Nuclear Data, Validation Methods, and Integral Needs

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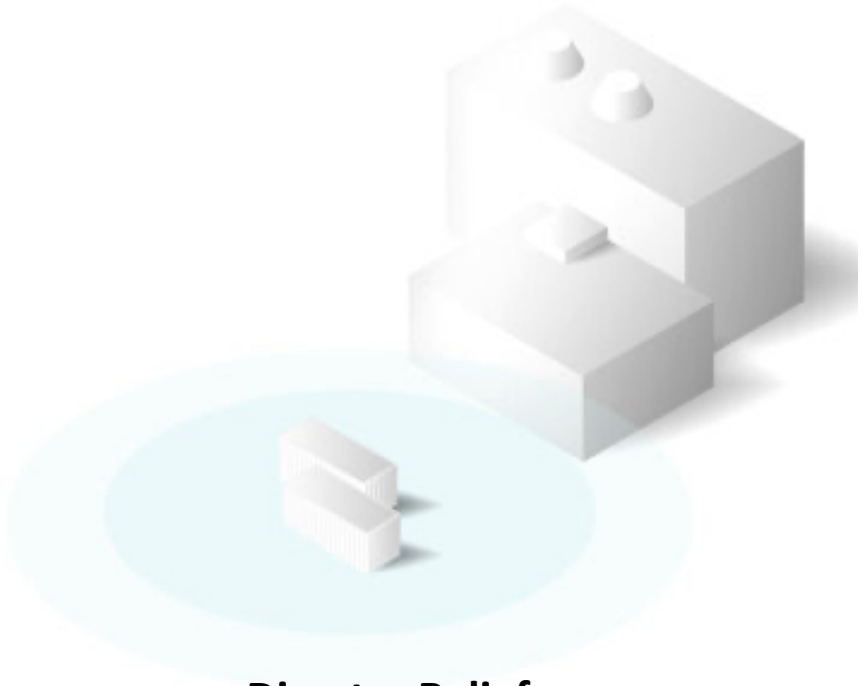
Novel Applications of Microreactors

Defense & forward bases

As the US Military prepares for “near-peer” adversaries of the future, highly portable power with a high energy density will be a game-changing technology.

Highly Portable Power



Disaster Relief

The ability to transport flexible electricity solutions that do not require fueling for months or years provides critical infrastructure to get railroads, water purification facilities, and hospitals powered again – within one week.

Be powered again – within one week

Remote Communities

Arid, Island and Alaskan/Canadian communities often use government-subsidized petroleum fuel deliveries to maintain their power. If their deliveries are disrupted, the impact can be significant.

