

National Aeronautics and  
Space Administration



# Recent FY18/FY19 NTP Materials Development Activities at NASA Marshall



**Presenting Author:** Kelsa Benensky<sup>1</sup>

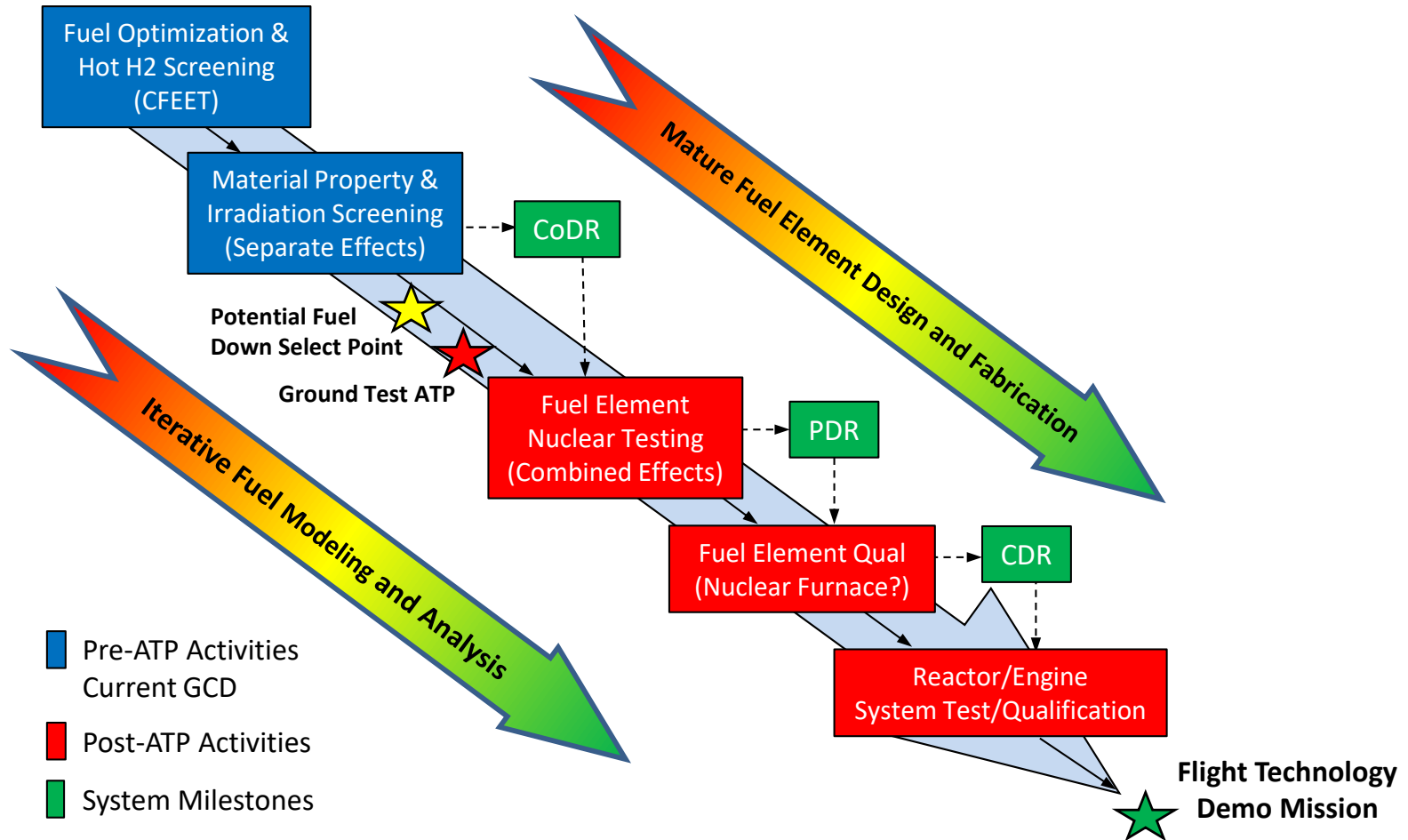
**Contributors:** Marvin Barnes, Jhonathan Rosales, Dennis Tucker, Ryan Wilkerson, and Martin Volz



