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

Center/Site: CANFSA/Colorado School of Mines

Tracking No.: 33a-L: In-situ Studies of Strain Rate Effects on Phase Transformations and Microstructural Evolution in β-Titanium Alloy	**Phone:** (720) 272-9125	**E-mail:** bellyson@mines.edu

Center/Site Director: M. Kaufman/P. Collins/A. Clarke	**Type: (Continuing)**
Project Leader: Benjamin Ellyson	**Proposed Budget**: $240,000, Leveraged

Project Description: This project aims to study the deformation mechanisms and microstructural evolution in metastable β-titanium alloys as a function of strain rate and composition to formulate an alloy design methodology for tailoring mechanical performance for blast resistance. Specifically, transformation and twinning induced plasticity (TRIP & TWIP) effects are the main focus of this project, as they allow for high work-hardening and uniform elongation, without compromising strength.

Experimental plan: Multiple alloys of varying compositions will be mechanically tested in different microstructural states during quasi-static and dynamic deformation. Material will be characterized pre- and post-deformation with state-of-the-art techniques to understand the dependencies of TRIP and TWIP effects on intrinsic and extrinsic factors. This understanding will be used to inform the design methodology by means of analytical and numerical methods.

Related work elsewhere: Experiments will be carried at the Advanced Photon Source at Argonne National Laboratory, Las Alamos National Laboratory, CHESS at Cornell University and Lawrence-Livermore National Laboratory.

How this project is different: Concurrent efforts by other groups have only utilized existing design methods to develop new alloys and only examine quasi-static deformation. This project is the first to propose a full-cycle study with the aim of producing and validating a design methodology aimed at specific applications, such as blast resistance.

Milestones for the current proposed year: Comparison of the TRIP/TWIP behavior and work hardening of metastable β-Titanium alloys in compression and tension as a function of strain rate and β grain size is planned. High-rate in-situ and post-mortem tests (Kolsky bar) of Ti-1023 and Ti-15Mo are planned to gain understanding of the strain-rate dependencies of TRIP/TWIP deformation mechanisms.

Deliverables for the current proposed year: The role of ω-phase on TRIP and work-hardening of Ti-1023 will be analyzed. A mechanism for controlling TWIP in Ti-15Mo will also be explored. A mechanistic model of deformation mechanisms (TRIP/TWIP/slip) and microstructural evolution as a function of testing conditions will also be explored.

How the project may be transformative and/or benefit society: Lightweight, blast resistant armor and crash-resistance structures are a major concern for defense applications, while increased formability will greatly extend the applicability of these alloys to more complex, plastically formed parts.

Research areas of expertise needed for project success: Mechanical testing and microstructural characterization (optical, electron microscopy, x-ray diffraction), in-situ studies during deformation at national user facilities, alloy design and material processing and fabrication.

Potential Member Company Benefits: The design methodology will permit the mechanical behavior of novel alloys to be tailored to specific applications. Increased formability of alloys studied would extend potential applications. Third, greater understanding of TRIP & TWIP effects will lead to better manufacturability and improved design tolerances. It is anticipated that these results will be of interest to CANFSA's members interested in aerospace and defense applications.

Progress to Date: Quasi-static and intermediate strain rate tensile testing has been completed at Mines on Ti-1023 and Ti-15Mo. Transmission electron microscopy of deformed material to understand to microstructural evolution as a function of strain rate is in progress. During February 2019 at the APS, in-situ Kolsky bar testing was conducted on Ti-1023, Ti-15Mo, Ti-35Zr-10Nb and TiZrNb. Data is currently being analyzed. Aging of Ti-1023 has been characterized and found to lead to significant strengthening, without significant loss of ductility.

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.**