Maintain Power

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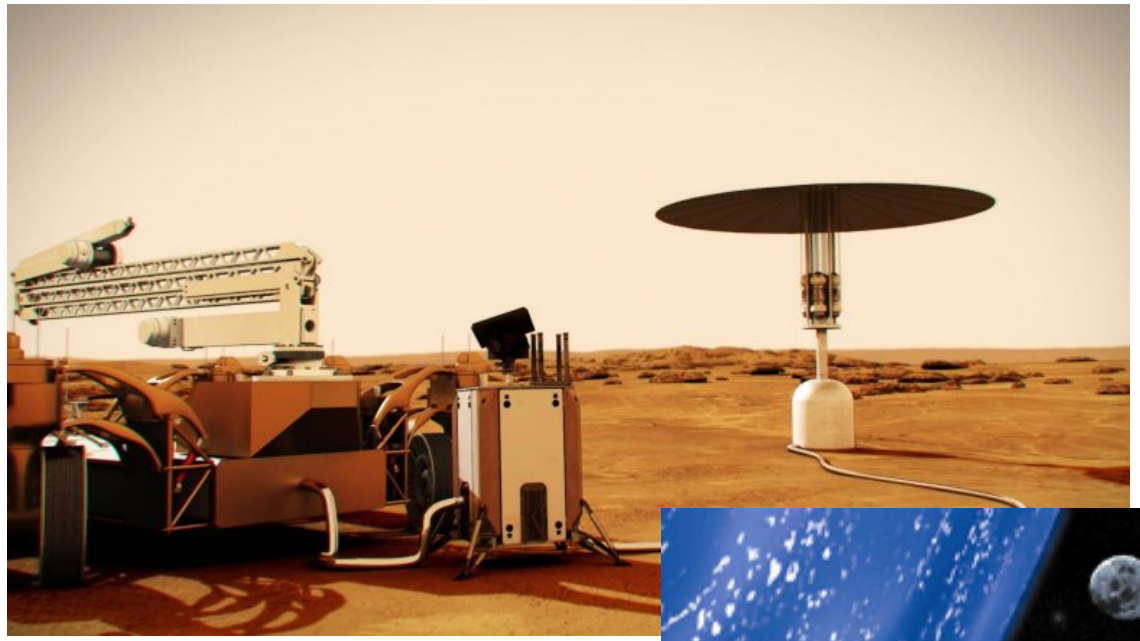
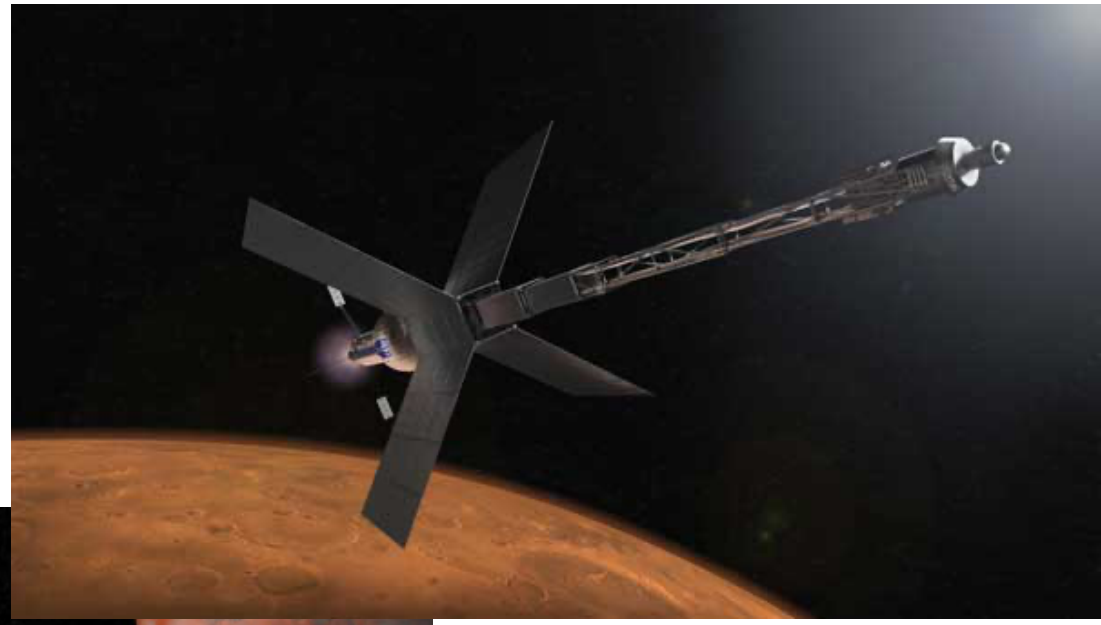
Space Nuclear Applications

