AFRL AM ManTech Overview

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AFRL AM Lead

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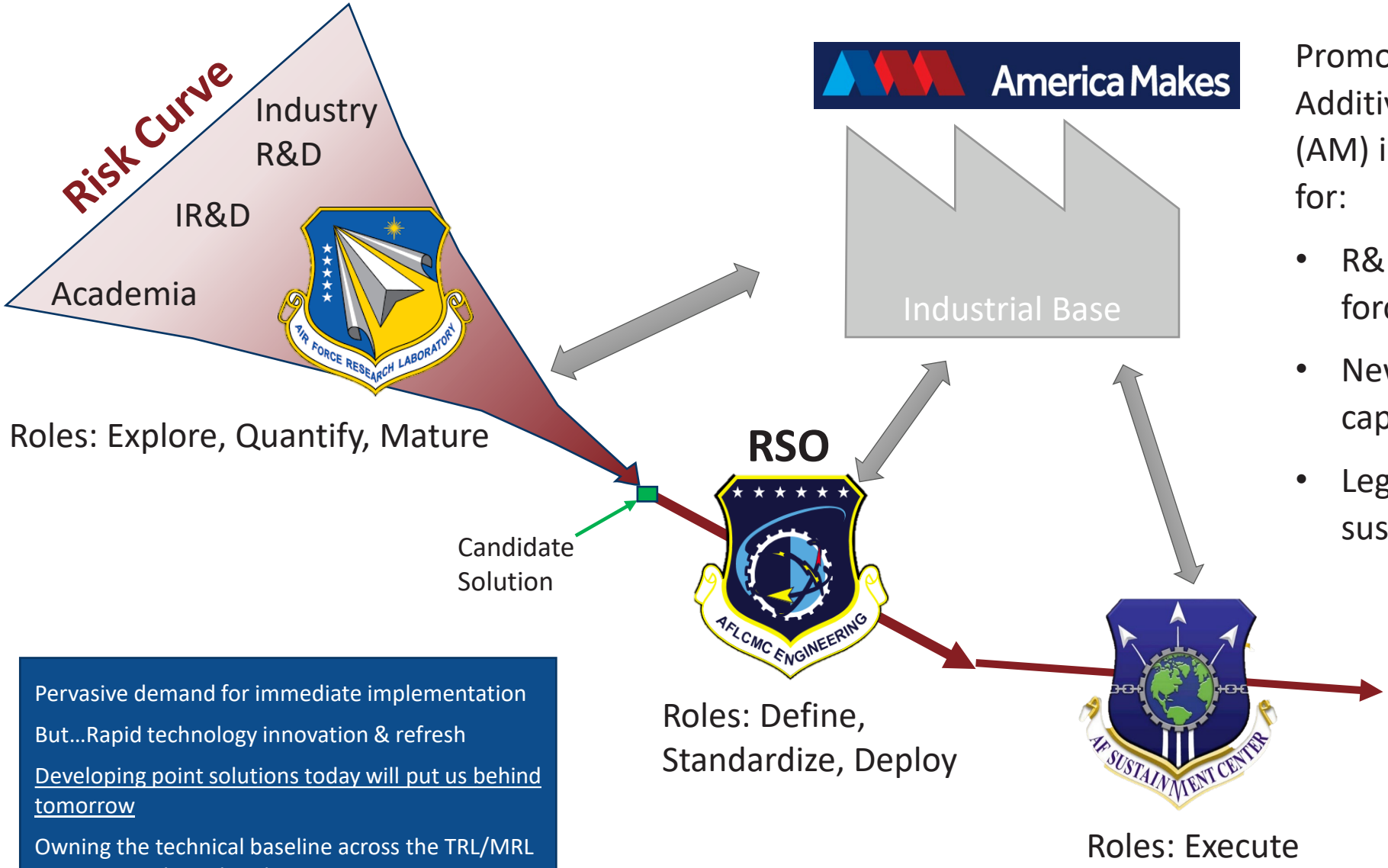
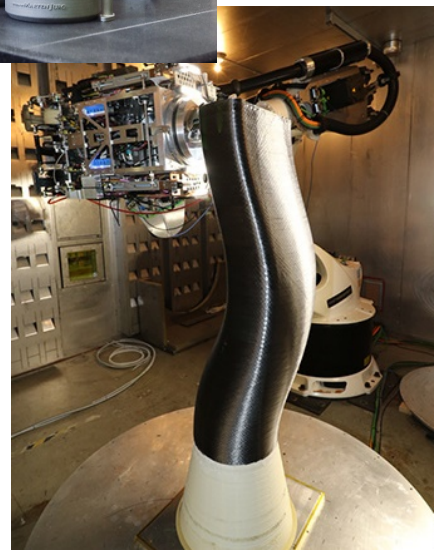
Operational Concept: Bending the Risk Curve for Additive Manufacturing

