NORAD and USNORTHCOM Perspective on Nuclear Energy

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Nuclear Energy

"Energy dominance enables the warfighters of the future in defense of the homelands"

- Nuclear history
- Reactor size, type, and fuels
- Potential use cases

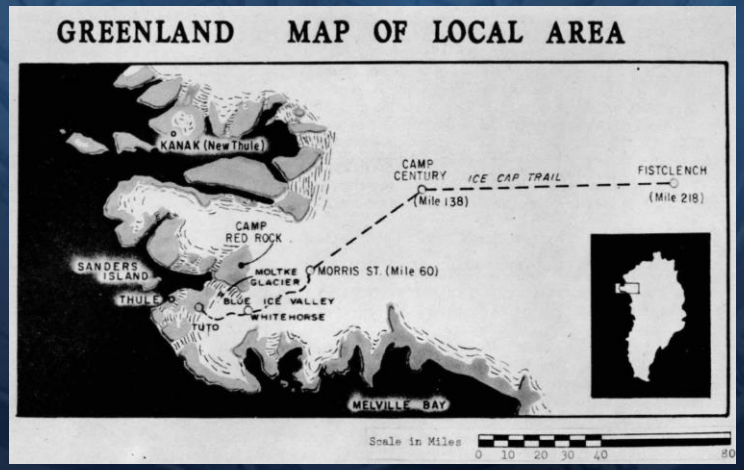
Nuclear History
Two Nuclear Pathways

Light Water Reactor

Molten Salt Reactor

Light Water Nuclear Reactor History

- Camp Century 1959 to 1967 – Project ICEWORM (YouTube)
- July 1960 Reactor PM-2A delivered to Thule Air Base
- Sledded 100 miles east to Camp Century
- 330 ton “portable” reactor



Reactor PM-2A #3 of 8 US Army reactors constructed

- October 1960 reactor started
  - Immediately leaking radiation
- Provided additional shielding
- Reactor replaced with Diesel in 1963
  - Highly radioactive reactor core disposed of in US
- Camp Century abandoned
  - 1965 closed in 1967
  - Nuclear waste left under the ice
- 1965 - Army abandons portable reactor development

Failures and Public Perception

- Commercial reactor success
- Fear
  - 3 Mile Island – China Syndrome
  - Chernobyl – bad technology
  - Fukushima – EQ & Tsunami
- Anti-Nuclear sentiments
  - Excessive regulation
  - Nuclear free zones
  - Nuclear technology crawled forward
  - Greater reliance on fossil fuels

Renewed Interest in Molten Salt Reactors

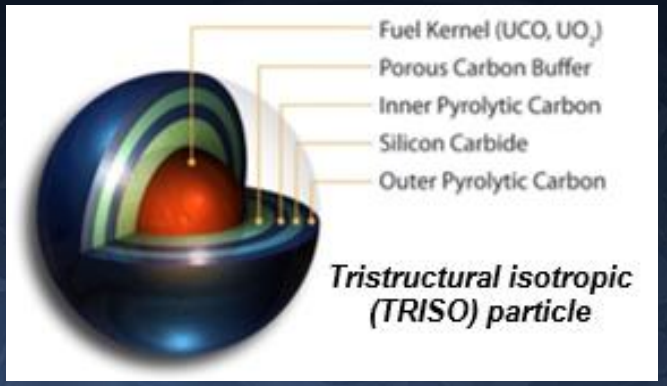
- Salt refinement enhanced - corrosion
- Improved material science
- Safety - few moving parts
- Recycle waste fuel
- Medical applications
- Qualified fuel form status

Nuclear Energy Production Scale

- Truck mounted
  VALKRE, 40-60 KW
- Micro nuclear 1-20 MW
  PELE, 1-3MW energy, 2MW heat
- Small Modular Reactor 20-300 MW
- Large scale commercial reactor 1GW
  Average 40 years old, oldest 1969,
  Newest GA-2023, TN-2016, 1996

TRISO Fuel: A Paradigm Shift For Nuclear Power

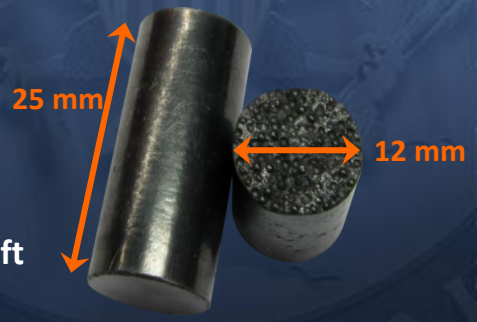
- **Incorporates Advanced Tristructural Isotropic (TRISO) encapsulated nuclear fuel for compact, safe operations**
  - Each encapsulated particle is <1 mm in diameter
  - Robust particle coatings are extremely resistant to meltdown or kinetic destruction
  - Changes paradigms for containment, nuclear safety, and transportation
  - SCO/DOE/NASA have re-established a national TRISO production capability



