Data Management for the Advancement of AM Technology Readiness

28 October 2020

Brandon D. Ribic, PhD.

Technology Director, America Makes

Brandon.Ribic@ncdmm.org

Overview

The three core activities of the Institute are:

- **Develop Additive Manufacturing Technology:**
  Projects, Innovation, Technology Transfer, Implementation

- **Accelerate Human Capital Development:**
  Workforce, Education, Training, Outreach

- **Maintain Collaborative Ecosystem:**
  Government, Membership, Community

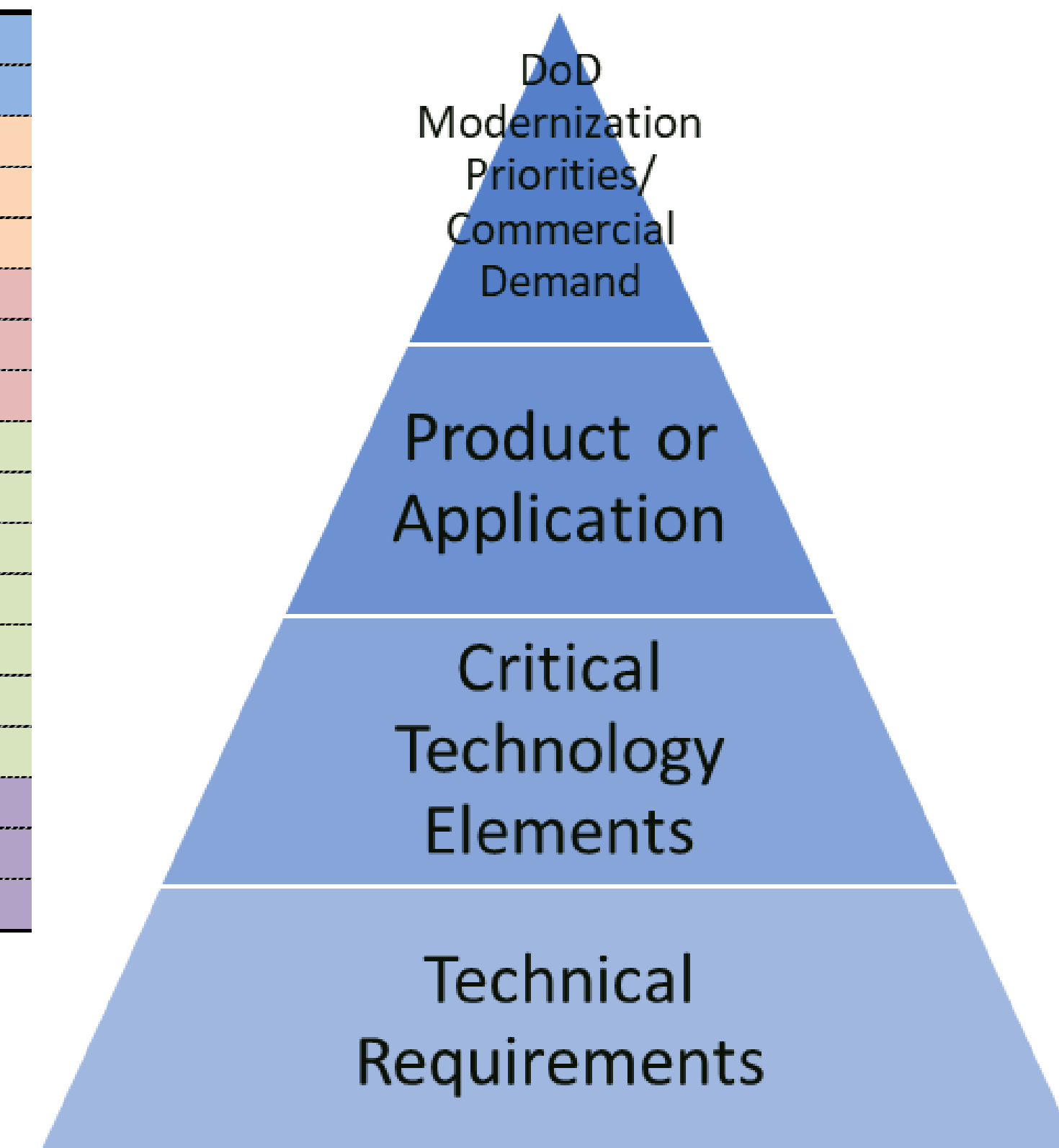*These focus areas are enabled by:*

- **Operations:** Run by a not-for-profit organization
  with a lean and collaborative structure

- **Technology:** A dynamic advanced manufacturing technology
  including the core AM technologies as well as supporting
  technologies like the digital thread, standards, etc.