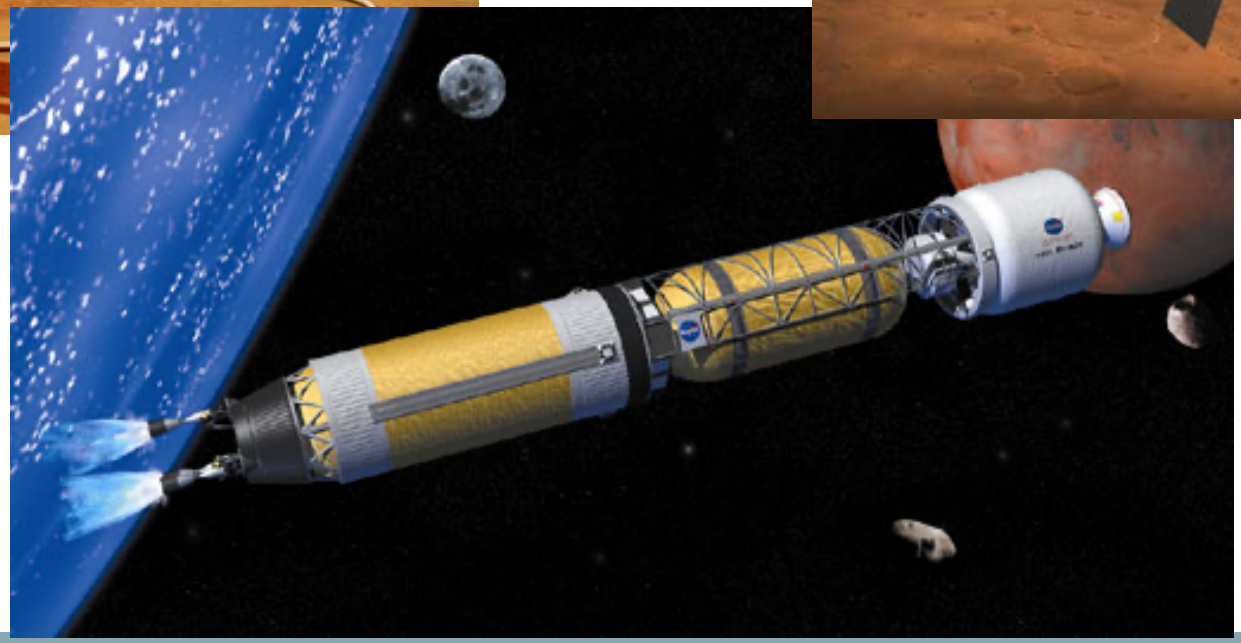
Fission Surface Power System



Nuclear Electric Propulsion



Nuclear Thermal Propulsion



Images: NASA

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Executive Actions and Appropriations

- **Promoting Small Modular Reactors for National Defense and Space Exploration (**Executive Order 13972, January 2021)
  - Demonstration of Commercial Reactors to Enhance Energy Flexibility at a Defense Installation
  - Defense Capabilities
  - Space Exploration
  - Domestic Fuel Supply
  - Common Technology Roadmap
- **Launch of Spacecraft Containing Space Nuclear Systems (**National Security Presidential Memorandum-20, August 2017)
  - Safety prescribed in terms of Total Effective Dose to population

- **DOE-NE** Advanced Reactor Demonstration Program ~$200M/yr, operational reactors 2027-2030s
- **DOD** Mobile Microreactor $70M FY21, demonstration unit in 2024
- **DARPA**/DRACO – ??
- **NASA NTP** ~$100M FY21
- **NASA FSP** – Launch ready 10 kWe, 10-year lifetime, 3500 kg power plant by 2026
- **NASA NEP** – Studies resuming in 2021

