

National Aeronautics and
Space Administration



Recent Advances in Space Nuclear Propulsion

Accelerating Space Science with Nuclear Technologies Workshop | 12-13 May 2026

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Recent Activities



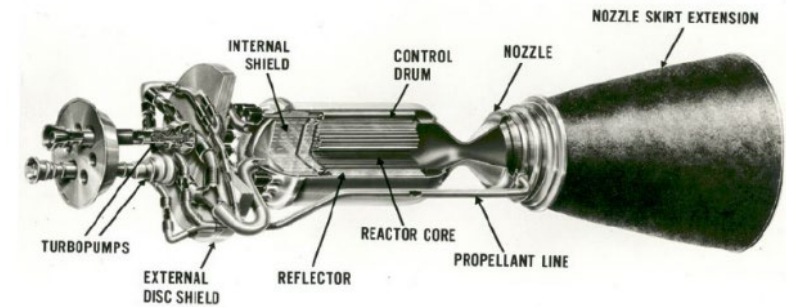
- DARPA-NASA DRACO NTP project (2023-2025)
- SNP's NTP and NEP development and maturation activities
- SR-1 'Freedom' Mars mission

What does nuclear enable that is otherwise not possible?

The Engineering Requirements of Nuclear Propulsion Systems

Nuclear Thermal Propulsion (NTP)

- $> 2700\text{ K}$ fuel (for 900 s and above I_{sp})
- Hydrogen flow through nuclear-heated fuel
- Rapid thermal transients

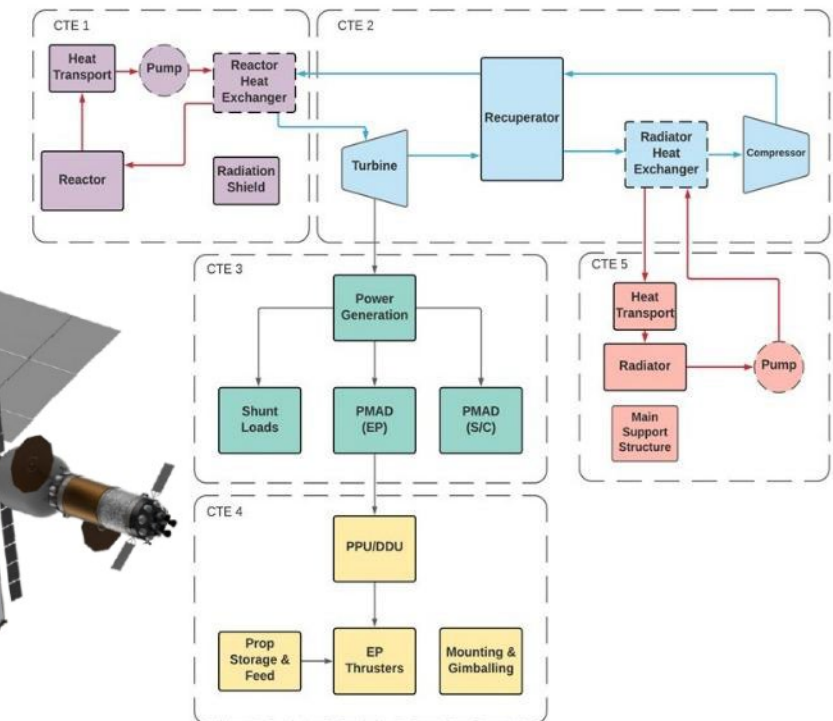
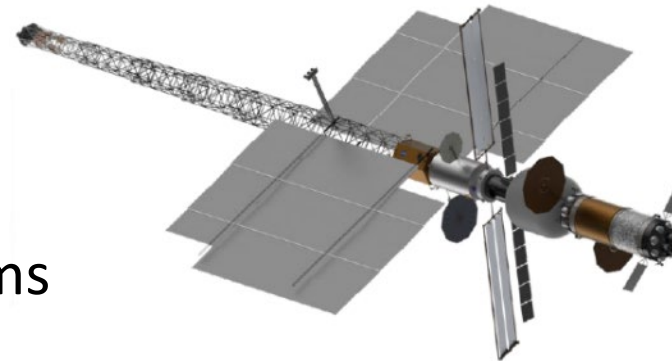


Nuclear Electric Propulsion (NEP)

