# U.S. Army RDECOM Additive Manufacturing Plans & Activities

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# Agenda

- Army-Unique Challenges
- AM Opportunity Space
- AM Acquisition Challenges & Logistics Challenges
- AM Activities Across the Army Materiel Command (AMC)
  - TRADOC/CASCOM/G-4 (Logistics)
  - RDECOM
  - Depots
- AMC-RDECOM Community of Practice (CoP)
  - Army-centric Materials
    - Steel 4340
    - Novel Polymer Composites
  - Design for Additive Manufacturing
  - 3D Model Based Enterprise

# BLUF

***Additive manufacturing technologies bring the promise of <u>enhanced performance</u> and <u>reduced logistics burden</u>***

However, there are also important considerations and limitations:

***Each part is unique***, therefore certification/qualification of the material and process are paramount

- There are very ***limited published standards*** and much of the work is still in progress
- There are a limited number of machines, additive processes and materials available from the equipment manufacturers
- ***Material performance is not "as advertised"*** on the equipment mfr. Data sheets and not fully characterized for all use cases
- ***No full materiel releases*** – no systems in the field using additive parts
- The few cases where additive has been used to produce a part are on an exception basis: SOCOM, REF for spares, repairs and/or tooling

***In order to fully realize the benefits of Additive Mfg, the community has recognized that there are specific roles the Army must play to mature this technology***

# Army Unique Challenges

- Wide breadth of equipment, platforms and payloads (186K items in inventory)
- Few "high value" items compared to AF and Navy
- Many depots and arsenals have traditional manufacturing capabilities.
- Disconnects between R&D, depots and program managers (different Chains of Command)

***In order to fully realize the benefits of Additive Mfg, the Army community needs to decide to work together…this decision cannot be done from the "top down".***

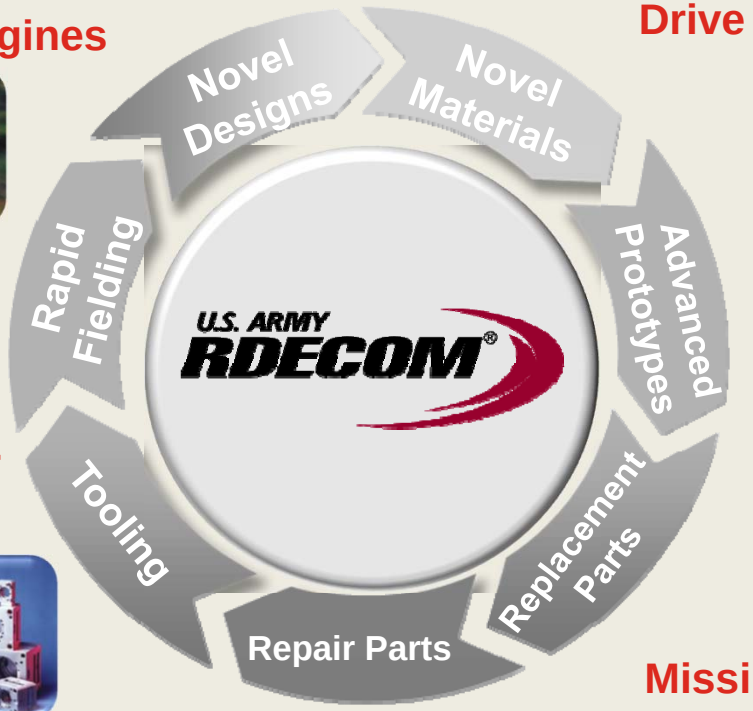
# AM Opportunity Space

**There are opportunities for AM to impact all Army systems**

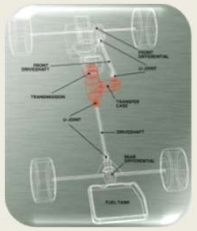
**UAVs, UGVs**
**Control Surfaces, Engines**