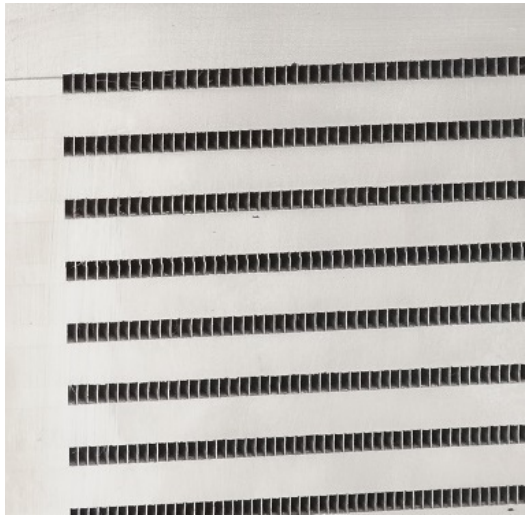


Promote the adoption of Additive Manufacturing (AM) in the US Air Force for:

- R&D + prototyping in force
- New parts and capabilities
- Legacy Parts and sustainment

Goal: Print as **big** as we need, as **small** as we can, with the **confidence** to fly, at a cost that is competitive.





S&T Program (Synopsis / Short Description)

Question	Short Answer
What is “IT”?	• Identifying and Maturing AM to meet DAF specific needs
What tech challenge is “IT” overcoming?	• Lack of maturity in Q/C methods, Immature AM Feedstock, Lack of mature Process Capability, Lack of Affordability, Lack of Design Knowledge
Why is AFRL working on “IT”?	• AFRL ManTech Has Unique Focus to broadly promote process maturity in order to reduce cost, lead time, and volume challenges • Constant contact with Industry, Other Gov, and DAF AM Stakeholders Puts ManTech in a unique Push/Pull opportunity space = MUCH Leveraging
Why is “IT” needed?	• **Features and Properties** - Deliver war winning new weapons platforms and availability • **AM at Scale** - Build Size, Rate, and Cost limitations hinder AM Adoption **Transition Support**– USAF must be at least a near-peer to industry best-in class to achieve best outcomes at current technology maturity
Who cares/should care about “IT”?	• Acquisition programs, ALCs, Maintenance Groups, Industrial base

Organizing Principles

Benefits:

Features and Properties	• New Materials • New Processes • Enhanced Performance	War Winning New Capabilities
AM at Scale	• Cost Reductions • Print Size Increases • Print Rate Increases	Resilient Acquisition Schedules
Transition Support	• Design for AM • Analysis / Lifing Validation • Qual/Cert Methodology	Agility for Sustainment

