Appendix D

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NEP MISSION SENSITIVITIES

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MAY 16, 1991

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NEP MISSION REQUIREMENTS

- **Parameters of Interest**
  - α - Specific Mass (kg/kWe) - Determines Trip Time Limits
  - Isp - Specific Impulse (seconds) - Determines Propellant Mass
  - η - Efficiency - Affects Trip Time and Propellant Requirements
- **Presentation Approach**
  - Illustrate the effects of above parameters when considered independently

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NEP Mission Evolution

- **Interplanetary Probe**
  - Near term application w/ SP-100, ion engines
  - Outer Planets - Neptune, Pluto, Jupiter
  - Long lifetime missions
  - Most demanding in terms of energy requirements
- **Orbital Transfer***
  - Low to Moderate Power (.1 - 1 MWe), α (10 - 50 kg/kWe) requirements
  - Includes LEO-GEO, Lunar
  - Planetary gravity well limits EP to cargo trip times
  - Approximate trajectory by ΔV's of 6 - 8 km/s
- **Planetary Cargo***
  - Moderate Power (1 - 5 MWe), α (10 - 20 kg/kWe) requirements
  - Larger Payloads (100 - 200 MT) Drive Power Level
  - Includes planetary spirals and heliocentric transfer
  - Reduced importance of trip time eases technology requirements
- **Piloted Interplanetary***
  - High Power (10 - 50 MWe), Low α (<10 kg/kWe) requirements
  - Trip time drives α, Power requirements
    - **Mars Trip Times of 1 - 1.5 years are desirable**

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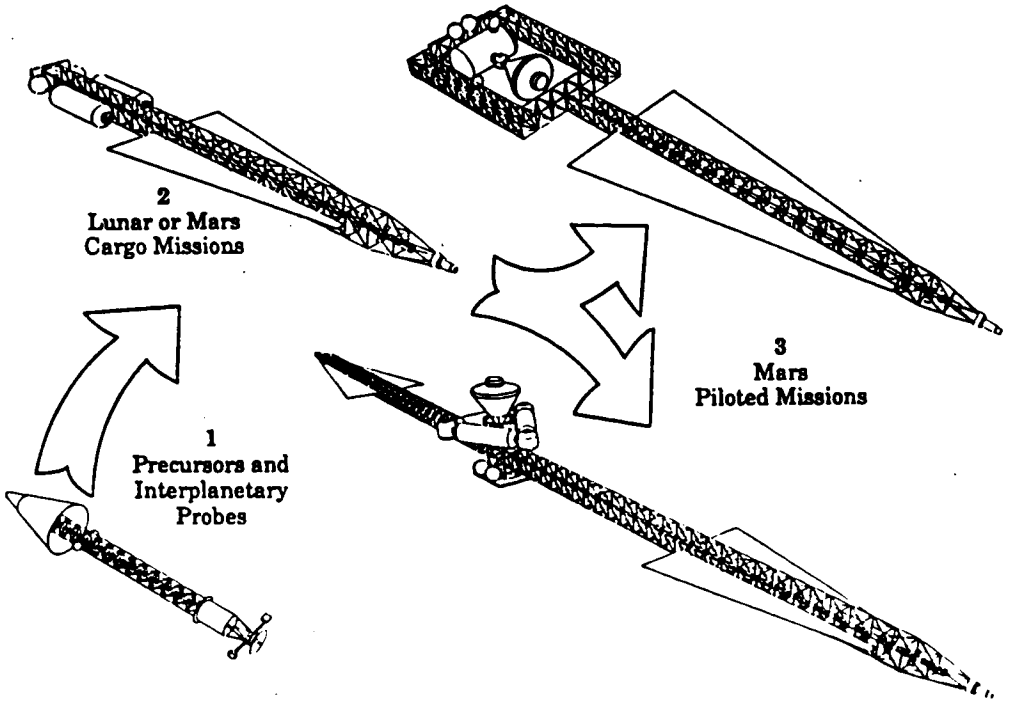
Mission Evolution



