I/UCRC Executive Summary - Project Synopsis		Date: April 2020
Center/Site: CANFSA/Colorado School of Mines		
Tracking No.: 33B-L: In-situ Studies of Strain Rate Effects on Phase Transformations and Microstructural Evolution in Multi-Principal Element Alloys	**Phone:** (469) 222-3811	**E-mail:** jacopley@mymail.mines.edu
Center/Site Director: M. Kaufman/P. Collins/A. Clarke		**Type: (Continuing)**
Project Leader: John Copley		**Proposed Budget**: $240,000, Leveraged

Project Description: Investigation of the deformation mechanisms and microstructural evolution in multi-principal element alloys (MPEAs) as a function of deformation pathway, processing and composition to formulate an alloy design methodology for blast resistance. Specifically, transformation and twinning induced plasticity (TRIP & TWIP) effects in MPEAs are the main focus of this study, as TRIP/TWIP behavior results in high work hardening rates, staving off mechanical instability and resulting in increased strength and uniform elongation. These alloys present potential blast and crash resistance, due to high toughness.

Experimental plan: Alloys of varying compositions will be mechanically tested in different microstructural states during quasi-static and dynamic deformation. Characterization of the samples will occur before, after and during deformation with state-of-the-art techniques to understand the dependencies of TRIP and TWIP effects on intrinsic and extrinsic factors, such as alloy composition, temperature and strain rate. This understanding will be used to inform the design methodology by means of analytical and numerical methods.

Related work elsewhere: Studies of strain effects on MPEAs exist only for a small range of tensile strain rates, but little literature explores large ranges of strain rate, especially the high strain rates (10^3 s^{-1} and greater) achieved by Kolsky bar and gas gun experiments. Other work also predominantly focuses on true HEAs, alloys with 5 or more elements, and equiatomic compositions.

How this project is different: This study will explore both larger ranges of strain rates and strain states than existing work, and will not constrain alloy design to high entropy alloys specifically, allowing for a larger design space.

Milestones for the current proposed year: Observation of TRIP behavior in-situ during high rate and quasi-static deformation. Characterization of the effects of alloying and temperature on the dominant deformation mechanism and degree of transformation (for TRIP behavior) in CoCrNi MPEAs.

Deliverables for the current proposed year: Model describing dependencies of TWIP and TRIP in CoCrNi as a function of deformation conditions and alloying. Mechanical testing, in-situ and post-mortem characterization will be performed this year.

How the project may be transformative and/or benefit society: The high work hardening rates associated with TRIP/TWIP behavior allows for both increased formability and strength in an alloy, allowing for the potential development of blast resistant structures with designed deformation mechanisms.

Research areas of expertise needed for project success: Microstructural characterization by means of optical and electron microscopy, X-ray diffraction, quasi-static mechanical testing and thermo-mechanical processing at Mines, in-situ deformation studies at national user facilities, alloy design and material fabrication.

Potential Member Company Benefits: TRIP/TWIP materials show promise for desirable strength/ductility combinations. This study will allow for better understanding of TRIP/TWIP behavior in lightweight non-ferrous alloys, leading to improved alloy design, manufacturability, and the potential for tailored microstructures and deformation mechanisms.

Progress to Date: TRIP behavior has been evidenced in a CoCrNi alloy. Experiments at the Advanced Photon Source have shown evidence of crystalline refinement, likely as a result of TWIP behavior. Simulations to predict better sample thicknesses for improved diffraction results have been performed. Material has been made by arc melting to allow for mechanical testing in the near term.

Estimated Start Date: Fall 2018	**Estimated Knowledge Transfer Date**: Summer 2020

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.**