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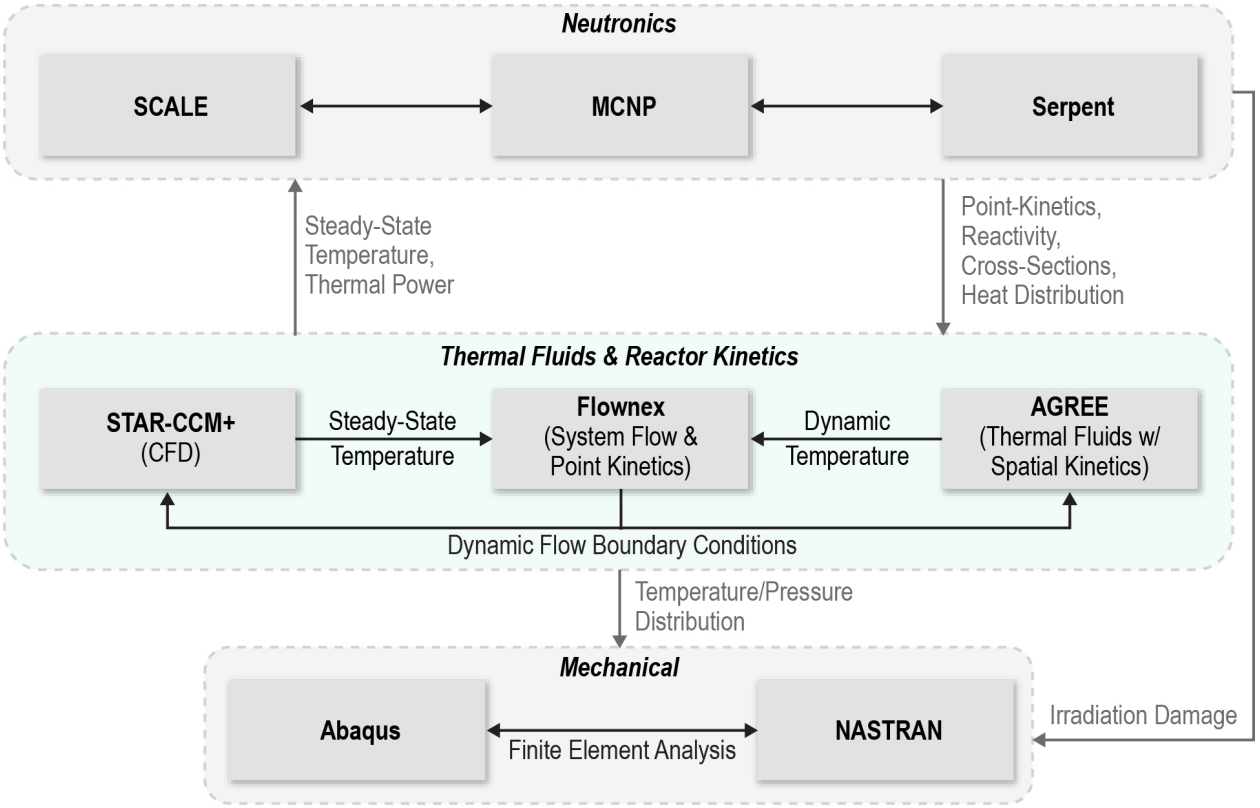
Nuclear data provide a foundation for performance and safety analysis



Analysis	Tool/Model	Analysis Type	Outcome
Core neutronics	SCALE/ KENO/ORIGEN	Steady-state Monte Carlo neutron transport and transmutation	Power Profiles, Core life, Burnable poison design, Temperature and control element reactivity
Cross section generation	Serpent	Steady-state Monte Carlo neutron transport	Generated few-group cross sections for AGREE-Xe and verified reactivity results from SCALE and MCNP
Photon/Neutron Transport	MCNP	Steady-state Monte Carlo neutron and photon transport	Ex-core heating rates
Reactor Thermo-fluid Analysis	StarCCM+	High fidelity heat conduction and thermo-fluid dynamic behavior	Spatially resolved temperatures and coolant flow rates
Coupled neutronic-thermal fluid analysis	AGREE-Xe	Steady-state and time-dependent neutron diffusion/heat conduction/ subchannel fluid behavior	Peak and average temperatures of structures during transient scenarios
Plant Dynamics	Flownex	Steady-state and time-dependent analysis of plant-wide behavior	Plant/Reactor response to perturbations and fault conditions. Startup, shutdown, and critical power maneuvers
Shielding	SCALE/ MAVRIC/ ORIGEN	Steady-state neutron and gamma transport, activation, decay	Ex-vessel dose and activation rates
Structural Dynamics	NASTRAN	Dynamic Finite Element Analysis	Static-equivalent accelerations to be used for stress analysis, Load Isolation System evaluation
Mechanical and thermal stress	Abaqus	Steady-state Finite Element Analysis	FEA-calculated stresses, to be compared against material allowables to determine if the parts meet design requirements
Instrumentation & Controls	PSCAD	Simulation of electric power conversion	Power Balance of EPCS with a notional load bank at steady state response of system to various load transients, including abnormal loads and fault conditions
Hazards Analysis (Fire, chemical, mechanical, electrical, etc.)		Identification of hazards associated with assembly, transport, and disassembly operations	Design requirements for hazard mitigation systems (e.g., Fire Detection and Suppression)

