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August 13, 2020

Re:	Technical Assistance Request for *American-Made Geothermal Prize*
Submission Title:	*Additively Manufactured Mechanical Metamaterials for Improving EGS Survivability in the Downhole Environment*
Principle Team:	Jesse Silverberg, PhD; Arthur Evans, PhD; Prajwal Bharadwaj, MS

To whom it may concern,

In our submission to the *American-Made Geothermal Manufacturing Prize Competition*, we plan to use a mix of in-house F&E and external resources to successfully demonstrate the impact of our technical innovation. The three external resources we seek through the National Lab system, private facility, or member of the American-Made Network are:

1. Additive manufacturing of metals, specifically steel and Inconel,
2. Access to subject matter experts (SMEs) with experience in geothermal drilling,
3. Assistance in field testing our innovation in downhole geothermal conditions.

Assistance from the Prize Administrator in broadcasting this request will help lower barriers and increase the speed we can drive this project forward. Specifically:

Additive manufacturing of metals, specifically steel and Inconel

Metal AM is significantly more challenging than AM with thermoplastics or composites. In part, this is due to the additional step of a post-print "sintering" that debinds "green matrix" from metallic grains and fuses the body into a solid mass. In addition to inducing shrinkage, sintering creates thermomechanical stress gradients that can fracture the AM metal part before it finishes. In-house, we can develop pre-prototypes with AM metal copper and conduct in-house sintering on relatively small test parts in an open-air furnace. We have also run tests on AM 6061 aluminum and 17-4 steel with various vendors and equipment. For this competition, we want to maximize our chances of success and therefore request access to AM facilities specializing in AM metal. For example, facilities with a Desktop Metal or Markforged MetalX metal AM equipment is desired. Between these two systems, 17-4 stainless steel and Inconel 625 are feasible. In addition, facilities with high-temperature sintering equipment would allow us to utilize filament produce by The Virtual Foundary, expanding our prototypes to allow for Inconel 718.

Access to subject matter experts with experience in geothermal drilling

We routinely reach out to SMEs to discuss projects and to establish parameters for comparative simulations used to benchmark our technology against conventional alternatives. In 2020, we began developing our network of contacts in geothermal energy and are constantly seeking to meet more SMEs. Expanding this network is crucial for our project success as we ultimately seek to commercialize the technology we are developing and to contribute to the value chain of drilling equipment manufacturers. Introductions to engineers, product developers, and R&D staff at these OEMs is best done through networking opportunities, and we seek assistance in initiating these conversations/interactions to lay the foundation for downstream commercial development.

Assistance in field testing our innovation in downhole geothermal conditions

We have in-house mechanical testing capabilities up to 250 kN at 1,000°C, which exceeds the extreme pressures and temperatures found downhole during geothermal drilling. While uniquely beneficial for our work, these lab-scale tests are no substitute for the true downhole environment where pressure-temperature loading conditions are mixed with a corrosive chemistries and encounters with heterogeneous, hard rock environments. As we proceed through successive rounds of the competition, we ultimately seek to demonstrate our technical abilities in downhole field-tests. We therefore seek assistance in planning a safe, rigorous, and thorough field test to demonstrate TRL 9 readiness at the final phase of the competition.

We look forward to working with our future partners as we advance our technology through the accelerated timeline of the geothermal manufacturing competition.

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