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Cases Considered

- **Orbital Transfer**
  - Lunar Cargo - ΔV = 8 km/s
  - LEO = 500 km, Lunar Orbit = 100 km
  - 10,20 kg/kWe
  - 58 MT payload outbound, return empty
  - Power, Isp optimized for maximum payload fraction
- **Planetary Cargo**
  - Mars Cargo - 800 day one-way, including spirals
  - 10 kg/kWe
  - Payloads ~ 100 - 200 MT
  - Power Optimized for fixed Efficiency, Isp
- **Piloted Planetary**
  - Piloted Mars Mission
  - Opposition Class - 30 day stay time - 500 day trip time
  - No crew on board during spiral escape, capture at Earth
    - **Crew trip time = heliocentric time + stay time**
  - 124 MT outbound, 40.3 MT inbound payload
  - 5 kg/kWe
  - Power Optimized for fixed Efficiency, Isp
  - Fixed Power (10 MWe) also examined

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Lunar Cargo

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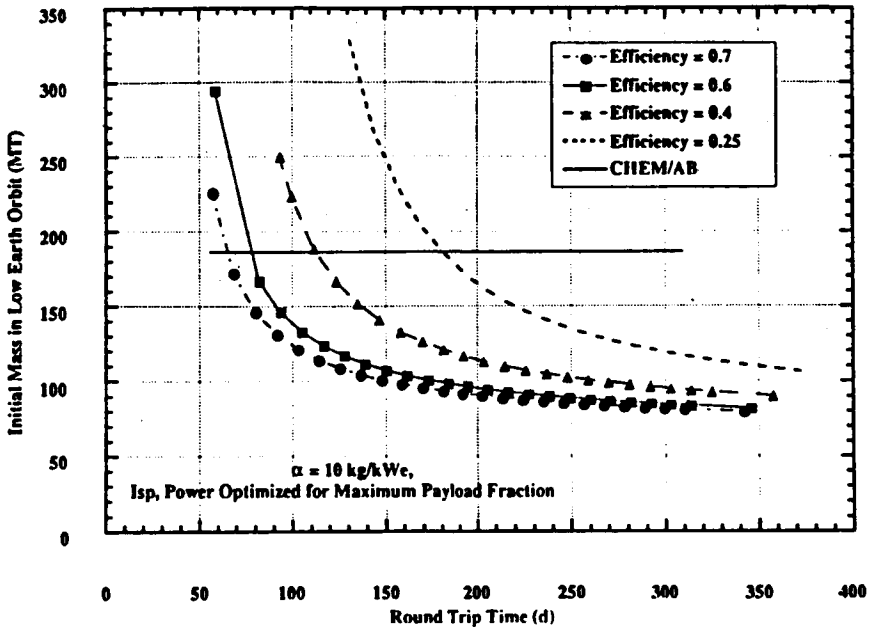
SENSITIVITY OF NEP TO EFFICIENCY
LUNAR CARGO MISSION - OPTIMIZED POWER, Isp



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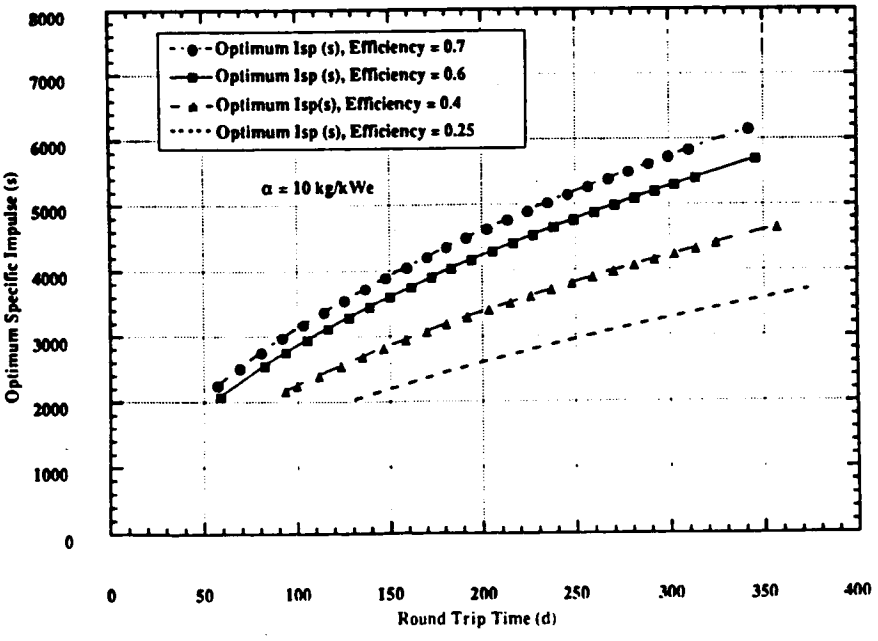
OPTIMIZED NEP Isp
LUNAR CARGO MISSION