- **Communications:** Spreading the word to government,
  members, stakeholders, community

CONVENE • COORDINATE • CATALYZE

DEVELOP ADDITIVE MANUFACTURING TECHNOLOGY

ACCELERATE HUMAN CAPITAL DEVELOPMENT

MAINTAIN COLLABORATIVE ECOSYSTEM

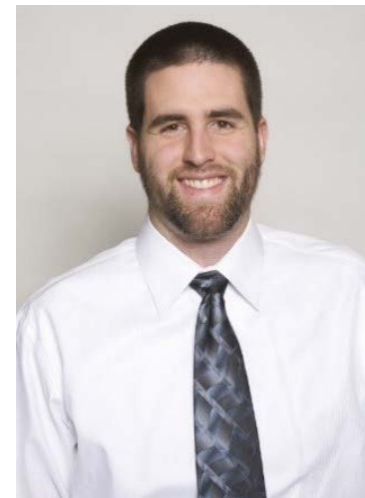OPERATIONS

TECHNOLOGY

COMMUNICATIONS
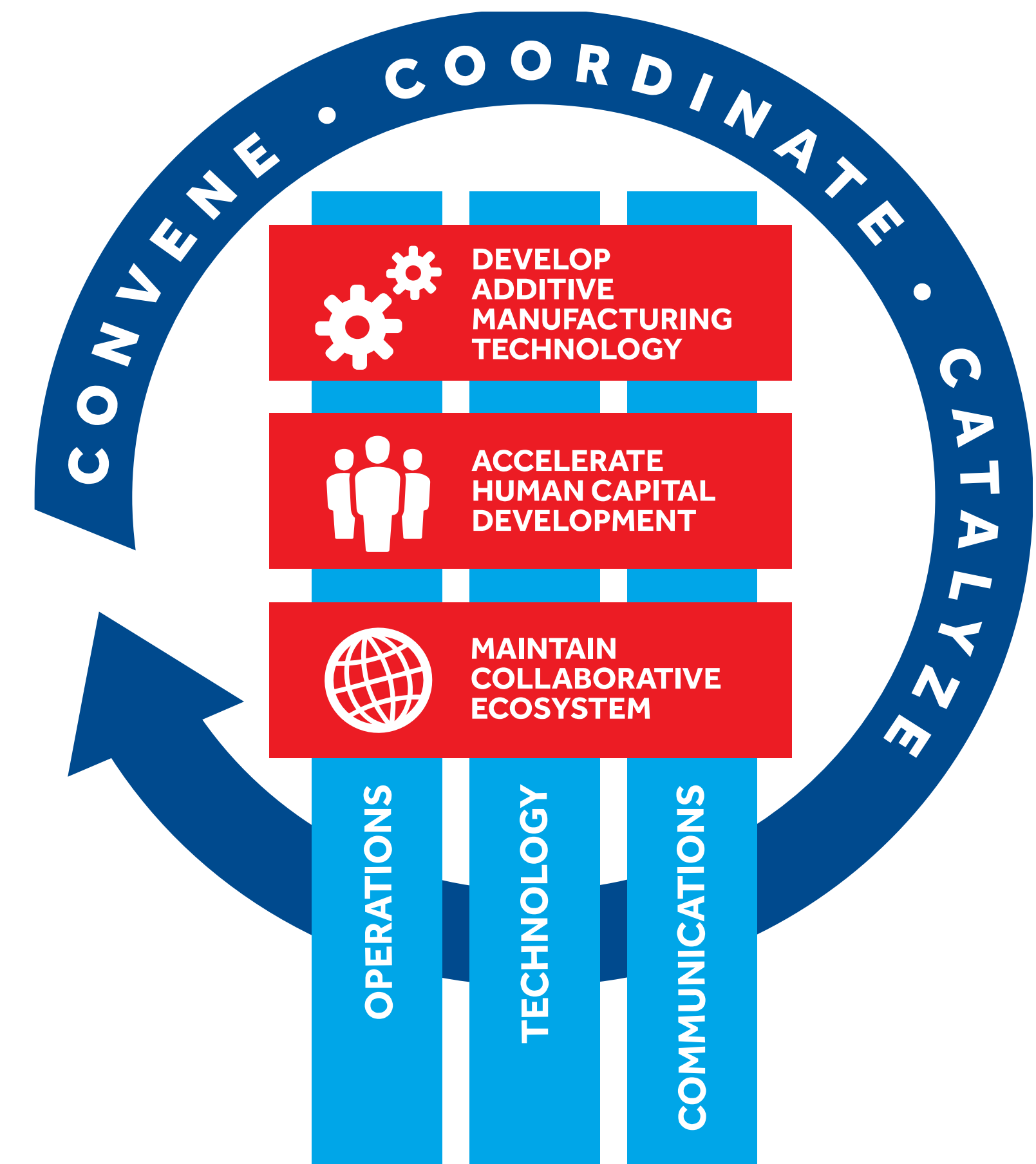
Collaboration Drives Our Strategic Focus

