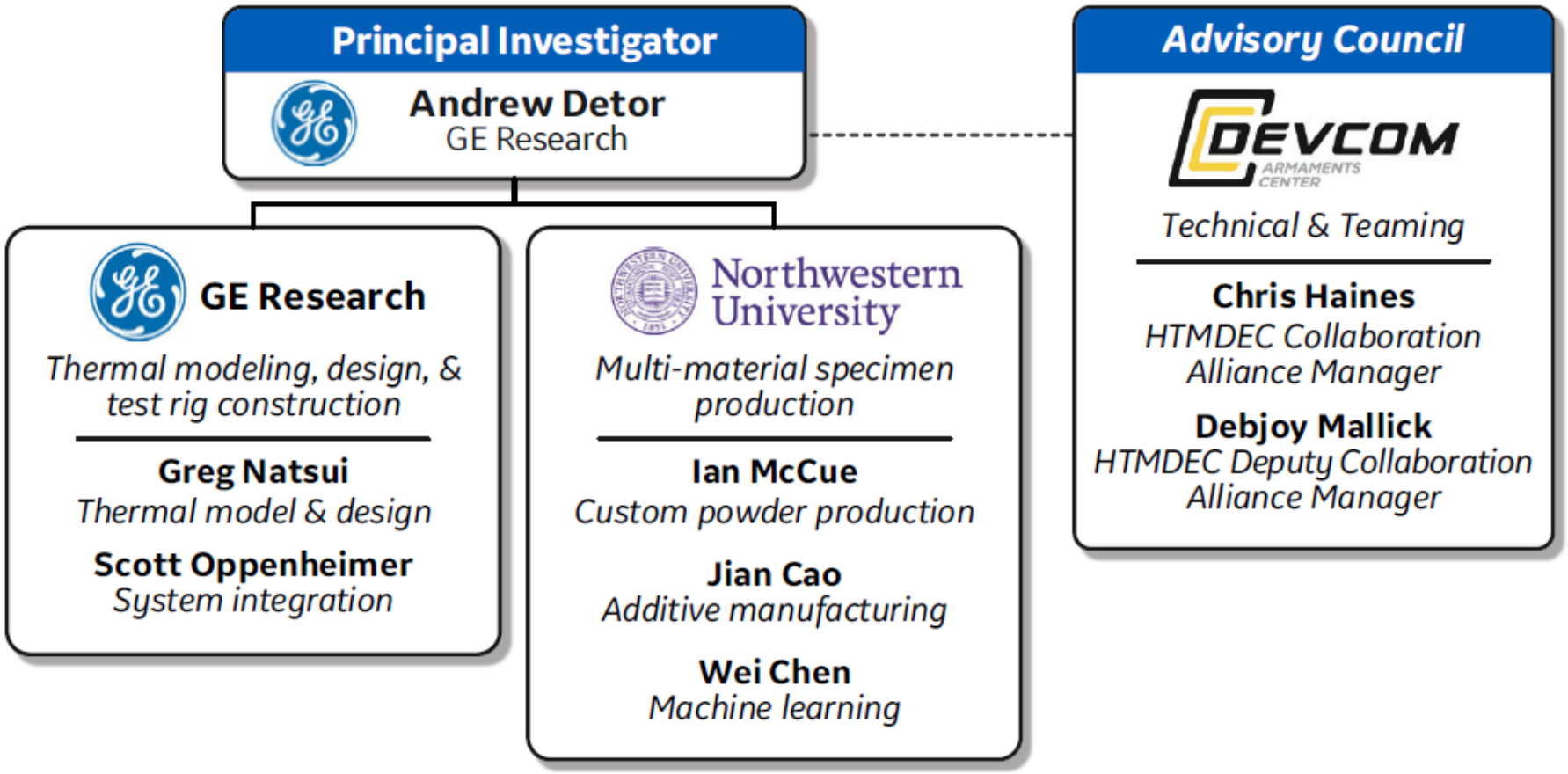
Design and Construction of a High Throughput Oxidation Screening Test (HOST)

DEVCOM - Army Research Laboratory
High Throughput Materials Discovery for Extreme Conditions (HTMDEC)
“High Throughput Characterization” General Thrust; Seeding Effort