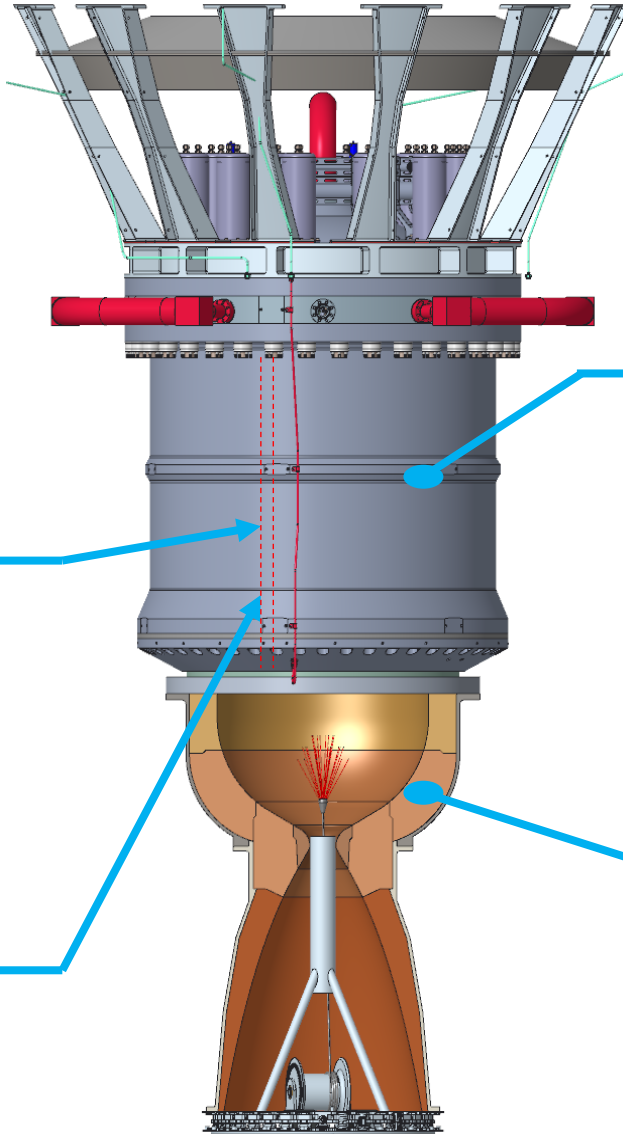
- Multi-year continuous operation
- Elevated core temperatures
- High radiation exposure & burn-up

Common to Both

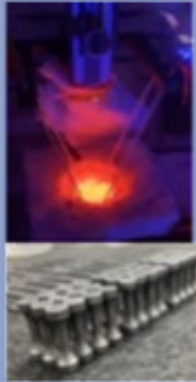
- Tightly coupled multiphysics systems
- Performance defined at interfaces



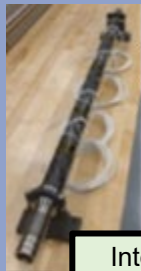
Additionally: Bridging nuclear and aerospace engineering cultures



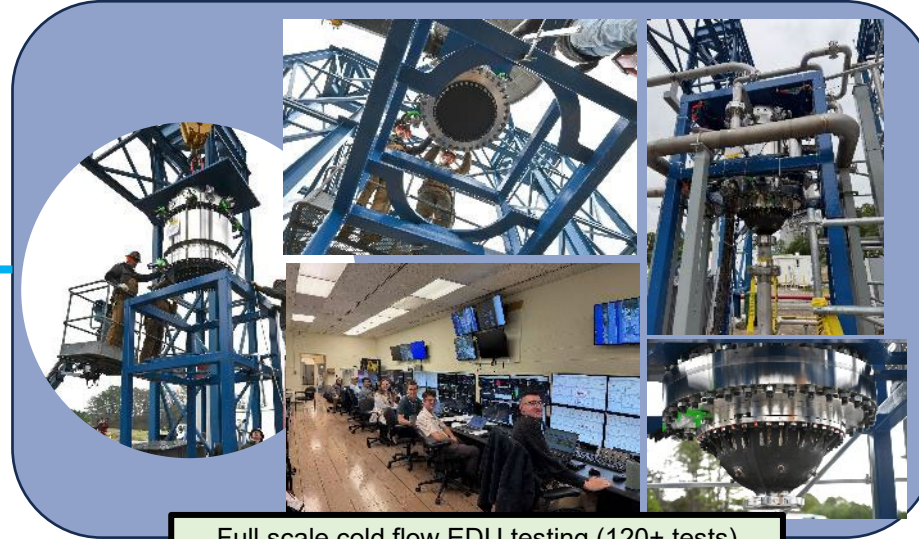
Hardware-In-The-Loop (HITL) test bed



Fuel material development and manufacturing maturation



Integrated Fuel Assembly Test (IFAT) – Vibe, TVac, and flow performance testing



Full scale cold flow EDU testing (120+ tests)

