I/UCRC Executive Summary - Project Synopsis	**Date**: September 14, 2018

Center/Site: CANFSA/Colorado School of Mines

Tracking No.: 29-L: Identification of Deformation Mechanisms of Thermally Stable Cast Al-Cu Alloys via Neutron Diffraction	**Phone :** (906) 370-9057	**E-mail :** bmilliga@mines.edu

Center/Site Director: CANFSA/M. Kaufman/P. Collins/A. Clarke	**Type:** Continuing
Project Leader: Brian Milligan	**Proposed Budget**: $240,000

Project Description: Cast Al-Cu alloys are an industrially relevant system due to low cost, high strength, and ease of manufacture. This project aims to study the mechanical properties and phase transformations in various as-cast and aged Al-Cu alloys, including thermally stable alloys developed at Oak Ridge National Laboratory (ORNL). In particular, deformation mechanisms will be identified and quantified over a large range of temperatures and microstructures at the grain scale, precipitate transformation will be observed by advanced characterization techniques, and relevant experimental data will be combined with modeling results to obtain new knowledge about the mechanical behavior of these alloys.

Experimental plan: Neutron diffraction at ORNL's Spallation Neutron Source (VULCAN beamline) will be used to observe the grain-level deformation mechanisms *in situ*. Transmission X-ray microscopy (TXM) at Argonne National Lab's Advanced Photon Source will be used to observe the precipitates and their evolution during aging. Transmission electron microscopy (TEM) will be implemented to observe fine-scale precipitate morphology pre- and post-mechanical testing. Constitutive modeling will be implemented to quantify deformation mechanism changes. Creep testing at ORNL will also be performed.

Related work elsewhere: A. Shyam's group (ORNL) is studying the mechanical behavior and phase transformations in the same alloys *ex situ*. N. Chawla's group (Arizona State University) is studying phase transformations of Al-Cu alloys *in situ*. C. Hutchinson's group (Monash University) is modeling deformation behavior of Al-Cu alloys from first principles.

How this project is different: This project connects phase transformations to temperature-dependent mechanical properties and enables the testing of new, thermally stable Al-Cu alloys. It will also bridge modeling efforts and *in situ* experimental methods.

Milestones for the current proposed year:
- Continue the development of a model for precipitate-related anisotropy in strain hardening;
- Perform additional TEM to observe sheared precipitate interfaces;
- Perform TXM experiments at the Advanced Photon Source;
- Continue creep testing at ORNL.

Deliverables for the current proposed year:
- Prepare and submit a journal article on precipitate-related anisotropy in strain hardening;
- Submit a journal article on 300 °C creep behavior in relevant alloys;
- Give talk at MS&T 2018;
- Give CANFSA talks and write CANFSA reports.

How the project may be transformative and/or benefit society: Understanding of temperature- and microstructure-dependent deformation mechanisms and phase transformations can be used to improve the mechanical properties of these alloys. This may allow for improved performance of relevant applications, including improved efficiency in cylinder heads for light duty engines.

Research areas of expertise needed for project success: Mechanical properties of metals, including dislocation behavior and strain hardening, kinetics of metastable phase formation and growth, and advanced characterization techniques such as neutron, electron, and X-ray diffraction and imaging.

Potential Member Company Benefits: This work may be applied directly to transportation/automotive applications; several alloys being studied are intended for cylinder head applications. High strength, thermally stable, low-cost Al alloys are also of interest to CANFSA's aerospace members.

Progress to Date: *In situ* neutron diffraction during tension and creep of various alloys, aging conditions, and temperatures; TEM of various alloys and aging conditions; creep testing at 300° and 350°C in various alloys; modeling of strain hardening phenomena.

Estimated Start Date: Fall 2017	**Estimated Knowledge Transfer Date**: Spring 2021

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.**