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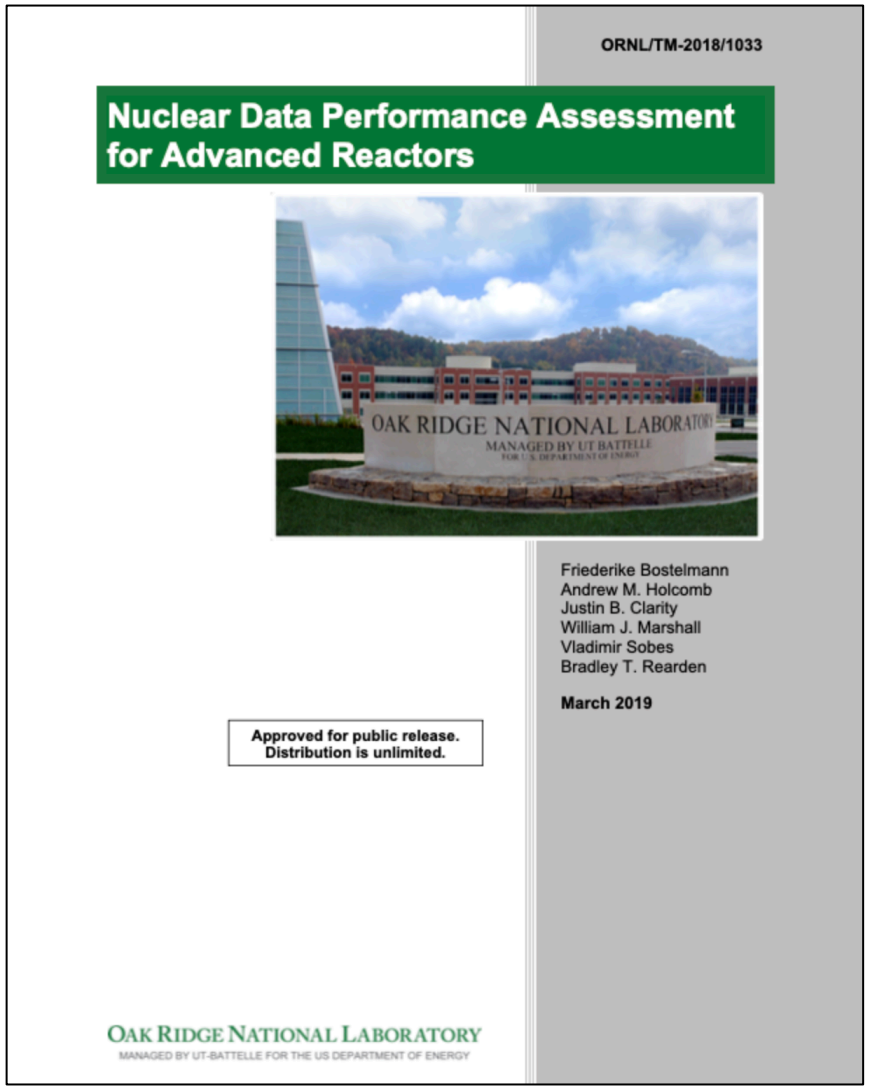
Concerns with changes in ENDF/V-III.0 without consideration for reactor applications


ORNL/TM-2018/1033

Nuclear Data Performance Assessment for Advanced Reactors

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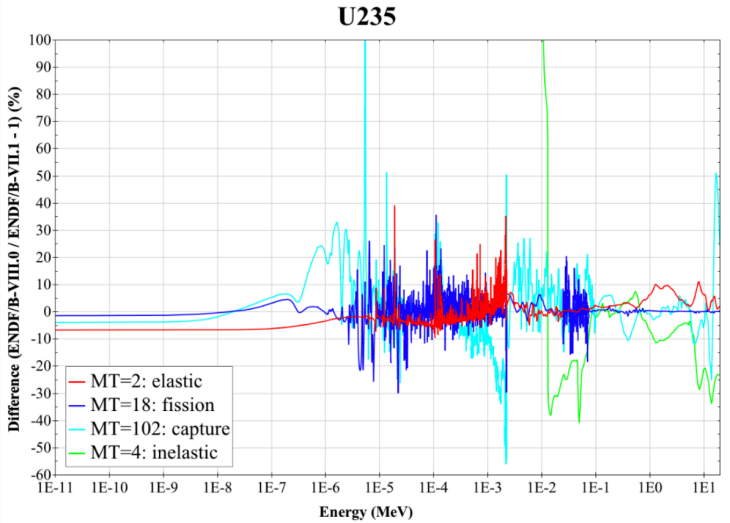

