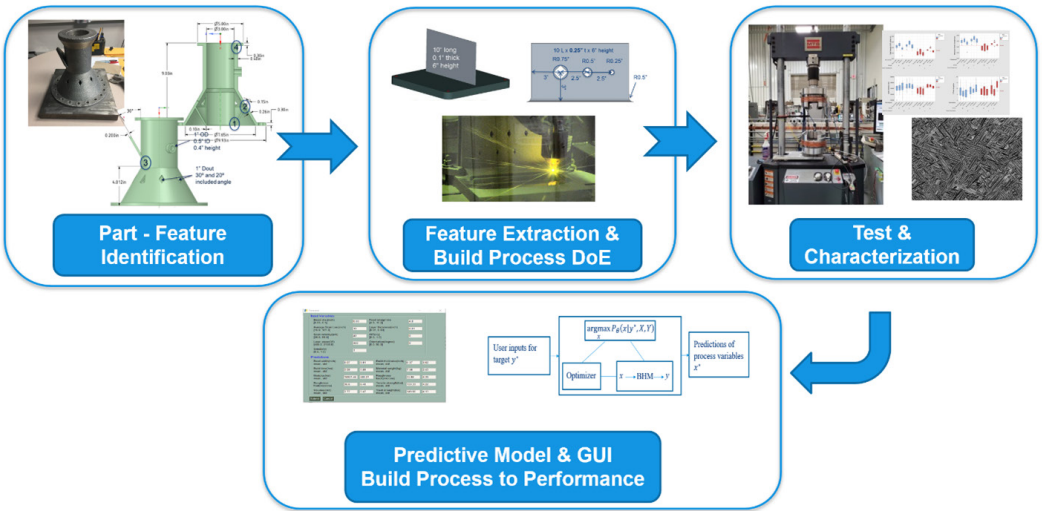
SUCCESS STORY 3011.001

Demonstrated method predicts critical feature tensile behavior and prescribes processing parameters using Bayesian probabilistic tools

Critical to Quality factors have 50% Lower Fabrication and Evaluation Costs while Achieving 37-50% Higher Reliability



Example of a feature-based qualification approach where the results of the mechanical testing and metallurgical characterization are utilized to train a Bayesian Hybrid Model for the prediction of the feature's tensile properties.

PROBLEM

It can take several years to go from concept to production for components produced by additive manufacturing (AM). The flexibility of the AM process allows for build customization including build strategy and process conditions. This can lead to long iterative evaluation cycles—printing parts, post processing, dimensional inspection, material performance, and functional performance—which greatly increases the time and cost of substantiating the process and component.

OBJECTIVE

The objective of this project was to improve the speed and confidence of directed energy deposition (DED) process qualification by identifying application space, process technology, and materials; developing and validating feature-based build qualifications (FBQ) by cataloging features, build process parameters, and material property relationships; and deploying the FBQ Bayesian Hybrid Model approach to accelerate design engineering and process qualification.

AMERICA MAKES TECHNOLOGY DEVELOPMENT ROADMAP

This project aligns to:

VALUE CHAIN

ASTM PROCESS CATEGORY
Directed Energy Deposition

EQUIPMENT
RPM 557

MATERIAL
Ti-6Al-4V

TECHNICAL APPROACH

GE Global Research Center (GEGRC) developed FBQ by first identifying part-based critical features (including engineering and performance requirements), testing protocols, and printing specimens, thus establishing additive characteristics and performance measurements. In addition, probabilistic modeling and efficient sampling were developed for a performance catalog based on FBQ methodology.

GE Bayesian Hybrid Modeling framework (GEBHM) in conjunction with Intelligent Design Analysis of Computer Experiments (IDACE) was used to build predictive models of each feature for the relationship among process parameters, additive build characteristics, and material performance. Implementation efforts included defining the application space, process technology and materials; generating hybrid probabilistic models relating feature performance to process; and deploying hybrid models to the engineering community. Training development and pilots were also planned.

ACCOMPLISMENTS

The team developed and successfully demonstrated the feasibility and accuracy of a probabilistic artificial intelligence/machine learning (AI/ ML) driven feature-based qualification framework for Ti64 DED builds. The approach offers the potential for 60 to 85% savings in fabrication and characterization costs compared to traditional qualification approaches. The model demonstrates the merits of AI/ML approaches for prediction of various feature tensile properties as well as the ability to prescribe process parameters for achieving a desired tensile property. This solution is applicable to a range of geometric features and can be a useful tool for accelerating development and qualification of metal AM products. A copy of the executable and all of the compiled data for the model is available to America Makes members. The team developed and delivered a video training course on their method and model which includes a detailed step-by-step guide on the feature-based qualification framework and a model user reference guide.

PROJECT END DATE

September 2020

DELIVERABLES

- Detailed guidelines for general feature-based decomposition and validation for GE Aviation and Raytheon use cases
- Standard test geometry definition
- Process definition for RPM/Ti6-4 and samples for predictive model population
- Samples for feature-based qualification methodology validation
- Screening level data to EWI to guide process definition
- Detailed property and quality data to generate the predictive model
- A predictive model for Ti6-4 on RPM platform— capable of predicting feature performance as a function of feature type to assist with component design
- A predictive model for Ti6-4 on RPM platform— designed to guide process and part qualification work scope
- A concise deployable packet of training information that can be distributed to America Makes, USAF, and DoD supply chain partners
- Two hands on training sessions and two virtual training sessions

FUNDING

$3.7M total project budget
($2.5M public funding/$1.2M private funding)

PROJECT PARTICIPANTS

Project Principal:
GE Global Research Center (GEGRC)

Other Project Participants:
Raytheon
EWI
Youngstown State University
GE Aviation

Public Participants:
U.S. Department of Defense