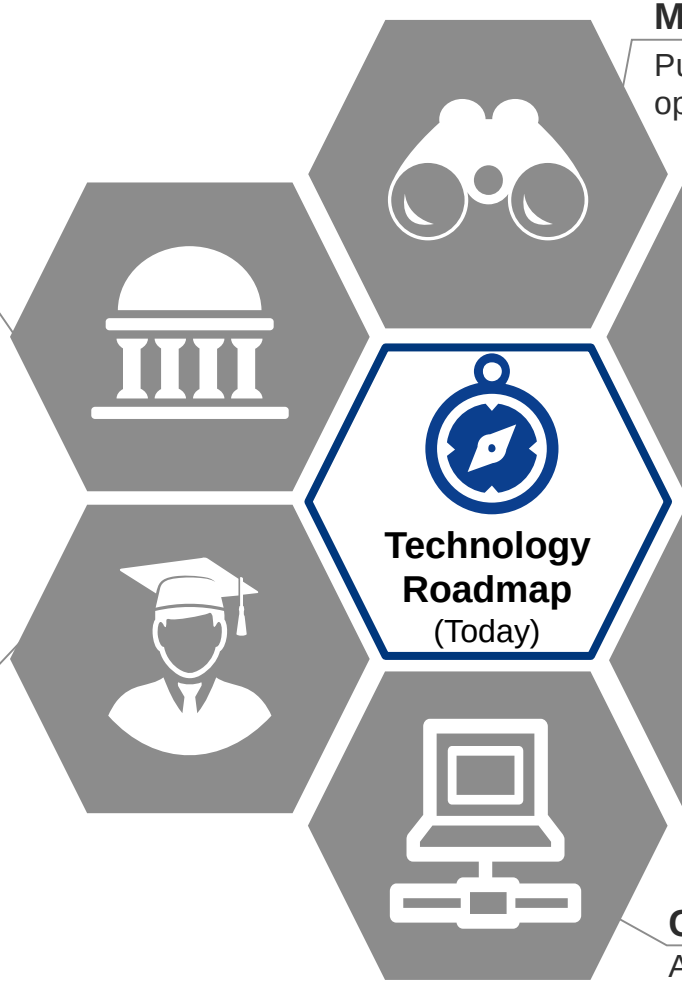
America Makes

NIST Polymer Workshop:
Additive Manufacturing Roadmapping Overview

Rob Gorham
America Makes
Director of Operations

Creating capabilities



Mission
Purpose of a capability, how it will operate, and what it will deliver

Governance
Clear roles, decision rights, and policies

Insights
Decision flows, information and analytics

Talent (People)
Competencies, skills, talent infrastructures and workforce planning

Process
Integrated set of process and activities designed to achieve an outcome

Complementary Technology
Additional technologies (i.e. IT) and tools required for a mature 3DP capability