- **The Advanced Gas Reactor (AGR) Fuel Development Program initiated in 2002**
  - TRISO fuel has already been subjected to rigorous testing by DOE, eliminating the need for DoD/SCO to develop or qualify a new fuel

- **Silicon carbide keeps fission products sealed inside, meaning that a containment vessel failure is no longer catastrophic**
  - Design reduces diversion and proliferation risks due to low (< 20% U235) enrichment and individually coated particles
  - Rugged, robust fuel structure deters use as an improvised weapon such as a dirty bomb

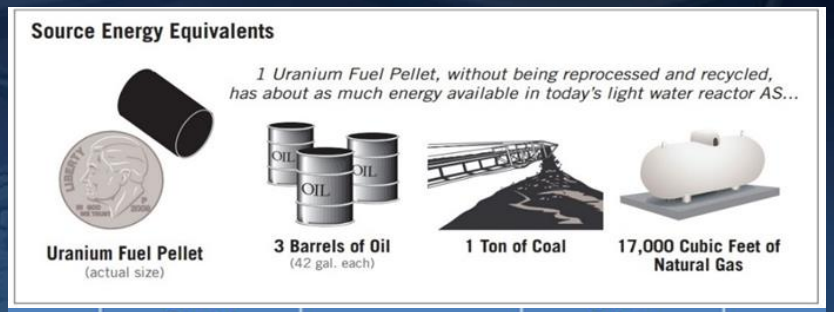

Cylindrical fuel compacts



- **Innovative pellet design as first line of containment is a paradigm shift in safety for nuclear power**
  - Standard industrial regulations could apply, significantly reducing manufacturing/safety/O&M/ regulatory costs
  - Pellets minimize consequences to the environment and population from events affecting structural integrity of reactor or causing release of contamination

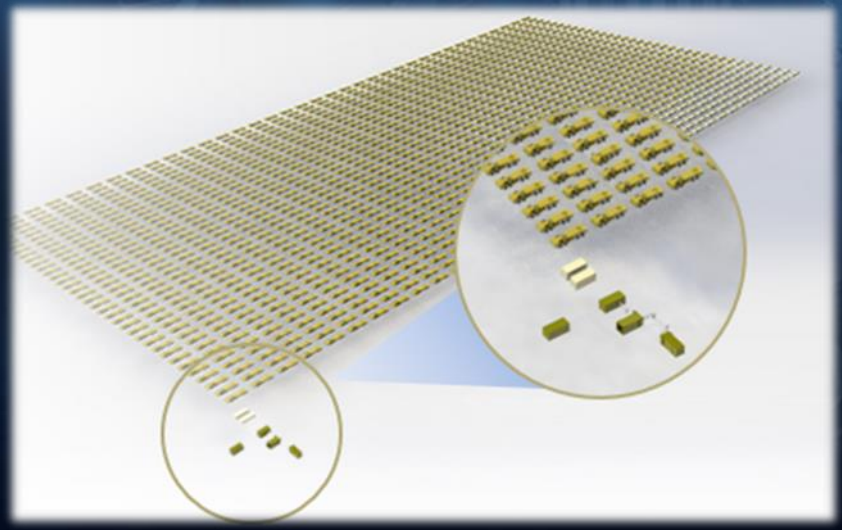
Kinetic impact testing of TRISO simulants is an element of Project PELE