- Focus and strategy is documented within the Technology Roadmap
  - Application/process agnostic
  - Informed by not only end users

- Multitude of interconnected technical considerations
  - TRL 4-7
  - Address risk and maturation
  - Assess performance/function

- Roadmap is a data model
  - Integral to institute operation
  - Connects research efforts to roadmap taxonomy
  - Identifying needs/opportunities
  - Charting progress
  - Organizes lessons learned

Swimlane	CTE
Design	Bio-Inspired Design & Manufacturing
Design	Product & Process Design Aides/Apps
Material	Material Property Characterization
Material	Next-Gen Materials
Material	Additive Manufacturing Tech Data Packages
Process	Multi-Material Delivery & Deposition Systems
Process	Next-Gen Machines
Process	Process Temperature Gradient Control
Value Chain	Advanced Sensing & Detection Methods
Value Chain	Cost & Energy Driver Analysis/Modeling
Value Chain	Digital Thread Integration
Value Chain	Intelligent Machine Control Methods
Value Chain	Rapid Inspection (Post-Build)
Value Chain	Repair Technologies
Value Chain	Standards/Schemas/Protocols
AM Genome	Benchmark Validation Use Cases
AM Genome	Model-Assisted Property Prediction
AM Genome	Physics-Based Modeling & Simulation

Pyramid (top to bottom): DoD Modernization Priorities/Commercial Demand; Product or Application; Critical Technology Elements; Technical Requirements

Roadmap Advisory Group

Brian Thompson
GE Additive
Brian.Thompson1
@ge.com

Teresa Clement
Raytheon
Technologies
Teresa.Clement
@Raytheon.com

Steven Floyd
Northrop Grumman
Floyd, Steven J
Steven.Floyd@ngc.com

Thierry Marchione
Caterpillar
Marchione_Thierry_A
@cat.com

Anil Chaudhary
Applied Optimization
anil1@ao.com

Federico Sciammarella
MxD
federico.sciammarella
@mxdusa.org

Prabir Chaudhary
Education and
Consulting LLC.
prabir.chaudhury
@gmail.com

Frank Medina
UTEP
fmedina@utep.edu

Craig Brice
Colorado School of
Mines
craigabrice@mines.edu
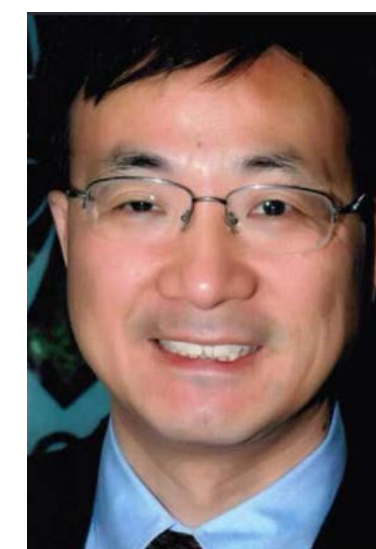
Ray Xu
Rolls-Royce Corp.
Ray.Xu@Rolls-
Royce.com

