Computational Tools for Additive Manufacture of Tailored Microstructure and Properties

United Technologies Research Center
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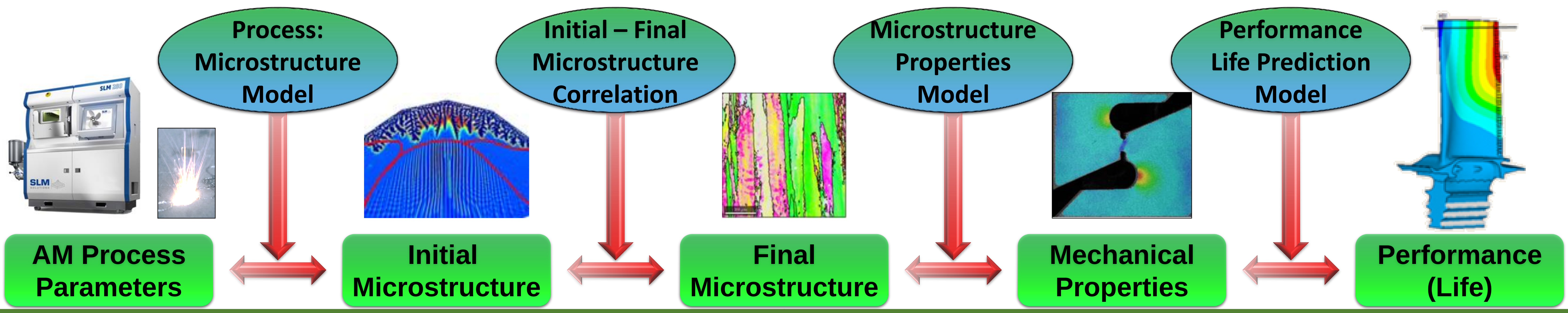
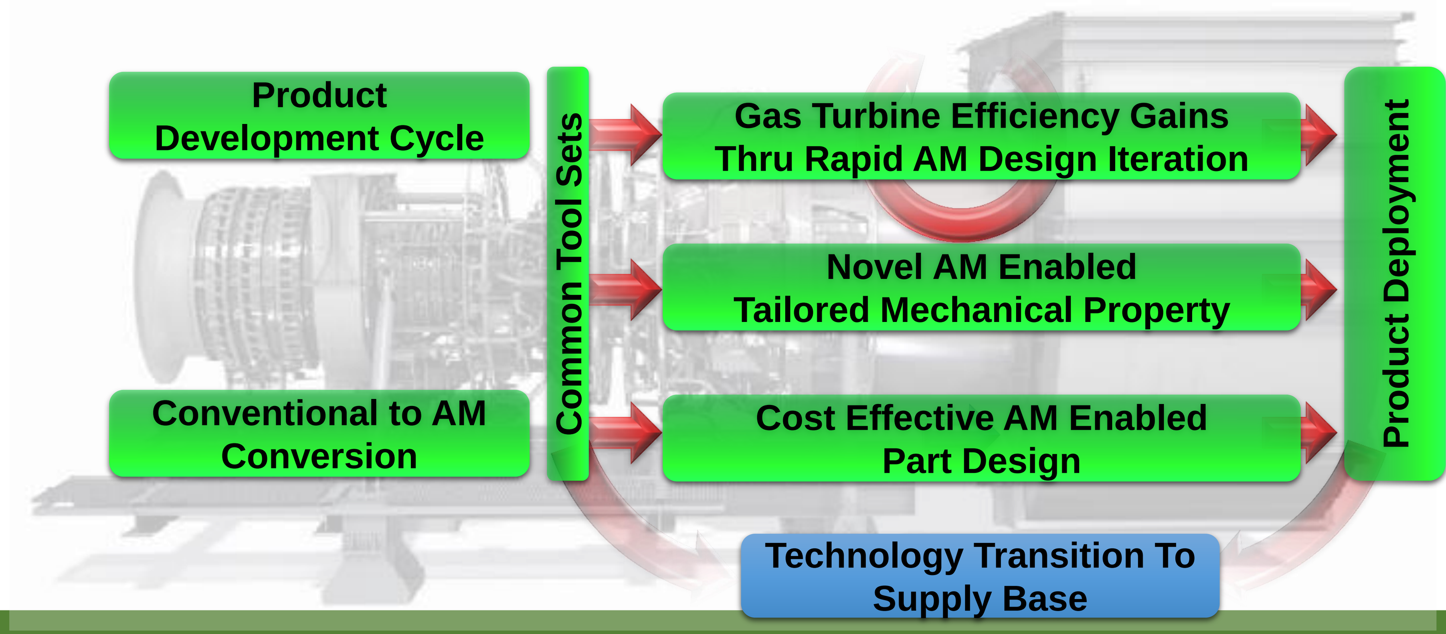
INTRO/APPROACH/DATA