America Makes Roadmapping Approach

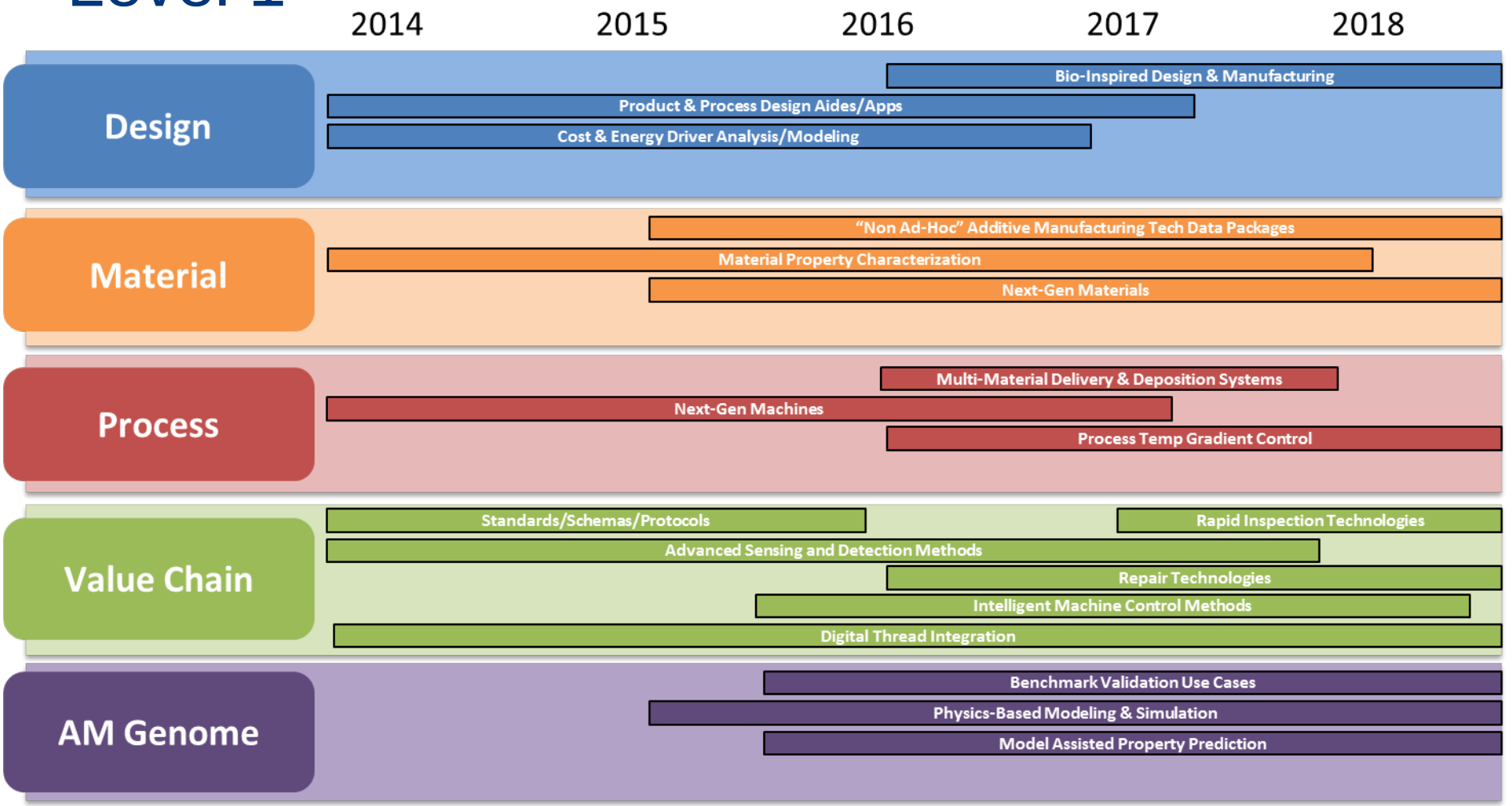
- America Makes has released v2.0 of the Technology Roadmap using a **systems engineering-based methodology**
- America Makes has partnered with Deloitte on a shared vision for growing from technology development to **capability development**
- Execute a continuous Systems Engineering-based approach to roadmap development, anchored by in-person workshops featuring a suite of enhanced **facilitation techniques**

America Makes

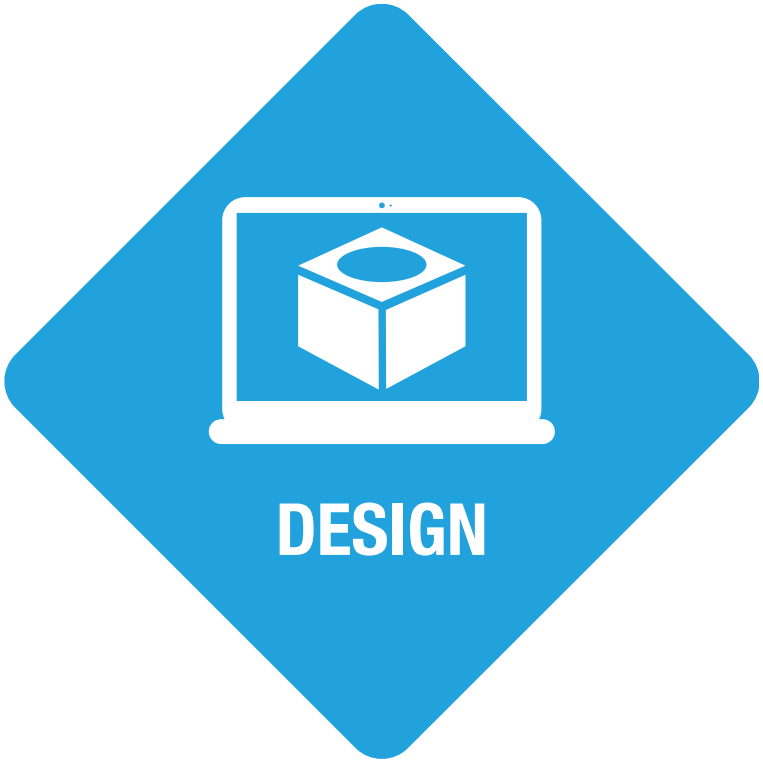
Deloitte.