Addressing Technology Gaps to Strengthen Domestic Supply Chain

Supply Chain & Sourcing	**Design**	**Performance & Durability**	**Post-Processing & Finishing**	**Inspection/ NDE**	**Cost & Rate**

Key Additive Manufacturing Technology Focus Areas

| **Supply Chain & Sourcing**	**Design**	**Performance & Durability**	**Post-Processing & Finishing**	**Inspection/ NDE**	**Cost & Rate**
• Reports (.doc, .pdf, .pptx) • Spreadsheets (.csv, .xlsx)	• Reports (.doc, .pdf, .pptx) • Spreadsheets (.csv, .xlsx) • Models (.cad, .prt, .stp, proprietary output files) • Images (.jpeg, .tiff)	• Reports (.doc, .pdf, .pptx) • Spreadsheets (.csv, .xlsx) • Models& CAD/CAM (.cad, .prt, .stp, .gcode, .magics) • Images (.jpeg, .tiff) • Videos (.mpeg, .avi, .mov)	• Reports (.doc, .pdf, .pptx) • Spreadsheets (.csv, .xlsx) • Models& CAD/CAM (.cad, .prt, .stp, .gcode) • Images (.jpeg, .tiff) • Videos (.mpeg, .avi, .mov)	• Reports (.doc, .pdf, .pptx) • Spreadsheets (.csv, .xlsx) • Images (.jpeg, .tiff) • Videos (.mpeg, .avi, .mov) • Voxel Data (.vgl) • Models (.cad, .obj, .stl, .stp, .pdf)	• Reports (.doc, .pdf, .pptx) • Spreadsheets (.csv, .xlsx)

Finding and Accessing Data

- The America Makes Digital Storefront is an online repository to share information across the community
  - Data, methods, lessons learned, and best practices
  - Searchable singular source
  - Organized according to the role it serves in executing the technology roadmap

- 5 key attributes included with each search return item
  - Project title
 - Organization
  - Process
  - Material
  - Equipment make/model

Project/Program Data Life Cycle

- Facilitated by
  - Value Assessment – Goals/Significance
  - Tools
  - Training
  - Methods
  - Standards/Specifications/Work Instructions
  - Security and auditing