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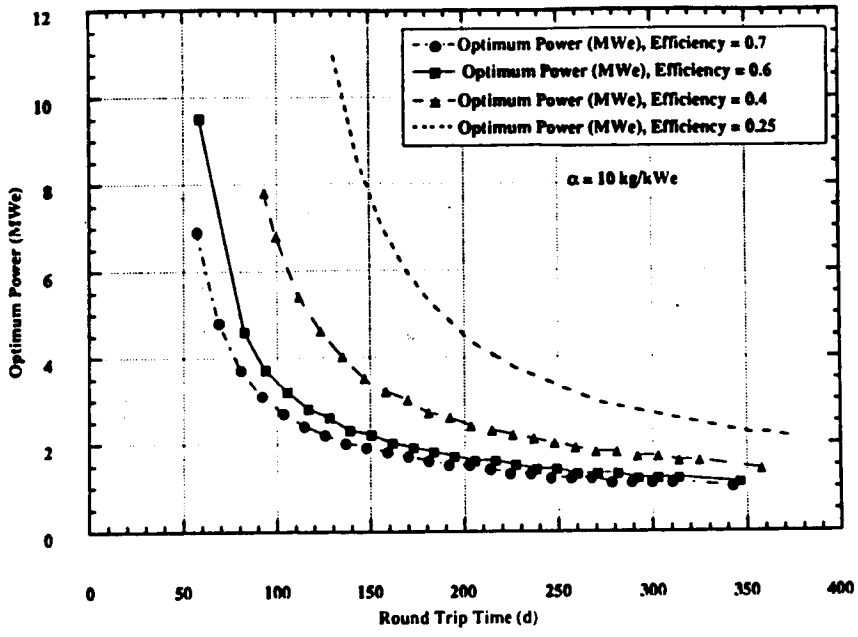
OPTIMIZED NEP POWER LUNAR CARGO MISSION



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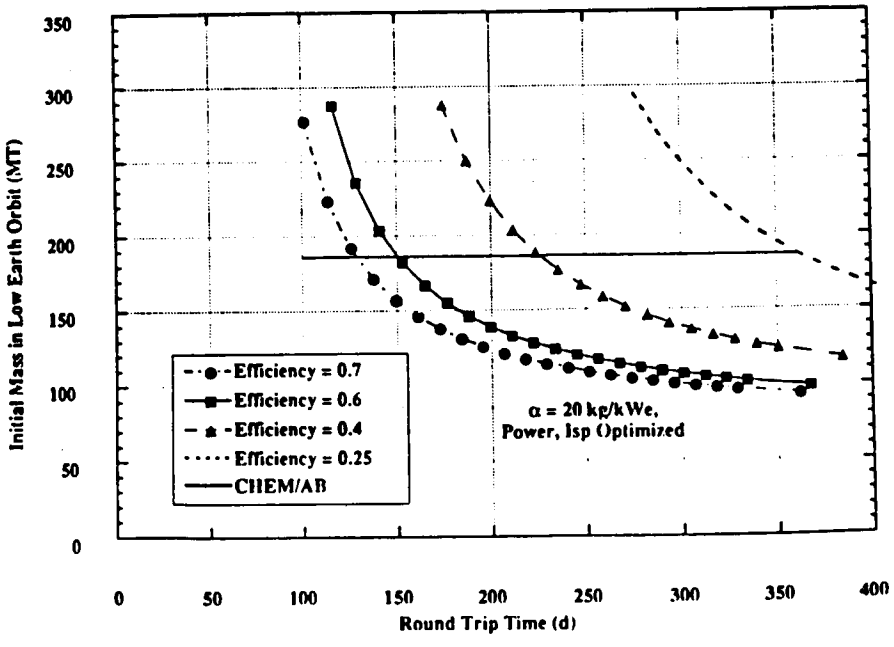
SENSITIVITY OF NEP TO EFFICIENCY LUNAR CARGO MISSION - OPTIMIZED POWER, Isp



