N93-22093

5.4 Nuclear Concepts / Propulsion – Thomas Miller, Lewis Research Center

Nuclear thermal and nuclear electric propulsion systems will enable and/or enhance important space exploration missions to the moon and Mars. Current efforts are addressing certain research areas, although NASA and DOE still have much work yet to do.

Relative to chemical systems, nuclear thermal propulsion offers the potential of reduced vehicle weight, wider launch windows, and shorter transit times, even without aerobrakes. This would improve crew safety by reducing their exposure to cosmic radiation. Advanced materials and structures will be an important resource in responding to the challenges posed by safety and test facility requirements, environmental concerns, high temperature fuels and the high radiation, hot hydrogen environment within nuclear thermal propulsion systems.

Nuclear electric propulsion (NEP) has its own distinct set of advantages relative to chemical systems. These include low resupply mass, the availability of large amounts of onboard electric power for other uses besides propulsion, improved launch windows, and the ability to share technology with surface power systems. Development efforts for NEP reactors will emphasize long-life operation of compact designs. This will require designs that provide high fuel burn-up and high temperature operation along with personnel and environmental safety.

NASA LEWIS RESEARCH CENTER

SPACE TRANSPORTATION MATERIALS AND STRUCTURES WORKSHOP

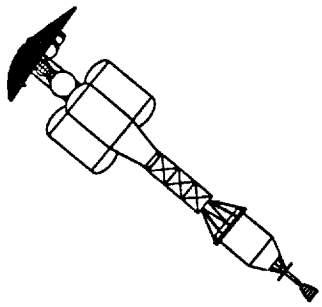
THOMAS J. MILLER

NUCLEAR PROPULSION OFFICE

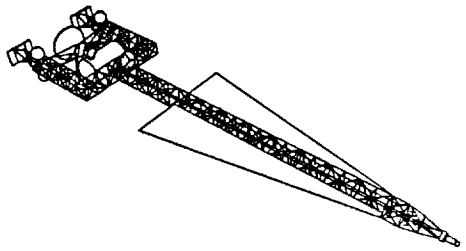
Integrated Technology Plan for the Civil Space Program

FOCUSED TECHNOLOGY: NUCLEAR PROPULSION

Nuclear Thermal Propulsion



Nuclear Electric Propulsion



FOCUSED TECHNOLOGY: NUCLEAR PROPULSION
SUMMARY

- **IMPACT:**
  - Nuclear Propulsion Enables and/or Enhances Space Exploration Missions

	Nuclear Electric Propulsion (NEP)	Nuclear Thermal Propulsion (NTP)
Enables:	Robotic Science Missions	Mars Piloted
Enhances:	*Lunar & Mars Cargo, & Mars Piloted Space Exploration*	*Lunar & Mars Cargo, Lunar Piloted & Robotic Science Space Exploration*

- **USER COORDINATION:**
  - Exploration Studies Identify Nuclear Propulsion as a Key Technology
  - OAST/RZ - Provide Performance Predictions for NASA Studies
  - OSSA Study on NEP for Robotic Science Missions
  - DOE, DoD & NASA Included on Steering Committee (also Astronaut Office)
- **TECHNICAL REVIEWS:**
  - Interagency Design Review Teams will Periodically Review Technical Progress
- **OVERALL TECHNICAL AND PROGRAMMATIC STATUS:**
  - High Priority Technology Areas Identified (some efforts initiated)
  - Budget Deliberations Continue
  - Single Multi Agency Plan Defined for FY92 Implementation
- **MAJOR TECHNICAL/PROGRAMMATIC ISSUES:**
  - Agency/Department Roles
  - Funding to Initiate Technical Efforts
  - Projected Budget Does Not Support Schedules

Nuclear Thermal Propulsion

PERFORMANCE OBJECTIVES

PARAMETER	STATE-OF-THE ART	OBJECTIVE
THRUST (Lbf)	75K (NERVA)	75K-125K/Engine
	250K (PHOEBUS)	(May cluster multiple engines)
SPECIFIC IMPULSE (sec)	825	≥ 925
CHAMBER PRESSURE	450	500 - 1000
EXHAUST TEMP. (°K)	2300-2500	≥ 2,700 (w/ Approp. Safety & Reliability Margin)
POWER (MWt)	1100 (NERVA)	≥ 1,600
	4,200 (PHOEBUS)	1.0
LIFETIME (Hrs) Single Burn	1.0	4.5 (3X Mission req.)
Cumulative	1.5	5
REUSABILITY (No. Missions)	1	