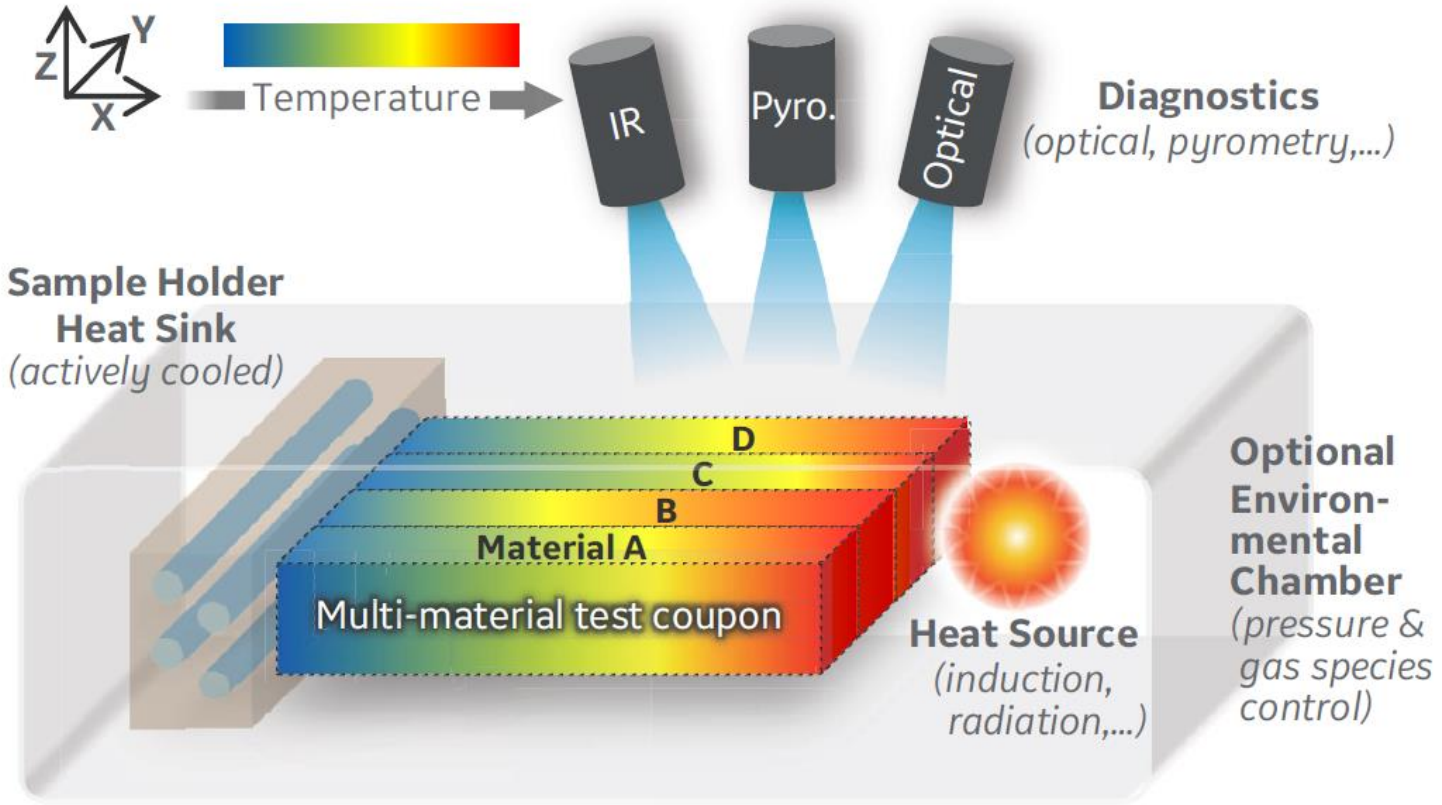
Principal Investigator: Andrew Detor, Senior Principal Scientist, GE Research
July 12, 2022

HOST Team and Responsibilities



Program Objective

Design, build, and validate a new method to rapidly screen the oxidation performance of metal alloys for extreme service conditions



Technical Approach

- Multi-material test coupon with steady-state temperature gradient
- Atmosphere control
- Real time diagnostics
- Data collection process built for analytics and machine learning

Technical Challenges

- Production of high-quality refractory powders
- Additive manufacturing of multi-material specimens
- Producing steady-state temperature gradient in desired range
- Interpreting real time diagnostic streams