Fuel Savings – TRISO Reactors

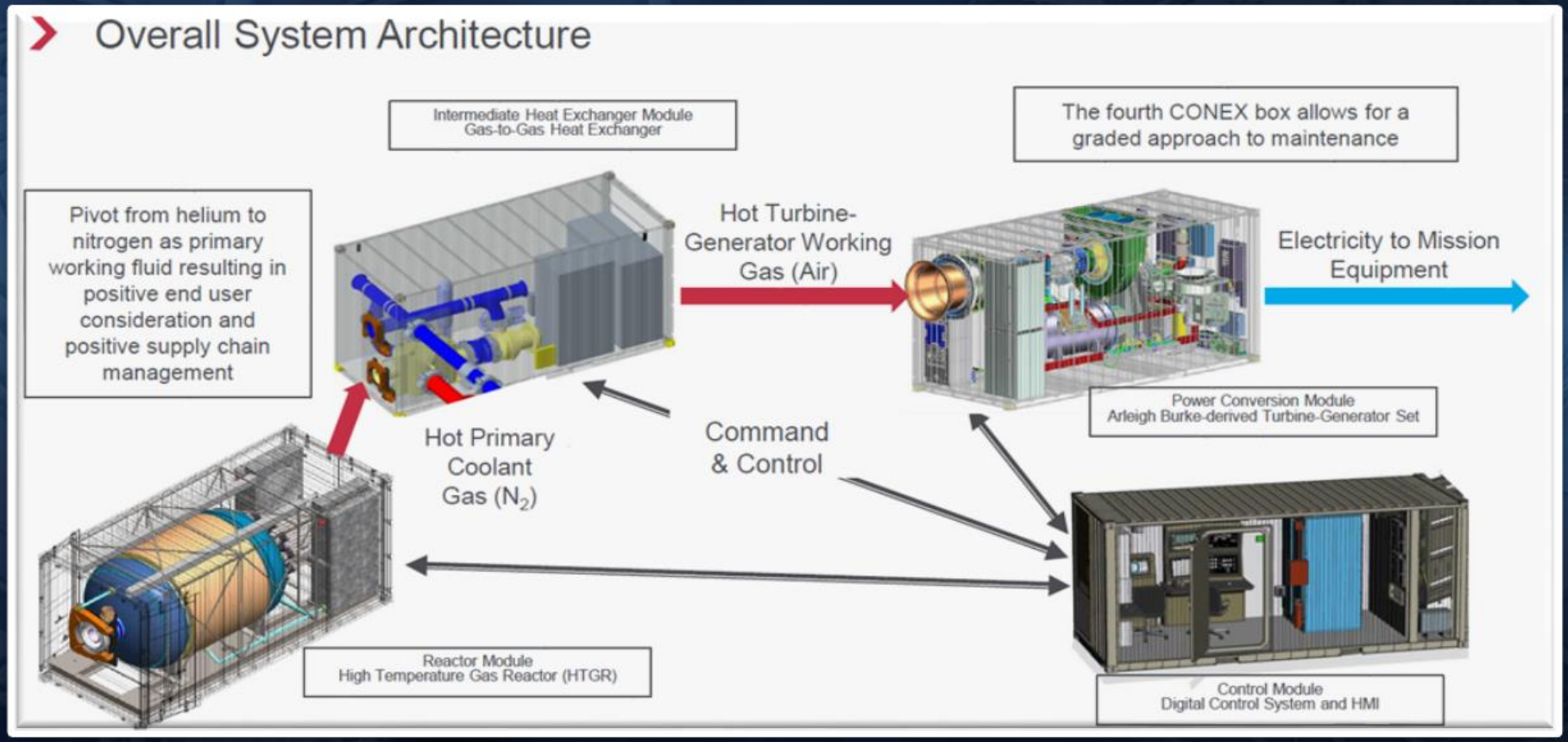


	Current Prime Power (MEP-PU-810)	Category	Future Prime Power (MNPP)	
✓	Air (C-17), land, & sea [5th Wheel Mounted)	Transportability	Air (C-17), land, & sea (3 x 20' ISO containers)	✓
✓	Diesel DL-1 & DL-2 Jet Fuel JP-8	Fuel Type	TRISO Fuel	✓
○	60 gallons per hour @ rated load	Fuel Usage	3+ years @ rated load	✓
○	813,428 gallons @ rated load	Sustainment / year (Class IIIB Demand Reduction / Fuel Avoidance)	0 gallons -- Does not require fuel sustainment	✓
—	650 hours	Reliability (MTBOMF)	T: 2,600 hours O: 26,280 hours	✓
✓	MIL-STD-1474	Human Factors	MIL-STD-1474	✓
✓	MIL-STD-461	EMI – electromagnetic Interference	MIL-STD-461	✓
✓	HAEMP IAW MIL-STD-2169	EMP – electromagnetic pulse	HAEMP IAW MIL-STD-2169	✓

1 MW Reactor offsets over 2.4 million gallons of diesel (3+ years)
$4/gallon = $10M
$16/gallon = $40M



PELE


Overall System Architecture
Intermediate Heat Exchanger Module
Gas-to-Gas Heat Exchanger
The fourth CONEX box allows for a graded approach to maintenance
Pivot from helium to nitrogen as primary working fluid resulting in positive end user consideration and positive supply chain management
Hot Turbine-Generator Working Gas (Air)
Electricity to Mission Equipment
Power Conversion Module
Arleigh Burke-derived Turbine-Generator Set
Hot Primary Coolant Gas (N_2)
Command & Control
Reactor Module
High Temperature Gas Reactor (HTGR)
Control Module
Digital Control System and HMI

VALKRE

Small Reactor Use Cases

- Contested locations
  - Arctic – radars / remote sites
  - INDOPACOM - islands
- CONUS mission assurance
- Match reactors to demand
- Cost/Benefit analysis

Small Nuclear Reactor Benefits

- Off-grid energy distribution
- Energy and thermal generation
  - Future weapons systems
  - Carbon sequestration
  - Synthetic fuels
  - Water desalinization
- Dramatically Reduced Logistics
- Factory production vice on-site construction
- Transportable

Partners


UNITED STATES
NORTHERN COMMAND


UNITED STATES
MARINE CORPS


OECIF


OFFICE OF THE CHIEF OF ENGINEERS
UNITED STATES ARMY


NASA


INL


Los Alamos
NATIONAL LABORATORY


MITRE

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For further discussion, please do not hesitate to contact:

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