**Individual Soldier Protection**

**Weapons Components**




**Vehicle Subsystems:**
**Drive Train, Suspension, Engine**



**Missiles/Munitions:**
**Warheads, Fuzes**

**What are most common AM needs for the Army in materials, processes?**

# Acquisition & Logistics Challenges

- Both communities can garner the benefits of AM, but often have conflicting needs.

| Acquisition Domain | Logistics Domain |
|---|---|
| Cost is often a driver | Time is often a driver |
| All parts must meet inspection and acceptance criteria | Not all parts are “critical” |
| Manufacturing processes must be reproducible | “Onesies” and “twosies” are OK |

- *Regardless, both require the use of 3D, digital data to store drawings and mfg data, which is still not considered “official data” by Army.*

***Develop business case*** for AM in part alternative scenarios at Point of Use and within the supply chain

# AM Activities Across the Army*

- **TRADOC/CASCOM: Developing policy and requirements to reduce logistical burden through point of use manufacturing**
  - Evaluating the Business Case for using AM at Point-of-Use
  - Working with Rapid Equipping Force on requirements for in-theatre manufacturing
  - Focus on parts that don't have extensive qualification requirements
- **RDECOM: Develop, mature and transition AM materials, technologies and processes to support qualified processes for end-item user requirements**
  - DoD and Industry recognized subject matter experts in metal and polymeric AM processes
  - Army Research Laboratory (ARL) focus' on research related to enhancing machine performance, material development, direct-write electronics and hybridization of processes
  - Research, Development & Engineering Centers (RDECs) focus on applications in prototyping, discrete part manufacturing, low-cost tooling, repair of metallic components and rapid fielding
  - Initiated an AM Community of Practice to leverage knowledge, materials and machines
  - With America Makes, kicking off an Army AM Strategic Road Mapping Exercise with all Army partners (summer 2015)
- **Army Depots and Arsenals**
  - Mostly metal-based technologies with some polymeric technologies
  - Depots: Some examples of using AM for repair; require validated material, process and engineering data before implementing AM-based repair processes on Army systems

# RDECOM AM Community of Practice

- The challenge of material and process certification demands collaboration
  - Robust data is required from multiple machines – ***enterprise approach for Knowledge Management is needed***
  - Sharing of data
  - Domain expertise in products maximize the potential for variety of applications for a given material (ground to aviation)
- AM machines are costly and complex
  - Need to maximize best practices
  - No one site can own all capability
- Army-centric materials need to be addressed

Materials of Interest:
Steel 4340 (ARDEC PhD candidate is developing AM build parameters for this steel)
Steel 52100 (ARDEC M&S Division has submitted a TEX3 proposal to study this bearing steel)
Tungsten - warheads
Tantalum - warheads
Copper - warheads
Titanium (to build upon prior Army efforts in lightweighting)
Aluminum - lightweighting
Ceramics - warheads, flexible electronics, capacitors

- Product data challenge requires enterprise sharing of design and manufacturing data

# RDECOM AM Capabilities

## TARDEC

Ground and Support Systems Technology Prototyping & Integration

| | |
|---|---|
| **Processes**<br><br>**Total # of machines** | • Direct Metal Deposition<br>• Fused Deposition Modeling<br>• Selectively depositing liquid binding material<br>• 4 machines in total |
| **Materials**<br><br>**Applications** | • Fe, Co, Ni, Ti, and Cermets<br>• Coating / part repair, 3D printing, & Multi-material joining |

