

Liquid Propulsion Subcommittee Additive Manufacturing for Propulsion Applications Technical Interchange Meeting

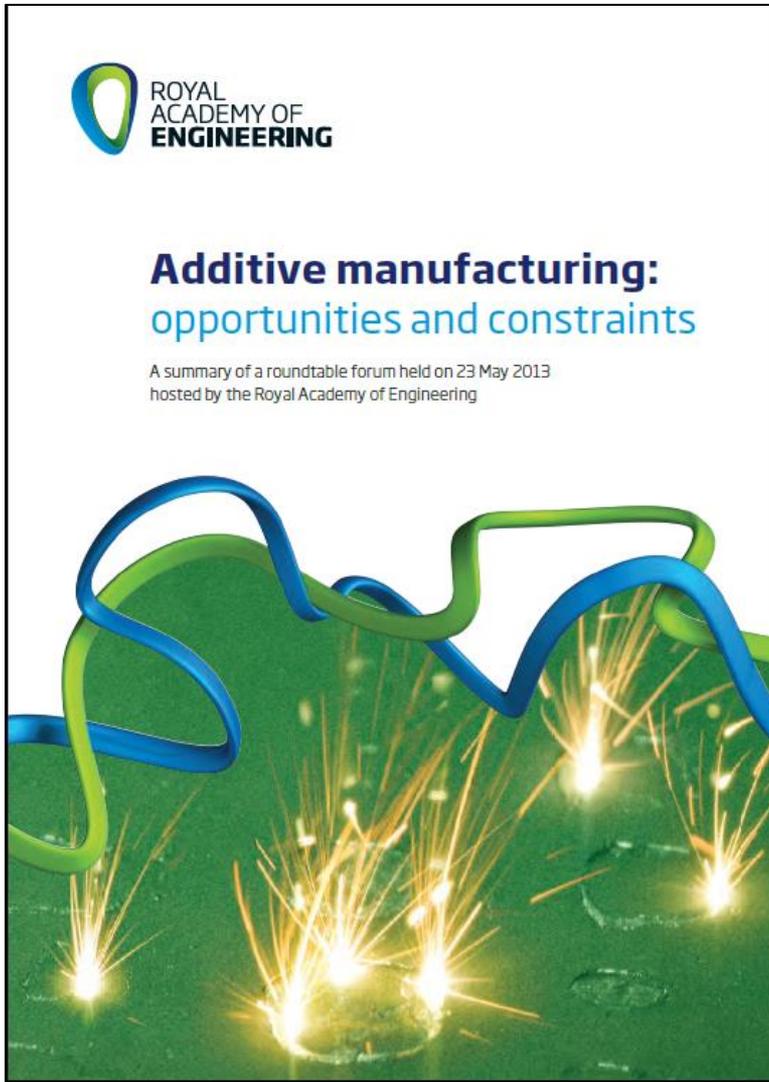
*Dr. Dale Thomas,
Associate Director, Technical
NASA Marshall Space Flight Center*

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JOINT ARMY NAVY NASA AIR FORCE
INTER AGENCY PROPULSION COMMITTEE

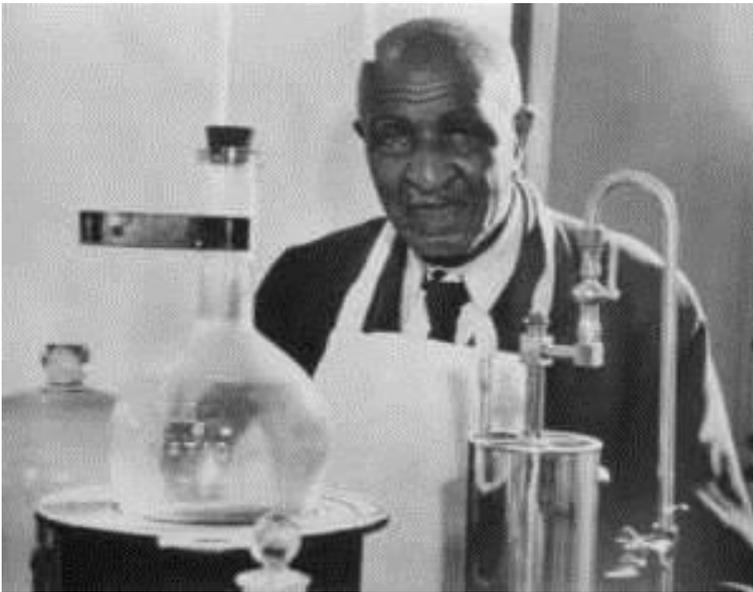
The Next Industrial Revolution(?)



