"NEAR TERM" NEP MISSIONS AND SYSTEMS

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NUCLEAR PROPULSION OFFICE NEP GOALS

- **NASA's Office of Space Science and Applications (OSSA) has identified NEP as first priority on its far term technology needs list to OAST**
- **NEP systems of interest to OSSA:**
  - TRL 5 by ~2000
  - 50 -100 kWe
  - $\alpha < 50$ kg/kWe
  - 7 year life
  - High Isp, η
- **NPO emphasis is on developing 10 - 20 kWe ion thrusters, PPU**
- **MWe NEP effort reduced in scope**

"NEAR TERM" SYSTEMS DEFINITION

- **Reactor: SP-100**
  - 2.5 MWt
  - 1350 K Outlet Temperature
  - 7 year life
- **Radiator**
  - Ti/K Heat Pipes
  - 5 - 10 kg/m^2 specific mass
  - < 900 K
- **PMAD**
  - SOA Si Electronics
  - T < 400 K

"NEAR TERM" SYSTEM DEFINITION (cont.)

- **Power Conversion**
  - Thermoelectrics
    - **~5% efficient**
    - **1350 K Hot Shoe Temperature**
  - Brayton
    - **SOA BRU**
    - **20 - 30% efficient**
    - **1050 K TIT**
    - **Possibility to extend to 1350 K**
  - Rankine
    - **SOA Moderate Power Reactor Experiment**
    - **20% efficient**
    - **1100 K TIT**
    - **Possibility to extend to 1350 K**

"NEAR TERM" SYSTEM DEFINITION (cont.)

- **MPD Thrusters**
  - 4.7 kg/kWe w/ Power Processing
  - Possibility for pulsed operation not yet assessed on a system level
  - Isp ~ 1000 - 7000 s
  - $\eta = 0.5$
  - Power levels from 100 to 1500 kWe total input power

REPRESENTATIVE NEAR TERM NEP SYSTEMS

PRELIMINARY

- **100 kWe SP-100/TE**
  - 1300 K
    - **35 - 51 kg/kWe**
- **500 kWe SP-100/Brayton**
  - 1100 K
    - **50.7 kg/kWe**
  - 1300 K
    - **35.7 kg/kWe**
- **500 kWe SP-100/Rankine**
  - 1100 K
    - **21 kg/kWe**
  - 1300 K
    - **16.4 kg/kWe**

Includes 4.7 kg/kWe MPD thruster subsystem (1 set of thrusters)

NEAR TERM NEP MISSIONS

- **Demo Missions (<100 kWe)**
  - LEO-GEO
    - **Van Allen Belt Science***
  - Lunar Science
    - **Lunar Mapper**
  - Mars Precursor
  - Interplanetary Robotic
    - **Main Belt Asteroid Rendezvous***

*To be discussed in this presentation

NEAR TERM NEP MISSIONS

- **Primary Missions (100 - 1500 kWe)**
  - Interplanetary Robotic
    - **Neptune Orbiter**
    - **Jupiter Grand Tour**
    - **Pluto Orbiter**
    - **Multiple Main Belt Asteroid Rendezvous**
    - **Comet Nucleus Sample Return***
  - Space Exploration Initiative Related
    - **Lunar Mapper**
    - **Lunar Cargo**
    - **Mars Probe**
    - **Mars Cargo***