Swimlane	Critical Technology Element	Impact Focus
Design	Bio-Inspired Design & Manufacturing	Complexity Exploitation, 3D Graded Materials, Multi-Material Integration, Model-Based Development, Product Customization
	Cost & Energy Driver Driver Analysiss	
	Design Aides/Apps	
Material	Additive Mfg Tech Data Packages	Standard Feedstock Materials, Benchmark Property Data, Microstructure Relationships, Process Window Definition, Processing Guidelines & Specifications
	Next-Gen Materials	
	Powder/Material Characterization	
Process	Multi-Material Delivery & Deposition	Faster Build Speeds, Improved Surface Quality, Larger Part Envelopes, Improved Detail Capability
	Next-Gen Machines	
	Process Temperature Gradient Control	
Value Chain	Digital Thread Integration	Material Costs, Processing Costs, Quality Control Costs, Productivity Costs, Energy Efficiency Costs
	Advanced Sensing & Detection Methods	
	Intelligent Machine Control Methods	
	Rapid Inspection (Post Build)	
	Repair Technologies	
	Standards/Schemas/Protocols	
AM Genome	Benchmark Validation Use Cases	Concurrent Methods, Computational Tools, Experimental Tools, Modular Open Simulations, Open Multi-Scale Data
	Physics-Based Modeling & Simulation	
	Model-Assisted Property Prediction	

Additive Manufacturing Technology Roadmap Level 1



Design Overview



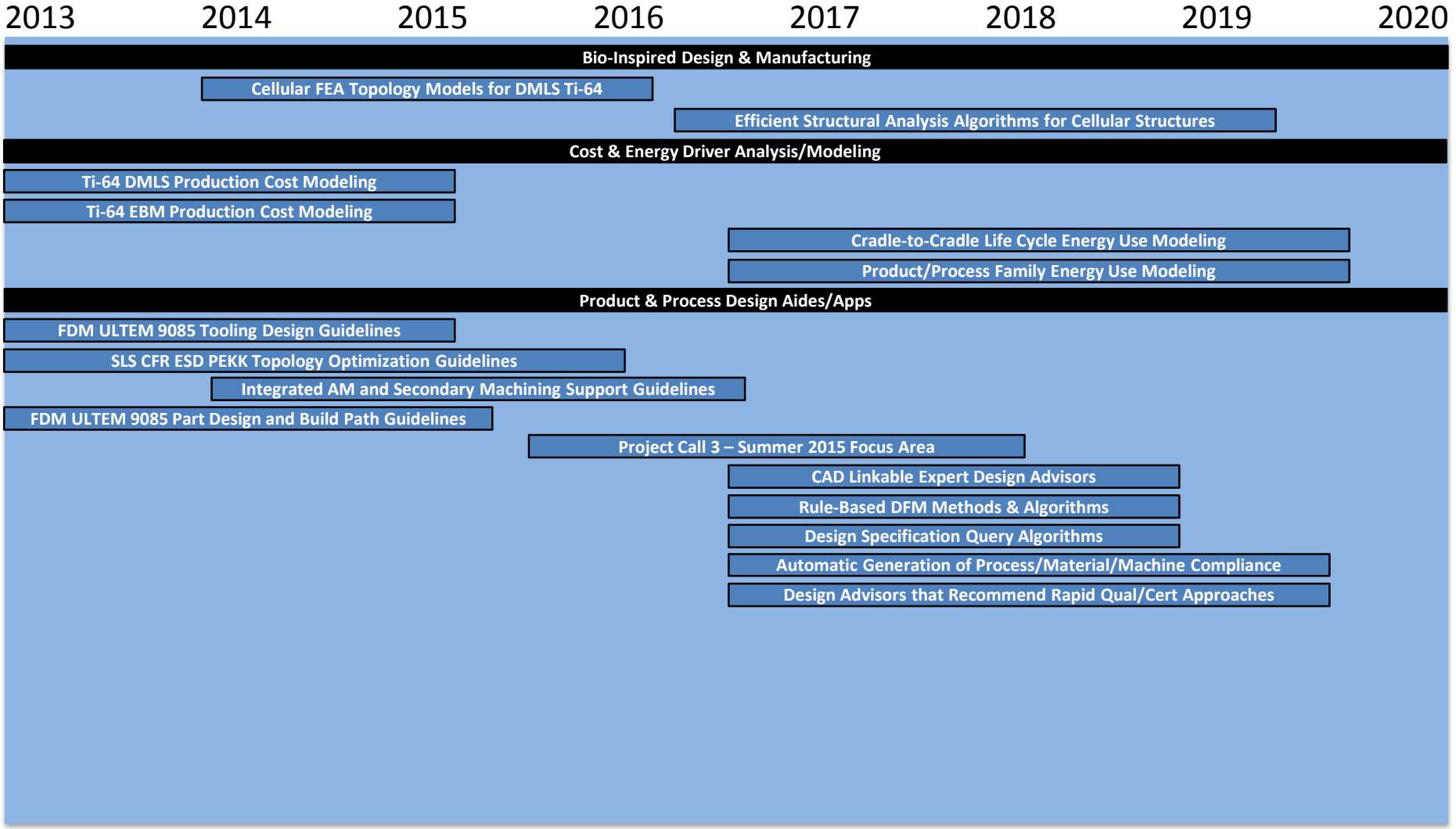
The Design focus area of the Roadmap is aimed at driving technological advancements in new and novel non-proprietary design methods and tools required to enable a culture change and break the cycle of designing additive manufacturing parts like cast or machined parts.