[Press Release](#)



Full scale nozzle and fuel assembly mockups and test article for rapid design iteration

- Fuel

- Solid Solution bi-carbide (U_xZr_y)C and tri-carbide surrogate ($Zr_xW_yTa_z$)C & ($Zr_xW_yNb_z$)C
 - > 95% theoretical densities, excellent performance under hot H_2 conditions
 - Tri-carbides under irradiation in a TRIGA reactor
 - Thermophysical properties at highest temperatures every performed

- Insulators

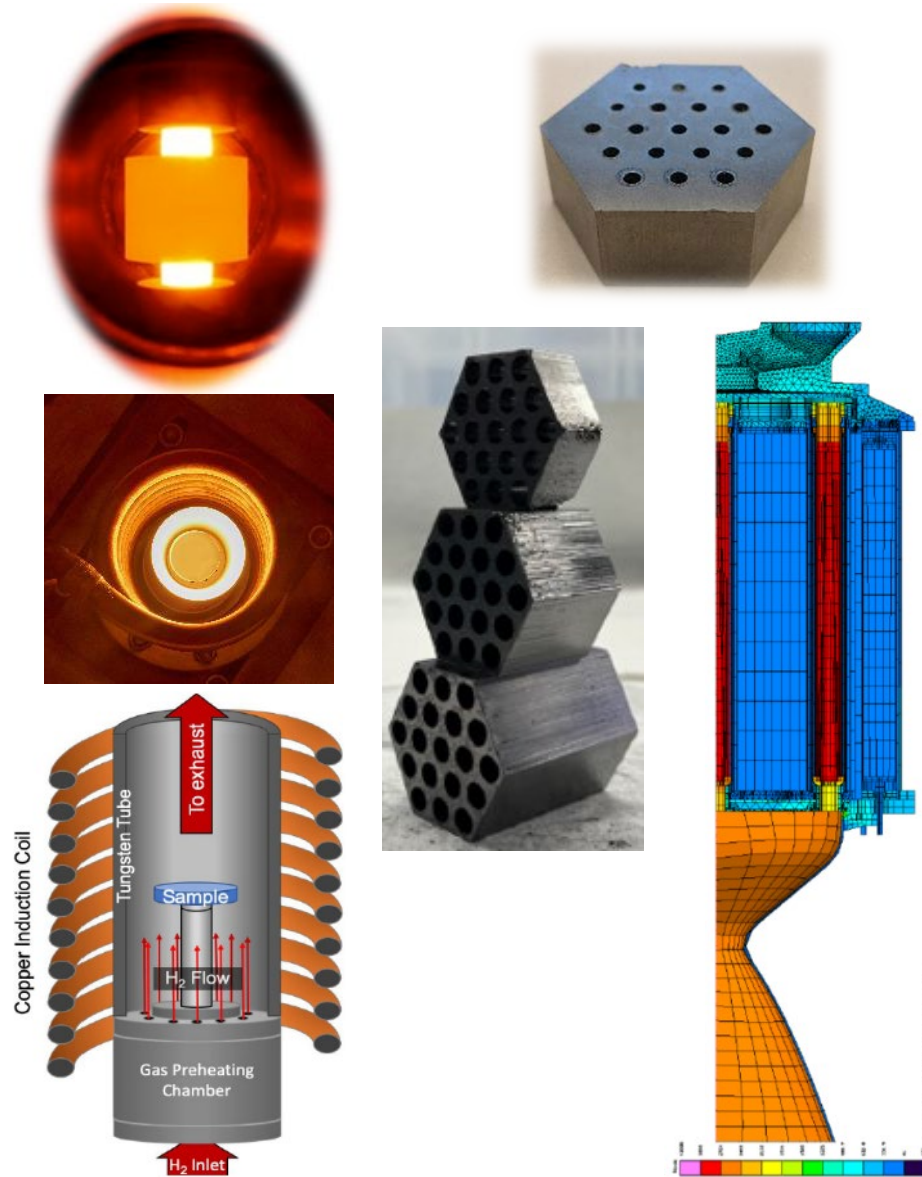
- ZrC and C-C composite materials

- Modeling

- Molecular dynamics of fuel channel erosion (H_2 w/addition of trace amounts of methane)