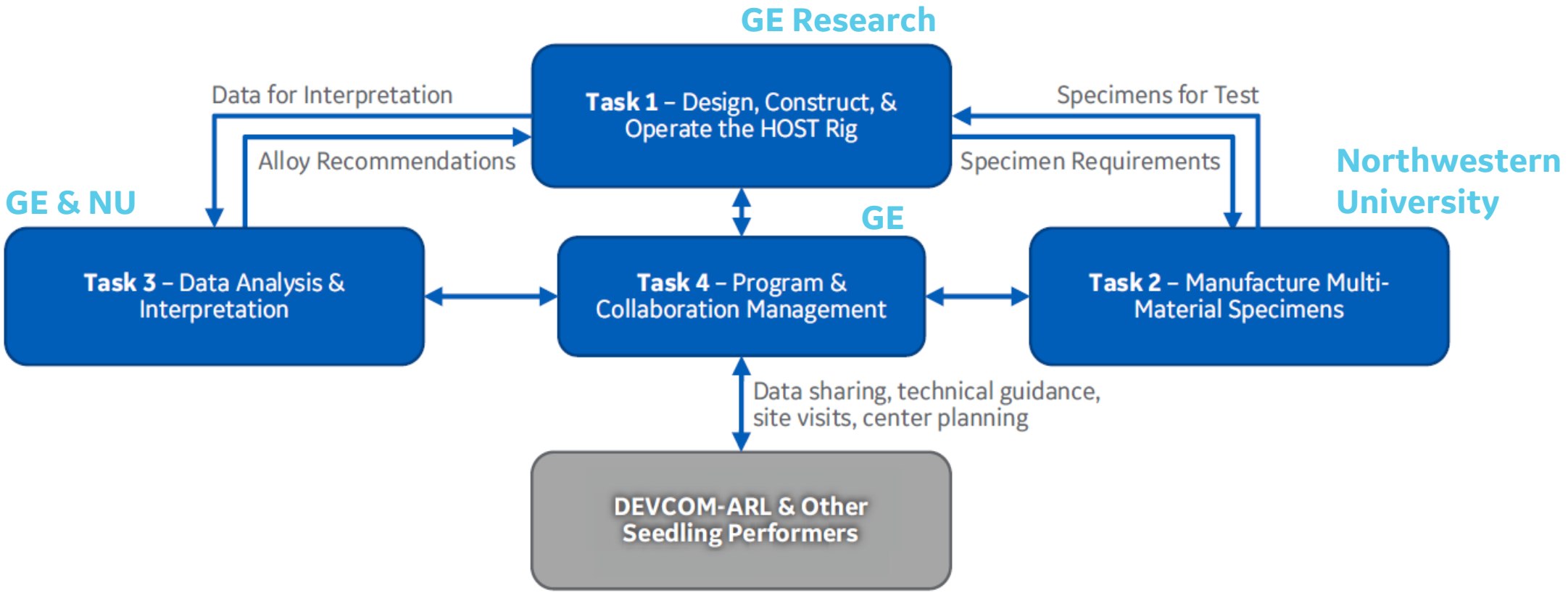
Step Change Relative to State-of-the-Art Oxidation Testing

Conventional commercial bottom load furnace cycle test (FCT) furnace considered as a state-of-the-art benchmark

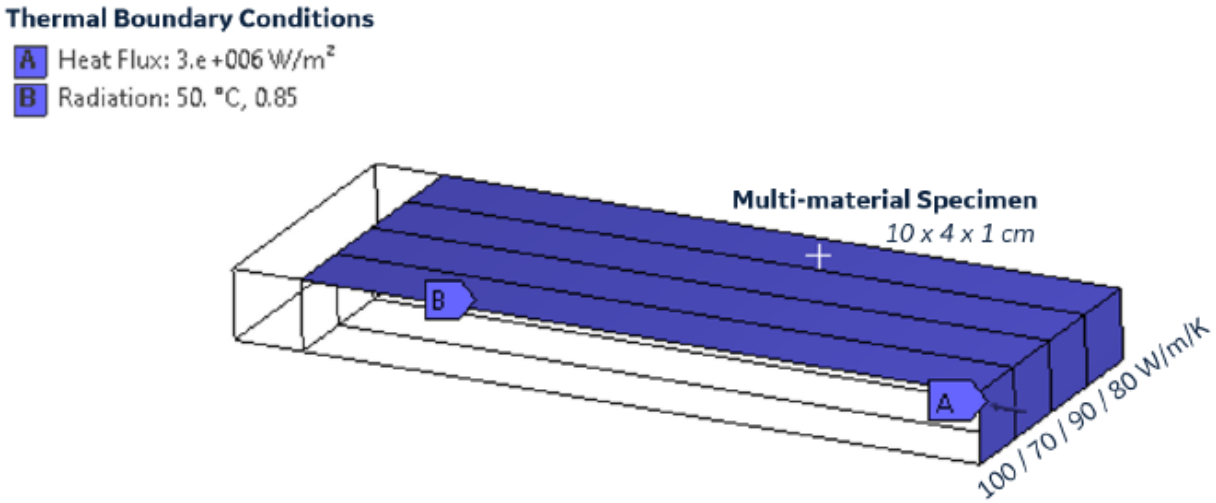
Metric	Current Limits	HOST Goals	Solution Approaches
Throughput (time-temp-material points/week)	8	≥40*	Multi-material additively manufactured specimen
Maximum Temperature (°C)	1600°C	2200°C+	Non-contact radiative/ induction heating
Temperature Range (°C)	Single temp.	1000°C+ gradient	Actively cooled sample holder
Environment	Lab air	Tunable gas species and pressure	Controlled environment chamber
In-situ Diagnostics	None	Real-time temp, emissivity, visual inspection	Optical & IR cameras, multi-wavelength pyrometer

