

# Demonstration Rocket for Agile Cislunar Operations Regulatory Pathfinding

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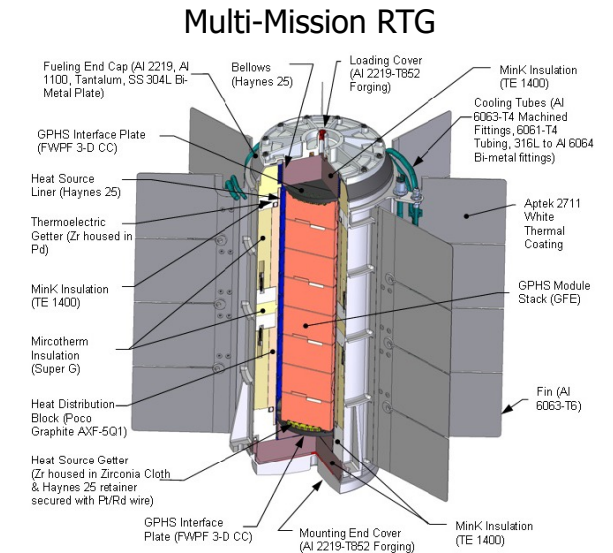


- Standard Operating Procedures (SOPs) exist for terrestrial handling, procurement, launch, and operation for NASA to launch RTGs with DOE.
- However, a nuclear reactor is not an RTG, and DRACO is a DoD program.
  - The United States has not launched a nuclear space reactor since 1965.
  - Unique SOPs will be followed under the DRACO program.
- On 1 April 2022, DARPA granted authorization to manufacture, produce, and acquire a “utilization facility” (nuclear reactor) to demonstrate DRACO nuclear thermal rocket
  - This authorization was granted by Secretary of the Department of Energy (DOE) in accordance with section 91.b of the Atomic Energy Act of 1954 (AEA), Public Law 83-703, as amended, codified at 42 U.S.C. § 2121(b), and in accordance with National Defense Decision Directive 282 (1987).
- For every phase of the mission, DRACO is leveraging existing nuclear regulatory policies, National Policy, and legislation.

## Launch of radioisotope thermoelectric generators (RTG) and nuclear reactors have vastly different safety considerations

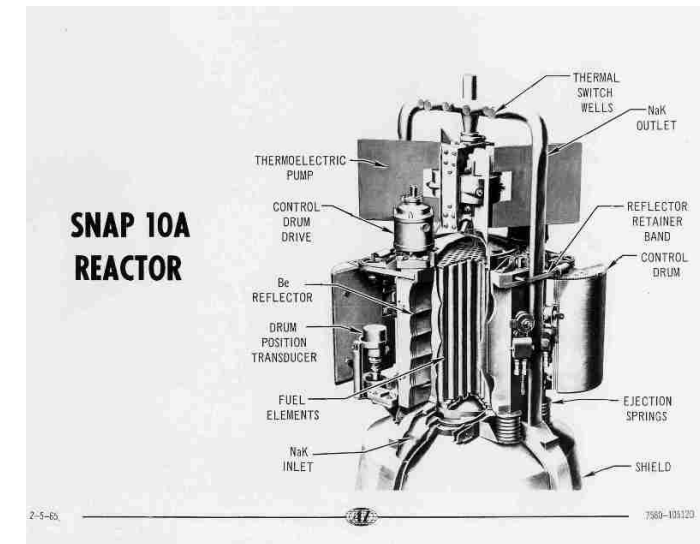
- **RTGs have been launched by the U.S. regularly since the first was launched in 1961 under SNAP 3B**

- RTGs utilize a small amount of Plutonium 238 radioisotope to generate heat and power
- Multi-Mission RTGs typically have around 60,000 Curies of radioactivity at launch
- Safety for RTGs focuses on containing the radioisotope in launch accident scenarios



- **DRACO will be the first reactor launched by the U.S. since SNAP 10A in 1965**

- DRACO will demonstrate NTP above LEO due to the lack of suitable ground facilities
- DRACO reactor will be "cold" and have minimal (~2-3 Curies) radioactivity at the time of launch
- Safety for reactors focuses on preventing criticality in launch accident scenarios
- DRACO reactor will not be operated prior to achieving a safe orbit above LEO
- After operation, reactor will remain in a long-term orbit for hundreds of years
  - Ensures fission products decay to a level of radioactivity comparable to U-235
  - Precludes possibility of hot reentry
  - Meets guidance published in Space Policy Directive 6 on 16 December 2020



## National Security Presidential Memorandum 20 (NSPM-20, 20 August 2019)

- Outlines objective safety guidelines that limit public exposure to risk
- Established 3-tiered launch authorization process approach:
  - Radioisotopes fall within Tier I, II, or III depending on quantity and risk to public
  - Reactors fall within Tier II or III, depending on enrichment and risk to public
- Charges the sponsoring agency to produce a Safety Analysis Report (SAR) that shows the NSPM-20 safety guidelines have been met or exceeded
- Established the Interagency Nuclear Safety Review Board (INSRB) to review the SAR and produce a Safety Evaluation Report (SER) to document findings

## DRACO is committed to the NSPM-20 launch authorization process

- Actively engaged with INSRB to set review schedule and expectations
- Working with DOE labs to establish design criteria and analysis approach to meet NSPM-20
- DRACO seeking Tier II launch authorization by:
  - Utilizing High-Assay, Low Enriched Uranium ( $\leq 19.75\%$  U-235)
  - Ensuring probability of an accident during or after launch resulting in an exposure in the range of 5 to 25 rem total effective dose (TED)  $\leq 1$  in 1,000,000