The technical focus for this area includes:

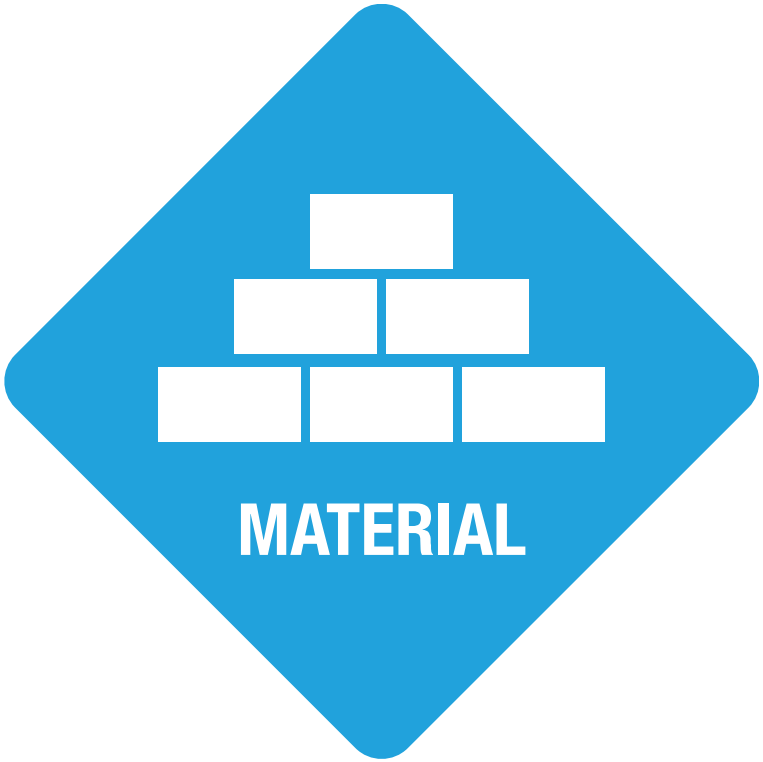
- Complexity exploitation
- 3D functionally graded materials
- Multi-material integration
- Model-based inspection
- Product individualization and customization

America Makes Technology Roadmap Level 2

DESIGN Level 2 Maturation Needs



Material Overview



The Material focus area of the Roadmap is aimed at building the body of knowledge for benchmark additive manufacturing property characterization data and eliminating variability in “as-built” material properties.

The technical focus for this area necessitates the development of:

- Standardized feedstock materials
- Benchmark material property data
- Process-property-structure relationships
- Process window boundary definition
- Post-processing guidelines and specifications

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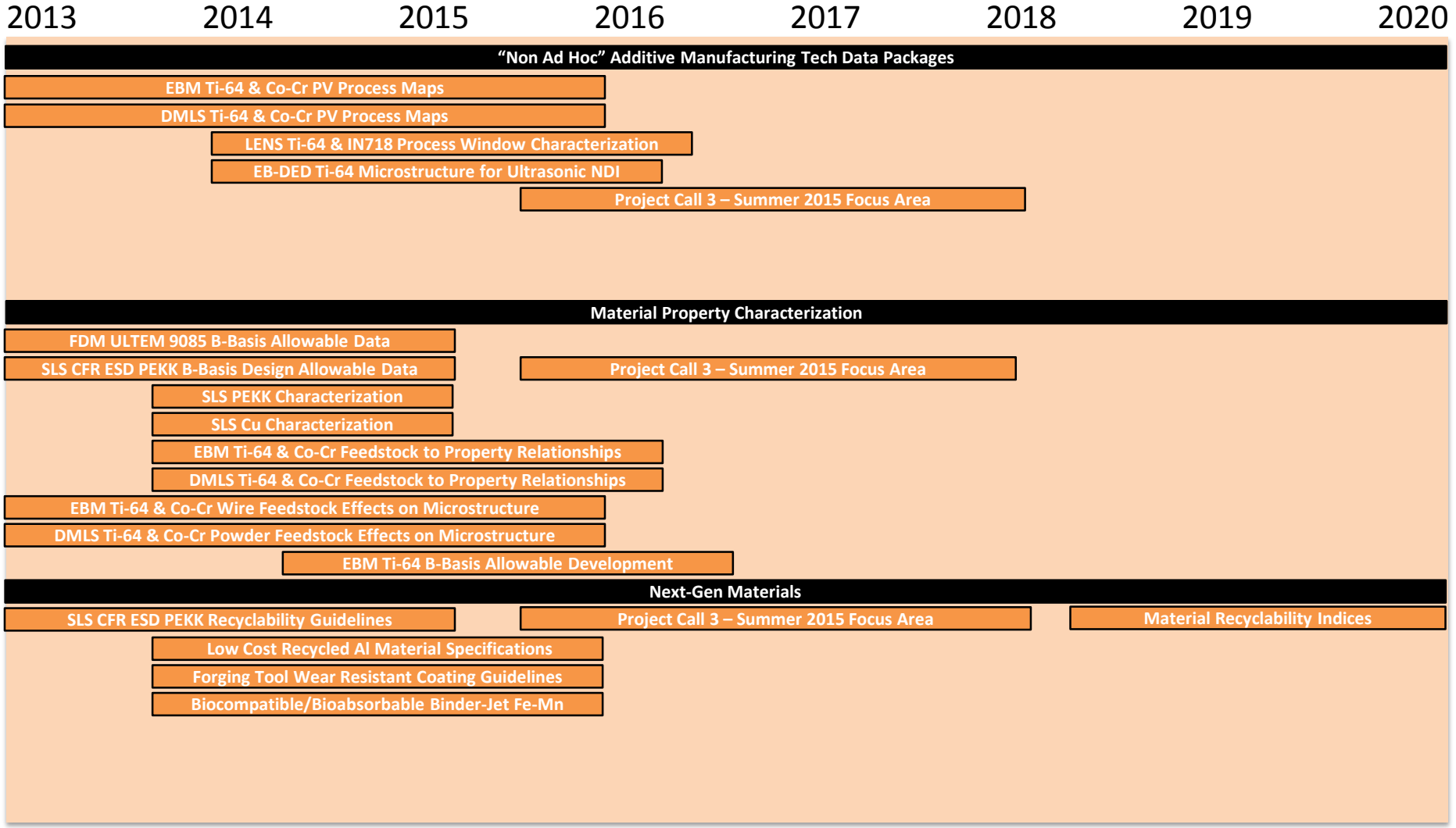
MATERIAL Level 2 Maturation Needs