<sup>1</sup>NASA Marshall Spaceflight Center

**MARSHALL**  
SPACE FLIGHT CENTER

# Pathways for NTP Fuel Development



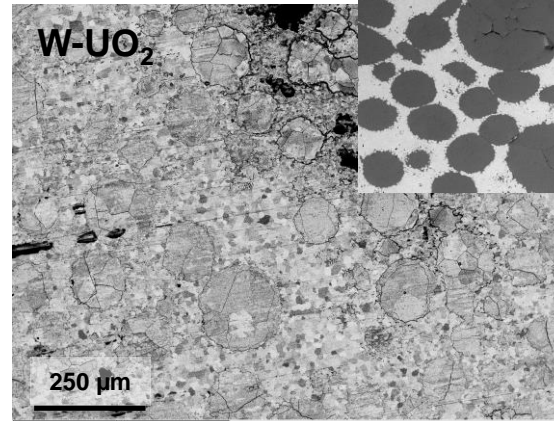
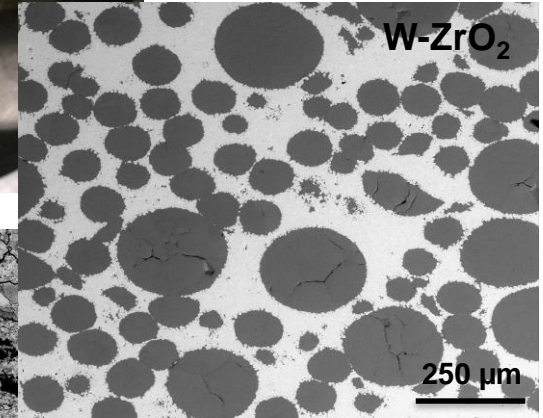
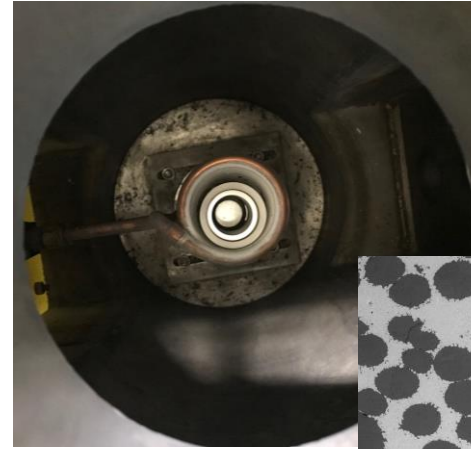


# W-Cermet Fabrication and Performance Assessment



FY17 MSFC Center Innovation Fund (CIF)

Optimization of High Volume loading W-UO<sub>2</sub> Cermets Fabricated via SPS

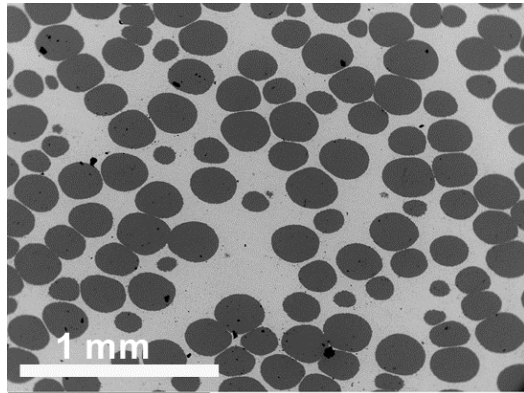
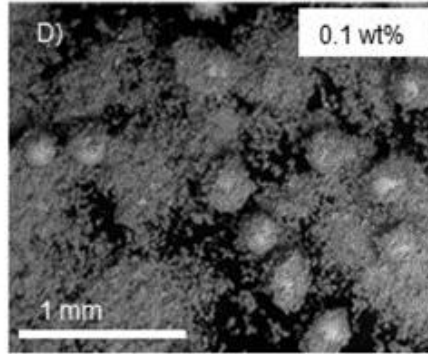
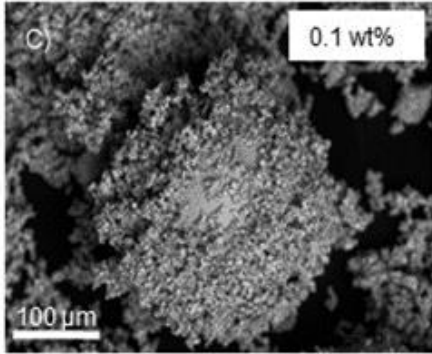


## Hot hydrogen testing and microstructural characterization of W-ZrO<sub>2</sub>, W-UO<sub>2</sub> cermets

Carpenter, W., Benensky, K., Barnes, M., and Tucker, D..  
“Microstructural Evolution of High Density W-Cermets Exposed to Flowing Hydrogen at Temperatures Exceeding 2000 K.”



