Additive Manufacturing Metrology Testbed (AMMT) Research Goals for Advancing LPBF

**CHALLENGES**
- Inconsistent build quality, part-to-part variability
- Multiple part deficiencies:
  - Surface cracks
  - High residual stress, distortion
  - Poorly coupled thermal response

**FUNDAMENTAL PROCESS PHYSICS RESEARCH**
- Process parameter development
- Laser beam trajectory development and optimization
- Defect formation mechanisms (pores, cracks, residual stress)
- Measurement of process envelope (melting, evaporation, radiation, emission, plasma)

**PROCESS MONITORING RESEARCH**
- Develop “verify as you build” methodologies
- Calibration/characterization of monitoring instruments
- Probability of detection (POD) analysis
- Develop correlations between input parameters, in-situ process signatures, and final part quality

**RESEARCH OUTPUT/GOALS**
- Rapid and material/process development
- Improved fundamental understanding
- Known required parameters for each new material

**SOLUTIONS USING CUSTOM TESTBED**
- Enables full control and flexibility to produce well-characterized research results
- Integrated through digital thread, results can facilitate rapid part qualification and widespread adoption

**AMMT METROLOGY SYSTEMS, TOOLS, AND CAPABILITIES**

**METROLOGY SYSTEMS FOR LPBF MONITORING & CONTROLS RESEARCH**
- Full high speed control of laser spot
  - Position, power, speed, spot size control at 100 kHz
  - Programmability with “AM G-code”
- Inter-vector and inter-vector power and speed control

**MATERIAL & PROCESS PARAMETERS**
- High speed imaging/thermography provides physical context for single-point sensors
- Use to relate observed phenomena (spatter, keyholing, melt pool dynamics, plume dynamics) to detector signal features

**FINAL PRODUCT QUALITY METRICS**
- Microstructure
- Mechanical properties
- Surface finish

**FORWARD-LOOKING RESEARCH POSSIBILITIES**
- Volumetrically Controlled Microstructure
- High Temperature Melt Flow Dynamics
- Plasma/Plume Dynamics and Spectroscopy
- Ceramics, Composites, and New Alloy Development

**KEY BENEFICIARIES**
- NIST Laboratories (EL, PML, MML, ITL, CNST, NCNR)
- Industrial stakeholders (R&D, America Makes Members, AMC Members)
- Other Federal agencies (DOE, NASA, FAA, FDA)
- Academia and International collaborators