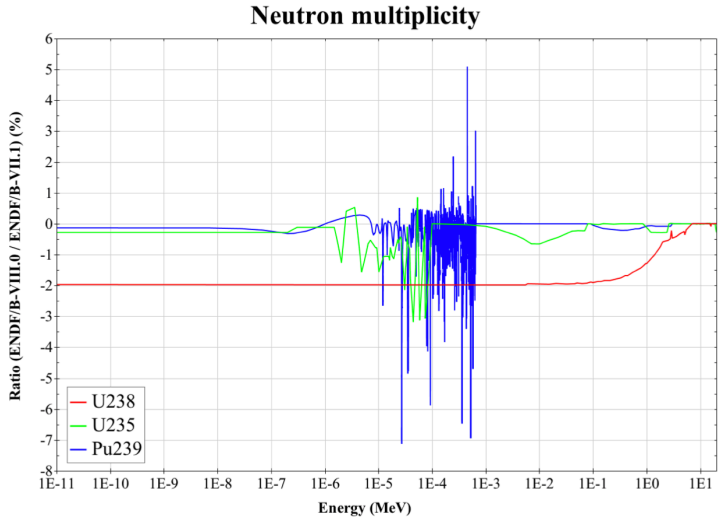

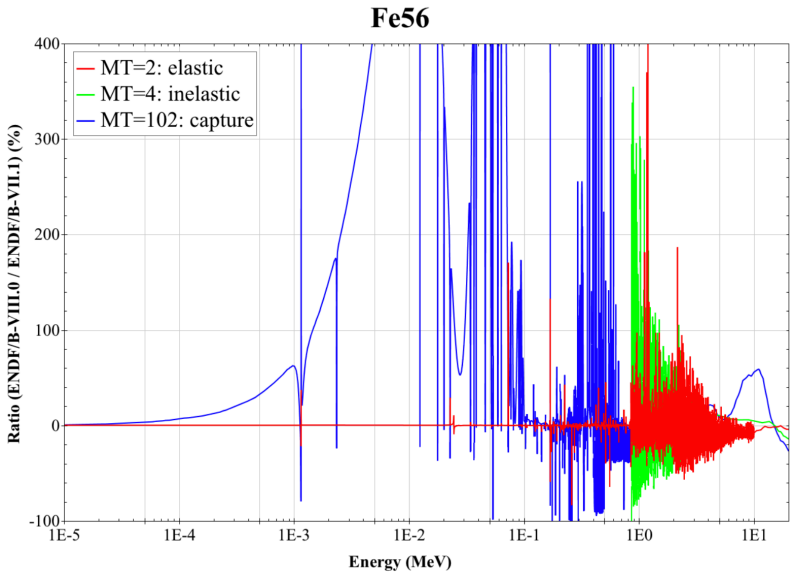

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Validated Nuclear Data Needs

- **Small and precise reactors require optimized power and lifetime predictions**
  - Power distribution
  - Reactivity control and shutdown margin
  - Fission product inventories
- **Close proximity to public and need for low mass solutions require precise source term and shielding data**
  - Prompt neutrons and gammas from fission
  - Gamma emissions from fission product decay
  - Material activation and decay
  - Neutron and gamma attenuation
- **Thermal scattering law data**
  - Advanced moderators/reflectors are needed for small HA-LEU cores
  - YH_x is of interest for lower temperature applications
  - NTP systems approach 3000 K for fuel and structural materials with H_2 as internal propellant
- **Irradiation damage assessment is needed for wide range of materials**
  - Damage cross sections should be included in ENDF libraries

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