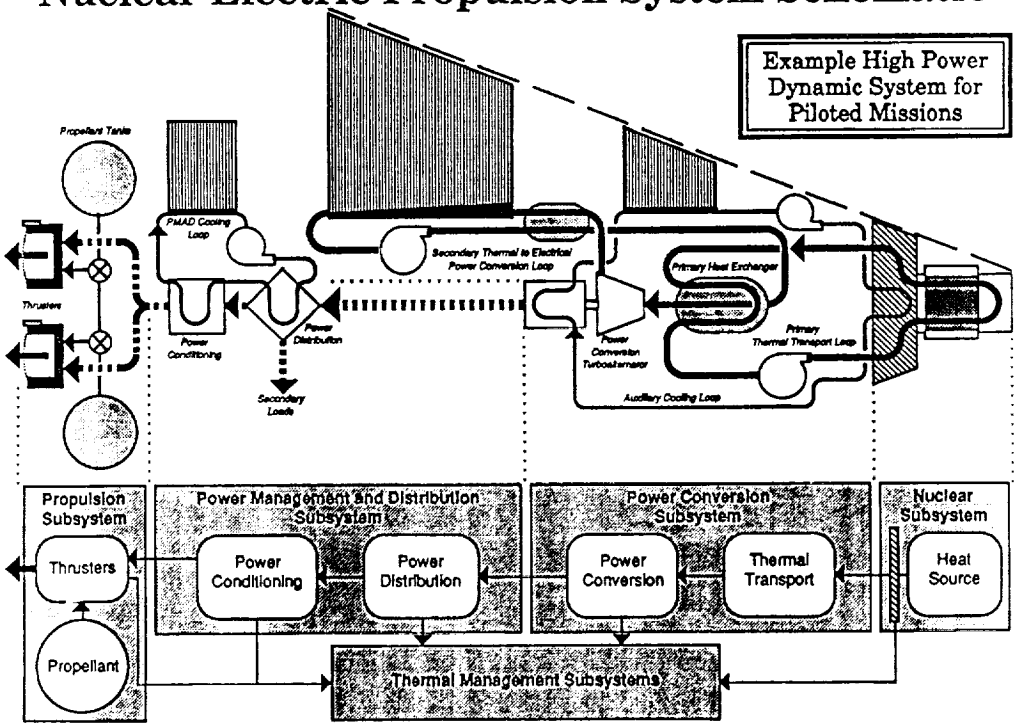
CHALLENGES

- High Temperature Fuel and Materials
- Hot Hydrogen Environment
- Test Facilities
- Safety
- Environmental Impact Compliance
- Concept Development

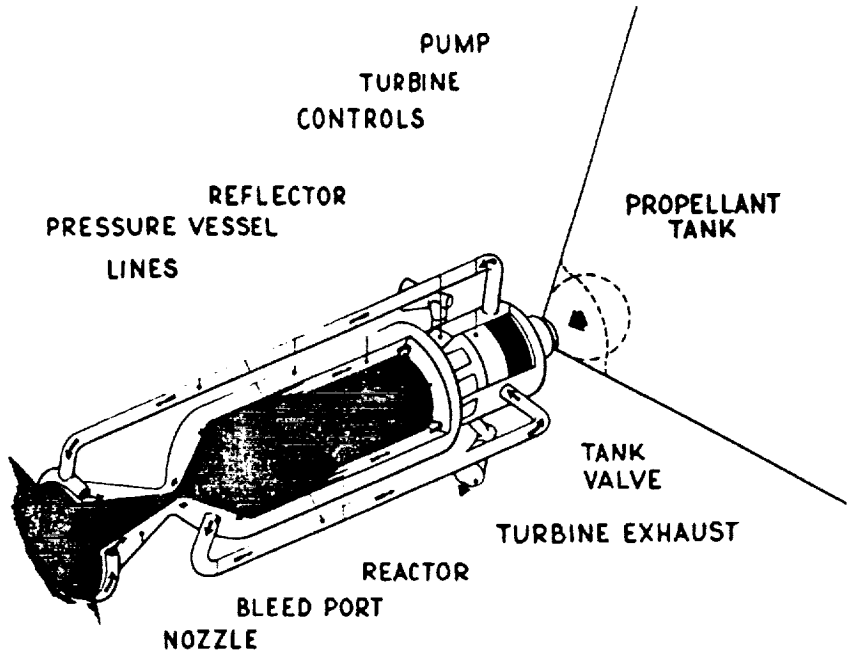
MISSION BENEFITS

- Short Transit Time Missions are Enabled
- Reduced IMLEO (~ 1/2 of Chemical)
- Crew Safety Enhanced
- Wider Launch Windows
- More Mars Opportunities
- High Thrust Available
- Aerobrake Not Required