Process Overview

The Process focus area of the Roadmap is aimed at driving technological advancements that enable faster, more accurate, and higher detail resolution additive manufacturing machines with larger build volumes and improved “as-built” part quality.

The technical focus for this area includes:

- Build speed
- Accuracy
- Detail capability
- Surface quality
- Maximum part size

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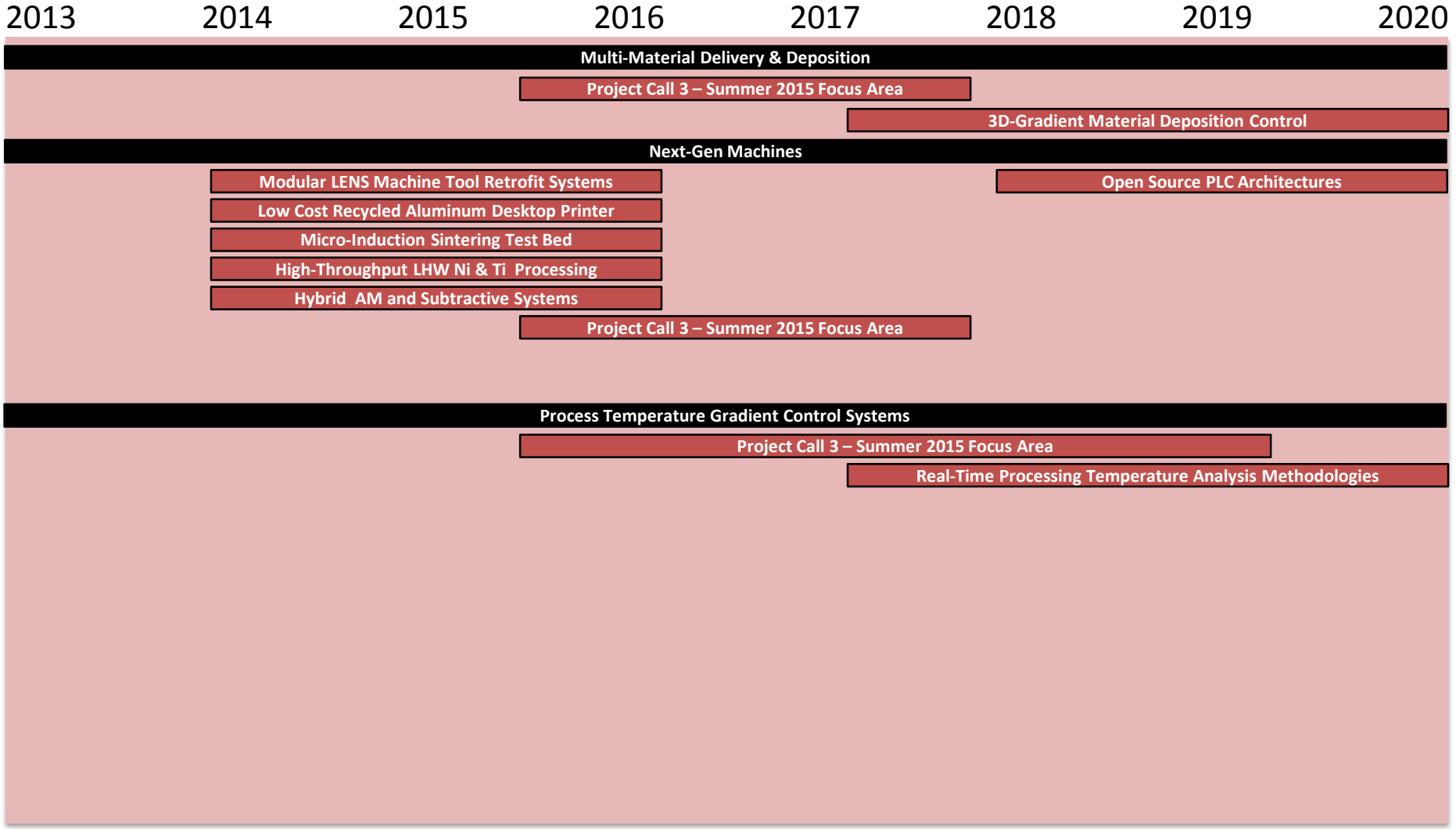
PROCESS Level 2 Maturation Needs