- Recognized (reuse/interoperable) by
  - Planning – structure (pedigree)
  - Transfer
  - Storage
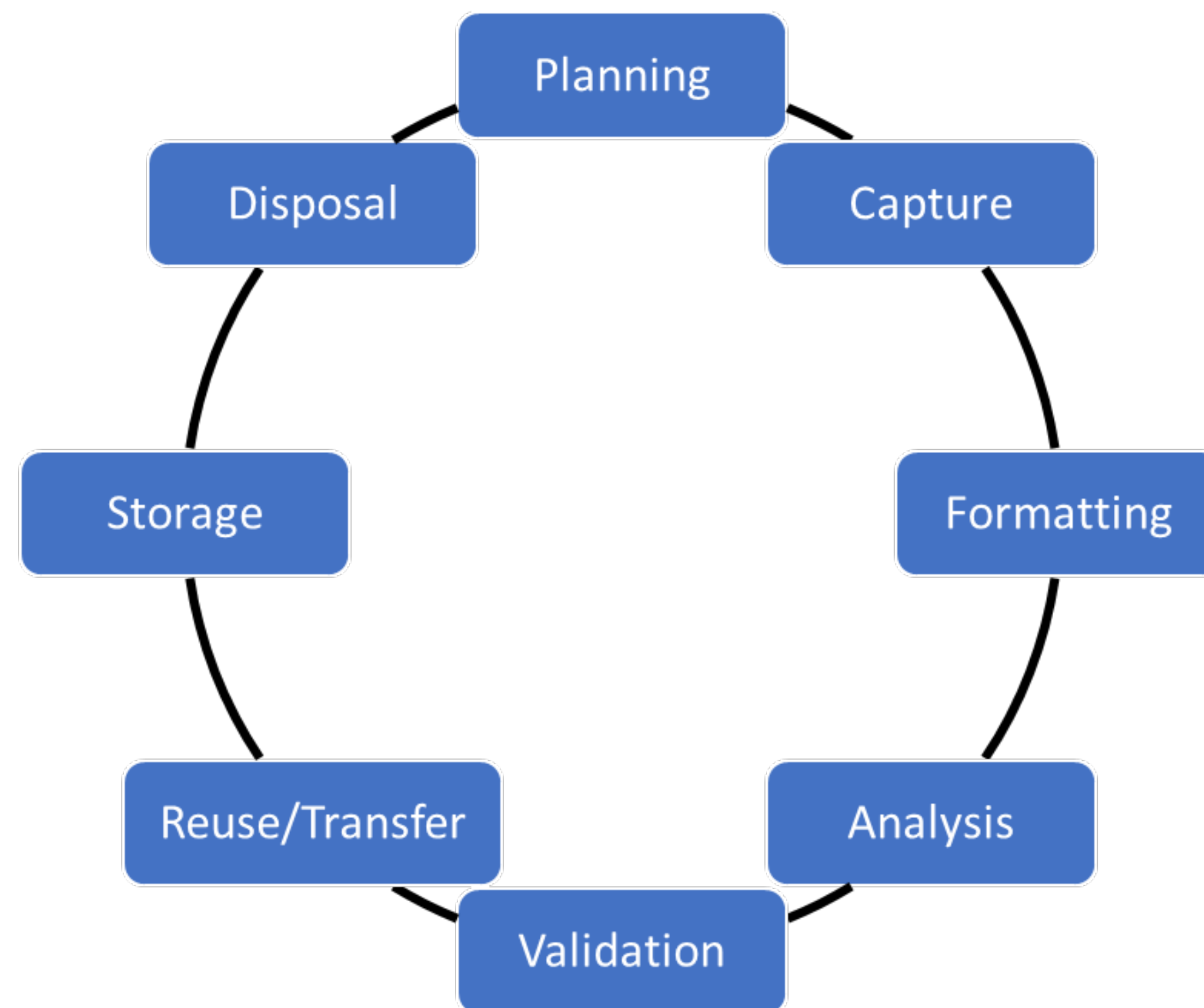
Heightened Focus on Data Management

- Value proposition is critical
  - We are actively exploring this question

- Technology development transitioning focus from feasibility to repeatability, transferability, efficiency
  - Representative of TRL >4 and driving towards 6/7

- New considerations – cultural shift
  - Data management
  - Alignment of effort and deliverables to roadmap taxonomy
  - KPP's – success measures
  - Transfer of data to membership
  - Promoting engagement with technical community – consensus building
    - Opportunity to insure value, reuse, interoperability of outcomes