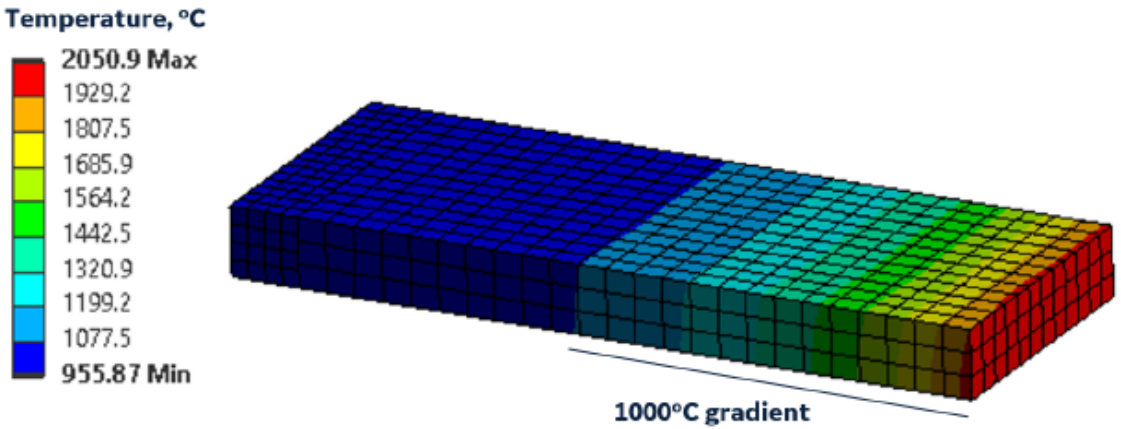
**Assumes 10 discrete temperature points along a 4-material sample as proof-of-concept; can be expanded to more materials and/or temperature points in the future.*