NERVA XE in Engine Test Stand 1 (ETS-1) at the Nevada Test Site

**DRACO program committed to meeting or exceeding the launch safety guidelines in NSPM-20**



## DRACO's General Design Criteria – Summary



- DRACO's safety, environmental, and launch approval strategies are grounded in DRACO's General Design Criteria (GDC), as a requirement imposed on industry by DARPA. Setting GDCs are standard in the nuclear industry.
- The GDC's are upon historical precedence and current risk guidance:
  - ***GDC-1:*** *The reactor shall not be operated prior to space deployment.*
  - ***GDC-2:*** *Inadvertent criticality shall be prevented for both normal and accident conditions in accordance with the risk criteria in NSPM-20.*
  - ***GDC-3:*** *The radiological risk to the public from the accidental hot re-entry of a reactor shall be prevented in accordance with the risk criteria in NSPM-20.*
  - ***GDC-4:*** *In-space disposal shall be limited to sufficiently high orbits in accordance with US and international guidelines (primarily Orbital Debris Mitigation Standard Practices)*
- These are draft requirements and will be evaluated as part of the system design review.

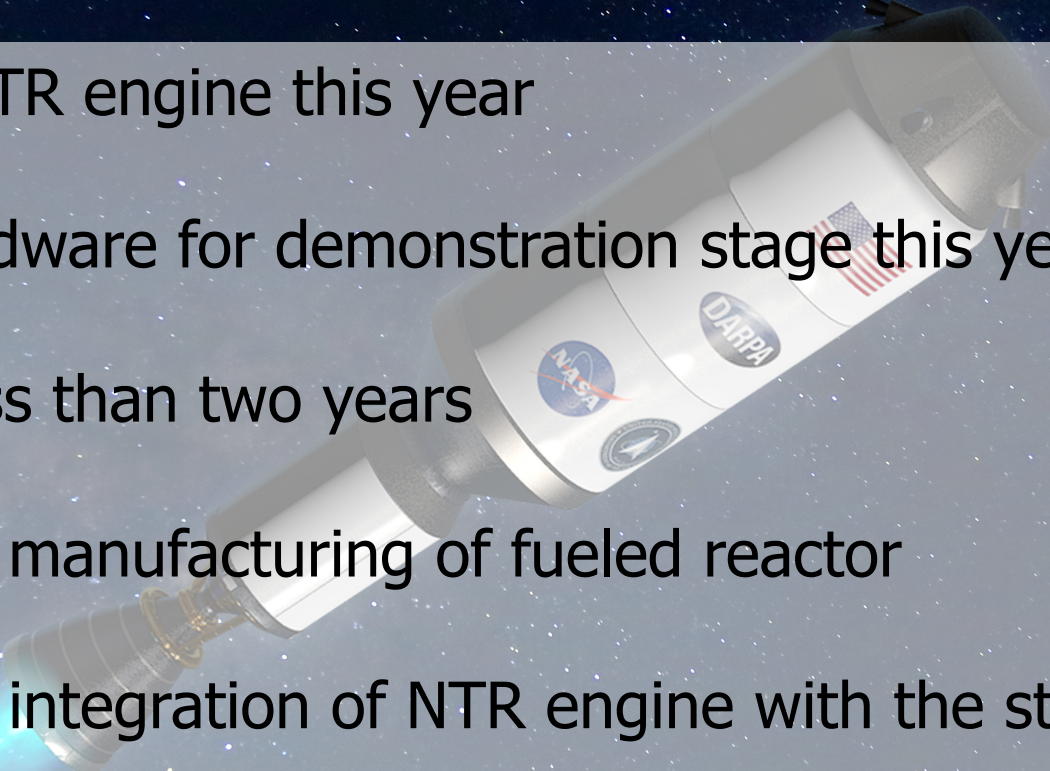
- A reactor which has not fissioned greatly simplifies transportation, launch-accident analyses and launch approval



- Rover/NERVA images proving that you can work on and around an NTR Reactor that has not been turned on



- Preliminary testing is not an academic exercise
- Preliminary testing will greatly increase the chance of a successful startup
- We have a first-of-a-kind (FOAK) complex system with a FOAK fast-acting instrumentation and control system.
- The three primary reasons for preliminary testing
  - Diagnose the diagnostics (instrumentation and processing)
  - Obtain values for uncertain system physical parameters that can be changed in the control algorithms.
  - Observe the response of the control system and elements and change startup and operational procedures accordingly.
- The preliminary testing will be set up to step through tests that isolate certain physical, mechanical, or control parameters – starting with very simple tests and increasing in complexity
- Expect that the test plan will look nothing like what we think today

- Cold flow testing of NTR engine this year
  - Procure long-lead hardware for demonstration stage this year
  - Phase 2 will end in less than two years
  - Phase 3 will complete manufacturing of fueled reactor
  - Phase 3 will complete integration of NTR engine with the stage
  - Early 2027 launch in Cape Canaveral Florida via an NSSL (National Security Space Launch) launch vehicle
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- A 3D rendering of the DRACO spacecraft, a small satellite, is shown in space. The satellite is cylindrical and white, with a blue NASA logo, a DARPA logo, and an American flag on its side. It is oriented diagonally across the frame, with a bright blue light source behind it, creating a lens flare effect.



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