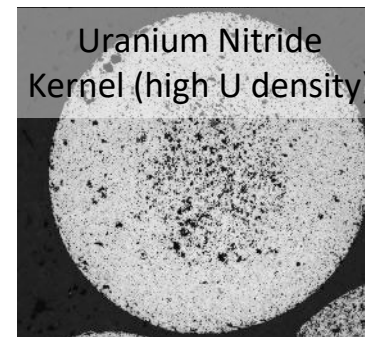
- Test & Evaluation

- Testing for H_2 -induced mass loss, microstructure degradation, & dimensional stability under coupled thermal and radiation loading

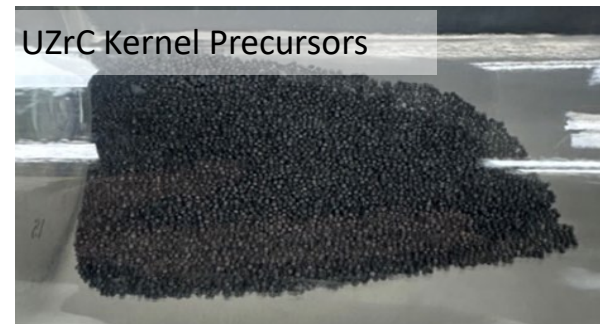
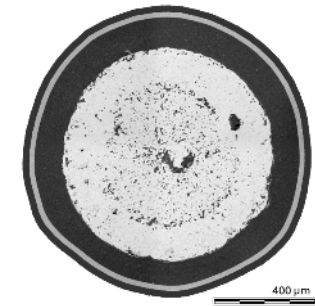


- General Atomics
 - Reactor design matured through multiple cycles
 - Candidate fuel tested in hot H_2 for multiple rounds
 - Manufacture of multiple full-scale components of the design

- Standard Nuclear
 - Multiple fuel developments
 - ZrC-coated UN kernels
 - UZrC Kernel
 - Printed at-scale ceramic structures



UN Particle Coated with ZrC



Expected Max Temp: 3000 C (3275 K)
UZrC resisted degradation in hot flowing H_2 up to 2600 K (so far).



Printed Hot Frit Concept



NEP Activities



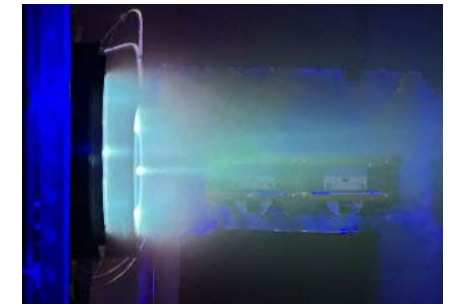
- Published High-Power NEP Technology Maturation Plan
 - DOI: [10.64631/IFOP7950](https://doi.org/10.64631/IFOP7950)
- High-power Lithium-fed MPD Thruster Development
 - First domestic thruster of this type in decades
 - [First test at JPL](#) at 120 kW and > 4000 A
- Clustered Dual 12.5 kW Hall-effect thruster test at GRC
 - Early indications are nominal performance on Xe and Kr
 - Measured effects of thruster-to-thruster interactions
- Advanced Closed Brayton Cycle (ACBC) Phase 1 (FSP-funded)
 - Targeted 1700 K inlet temperatures
 - Design + some materials testing