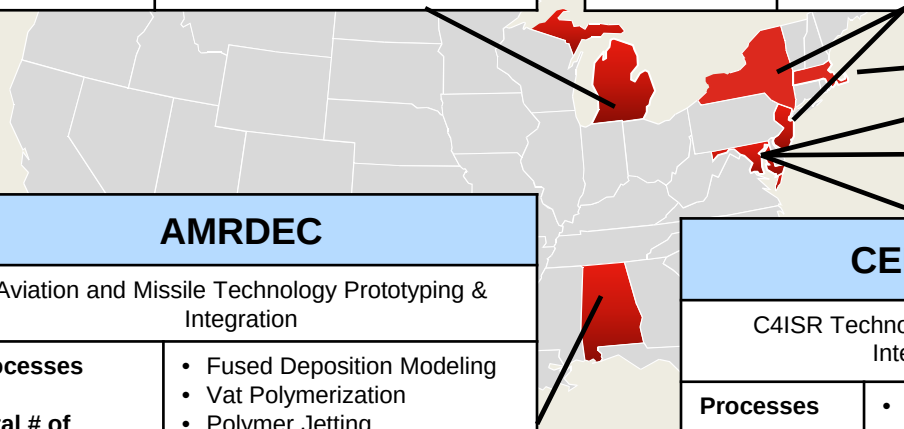
## ARDEC

Armaments Technology Prototyping & Integration

| | |
|---|---|
| **Processes**<br><br>**Total # of machines** | • Polymer Extrusion, Vat Polymerization, Powder Bed Polymer, LENS, DMLS<br><br>• 16 machines jn total |
| **Materials**<br><br>**Applications** | • Epoxy, ABS, PLA, Wax, 17-4 SS, 300 Maraging Steel, Nylon, Alumide<br>• Casting molds, Prototypes |

## Army Research Lab

| | |
|---|---|
| **Processes**<br><br>**Total # of machines** | • Polymer extrusion<br>• Vat Polymerization<br>• Powder Bed Metal<br>• InkJet<br>• Aerosol Jet<br>• Micro Pump Deposition<br>• Non-Commercial Systems<br>• Cold Spray<br><br>• 13 machines in total |
| **Materials**<br><br>**Applications** | • Polymers, Metals, Ceramics & materials for printed electronics<br>• 6.1-6.2 materials and tech development |



## AMRDEC

Aviation and Missile Technology Prototyping & Integration

| | |
|---|---|
| **Processes**<br><br>**Total # of machines** | • Fused Deposition Modeling<br>• Vat Polymerization<br>• Polymer Jetting<br>• Dimatix<br><br>• 10 machines in total |
| **Materials**<br><br>**Applications** | • ULTEM*, ABS (Acrylonitrile Butadiene Styrene), PLA (polylactide)<br><br>• Prototypes, electronics |

