I/UCRC Executive Summary - Project Synopsis	**Date**: October 2021
Center/Site: CANFSA/Colorado School of Mines	
Tracking No. 55-L: Fe-Containing Multi-Principal Element Alloys for Protective Structures	**E-mail :** jfrishkoff@mines.edu **Phone :** 215-475-7429
Center/Site Director: CANFSA/M. Kaufman/P. Collins/A. Clarke	**Type: (Continuing)**
Project Leader: James Frishkoff	**Proposed Budget**: $160K

Project Description: Recently, a family of iron-rich dual-phase multi-principal element alloys (Fe DP-MPEAs) have been reported that exhibit high work hardening rates, ultimate tensile strengths (>1 GPa) and ductilities (>50% strain to fracture). These properties are the result of combined transformation- and twinning-induced plasticity. This project will employ a multi-factor thermodynamic screening method to attempt to develop Fe DP-MPEAs with desired mechanical properties, while reducing the content of expensive alloying elements like Co.

Experimental plan: A computational screening process will be implemented to assess compositions for several performance metrics. Six alloys will be selected and prepared in an arc melter at Mines. These samples will be subjected to Gleeble tensile and compression testing at a variety of strain rates and temperature conditions to assess microstructural evolution and mechanical response. These samples will also undergo pre- and post-deformation microstructural characterization. Samples of three industrially produced alloys will also be prepared and subjected to the same mechanical testing regimen. The data from these tests will act as a benchmark for the microstructural response and mechanical performance of the new Fe DP-MPEAs.

Related work elsewhere: Metastable DP-MPEAs are a topic of active interest. Centers for related work include University of North Texas (R. Mishra & R. Banarjee), Massachusetts Institute of Technology (C. Tasan), Max-Planck-Institut für Eisenforschung in Germany (D. Raabe), and POSTECH in Korea (Y.H. Jo).

How this project is different: Other studies have generally not focused on improving the yield strength of these materials, which is often relatively low. Most reported mechanical behavior for MPEAs is either room temperature quasi-static tension or fracture toughness, so reporting elevated temperature & strain rate data is a novel addition to the field. The focus in this study on the elimination of cobalt is also novel, as most reported DP-MPEAs are ≥9 at.% Co.

Milestones for the current proposed year: Identify and prepare samples of six compositions. Perform Gleeble testing and microstructure characterization of three industrially-produced baseline alloys.

Deliverables for the current proposed year: A report detailing the microstructural evolution and of three baseline alloys under a range of strain rates and deformation temperatures. The six down-selected alloy compositions will also be reported for the next reporting period.

How the project may be transformative and/or benefit society: Materials with both high ductility and tensile strength are desired for a number of applications, including automotive crash structures and structures for blast and ballistic protection. Obtaining this property combination in alloys with reduced alloying element cost expands the number of applications which may take advantage of these properties.

Research areas of expertise needed for project success: Competency on an arc melting furnace for rapid sample preparation, competency in programming test profiles in a Gleeble thermomechanical processing simulator, Thermo-Calc thermodynamic modeling software.

Potential Member Company Benefits: Developing understanding of MPEA design and mechanical behavior will allow companies to be early adopters of novel alloying concepts.

Progress to Date: Several candidate compositions have been identified so far. The arc melter has been delivered to campus, and is awaiting a commissioning and training visit from the vendor. Large samples of industrial baseline alloys have been sourced from ATI. This material has been sent to an outside shop for sectioning and machining.

Estimated Start Date: Spring 2021	**Estimated Knowledge Transfer Date**: Spring 2023

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.**