NEED

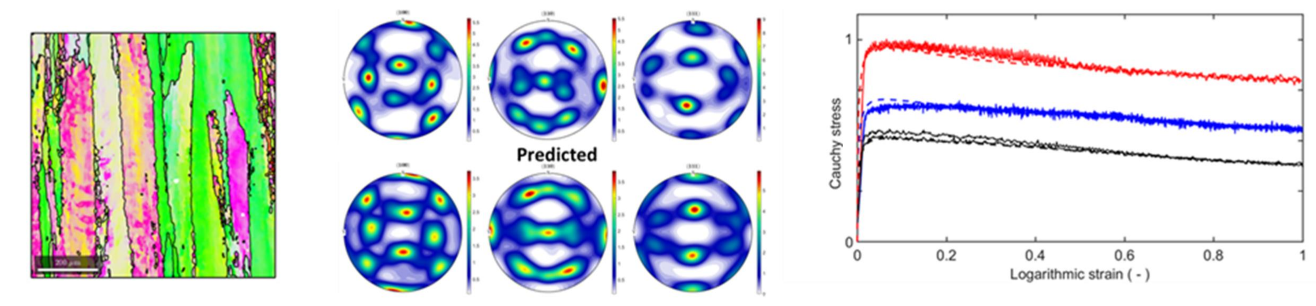
Impact on Fossil Energy

- Additively Manufactured (AM) hardware has the potential to revolutionize industrial hardware across all platforms including Industrial Gas Turbines (IGT).
- Process efficiency gains through new component design are expected through rapid concept iteration as casting development cycle times are erased.
- Part repair and replacement supply chains will also potentially be upended with new processing developments impacting a large existing base including F-Class IGT's.



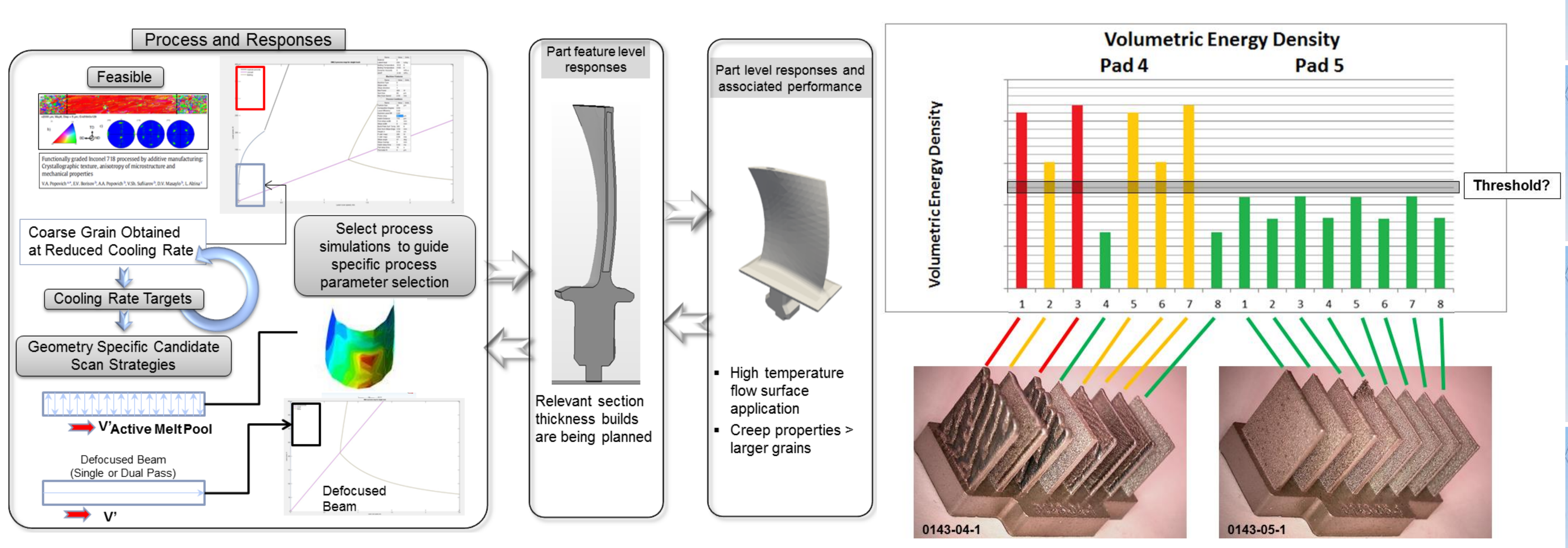
APPROACH

- Establish a Digital Thread through the Additive Manufacturing (AM) Process
- Tailored placement of properties enabled by additive manufacturing build parameter control
- Land based IGT's:
  - Hot section polycrystalline hardware: Airfoils, combustors, liners, hot static structure
- Competing Requirements:
  - Creep: Large grain size increases creep resistance.
  - Fatigue: Small grain size increases fatigue resistance.
  - Strong function of Temp: T, Stress: σ, Time: t
  - The T(t,x,y,z) and σ(t,x,y,z) functions vary across the hardware
- Integrated Computational Materials Engineering (ICME)
- Demonstrate the application of computational methods and tools on microstructure evolution and mechanical properties prediction for additively manufactured (AM) nickel-based superalloy parts.