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Mars Cargo

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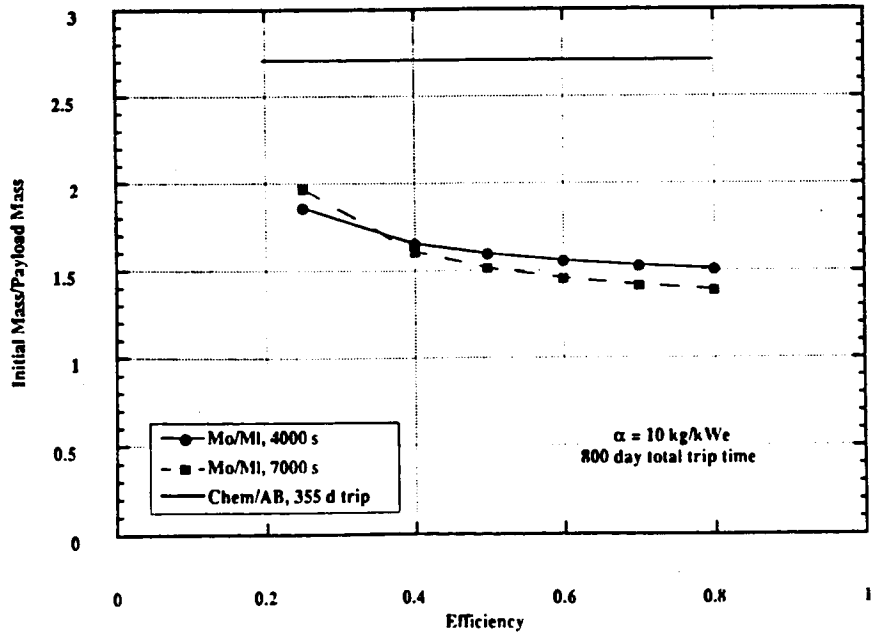
SENSITIVITY OF NEP TO EFFICIENCY, Isp MARS CARGO MISSION, VARYING POWER



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Mars Piloted

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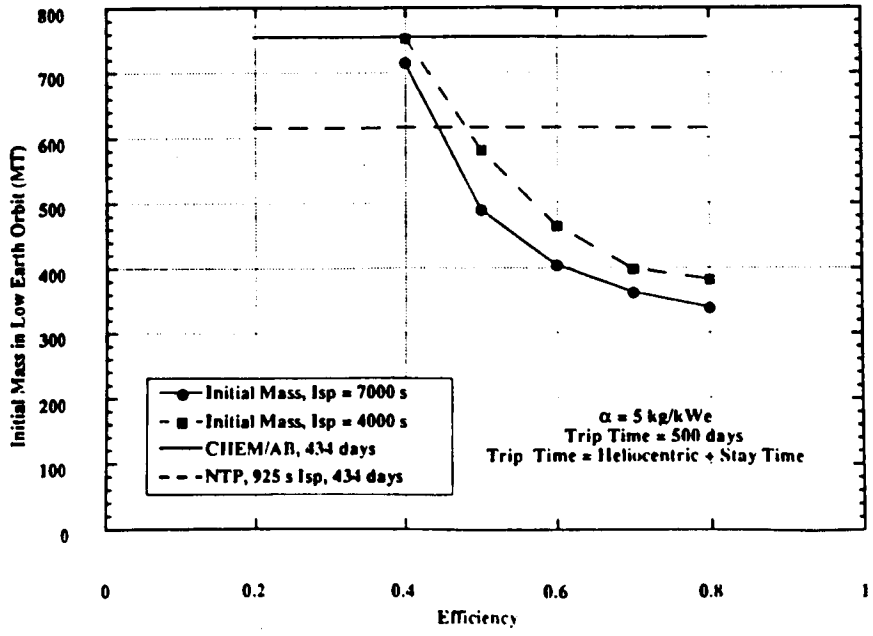
SENSITIVITY OF NEP TO EFFICIENCY, Isp PILOTED MARS MISSION, VARYING POWER