Value Chain Overview

The Value Chain focus area of the Roadmap is aimed at driving technological advancements that enable step change improvements in end-to-end value chain cost and time to market for additive manufacturing produced products.

The technical focus for this area includes:

- Processing costs
- Feedstock material costs
- Quality control costs
- Labor productivity costs
- Energy efficiency costs

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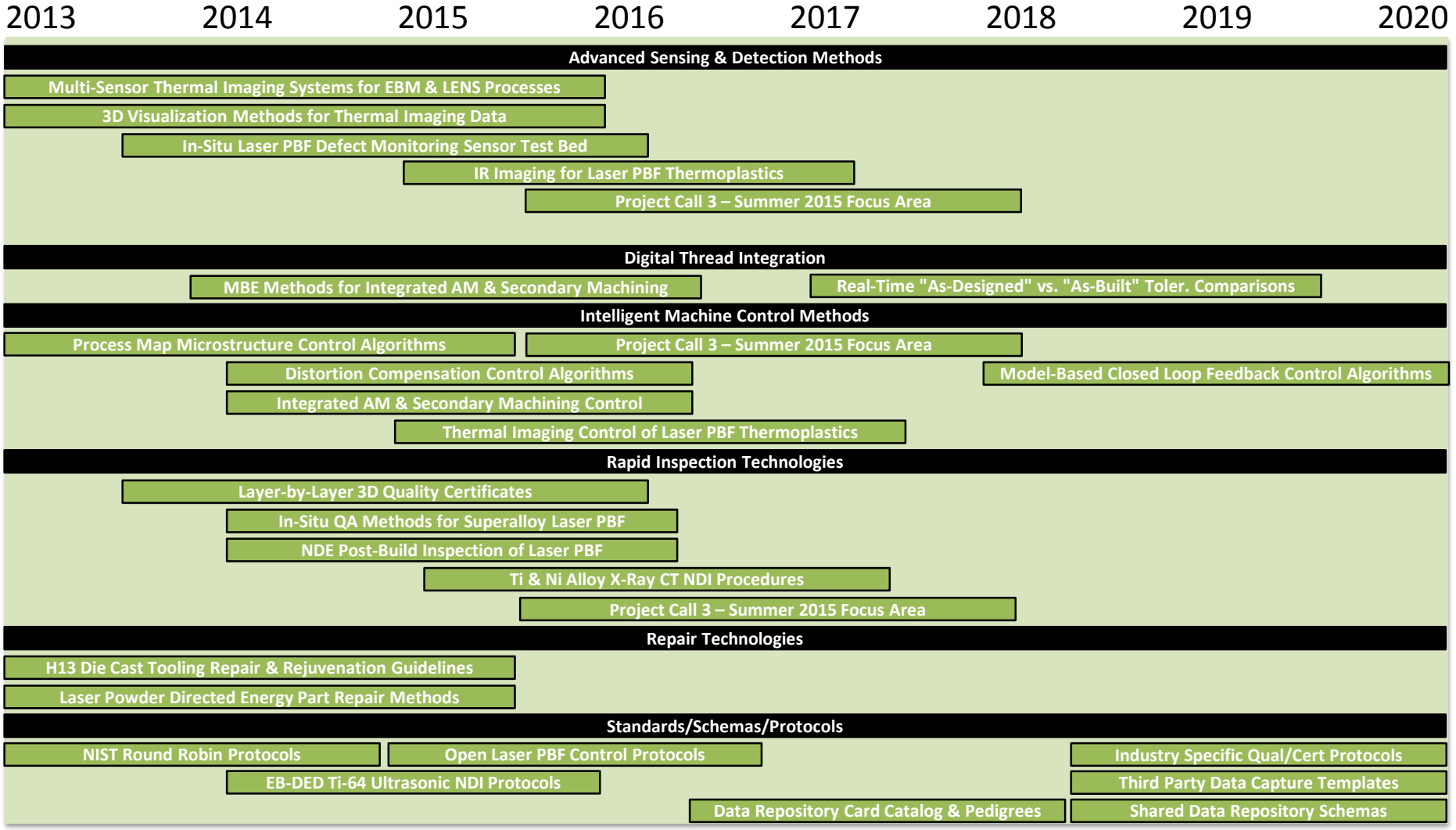
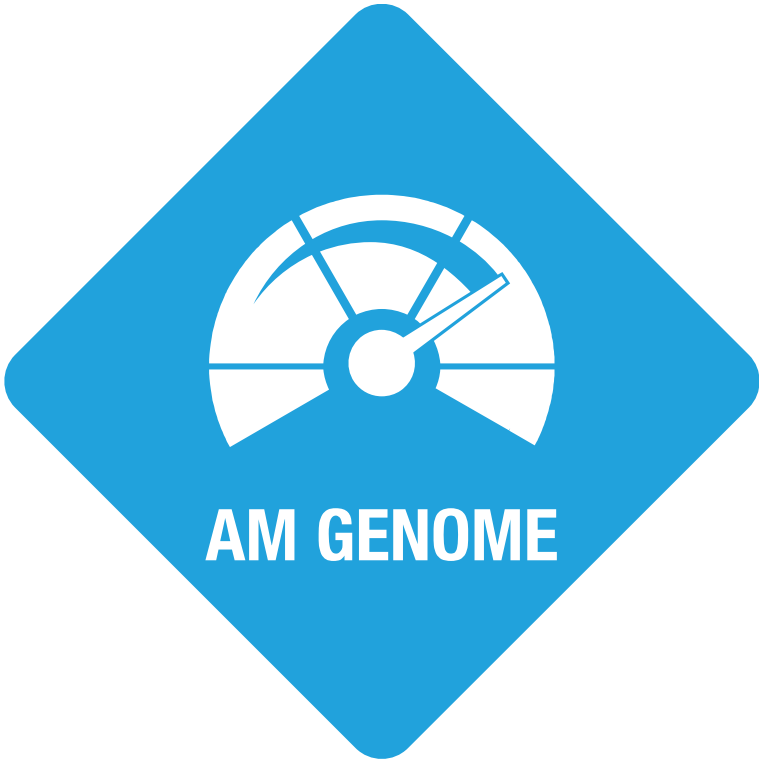
VALUE CHAIN Level 2 Maturation Needs