*To be discussed in this presentation

DEMO MISSIONS

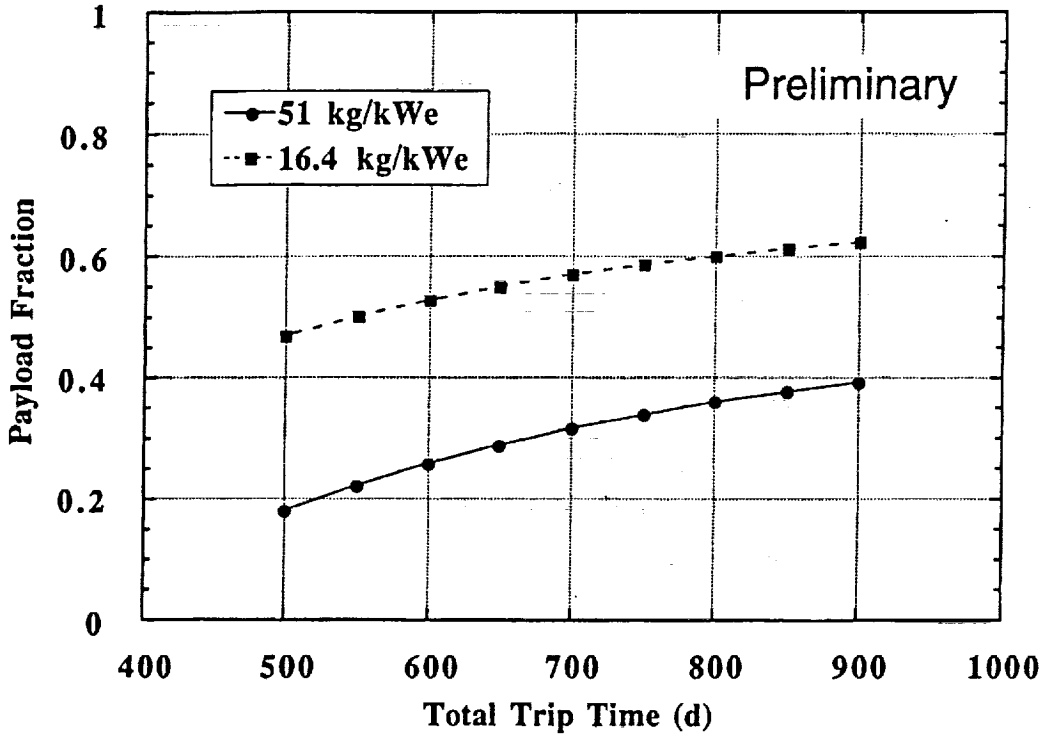
- **Observations Based Upon JPL, NASA LeRC studies**
- **Mission studies were based on Xe Ion thrusters, SP-100 capabilities**
- **Low power SP-100 (<50 kWe) has high α, up to 200 kg/kWe**
- **Launch Vehicle constraints: Atlas IIAS, Titan III, Titan IV**
- **Possible missions applicable to MPD thrusters:**
  - Key factor: Isp $\leq$ 5000 s
  - Most outer planet missions require Isp of > 7000 s
  - Power $\leq$ 100 kWe
  - Missions:
    - **Comet Nucleus Sample Return**
    - **Main Belt Asteroid Rendezvous**
    - **Van Allen Belt Mapper**

PRIMARY MISSIONS

- **Observations Based Upon In-house NASA LeRC studies**
- **Preliminary JPL study also investigated near term Mars missions**
- **Power levels from 100 to 1500 kWe**
- **Specific Masses as given previously**
- **Mars Cargo Results Shown**
  - Best and Worst Case SP-100 Dynamic
  - Payloads and initial masses based on 1500 kWe system
  - 1500 kWe = 3 power modules grouped together