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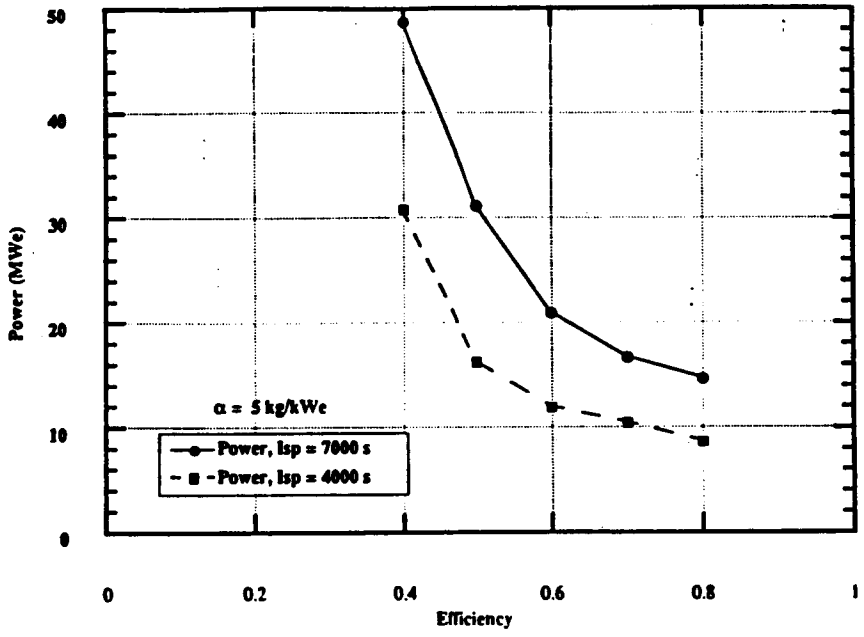
POWER REQUIREMENTS PILOTED MARS MISSION



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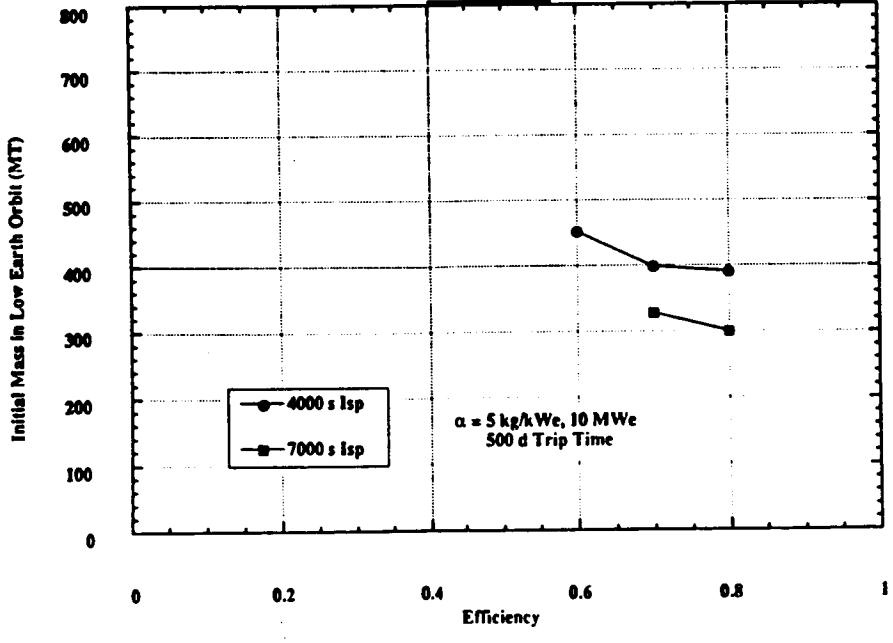
SENSITIVITY OF NEP TO EFFICIENCY, Isp PILOTED MARS MISSION, FIXED POWER (10 MWe)