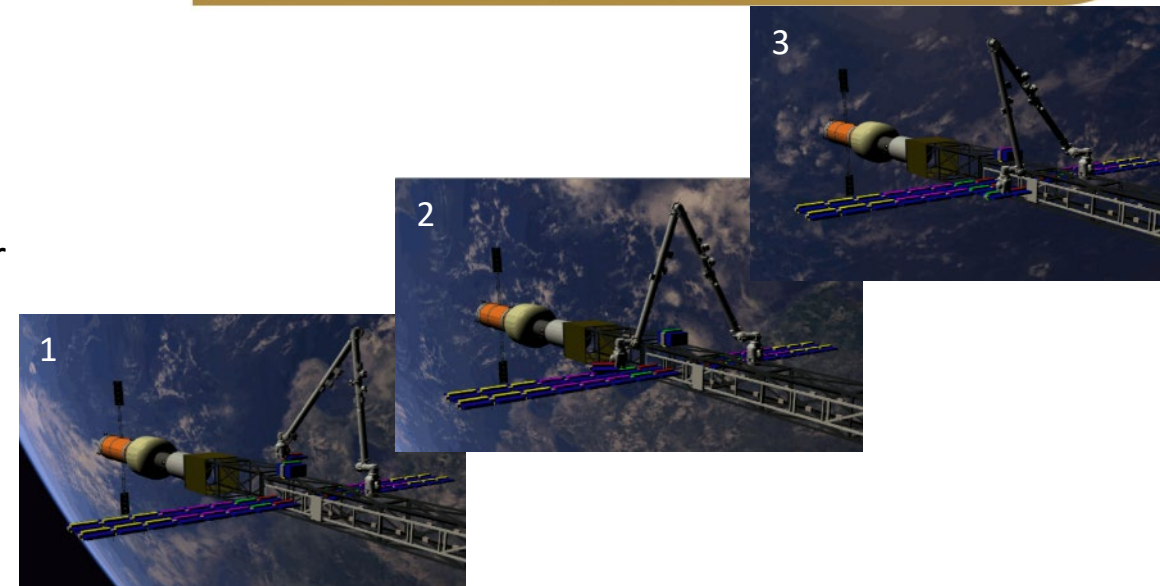
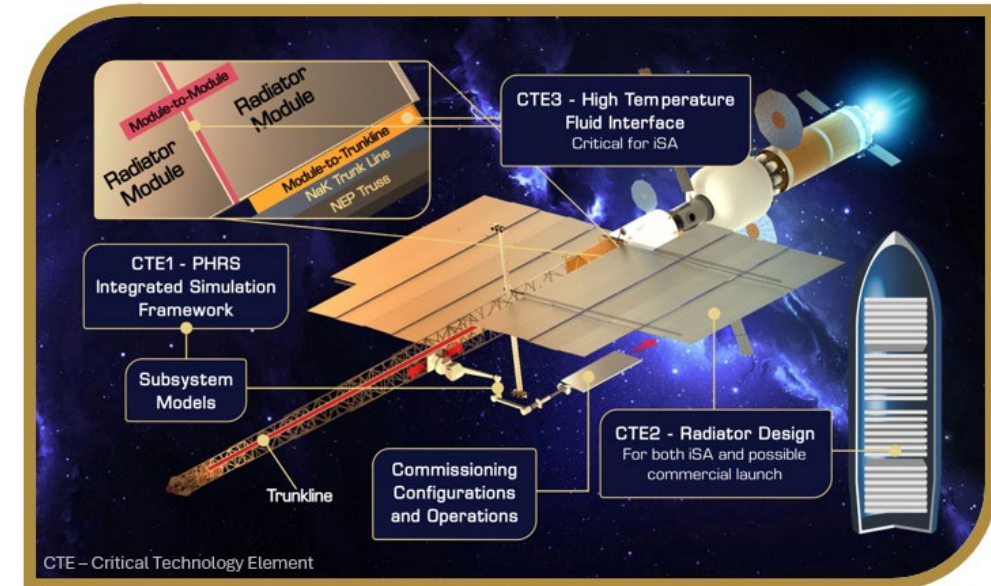
Li-fed MPD Thruster Test



Dual 12.5 kW Hall thrusters



- Radiator Fabrication and Testing
 - Parallel wick-based and oscillating heat pipe architectures
 - Structural and thermal validation underway
- MARVL – **M**odular **A**ssembled **R**adiators for NEP **V**ehic**L**es
 - In-space assembly vs deployment paradigm
 - Cross-organizational early-career integration
- Silicon Carbide for **H**igh Voltage in **R**adiation **E**nvironments (SHiRE)
 - Investments in Single-Event Burnout (SEB) hardened SiC for systems at 1.5 kV and above
 - Utilize relationship between SEB voltage and doping to design and iterate on field-effect transistors (FETs)
 - Experimentally demonstrate radiation-hardening





In Closing



- NTP
 - **Multiple** fuel options for 900 s I_{sp} (2700 K propellant temperature) and beyond **identified** and **showing great promise** in testing to date
 - Most complete series of nuclear propulsion system tests **at scale** in recent history
- NEP
 - Broad effort initiated across **all critical technology elements**
 - Several **high payoff** fabrication and test activities presently ongoing
 - Several 'firsts' in thruster testing with both Li-fed MPDs (domestic first) and clustered Hall (first clustered test at this scale)
- Activities presented here are **not all-inclusive**
 - Represents a subset of the overall SNP portfolio

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