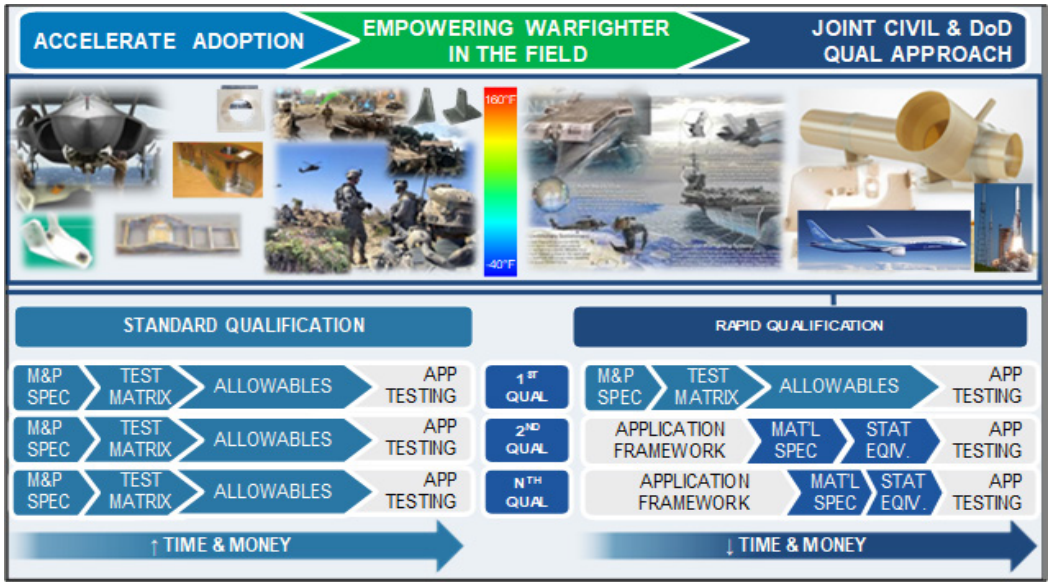
SUCCESS STORY 3026.004

Components used to develop AM ULTEM 9085 service guide for harsh environments

Material met requirements pertaining to surface flammability and rate of smoke generation



SLAM takes an application-driven approach, across a wide array of requirements, to understand the adoption areas for various material extrusion polymer-AM material systems to reduce material testing.

PROBLEM

Only recently have appropriate process controls been applied to three-dimensional (3D) printers with production floor readiness capabilities in mind. Publicly available data is limited to test results provided by material providers or printer original equipment manufacturers (OEMs), often reporting averages of limited test sampling, and ignoring low-performing specimens or the overall spread of data. The lack of reliable data is a barrier to the translation of additively manufactured (AM) parts into a production setting, leaving production applications vulnerable even when used in a non-load, non-critical application space. Additionally, until recently, no standard criteria or specification of printing was available for creating a reliable and understandable data set.

OBJECTIVE

The objective of this project was to deliver an open and comprehensive set of manufacturing tools to improve the rate of qualifying materials and part families. Another goal was to develop an application-driven framework to create material performance guidelines and service life predictive tools for manufactured components. The project sought to provide scalability from coupon level, combined with dataset interoperability, to further enable manufacturing technology implementations across relevant DoD services and their strategic/operational/tactical-level sustainment commands.

AMERICA MAKES TECHNOLOGY DEVELOPMENT ROADMAP

This project aligns to:

MATERIAL

ASTM PROCESS CATEGORY:
Material Extrusion

EQUIPMENT:
Fortus 400MC, Fortus 900MC, 3DP 400 Series, Mark Forged MII

MATERIAL
ULTEM 9085
Onyx FR
ABS

TECHNICAL APPROACH

The technical approach included two phases. Phase 1 involved the creation of a rapid qualification methodology built around a full set of environmental conditioning with extensive dynamic characterizations performed on ULTEM 9085. RP+M's AS9100-certified facility, used to generate the B-Basis Allowables for the previous UTLEM qualification, enabled the specimens and components to be analyzed without concern for unknown processing variables. Testing of the initial ULTEM 9085 specimens was conducted at the National Institute for Aviation Research (NIAR) and Auburn University. EWI's nondestructive evaluation (NDE) techniques captured failure mechanisms and degradation progressions by sampling specimens at different aging stages and cycles. The results of the characterization and NDE methods created a probabilistic framework with the intent to estimate service life reduction and determine the risk of using AM for the proposed environmental conditions.

Phase 2 of the program continued with the selection of two additional materials from the provided prioritized list based on requirements gathered at the beginning of the program. The selected materials were Onyx FR, a composite-based carbon fiber-filled nylon, and ABS, a thermoplastic polymer. Optimized ULTEM 9085, Onyx FR, and ABS specimens and components were sent through a scoped characterization effort (aging and NDE). This provided an opportunity to quantify the process optimization efforts captured in the service life guide, validate the predictive service life model, and demonstrate the efficiencies gained by exercising the rapid qualification methodology. Specimens were tested after being fabricated and exposed to various environmental conditions in accordance with the standards outlined in the approved test matrix. The materials were exposed to elevated and cold temperatures, chemical corrosion, and solar exposure. After designated exposure, the materials were subjected to a designated static or fatigue test depending on the specimens' respective geometries. Testing was performed using the setup requirements established per ASTM standards for each test type and geometry.

ACCOMPLISHMENTS

Testing and inspection of AM ULTEM 9085, Onyx FR, and ABS components were used to add entries to an existing service guide for materials in harsh environments. The project team effectively developed a predictive model that allows users to evaluate expected performance of AM materials under a wide range of conditions. These conditions include baseline material properties, build orientation, and environmental conditioning. The model development utilized the data generated during this program including mechanical test data, NDE data provided by EWI, and fractography imaging. All the data was then input into artificial intelligence (AI) and machine learning (ML) software supplied and performed by MSC Software to train a predictive model for public use. The plastic sheet material identified in this report meets the Federal Railroad Administration (FRA) and NFPA 130 requirements as they pertain to surface flammability and rate of smoke generation.

PROJECT END DATE

December 2021

DELIVERABLES

- Completed market requirements document by service branch
- Specifications for each material and process identified
- Process failure modes, effects analysis, and probabilistic framework
- NDE methods, fatigue test(s), and wear test(s) validated for austere environments
- Service guide outline with ULTEM 9085 initial service life results
- Supplemental dataset created for ULTEM 9085
- Final report

FUNDING

$1,477,122 total project budget
(1,056,840 public funding/$420,282 private funding)

PROJECT PARTICIPANTS

Project Principal:
National Institute for Aviation Research (NIAR)

Other Project Participants:
Auburn University
EWI
RP+M
ASTM International
Northrup Grumman
Lockheed Martin
Boeing
MSC Software

Public Participant:
U.S. Department of Defense