AM Genome Overview



The Additive Manufacturing Genome focus area of the Roadmap is aimed at accelerating technological advancements that enable step change improvements in the time and cost required to design, develop, and qualify new materials for additive manufacturing.

The technical focus for this area includes:

- Computer-aided materials development
- Modular open simulation frameworks
- Access to open transparent material property data
- Multi-scale data management
- Sharing efficient material property characterization method

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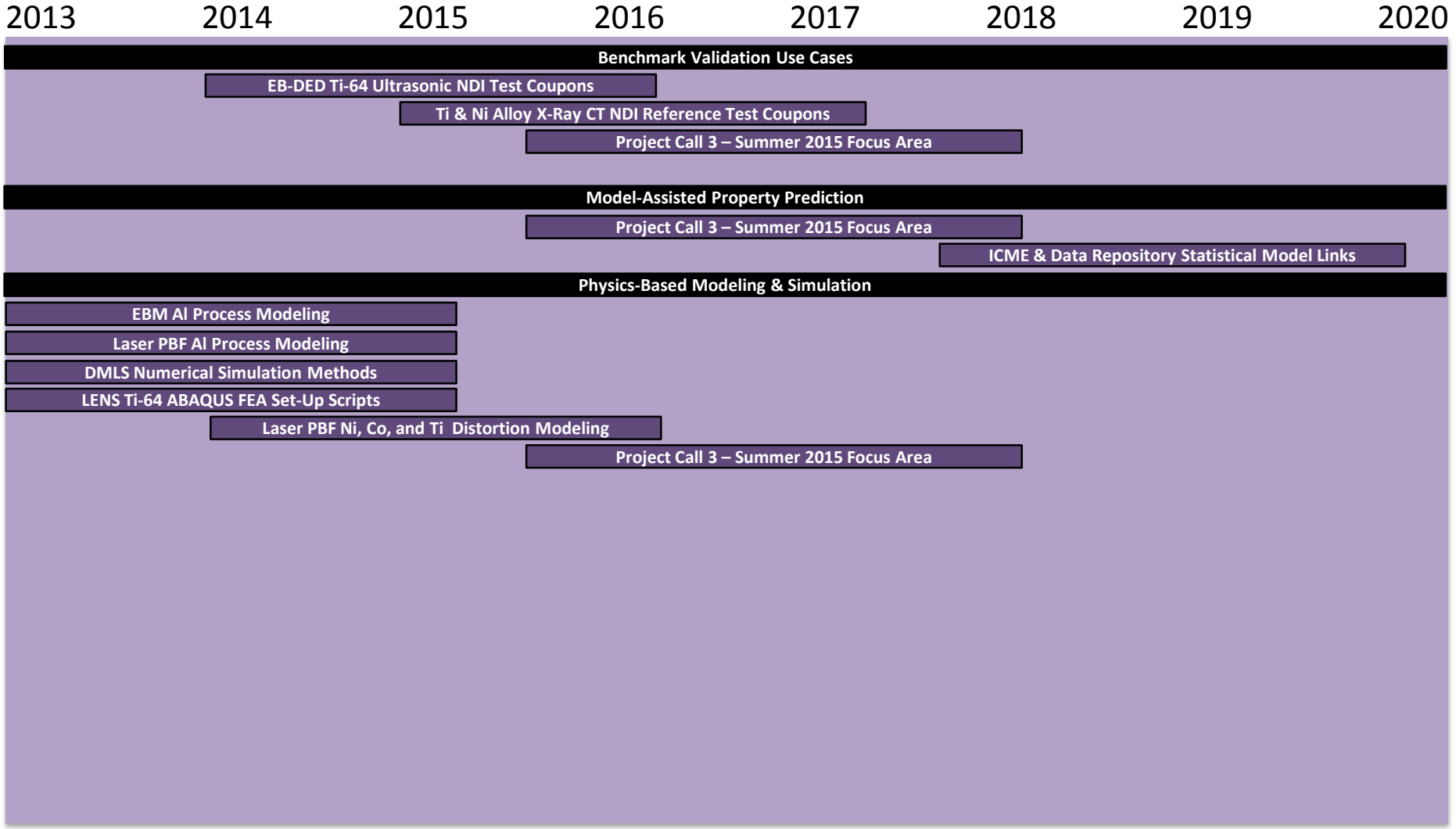
AM GENOME Level 2 Maturation Needs



America Makes Projects: Polymers

Title	Lead Organization	Lead Investigator	NCDMM Project Manager	Total Funding
3D Printing Multi-Functionality: Additive Manufacturing for Aerospace Applications	University of Texas-El Paso	Ryan Wicker	Randy Gilmore	$2,369,652.45
3D Printing Skills Development	America Makes	Mike Hripko		$164,002.11
3D Printing Process Migration (Plastic → Metal) and Materials	Lehigh University	Alparslan Oztekin	John Wilczynski	$228,176.96
A Design Guidance System for Additive Manufacturing	Georgia Institute of Technology	David Rosen	John Kimball	$2,083,929.00
A Low Cost Industrial Multi3D Systems for 3D Electronics Manufacturing	University of Texas-El Paso	David Espalin	Randy Gilmore	$2,408,935.00
Closed Loop Process Control for Powder Bed Fusion Thermoplastics	University of Texas-Austin	Scott Fish	Ed Nemeth	$675,000.00