# Mo-Cermet Fabrication and Performance Assessment



## FY18 MSFC Center Innovation Fund (CIF)

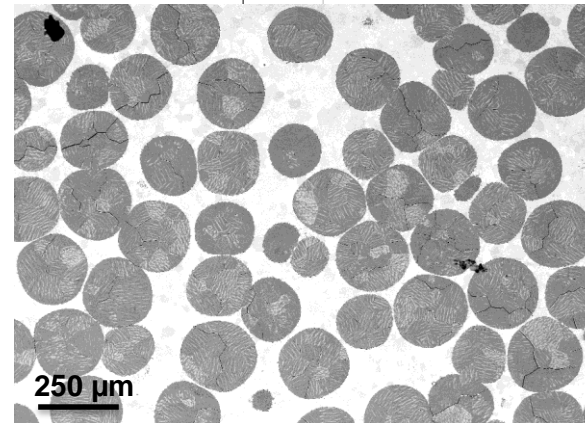
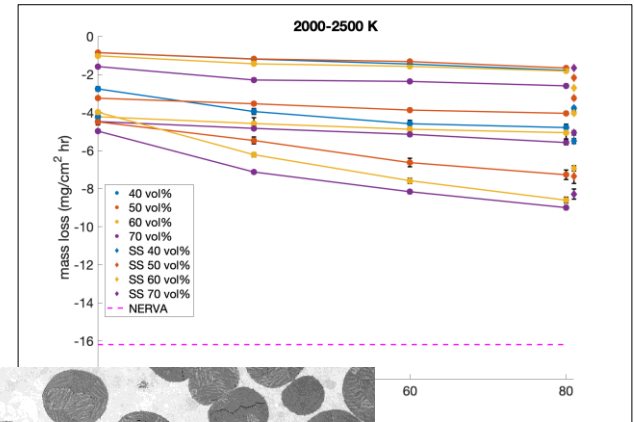
### Optimization of High Volume loading Mo Cermet Fabricated via SPS

Zillinger, J., Segel, B., Benensky, K., Barnes, M., and Tucker, D..  
 "Investigation of Process Parameter Effects on Spark Plasma Sintered Molybdenum Cermet for Nuclear Thermal Propulsion Applications

## FY18 MSFC Center Innovation Fund (CIF)

### Performance Assessment of Mo-Cermet under Thermal Cycling Conditions

Duffin, T., Benensky, K., Barnes, M., and Zinkle, S.. "Hot Hydrogen Testing and Microstructural Characterization of Molybdenum Cermet for Nuclear Thermal Propulsion





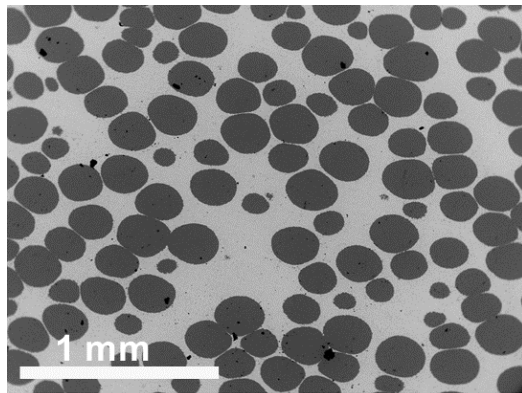
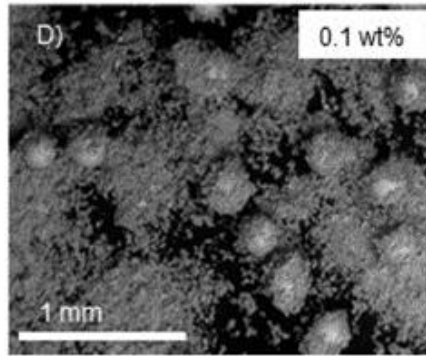
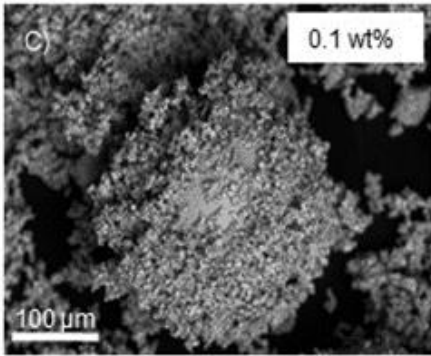
# Mo-Cermet Fabrication and Performance Assessment



## FY19 MSFC Center Innovation Fund (CIF)

### Performance Assessment of Mo-Cermets under Irradiation

Gaffin, N., Zinkle, S., and Benensky, K. "Review of Irradiation Hardening and Embrittlement Effects in Refractory Metals Relevant to Nuclear Thermal Propulsion Applications."