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SUMMARY

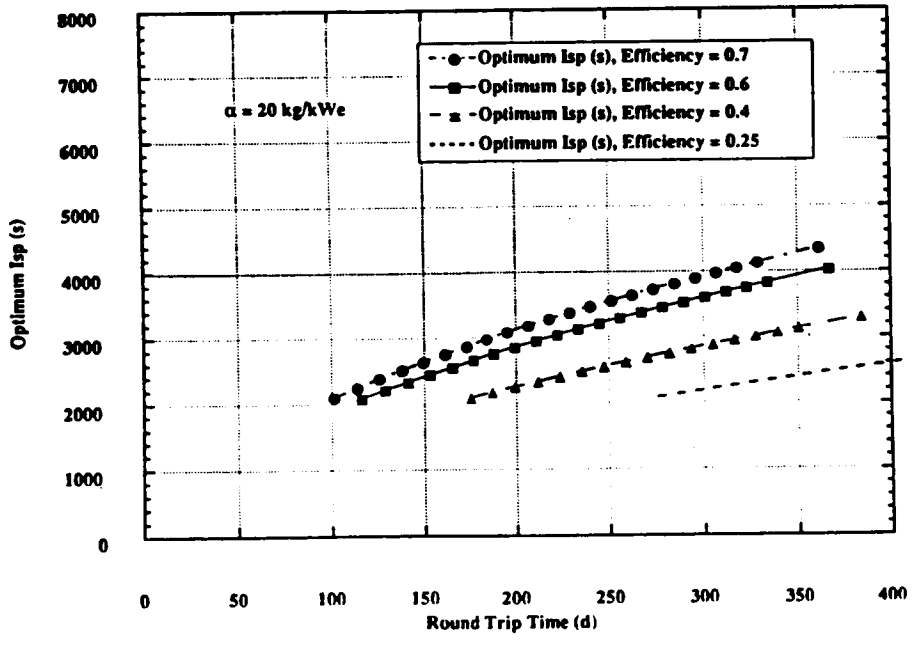
- **Parameters considered:**
  - Specific Mass
  - Efficiency
  - Isp
  - Power
- **Specific Mass (α)**
  - For reduced trip time Missions, α is key driver
    - **α primarily dependent on power system**
- **Efficiency**
  - Interplanetary
    - **Near term needs, high performance requirements lead to use of ion engine**
  - Lunar Cargo
    - **For 10 kg/kWe, η as low as 0.25 may be competitive with Chem/Aerobrake**
    - **For 20 kg/kWe, η must be 0.4 or greater**
  - Mars Cargo
    - **Extended trip time (800 d) reduces impact of efficiency, Isp variations; η > 0.25 may be useful**
  - Piloted Mars
    - **Short trip times drive η to values > 0.6**
  - Sensitivity to η will be greater for higher values of specific mass

SUMMARY (cont.)

- **Specific Impulse**
  - For the same efficiency, Isp shows a secondary impact on mission performance
  - Cargo
    - **2000 - 5000 s Isp suitable for low ΔV Earth-orbital missions**
    - **4000 s suitable for Mars Cargo**
  - Piloted
    - **Isp >= 4000 s satisfactory**
  - *Dependence of η upon Isp will affect choice of Isp*

APPENDIX

OPTIMIZED NEP Isp
LUNAR CARGO MISSION



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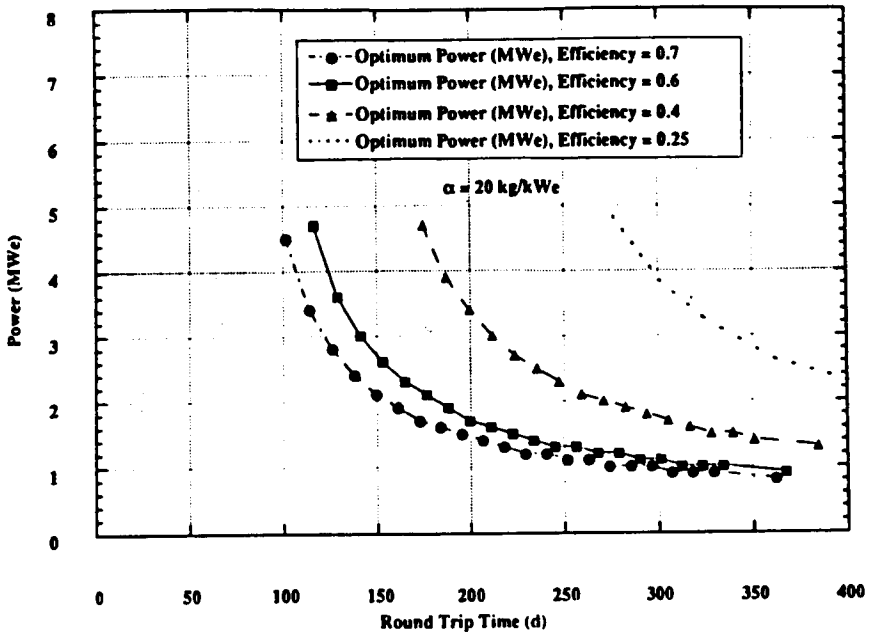
OPTIMIZED NEP POWER LUNAR CARGO MISSION