- Exploring opportunities to improve organization, storage, and sharing of datasets
  - Open project Call 2020
  - Rapid Innovation Call
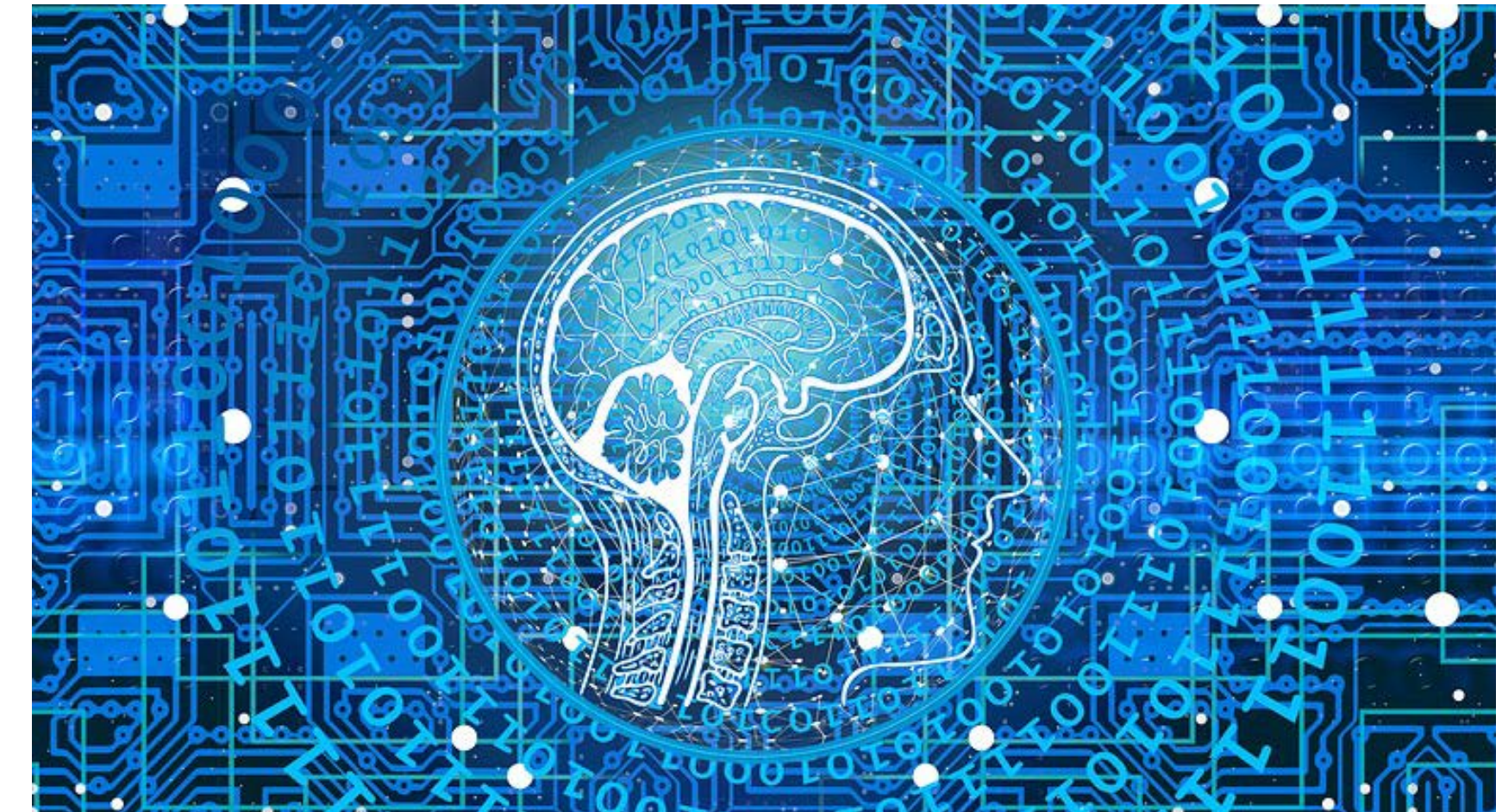
Addressing Interoperable and Reusable Data

- Good opportunity space
  - Education, conversation, prioritization, development, and standardization

- Well aligned to efforts observed in standards domain
  - Systematic assessment of reliable methods, tools, data
  - ASTM CoE
  - ASTM Data Subcommittee
  - SAE Additive Manufacturing Data Consortium
  - ASME Verification and Validation in Computational Modeling and Simulation Committee

- 2019 Data Management and Schema Workshop
  - Common Data Dictionary
  - Common data exchange format
  - Automated data acquisition
  - Public use cases
  - Minimum viable data package

- Opportunity to transfer, reuse, and exploit process/measured/materials data
  - Need to understand pace and cost
  - ML/AI, monitoring/modeling, database development, data acquisition, cybersecurity

Summary

- Data management is a relevant and important component to AM technology maturation

- ~95% of the standards gaps within the AMSC roadmap can benefit or rely on data management

- Opportunity to benefit endeavors which address statistical significance and validation

- Expectations remain positive for accelerating supply chain efforts in AM technology maturation

- Stands to considerably benefit education and workforce
  - Content for training and accreditation

- Pursuit of data management value proposition
  - Applications with strong end user demand
  - Demonstrate transferability enabled by good data management practices