I/UCRC Executive Summary - Project Synopsis	**Date**: March 2019

Center/Site: CANFSA/Colorado School of Mines

Tracking No.:36-L: Rationalization of Liquid/Solid and Solid/Solid Interphase Instabilities During Thermal – Mechanical Transients of Metal Additive Manufacturing	**Phone:** (303) 990–0939	**E-mail:** asaville@mymail.mines.edu

Center/Site Director: CANFSA/M. Kaufman/P. Collins/A. Clarke	**Type: (Continuing)**
Project Leader: Alec Saville	**Proposed Budget**: $320K Leveraged

Project Description: Solidification behavior in additive manufacturing (AM) is more complex than standard casting solidification behavior, due to the evolution of spatial and thermal transients evolving during a build process. Here, instabilities during solidification and microstructural evolution of electron beam melted Ti-6-4 and Inconel 738 are being analyzed to gain a better insight into how temperature gradients, solute dispersion and other factors play into solidification behavior and ultimately material performance. Primarily focused on fundamental research, this project aims to identify key areas of interest in additive manufacturing processes that can be further explored to refine the properties and performance of materials made via this method. This project is part of a Multidisciplinary University Research Initiative (MURI) involving five universities, the US Navy, and the Australian DOD.

Experimental plan: To evaluate the influence of spatial and temporal instabilities, several experiments are planned and/or already underway. Bulk and local texture analysis via neutron diffraction at the HIPPO neutron diffraction beamline at Los Alamos National Laboratory is being completed to analyze texture evolution for various build strategies. Experiments at the Advanced Photon Source (APS) using the AM simulator and observing solidification behavior *in-situ* are planned. APS experiments will focus on nickel and titanium alloys, aiming to observe solidification behavior, phase transformations, and any orientation dictated phenomenon pertinent to the alloys used.

Related work elsewhere: Other institutions involved in the MURI will be supporting this project with simulations, *ex-situ* crystallographic analysis, and developing new techniques for *in-situ* transmission electron microscopy (UT, Virginia Tech, OSU, ISU). Other studies on texture evolution during AM have thus far been limited in scope, only analyzing local texture evolution rather than throughout the entirety of the build volume and for different scan strategies.

How this project is different: This project analyzes AM build processes via characterization and analysis techniques seldom used before. These include full-specimen height texture profiles via neutron diffraction and simulating AM conditions with *in-situ* X-ray radiography and diffraction.

Milestones for the current proposed year: Calculate prior beta-Ti texture from alpha-Ti orientation distribution functions (ODF), characterize Ti-6Al-4V samples, rationalize texture findings via characterization, and begin Inconel 738 texture/characterization experiments.

Deliverables for the current proposed year: Publish work on neutron diffraction texture data, present at the Additive Manufacturing and Powder Metallurgy (AMPM) conference, present at bi-weekly MURI status-update meeting, and provide a presentation at the annual MURI meeting in Fall 2019.

How the project may be transformative and/or benefit society: Qualification of AM materials is highly needed for the production of parts; rationalizing instability evolution will provide a new level of insight into microstructure - processing relationships in AM.

Research areas of expertise needed for project success: Access to neutron diffraction equipment, access to AM simulator with *in-situ* x-ray radiography and diffraction, access to Material Analysis Using Diffraction (MAUD) software, access to microscopy equipment equipped with energy dispersive spectroscopy (EDS), and electron backscatter diffraction (EBSD).

Potential Member Company Benefits: Rationalization of interfaces will lead to drastic improvements in AM production and certification of parts, which are ideal for aerospace and performance-driven applications.

Progress to Date: Bulk and local neutron diffraction experiments have been completed. Data from both sets of experiments has been processed, and is in the process of being explained. Characterization training for Ti-6Al-4V specimens and IN 738 is ongoing.

Estimated Start Date: Fall 2018	**Estimated Knowledge Transfer Date**: May 2022

The Executive Summary is used by corporate stakeholders in evaluating the value of their leveraged investment in the center and its projects. It also enables stakeholders to discuss and decide on the projects that provide value to their respective organizations. **Ideally, the tool is completed and shared in advance of IAB meetings to help enable rational decision making.**