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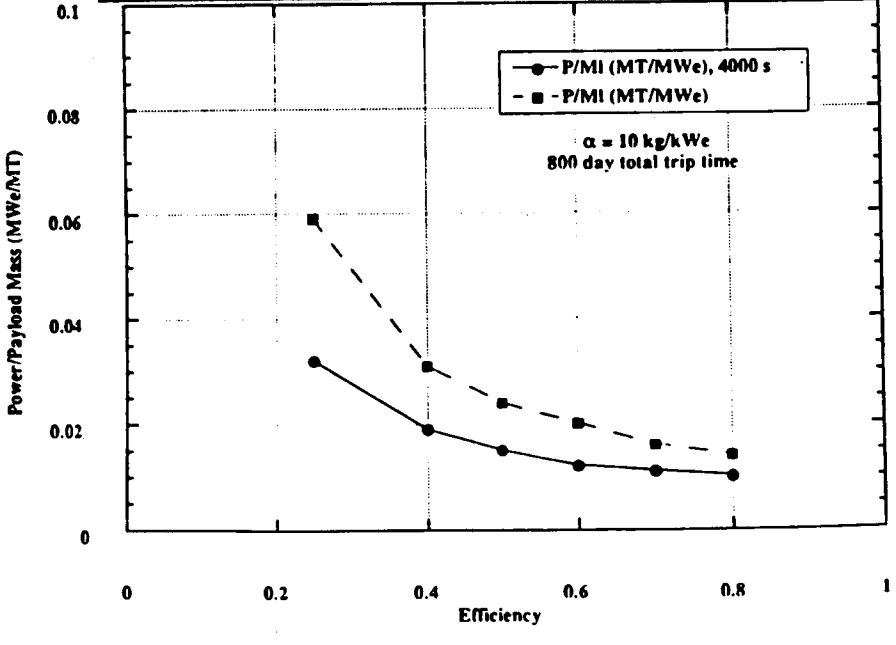
MARS CARGO MISSION POWER REQUIREMENTS NORMALIZED TO PAYLOAD MASS



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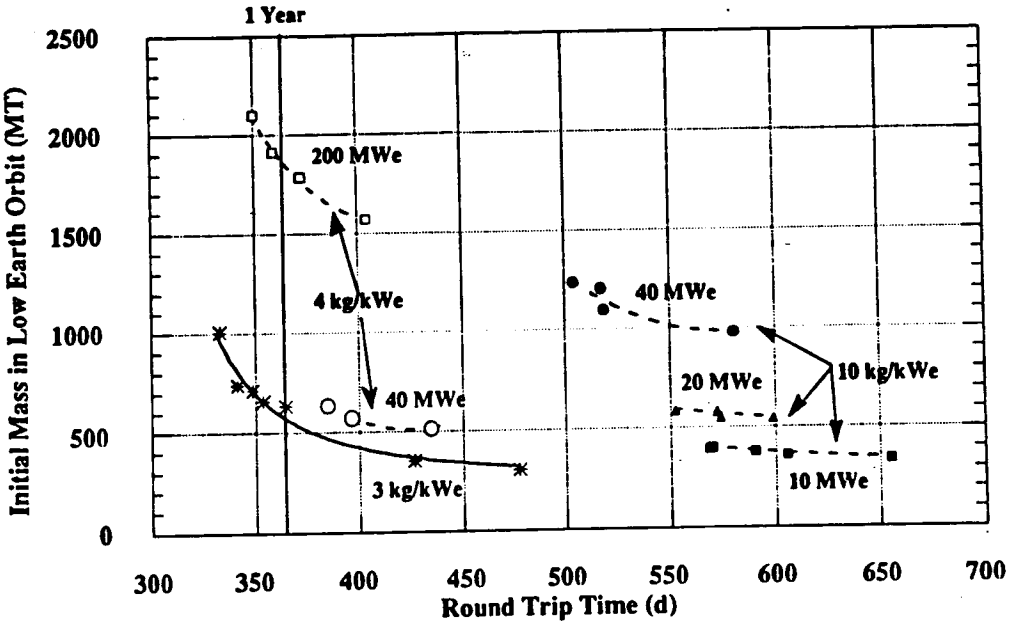
Piloted Mars Relative Mission Performance



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