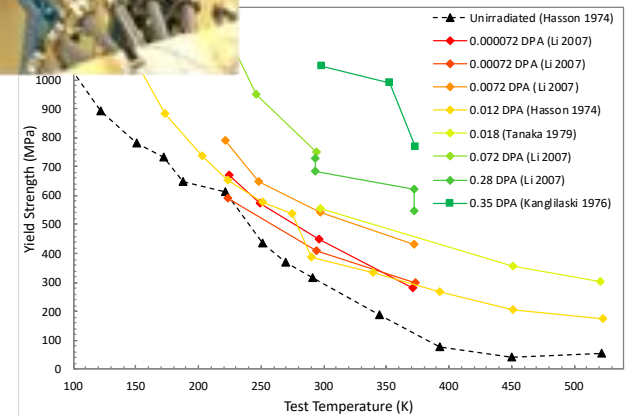
## FY18 MSFC Center Innovation Fund (CIF)

### Optimization of High Volume loading Mo Cermets Fabricated via SPS

Zillinger, J., Segel, B., Benensky, K., Barnes, M., and Tucker, D.. "Investigation of Process Parameter Effects on Spark Plasma Sintered Molybdenum Cermets for Nuclear Thermal Propulsion Applications"



W-cermet  
Mo-cermet

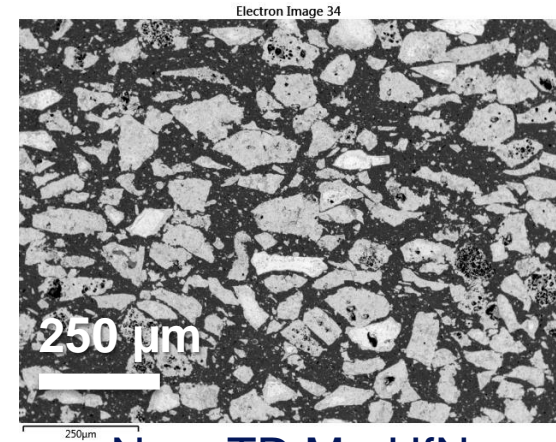




# Recent Fuel Fabrication Developments



- Fabrication of net shape pellet – <1” FTF, 19 x 0.25” coolant channels
- Optimization of Mo-HfN cermets
- Fabrication of rad Mo-cermets (Mo-UO<sub>2</sub>)
- Initial fabrication studies of Mo29W mixed cermet pellets
- Assessment of challenges scaling up wafer production to net shape fuel elements
- Received dUN powder from LANL – planned activities to assess feedstock and sinter Mo-UN, MoW-UN cermets

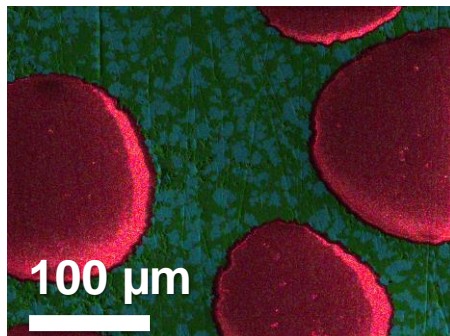
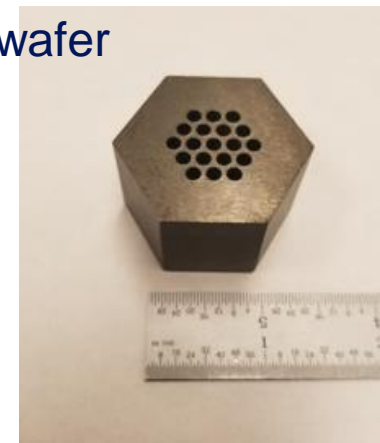
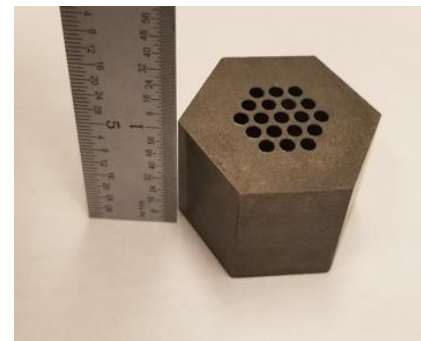


Near TD Mo-HfN cermet microstructure

First Rad cermet Sample Made at MSFC! (Mo-UO<sub>2</sub>)



Net Shape Mo-HfN cermet wafer



Mixed Mo (Green) 30W (Blue) ZrO<sub>2</sub> cermet



**Thank You!**