## CERDEC

C4ISR Technology Prototyping & Integration

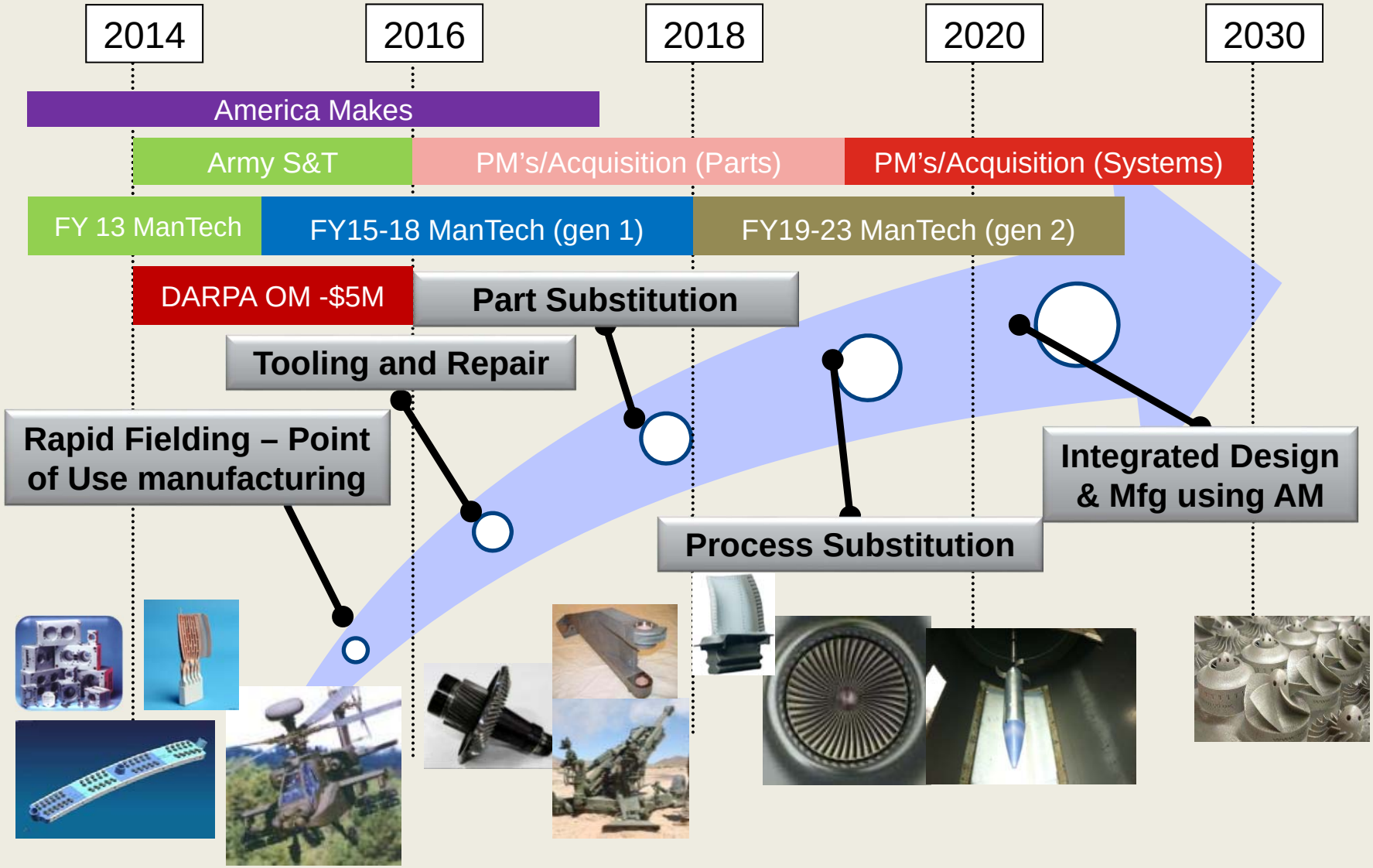
| | |
|---|---|
| **Processes**<br><br>**Total # of machines** | • Polymer jet printing<br><br>• 1 machine |
| **Materials**<br><br>**Applications** | • photopolymer<br><br>• Engineering development prototyping |

## ECBC

Chemical and Biological Technology Prototyping and Integration

| | |
|---|---|
| **Processes**<br><br>**Total # of machines** | • Polymer extrusion<br>• Vat Polymerization<br>• Powder Bed Polymer and Metal<br>• Polymer Jetting<br>• Binder Jetting<br><br>• 13 machines in total |
| **Materials**<br><br>**Applications** | • ABS, ULTEM*, PC, PPSF (polyphenylsulfone), Nylon 11, Nylon 12, Steels, Cobalt Chrome, plus more.<br>• Prototypes, unique fixtures, end-use items, Tooling and tooling inserts |

# RDECOM AM Applications Roadmap



# RDECOM AM Focus Areas

- **Three 5-year progressive stages of adoption with four distinct pillars of investment:**

| FY14–19 | FY20–24 | FY25–29+ |
|---|---|---|
| **Part Alternative** | **Process Alternative** | **Product Alternative** |
| Tooling and Repair | Process Substitution | Novel Designs |
| Part Substitution | Primary manufacturing | Novel Materials |
| | Point of Use manufacturing | |