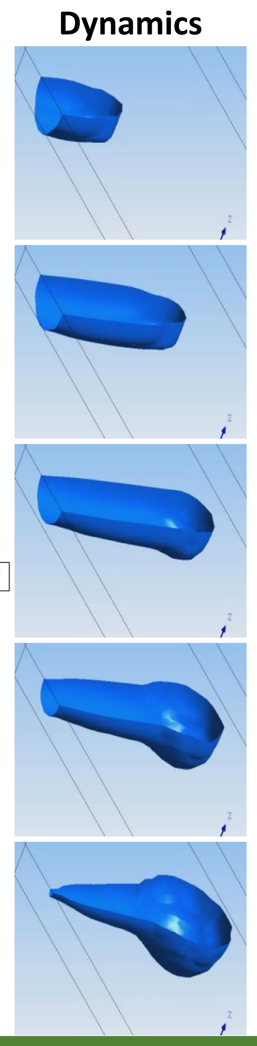


RESULTS

- Predicted and demonstrated grain size control with Active Melt Pool
- Applied process quality mapping tools for defect avoidance
- Successfully produced low porosity, low defect specimens guided by defect map
- Identifying trends correlating to volumetric energy density
- Linkage to AM process parameters:
  - Surface finish, as deposited microstructure, evolution in heat treatment
- Beginning grain texture quantification for Crystal Plasticity code integration



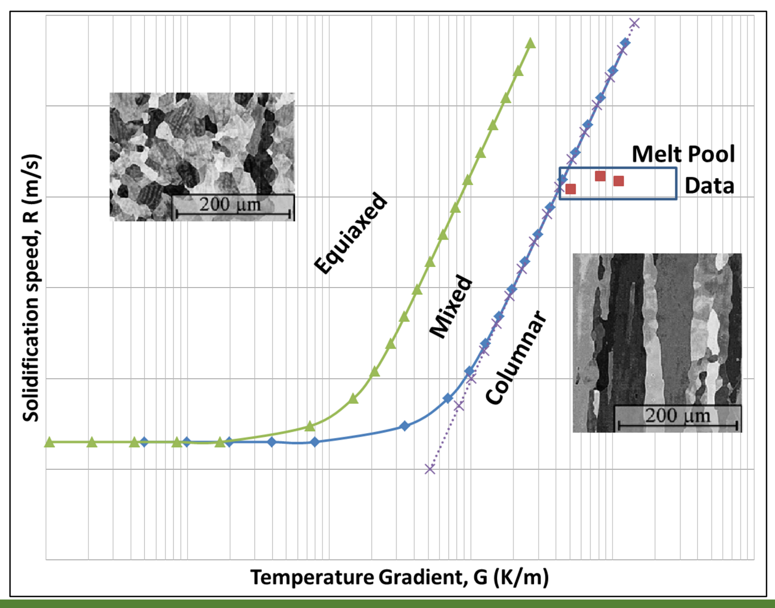
Tailored Active Melt Pool Dynamics



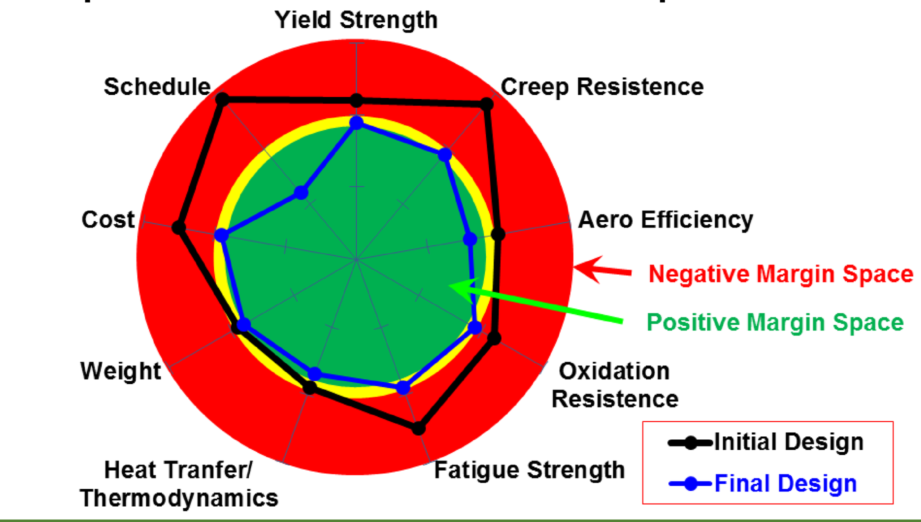
BENFITS AND FUTURE WORK

AM Impact on Design Requirements

- Creep strength where needed most, enhanced fatigue strength localized
- Tailored property placement based on varying operational requirements
- Cost effective, reliable, RAPID concept evaluation in metal
- Aero efficiency iteration
- Novel cooling scheme geometries enabled only through AM
- Continuing development potential for:
  - Tailored heat treatment and physics based microstructural evolution prediction
  - Wrap around connection of prediction to AM machine control



Design Process Balancing Multiple Requirements
Computational AM Accelerates Concept Evaluation



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