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

Center/Site: CANFSA

Tracking No.: 17: Development of Advanced Nickel-Titanium-Hafnium Alloys for Tribology Applications	**Phone :** (614)313-3371	**E-mail :** seanmills@mines.edu

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

Project Description: This project is designed to elucidate the effect of hafnium ternary alloying on the metallurgy and bearing element performance in Ni-Ti-Hf alloys. The overall benefits of hafnium alloying include that hafnium controls the transformation kinetics, which can reduce the residual stress and still retain the high strength and hardness of quenched binary Ni-Ti alloys.

Experimental plan: This multimodal study will include rolling contact fatigue characterization, residual stress and hardness measurement and a time/temperature/transformation study of NiTiHf alloys. Alloy optimization will be conducted by varying nickel by 50.3 – 56 at.% and hafnium contents by 1 – 8 at.%.

Related work elsewhere: The NASA Glenn Research Center is involved in NiTiHf alloy development for shape memory actuation and superelastic applications.

How this project is different: Higher nickel contents and optimized processing to increase the compressive/torsional toughness of the material. The alloying and microstructural condition can be optimized for tooling and wear-limited applications.

Milestones for the current proposed year: Nanoscale microstructural characterization of NiTiHf alloys is being performed by transmission electron microscopy (TEM). Uniaxial mechanical testing of NiTiHf alloy compositions is underway. Microstructure analysis on deformed samples comparing static vs. dynamic compressive loading conditions is being performed. Further understanding of relevant phase transformation, processing conditions, and kinetics is of interest. Continued rolling contact fatigue experimentation on $Ni_{56}Ti_{36}Hf_8$ and $Ni_{50.8}Ti_{46.2}Hf_3$ alloys will be performed.

Deliverables for the current proposed year: An Acta Materialia paper on NiTiHf alloy microstructure development for tribology is being prepared, in addition to a paper on NiTiHf alloys deformed via static vs. dynamic loading. A paper on NiTiHf alloy transformations via high energy x-ray diffraction and machine-learning assisted discovery, rolling contact fatigue testing, and the performance of ultra-hard NiTiHf alloys is also in preparation.

How the project may be transformative and/or benefit society: Alloys will be optimized for rotary bearings in the International Space Station. Space-age applications can have a long-term impact on many other industries, driving performance in extreme environments.

Research areas of expertise needed for project success: Fatigue and fracture, phase transformation, strengthening mechanisms, failure analysis.

Potential Member Company Benefits: Greater understanding of NiTiHf alloys, phase transformations, microstructural evolution, and potential applications of this alloy system.

Progress to Date: Rolling contact fatigue experimentation, microstructure characterization, failure analysis, phase transformations.

Estimated Start Date: Fall 2015	**Estimated Knowledge Transfer Date**: Fall 2019

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.**