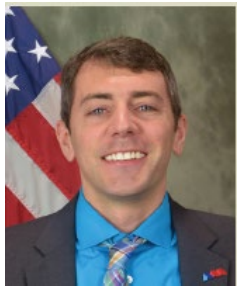
Additive Manufacturing

New Design Paradigms
Rapid Spare Manufacturing
Airworthiness Certification


Adam Hicks


Dr. Mark Benedict


Dr. Tom Broderick


Dr. Dennis Butcher

America Makes

2021 Highlights

- Change in Program Team Leadership
- COVID 19 Response
- Digital Engagement
  - AMO
  - MANY digital conferences

2022 Forecast

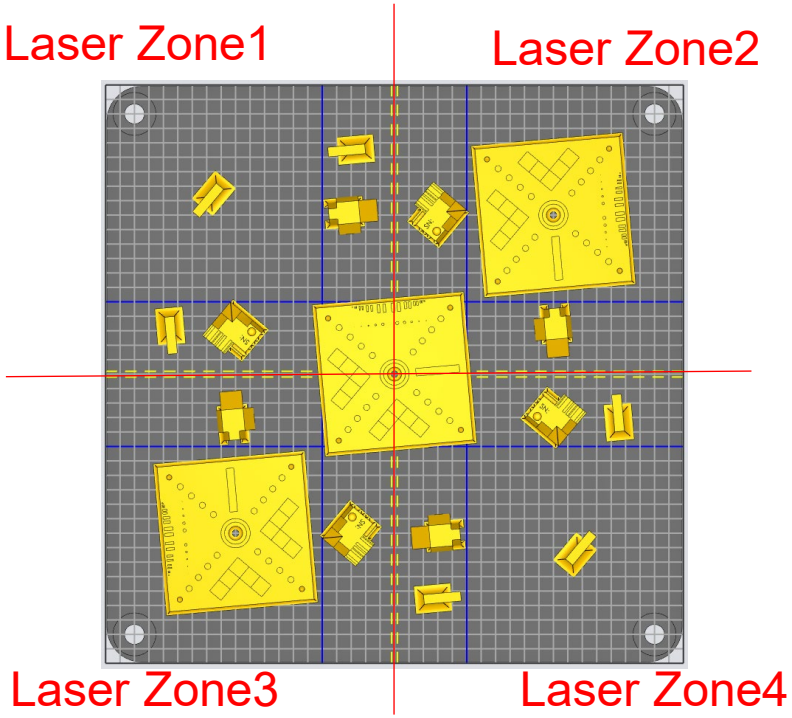
  - Hypersonics
  - CII 2020: Lead $44.7M, Leverage/Watch $13.6M
    - 2021: $74.7M, Leverage/Watch $35.3M

2021 Roadblocks

- Manpower
- COVID and Travel

FlexSpecs (funded)

Contractor: UDRI, Senvol **AFRL PM: Dr. Mark D. Benedict, AFRL/RXMS**



Air Force Problem

While Multi-laser powder bed additive manufacturing systems appear to offer critical production speed improvements, little is known about the material quality produced by these machines, and a validated process qualification methodology is sorely needed

Benefits to the Air Force

Increased build rates and decreased build costs for critical AM parts such as Hypersonics scramjet engines and heat exchangers

Ability to work with multiple parameter sets and bound material performance response

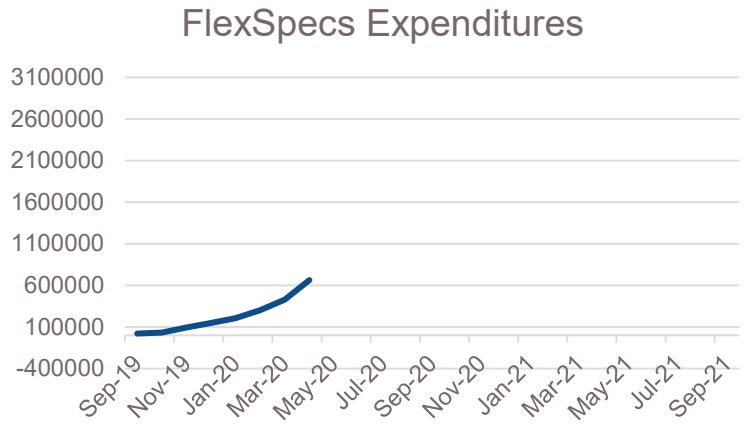
Technology Approach

Work with AFLCMC/EZP and UDRI technical staff to develop Technically Viable Methodology to Engage with the AWB-1015 process