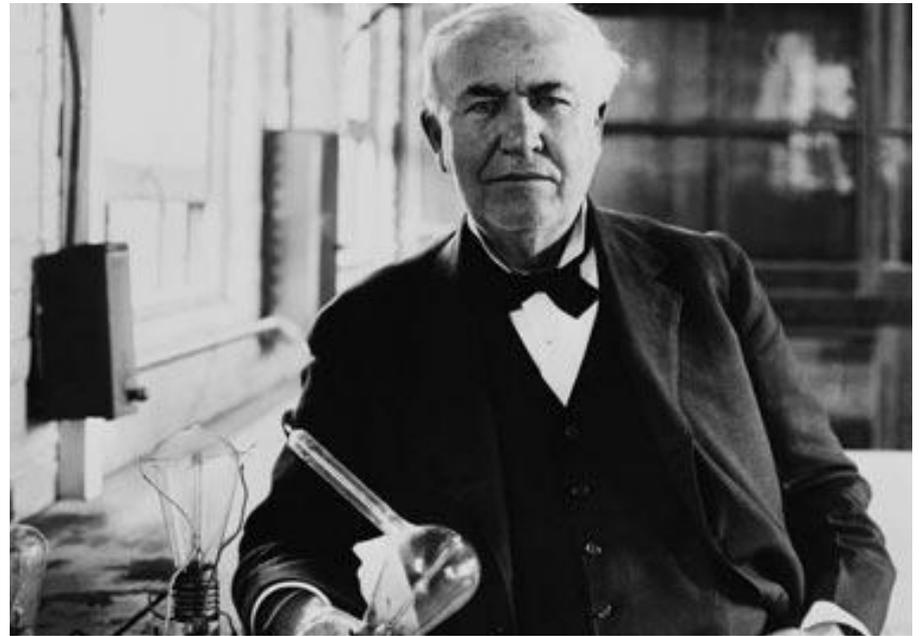
- “... while AM is widely billed as ‘**the next industrial revolution**’, in reality there are still significant hurdles for successful commercialization of the technologies.”
- “...AM is not only a **disruptive technology** that has the potential to replace many conventional manufacturing processes, but also **an enabling technology** allowing new business models, new products and new supply chains to flourish.”
- “Three of the fastest-growing areas for AM include the medical and dental, automotive and **aerospace** sectors.”

Realizing the Potential

Innovation requires hard work to transform a vision into reality!

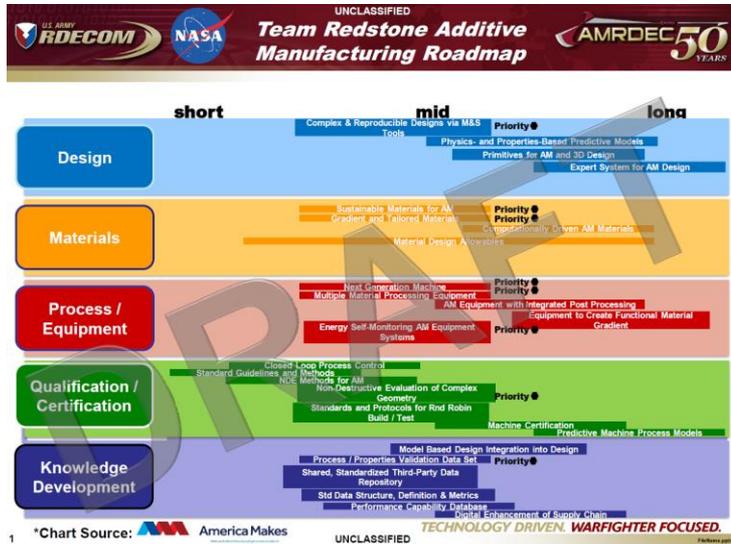


“There is no short cut to achievement. Life requires thorough preparation – veneer isn't worth anything..” George Washington Carver



“Opportunity is missed by most people because it is dressed in overalls and looks like work.” Thomas Edison

Exploring the AM Knowledge Landscape



- The knowledge landscape is quite large, and most of it is unexplored
 - Design
 - Materials
 - Process / Equipment
 - Qualification / Certification
 - Knowledge Development

Additive Manufacturing Development

Processing-Structure-Property Relationships

Problem Statement

Additive Manufacturing (AM) technologies, especially metal-based AM, are still emerging. Few data are available in open literature that characterize the processing-structure-property relationships of powder-bed fusion aerospace alloys. Companies that are pushing the envelope of AM technologies (GE, Aerojet/Rocketdyne) tend to maintain their relationship data as IP. Understanding how composition, structure, impurities, and thermo-mechanical processing relate to mechanical properties is necessary to permit qualification and ensure the safe performance of AM parts and structures for aerospace applications.

Technical Objectives

Build the standard level of information on AM powder bed fusion processes that is required for qualification of any new critical process used for aerospace applications.

1. Build Interactions / Effects
2. Powder Influence / Effects
3. Thermal Processing / Effects
4. Surface Improvement / Effects
5. Applied Materials Characterization
6. Qualification of AM Critical Components

Areas of Applicability

- Airframes
 - Lightweight Structures, Tailored Load Path Design
- Air-Breathing and Rocket-Based Propulsion Systems
 - Affordability, Complex Component Manufacturing, Advanced Propulsion Design
- AM Supply Chain Development
 - Open Databases, Standardization, Improved Vendor Competency

- NASA MSFC formulating AM collaborations with other NASA Centers and Other Government Organizations
 - Eager to engage Academia & Industry

From America Makes Year in Review (January 23, 2014)



Summary

- *Huge Opportunity with High Stakes*
- *“None of us can do it alone. For this to succeed, it needs to scale, and for it to scale, we need a passionate and motivated community”*
 - Avi Reichental, President and CEO, 3D Systems
- *“Rather than companies having to bear all of the cost and burden of qualifying these processes and materials, much can be done through collaborative efforts”*
 - Terry Wohlers, Principle Consultant and President, Wohlers Associates

Realizing the Potential of AM for Propulsion Applications



“Coming together is a beginning; keeping together is progress; working together is success.” Henry Ford



We Know the History – What's the Future?



- “It is difficult to say what is impossible, for the dream of yesterday is the hope of today and the reality of tomorrow.” Robert H. Goddard