Digital Threading of Additive Manufacturing	Boeing	David Dietrich	Brian Schmidt	$2,071,111.00
Economic Production of Next Generation Orthopedic Materials through Powder Reuse in Additive Manufacturing	University of Notre Dame	Steven Schmid	Jim Fisher	$1,975,086.00
Fused Deposition Modeling (FDM) of Complex Composites Tooling	Northrup Grumman Corporation	Pedro Gonzalez	Rob Gorham	$697,902.12

America Makes Projects: Polymers Cont.

Title	Lead Organization	Lead Investigator	NCDMM Project Manager	Total Funding
Integrated Design Tool Development for High Potential Additive Manufacturing Applications	University of Pittsburgh	Albert To	Ed Nemeth	$2,883,517.00
Maturation of FDM Component Manufacturing	RP+M	Tom Santelle	Rob Gorham	$1,933,542.33
Maturation of High Temperature Laser Sintering (LS) Technologies and Infrastructure for Air and Space Vehicles	Northrop Grumman Corporation	Pedro Gonzalez	Rob Gorham	$2,597,478.45
Maturing Additive Manufacturing for Low Cost Sustainment	University of Dayton Research Institute	Brian Rice	Dave Siddle	$11,860,512.00
Multidisciplinary Design Analysis for Seamless Additive Manufacturing Design, Analysis, Build, and Redesign Workflows	Raytheon	Jeff Shubrooks	Bill Walch	$2,768,966.00
Optimizing SLS Processing Parameters for Polymer Nanocomposites	Lehigh University	Ray Pearson	John Wilczynski	$162,117.04
Sparse-Build Rapid Tooling by Fused Deposition Modeling for Composite Manufacturing and Hydroforming	Missouri Science & Technology	Ming Leu	Rob Gorham	$479,192.79

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