Program Task Structure and Relationships



Preliminary Thermal Simulation and Early Challenges

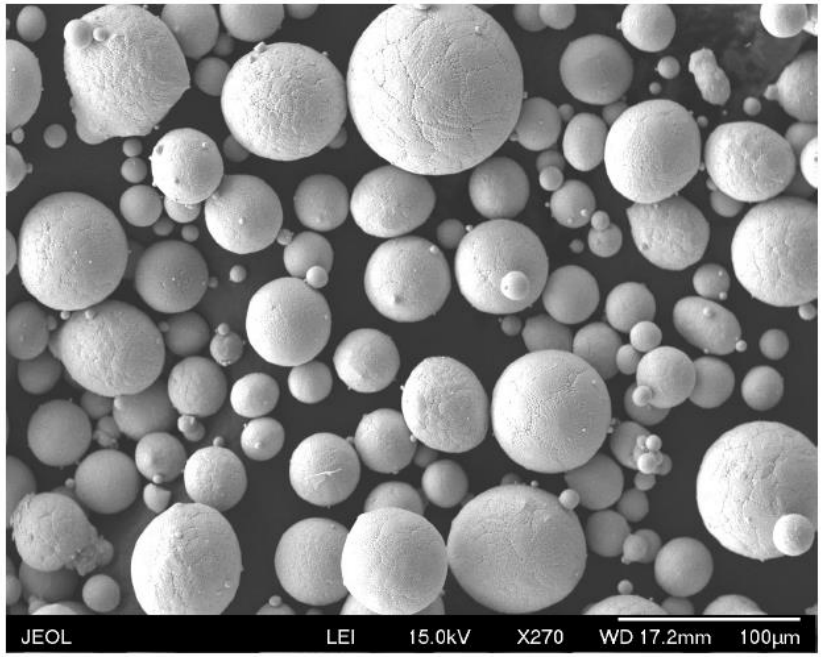




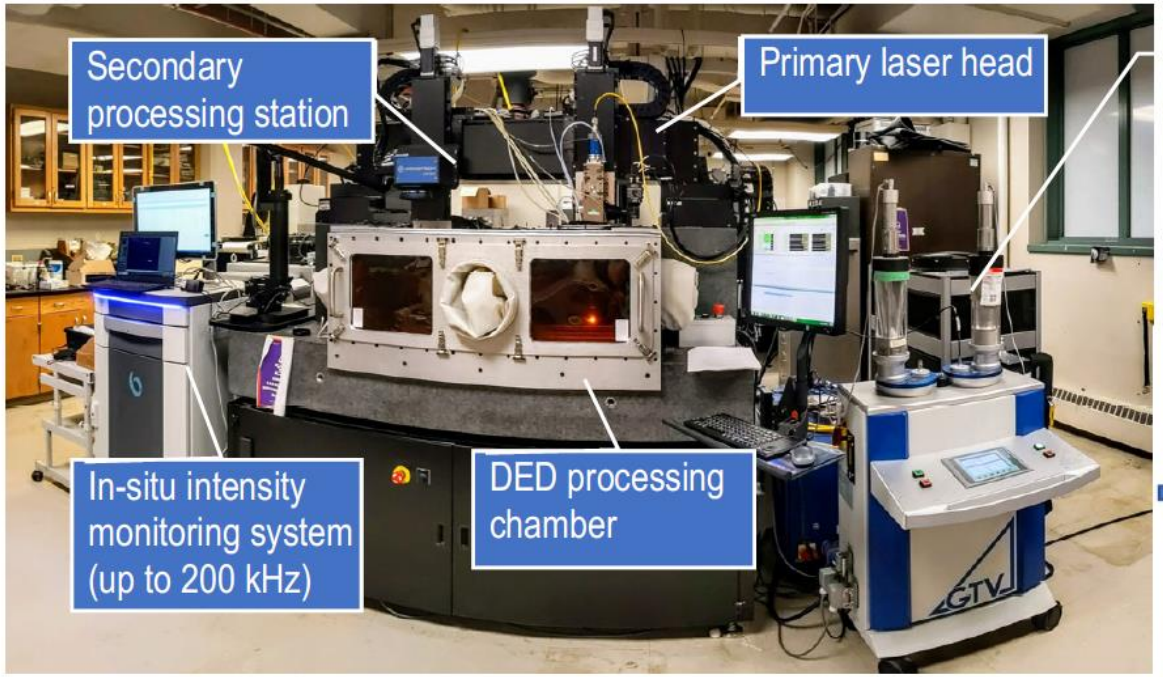
- Thermal model of a multi-material specimen with thermal conductivity ranging from 70-100 W/m-K
- Includes a heat source ($3x10^6$ W/m^2) and radiative heat loss (0.85 emissivity assumed)
- Significant radiative loss biases temperature gradient to the hot end – will be managed through **detailed specimen design** on program and the inclusion of **secondary heat sources and/or reflectors as needed**

Multi-Material Specimen Manufacturing

Powder Produced Using NU's Atomizer (Example of $Ti_{40}Ta_{60}$)