**Pillar 1: Material and process certification and qualification**

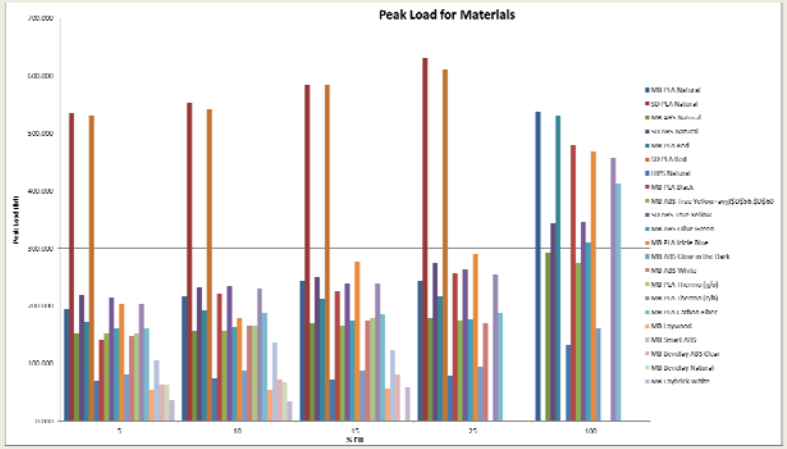
**Pillar 2: Army Additive Manufacturing Knowledge-base**

**Pillar 3: Machine Technology and Material Improvements**

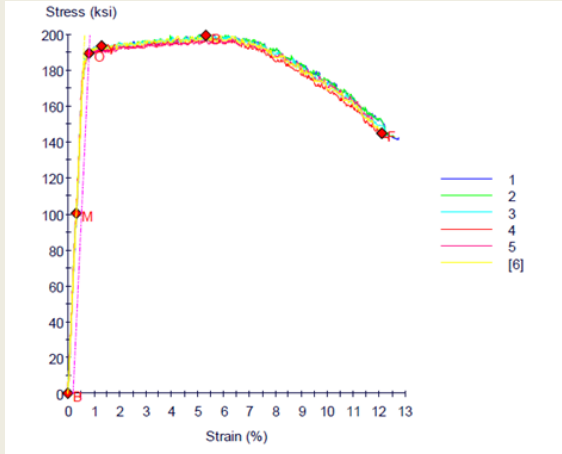
**Pillar 4: Transfer technology to the industrial base and field**

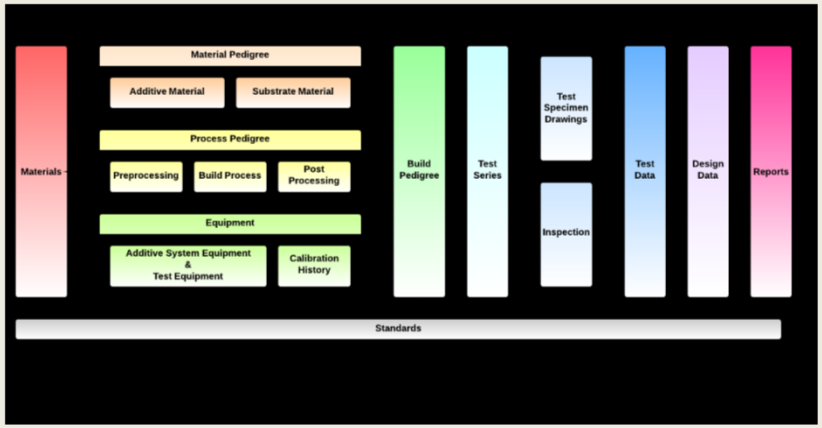
***Level of complexity from low to high, evolving from part to system, and from early adopters to traditional acquisition***

