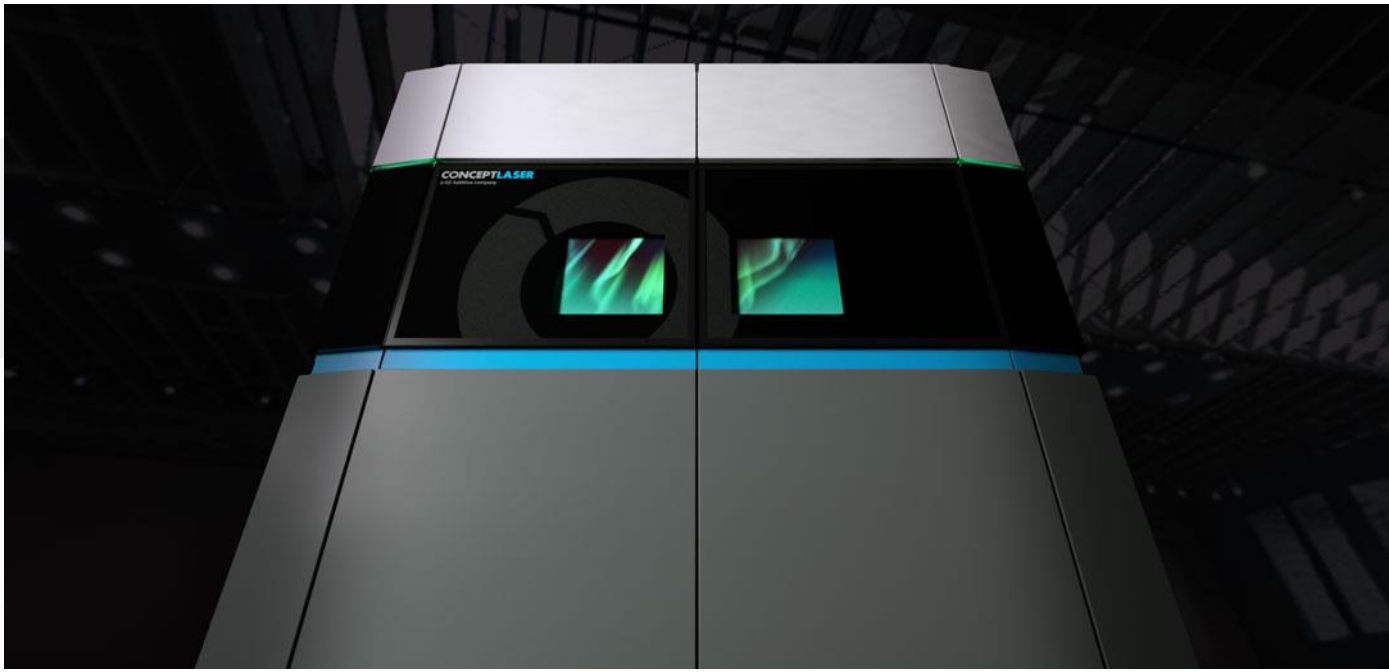

Project A.T.L.A.S (Additive Technology Large Area System)

Bringing scalable, customizable innovation to additive manufacturing

- Scalable, **meter-class**, laser powder-bed fusion BETA machine represents significant innovation breakthrough for metal powder additive manufacturing sector
- Built to allow manufacturers of large parts and components configure and customize to their own unique requirements

Materials

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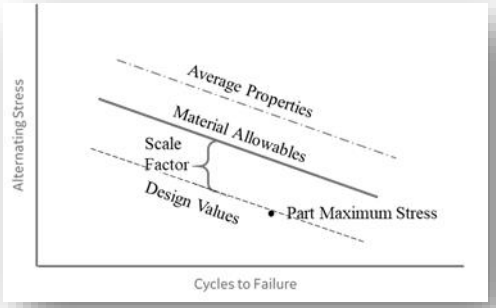
GE Additive - Powders

GE Additive offer total solutions for selections of standard materials. For these materials, metal powder, process settings and support are provided.

