I/UCRC Executive Summary - Project Synopsis	**Date**: April 3, 2018

Center/Site: CANFSA/Colorado School of Mines

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

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

Project Description: Investigate the deformation mechanisms and microstructural evolution in metastable β-titanium and multi-principal element alloys (MPEAs) as a function of deformation pathway, processing and composition to formulate an alloy design methodology. 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. These alloys present potential blast and crash resistance due to high absorbed-energy, as well as increased formability due to high uniform elongation.

Experimental plan: Multiple alloys of varying compositions will be mechanically tested in different microstructural states produced by thermo-mechanical processing. Characterization of the samples will occur before, after and during deformation 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: The high-rate compressive and tensile deformation behavior of metastable β-titanium alloys is sparse to non-existent in the literature. Limited studies have started to explore the role of strain rate on compression, but not at high rates or in tension.

How this project is different: Concurrent efforts by other groups have only utilized existing design methods to develop new alloys. 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: Characterization of TRIP and TWIP effects in Ti-1023 and Ti-15Mo and dependencies on strain-path, strain rate, temperature, prior processing and microstructure (Feb 2019). In-situ characterization of microstructural evolution during high rate deformation of both alloys (Dec 2018). In-situ study of TRIP & TWIP effects of Ti-15Mo by TEM (May 2019).

Deliverables for the current proposed year: Model describing dependencies of TWIP and TRIP in Ti-1023 and Ti-15Mo as a function of heat-treatment and deformation conditions, specifically compression, tension and high-rate deformation. Mechanical testing and in-situ and post-mortem characterization will be performed this year.

How the project may be transformative and/or benefit society: Lightweight, blast resistant armor and crash-resistance structural component 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, advanced electron microscopy, x-ray diffraction), in-situ studies during deformation at national user facilities, analytical and numerical material modeling, alloy design and material processing and fabrication.

Potential Member Company Benefits: The benefits will be threefold: First, the design methodology will permit the mechanical behavior of novel alloys to be tailored to specific applications. Second, increased formability of alloys studied would extend potential applications. Third, greater understanding of TRIP & TWIP effects will lead to better manufacturability and improved end-user 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: Initial high-throughput compression studies of Ti-1023 are near completion. This study aims to determine the effect of heat treatment on TRIP and TWIP effects in compression to produce promising heat treatments for upcoming tensile and strain rate studies. Compression tests have been performed and microstructural characterization is underway.

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