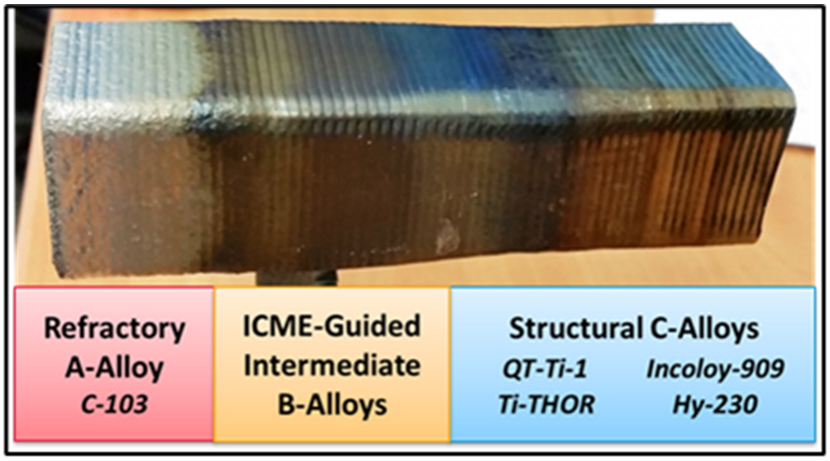
PROJECT SUMMARY 102575.000.5001.001.001.007

# Development of Graded Alloy Transitions for Hypersonic Systems




*GRaded Alloy Transition Development (GRATD) employs Integrated Computational Materials Engineering (ICME).*

## PROBLEM

Additive manufacturing (AM) is a proven valuable enabler for the rapid manufacture of complex assemblies. The Office of the Under Secretary of Research and Engineering's (OUSD R&E) Technology & Manufacturing Industrial Base in collaboration with the Assistant Director, Hypersonics have identified development of AM for high temperature metals as key to timely fielding of hypersonic capabilities, addressing shortfalls of traditional manufacturing processes which are often costly, low-yield, and labor intensive. Additionally, aero-thermal environments experienced by hypersonic vehicles require joining dissimilar materials to reduce weight and increase thermal/structural performance. Developments in AM techniques for the processing of high temperature and dissimilar material sets for hypersonic applications are needed to exploit the advantages of AM.

## OBJECTIVE

The objective of this program is to develop graded alloy transitions for hypersonic systems by demonstrating and validating the ability of AM techniques to achieve higher joint performance for a relevant material set compared to baseline processing/bonding method(s). This project seeks to combine Boeing's hypersonic design knowledge and AM experience, QuesTek's state-of-the-art integrated computational materials engineering (ICME) tools, and RPM Innovations proven powder feed direct energy deposition (DED) procedures and build parameters to develop additive-enabled leading and control fin edge transition joints.

**AMERICA MAKES TECHNOLOGY DEVELOPMENT ROADMAP**

This project aligns to:

MATERIAL

**ASTM PROCESS CATEGORY**
Directed Energy Deposition

**MATERIAL**
Niobium alloy tip (C-103), Nickel (Incoloy-909 and Hy-230),Titanium (Ti-THOR and QuesTek Ti-1)

## TECHNICAL APPROACH

The Boeing Company is leading the GRaded Alloy Transition Development (GRATD) project. Graded materials are being identified and down-selected using ICME tools. Non-equilibrium (Scheil) thermodynamic calculations are being performed along the gradient to assess the potential formation of undesirable phases (brittle intermetallic phases) during solidification, thermal exposures, or heat treatment. Other calculations are being performed to assess the additive manufacturability in terms of freezing range and cracking susceptibility coefficient. The selected transitional process(es) are being developed and base alloy properties determined. The graded transition interface and properties are being characterized using ICME to minimize costs and time associated with trial and error techniques.

Test specimens using the down-selected graded materials are produced once build quality issues such as cracking, stress deformation, and high porosity are resolved. The test specimens are fully machined to eliminate as-deposited surface effects when performing metallographic examinations and testing as well as analyzing property characterization, process parameters, and build variability to quantify transition region quality.

## PROJECT START DATE

April 2021

## EXPECTED END DATE

July 2022

## DELIVERABLES

- Annual briefing to America Makes members
- Final report

## FUNDING

**$844K total project budget**
($466K public funding/$378K private funding)

## PROJECT PARTICIPANTS

**Project Principal:**
The Boeing Company

**Other Project Participants:**
QuesTek Innovations LLC
RPM Innovations Inc. (RPMI)

**Public Participants:**
U.S. Department of Defense