# Army-Centric Materials (ARDEC, ARL)

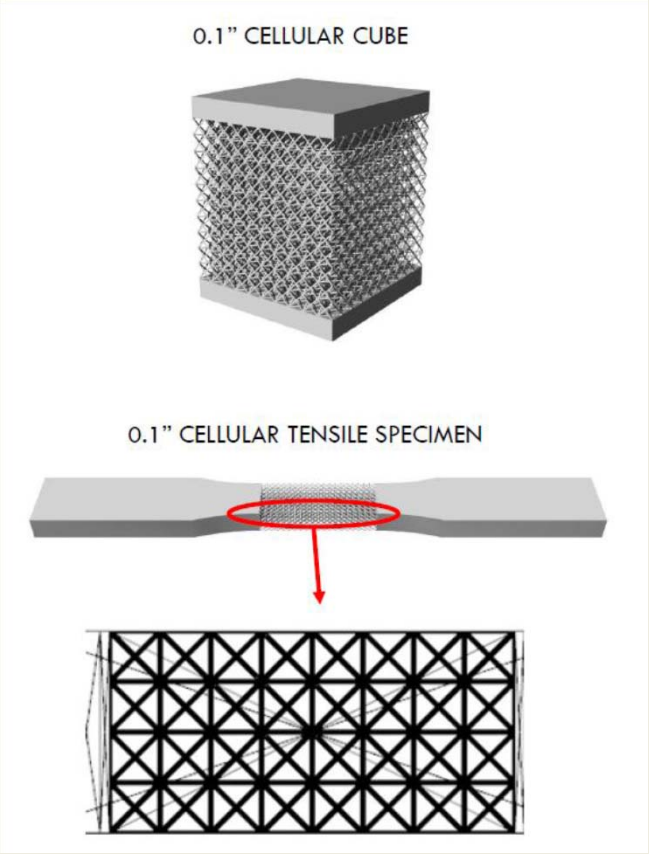


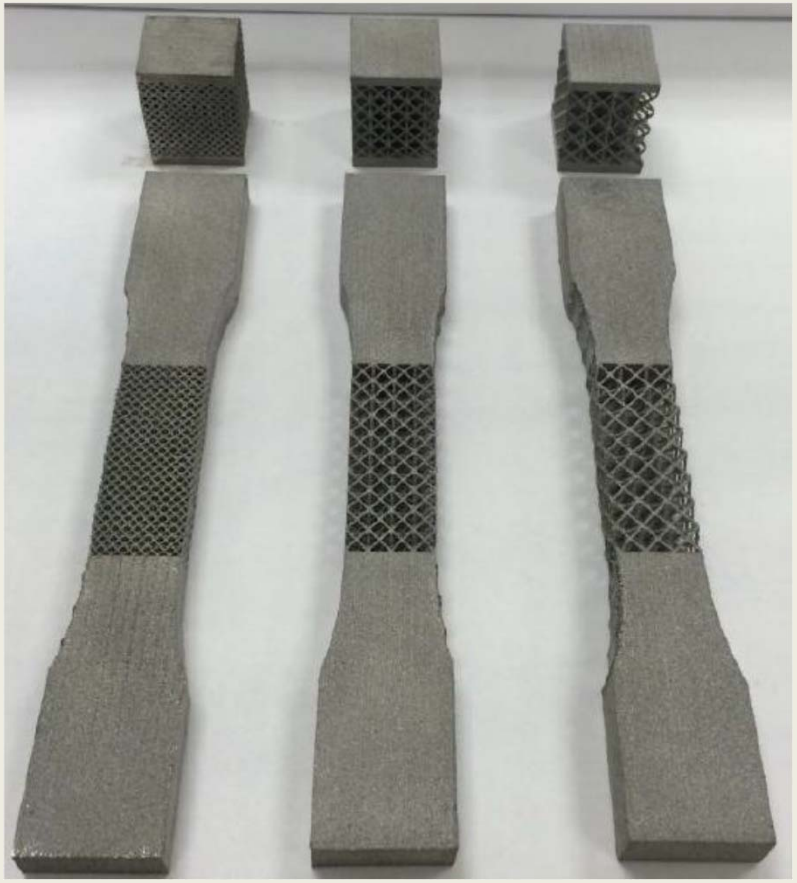

| Material Condition | Modulus | Yield Strength | Tensile | Elongation |
|---|---|---|---|---|
| Typical Wrought 4340 properties from ASM international [23,24] | 29,000 ksi | 183 ksi | 199ksi | 15% |
| Run A: DMLS of Virgin Powder | 31,000 ksi | 189-190 ksi | 199ksi | 16-17% |
| Run B: DMLS after once recycled powder. | 31,000 ksi | 187-190 ksi | 198ksi | 16-17% |