Additive Rapid Prototyping Instrument (ARPI) at Northwestern University

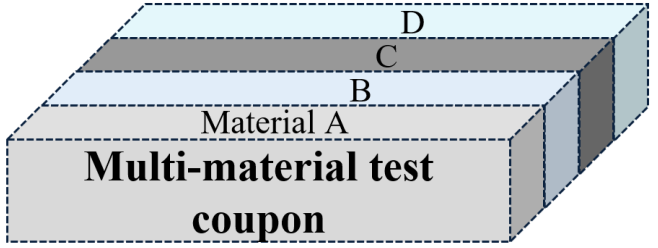


Existing two hoppers

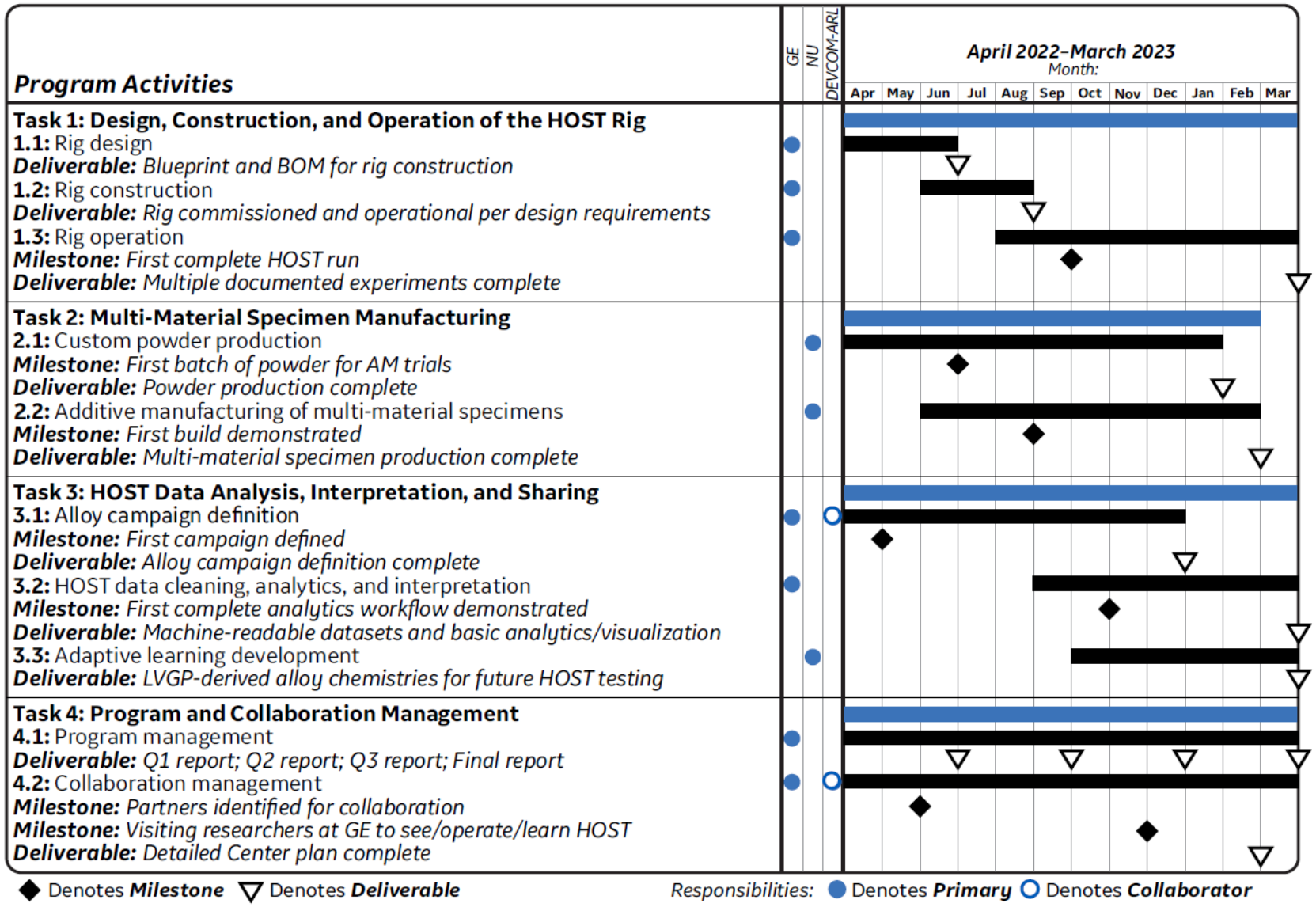
+ New two hoppers

× 2

Northwestern will produce custom metal alloy powder and build multi-material test coupons per GE's design



Project Schedule , Milestones, and Deliverables



Key Early Milestones/Deliverables

1.1: Blueprint and BOM for HOST rig (mo. 3)
1.2: Rig commissioned and operational (mo. 5)