GE Additive – Material Development

- ✓ Materials selection consulting
- ✓ Parameters development
- ✓ Develop desired material properties
- ✓ Reduced material development cycle time



GE Additive – Material Data

- ✓ Specifications
- ✓ Allowables
- ✓ Design Values

AddWorks Engineering

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GE Additive – Materials Engineering

- ✓ Materials selection consulting
- ✓ Parameters development
- ✓ Develop desired material properties
- ✓ Specs, allowables, design values

GE Additive – Design Engineering

- ✓ Additive design assistance
- ✓ Design files to print
- ✓ Design of experiments (DOE) for risk areas
- ✓ Finite element analysis (FEA), thermal design
- ✓ distortion modeling and testing
- ✓ •Additive roadmap

GE Additive – Industrialization Engineering

- ✓ Factory design
- ✓ Health and safety design
- ✓ Machine operation qualification
- ✓ Process performance qualification

GE Additive Parts

GE Additive – Print Services

- ✓ Prototype printing
- ✓ Production process development
- ✓ Qualified production parts

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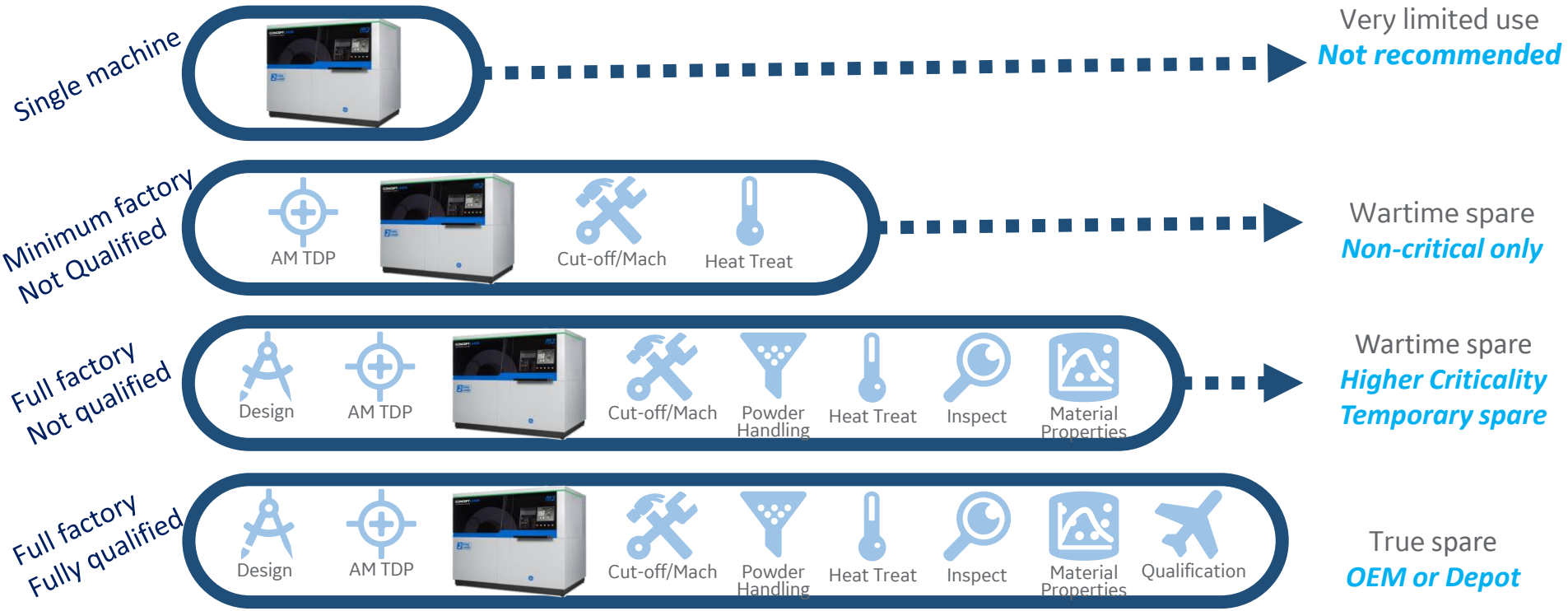
Metal additive application options for DoD sustainment

USN applications



Defense One

Global Business Brief

September 5, 2019

...Roper's looking into other ideas as well. General Electric has offered the Air Force a licensing agreement allowing the military to 3D-print engine parts.

"If we put it into our printer queue, then we pay the fee to print that part. I think that's a great idea," Roper said. "It's something that we probably don't want to do for lots or hundreds of thousands [of parts], but if we need a few things that are currently not available, I think that's great to up our readiness and lower cost."

Dr. Will Roper is the Assistant Secretary of the Air Force for Acquisition, Technology and Logistics.


NATIONAL SHIPBUILDING
NSRP
RESEARCH PROGRAM