- Try to deconflict multiple industry standards for AM Qualification
- Attempt to qualify a parameter space, not a parameter set
- Work with AI/ML techniques to more rapidly explore parameter space and quantify sensitivities

Work with AFLCMC/EZP, UDRI, Army Futures Command, NAVAIR, MDA to establish a Ti64 LPFAM Data repository and establish the value proposition of data federation.

Performance



Current Results

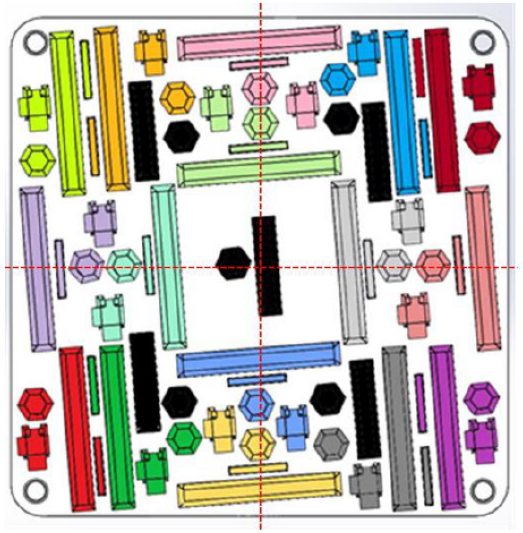


Figure 1. Parameter Development Repeat Build Layout

Table 2. Senvol ML Generated Processing Window for Alloy 625 on an EOS M400-4

Process Parameter	Acceptable Range
Volumetric Energy Density	52 – 77 J/mm^3
Core Power	260 – 300 W
Core Speed	860 – 1160 mm/s
Core Hatch Spacing	0.09 – 0.12 mm
Overlap Amplitude	26 – 79 mm
Overlap Period	0.20 – 0.48 mm

Table 4. AMS 7000 Minimum Tensile Requirements

0.2% Y.S. (ksi)	U.T.S. (ksi)	Elongation (%)
50.0	120	30

Table 3. Summary of Tensile Results

Orientation and Laser Overlap		0.2% Y.S. (ksi)		U.T.S. (ksi)		Elongation (%)		Specimen Count
		Min.	Mean	Min.	Mean	Min.	Mean	
Horizontal	Single Laser	54.2	54.4	123	125.7	54.7	57.9	64
	Laser Overlap	53.9	55.6	123	124.2	51.9	55.6	20
	Combined	53.9	55.5	123	125.3	51.9	57.4	84
Vertical	Single Laser	53.2	55.4	121	123.7	38.3	58.6	66
	Laser Overlap	53.1	54.0	119	122.4	38.4	56.0	21
	Combined	53.1	55.1	119	123.4	38.3	58.0	87

Executive Summary:

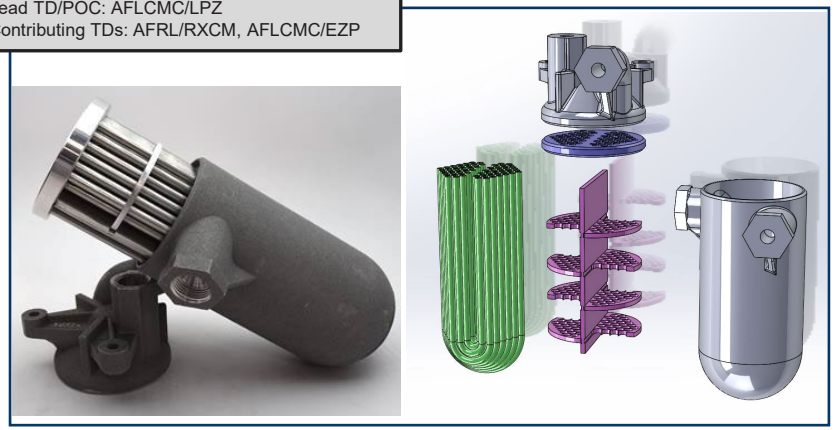
The results from the metallography, tensile, fatigue crack growth rate, surface roughness and dimensional analysis have allowed UDRI deem the EOS M400-4 qualified for producing alloy 625 components of acceptable quality. Under the guidance of AFRL, UDRI will continue characterization of intrinsic, static, and dynamic properties required for design and production of complex, aerospace-relevant geometries with the M400-4. Current efforts seek to verify the processing parameter window and quantify fatigue and minimum allowable tensile properties.

The EOS M400-4 multi-laser system provides increased productivity without sacrificing material properties within the laser overlap regions. Porosity and melt pool geometry are unaffected by the laser stitching. Tensile properties are comparable for material built both in the single laser and laser stitch regions. With regular verification of the laser alignment with the EOS SmartCAL system, dimensional requirements and surface finish quality can be assured through the laser overlap region. Additionally, the EOS M400-4 maintains the proven architecture and build management of the M400-1 and laser scanners from the M290, making it a smart buy for organizations familiar with either syst

New Start: HAMOC

S&T Funding: $1.5M, FY21
Current TRL/TAD: TRL 4/FY20
Transition to:
Lead TD/POC: AFLCMC/LPZ
Contributing TDs: AFRL/RXCM, AFLCMC/EZP

Hybrid AM Oil Cooler



		FY	21	22	23
Task/Project/Work Unit #1					
Unburdened Funding ($M)	S&T		0.8	0.7	
	External ($M) AFLCMC(EZP)		0.7	0.7	

Description

- Increasing availability and affordability of Fuel Cooled Oil Cooler (FCOC) components
- AM casting replacement into a traditional oil cooler design

Delivering

- Best practices involving hybrid AM/Traditional manufacturing design and processes.
- Relevant test data using operational conditions

Technological Approach

- Supporting AFLCMC/EZP effort by tackling manufacturing related challenges
- Focused on gathering data surrounding AM/Traditional material welding, powder removal processes, and laser welding applications

Benefits to the Warfighter

- Increased availability and reduced lead times for much needed FCOC components
- Decreased cost for small lot oil cooler purchases
- Support ongoing AFLCMC J85 oil cooler effort

New Start: Essentium Strategic Finance Increase (StratFI)

RSO

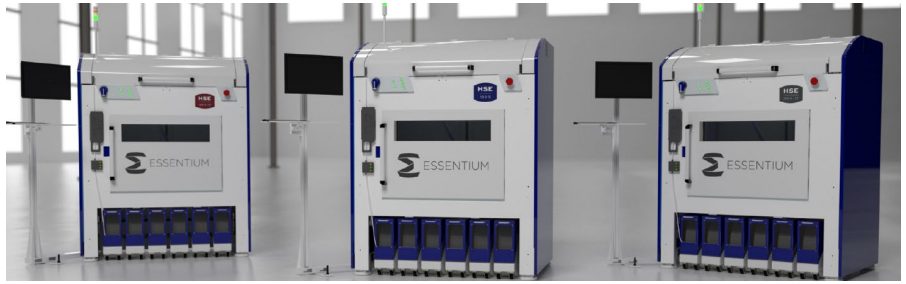
AFWERX

ESSENTIUM
BUILD YOUR WORLD™

$13.75M ($1.75M from AFRL) + $13.75M + $30M

AIR NATIONAL GUARD

- Printers
- Tech Orders
- Validated Materials



Technically a Phase 2 SBIR Contract: Waiver obtained to $28M