Nuclear Electric Propulsion System Schematic



NUCLEAR ROCKET ENGINE SCHEMATIC



Nuclear Electric Propulsion

PERFORMANCE OBJECTIVES

PARAMETER	STATE-OF-THE ART		OBJECTIVE	
POWER	SP-100			
POWER LEVEL (MWe)	0.1		≥10.0	
SPECIFIC MASS (Kg/KWe)	30			
PROPULSION	ION	MPD	ION	MPD
SPECIFIC IMPULSE (sec)	2000-9000	1000-5000	2000-9000	1000-7000
EFFICIENCY	0.7-0.8	0.3	0.7-0.8	>0.5
POWER LEVEL (MWe)	0.01-0.03	0.01-0.5	1 - 2	1 - 5
LIFETIME (Hrs)	10,000	?	10,000	≥ 2000
PMAD				
EFFICIENCY	0.90		0.95	
SPECIFIC MASS (Kg/KWe)	4		≤ 2.5	
REJECTION TEMP. (°K)	400		600	

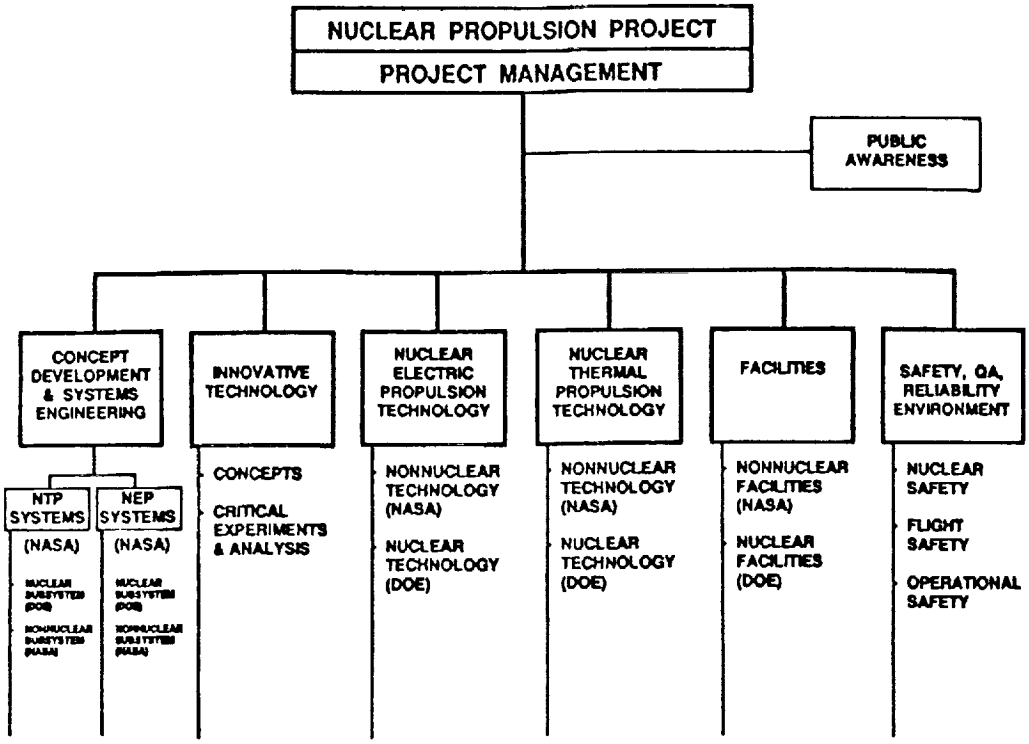
CHALLENGES

- Long Operational Lifetime
- High Temperature Reactors, Turbines, Radiators
- High Fuel Burn-up Reactor Fuels, Designs
- Efficient, High Temperature Power Conditioning
- High Efficiency, Long Life Thrusters
- Safety
- Environmental Impact Compliance
- Concept Development

MISSION BENEFITS

- Low Resupply Mass
- Availability of Onboard Power
- Reduced IMLEO Sensitivity w/Mission Opportunity
- Broad Launch Windows
- Commonality with Surface Nuclear Power
- Aerobrake Not Required

PROJECT WORK BREAKDOWN STRUCTURE



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