# Design for Additive Manufacturing (AMRDEC)

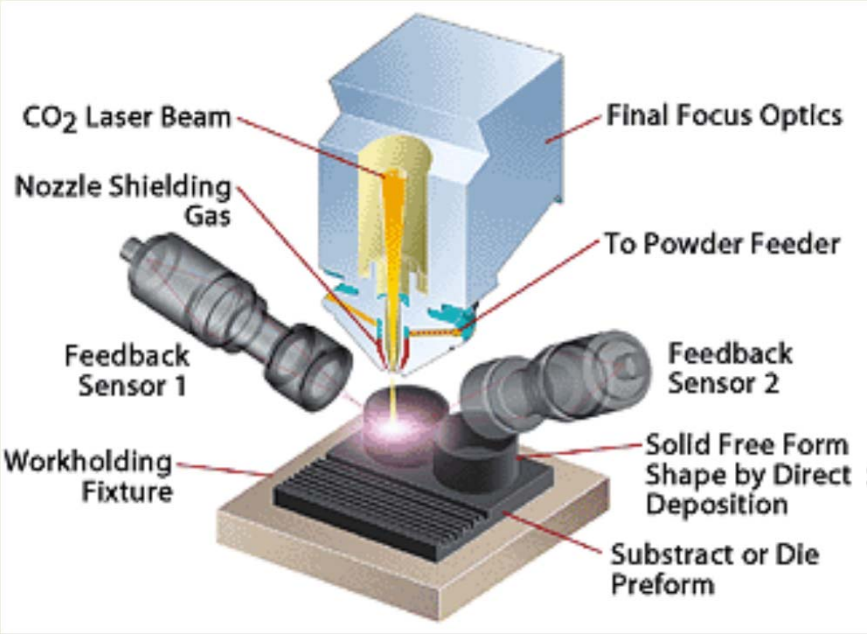


# AM for Repair

## Direct metal Deposition – Abrams Suspension Arm

***Technology available at TARDEC, Benet Labs (ARDEC), & Anniston Army Depot***




Reduced down time and costs. Must work with OEM.

# Model Based Enterprise: RDECOM

## Model Based Definition (MBD)

- Fully annotated 3D models
  - that include all information typically found on a 2D drawing
  - Follow MIL-STD-31000A
  - Reusable by activities throughout the product lifecycle
  - The basis for Digital Work Instructions and Interactive Electronic Technical Manuals

## Model Based Enterprise (MBE)

- An integrated and collaborative digital environment that deploys MBD
- Connects and automates the system engineering process around the product technical data
- Enables reuse of 3D tech data at all points on the lifecycle

# An Army AM CoP Can Contribute

- Government-driven efforts can help create "predictive models" by creating Knowledge Management systems
  - Community/shared data will accelerate standards development
  - Expand the scope of materials beyond the interest of risk of industry

- Lead enterprise efforts in creating Parts Libraries
  - PLM/ePDM efforts are ready to store both geometry and process information in enterprsie prouct data systems
  - RDECOM enterprise approach in product data will make AM available to the industrial base

- Provide qualified processes to depots/arsenals to help them use AM and become more competitive
  - Work with depots to scale their capability to use AM where business case warrants
  - help depots be ready for future products that use AM processes (particularly unique materials like ammo/energetics)

# Summary

- Additive Manufacturing is an enabling technology that has the potential to provide rapid, agile, efficient and complex production solutions with improved cost, schedule and performance

- The U.S. Army RDECOM focus is on
  - AM material and process certification/qualification
  - Establishing a robust knowledge base for AM processes and parts
  - Improving AM materials and machine technologies
  - Transferring AM technology to the industrial base

- Partnerships will be the key to success