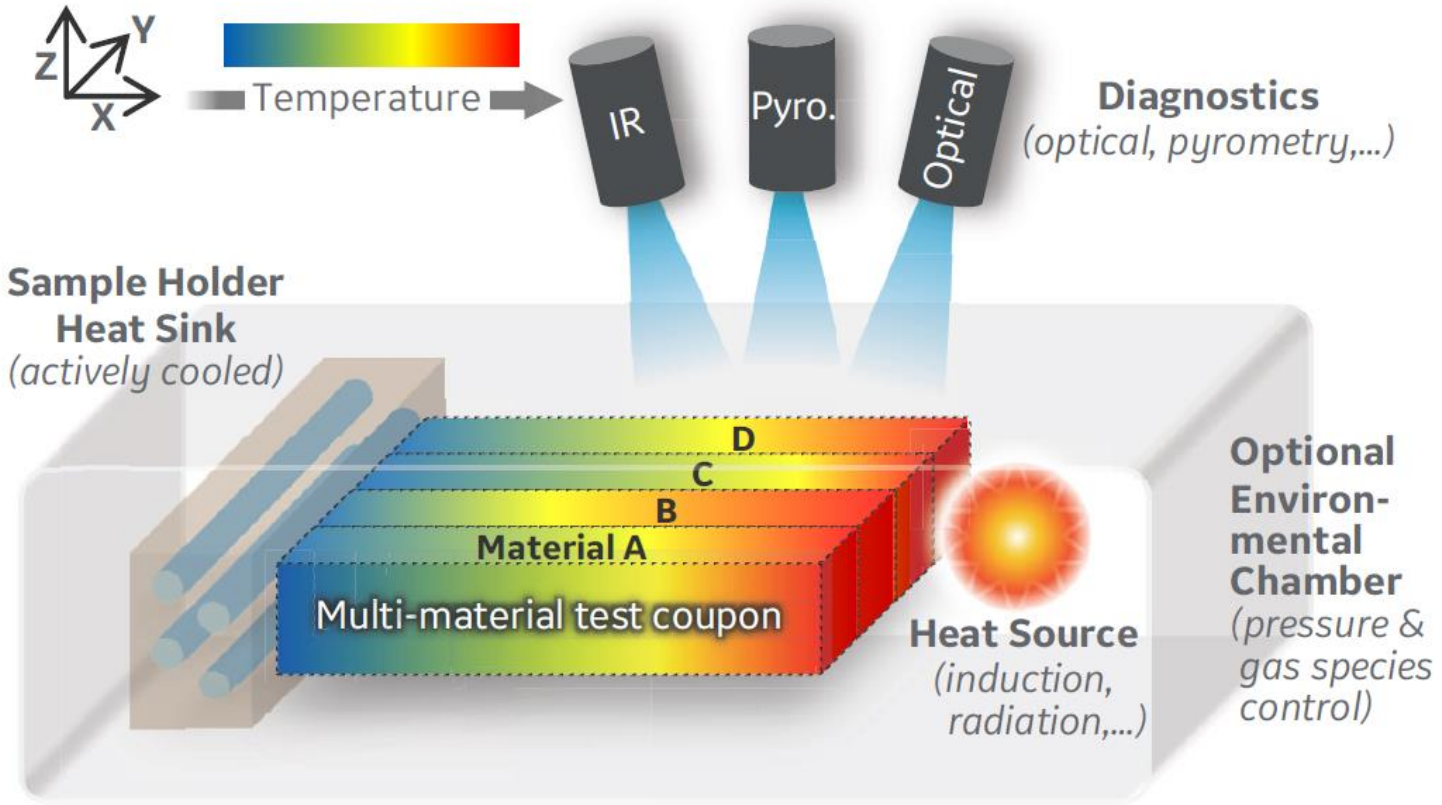
2.1: First batch of powder processed (mo. 3)
2.2: First multi-material specimen built (mo. 5)

3.1: First alloy campaign defined (mo. 1)
3.2: Complete test workflow demonstrated (mo. 7)

4.2: Partners identified for collaboration (mo. 2)

Program Objective

Design, build, and validate a new method to rapidly screen the oxidation performance of metal alloys for extreme service conditions



Technical Approach

- Multi-material test coupon with steady-state temperature gradient
- Atmosphere control
- Real time diagnostics
- Data collection process built for analytics and machine learning

Technical Challenges

- Production of high-quality refractory powders
- Additive manufacturing of multi-material specimens
- Producing steady-state temperature gradient in desired range
- Interpreting real time diagnostic streams

Building a world that works