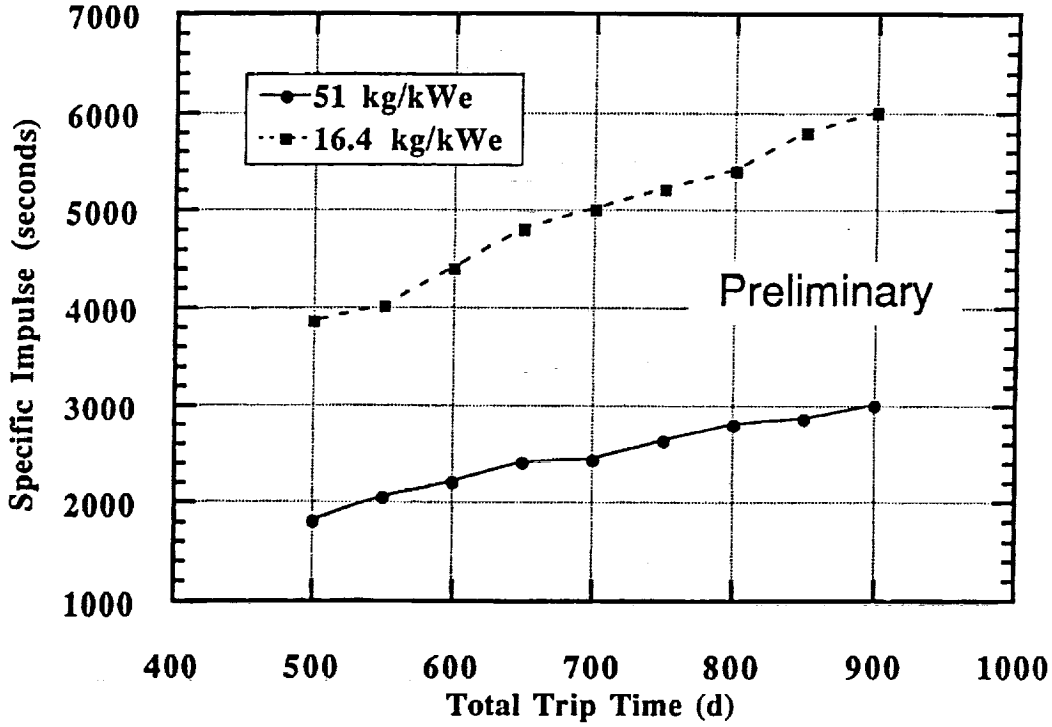
NEAR TERM NEP MARS CARGO MISSION

Optimal power, Isp - Trip time includes planetary spirals



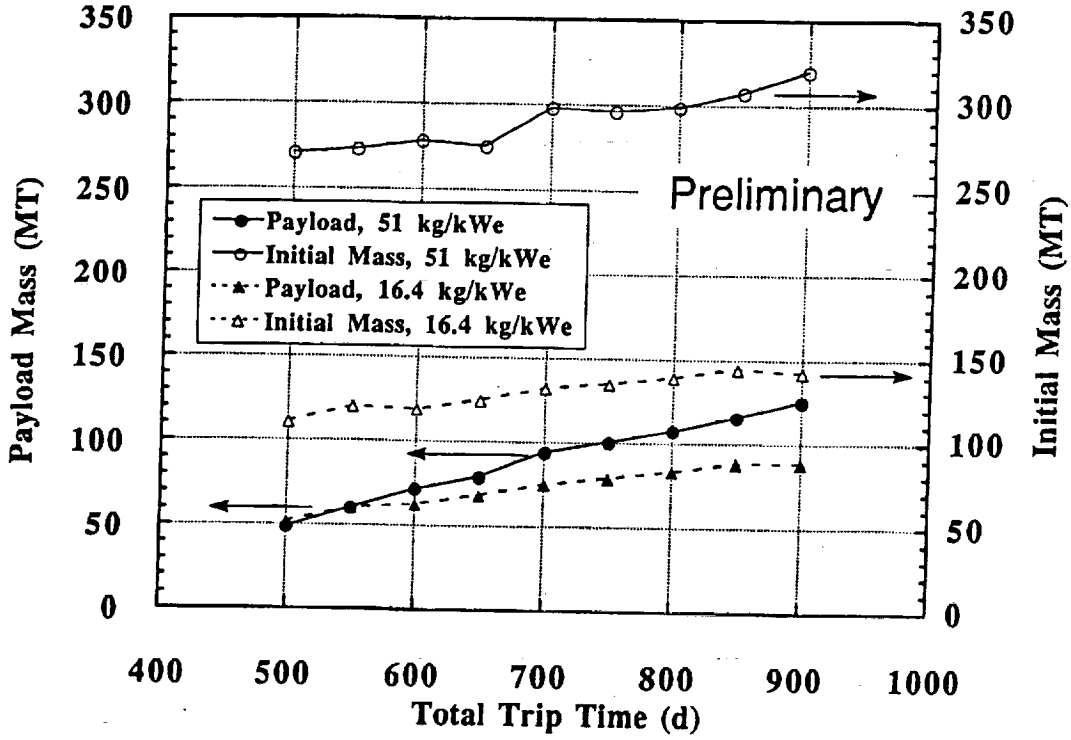
NEAR TERM NEP MARS MISSION ANALYSIS

Optimal power, Isp - Trip time includes planetary spirals



NEAR TERM NEP MARS MISSION

1500 kWe, trip time includes planetary spirals



SUMMARY

- **Near term missions impose new constraints on NEP technology**
  - High specific mass, low power
  - Constrained launch vehicles
  - Increased impact of efficiency, Isp on mission capability
- **For near term, <100 kWe missions, Ion propulsion is still primary choice based on state of technology and mission capability**

SUMMARY (cont.)

- **Some missions that could utilize MPD technology have been identified in preliminary fashion**
  - Earth orbital
  - Comet, asteroid belt exploration
  - Mars cargo vehicles
- **Key assumptions in studies to date**
  - 1 set of MPD thrusters - lifetime issues
  - 100 - 500 kWe MPD thrusters can achieve
    - **Isp ~ 1000 - 7000 seconds**
    - **α ~ 5 kg/kWe**
    - **η ~ 0.5**
  - Development time for MPD matches mission needs