Earth Observation Telescope at L2 Draft Final Report

Power Subsystem

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Power System Overview

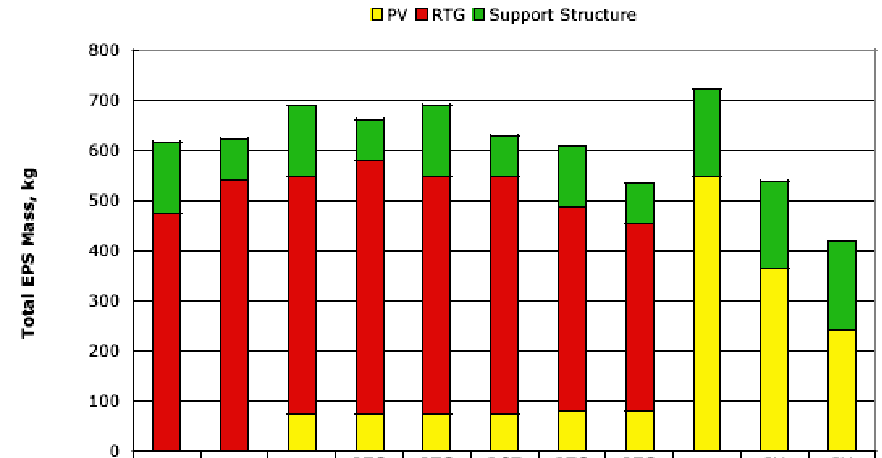
- Requirements
  - Projected power level = 3 kWe for each spacecraft
  - 100 % Duty cycle required
  - Mission duration = 10 years
- Considerations
  - Spacecraft flying in reduced Solar Illumination region in order to image solar annulus
    - Reduced solar insolation determined & incorporated into calculations
      - Some concern about further reduction due to attenuation at UV end of spectrum
    - Also, solar illumination expected to be varying due to perturbed motion around target point
      - System design would have to incorporate capability to handle maximum illumination but availability of max. power level cannot be assumed
  - Occlusion of critical spacecraft surfaces by PV arrays on secondary spacecraft not acceptable
    - Therefore, available array area on secondary spacecraft highly constrained

Power System Design Drivers

- 3 kWe for spacecraft bus and thruster operation on the primary and secondary spacecraft
- Minimize power system size and mass
- Reduced solar intensity within Earth's anti-umbra
  - Only ~10% that of Earth's orbit values
- Integration of power system unobtrusive to spacecraft operation
  - Large array size interferes with spacecraft operations
- High efficiency power conversion to reduce isotope quantities
- Nuclear power source would require additional launch and separate spacecraft to fly in formation.
  - Scenario would be to beam power to both primary and secondary spacecraft from reactor flying in formation
  - Additional propellant and thrusters needed

System Trades

- Two methods of power generation considered for L2 telescope
  - PV arrays
  - Radioisotope Power System (RPS)
- Most feasible for mission specifications
  - PV arrays attractive because there is continual, albeit attenuated, illumination at target location; also, lower cost
  - RPS attractive because of continuous duty cycle and relatively small system size; also no impact on imaging of solar annulus
- Power Systems Trades performed:
  - At 3 kWe, RPS lowest mass option
  - Operational considerations also advantageous over PV arrays
    - Power available earlier in mission
    - Reduced pointing requirements



	RTG Only - Near	RTG Only - Few	RTG w/PV - worse	RTG few w/PV - worse	RTG w/PV - no degrad	RGT feww/PV - no degrad	RTG w/PV - adv + no	RTG few w/PV - adv +	PV Only - worse	PV Only - no degrad	PV Only - adv + no
Support Structure	141.75	81	141.75	81	141.75	81	121.5	81	175.5	175.5	175.5
RTG	473.8	541.44	473.8	507.6	473.8	473.76	406.1	372.24	0	0	0
PV	0	0	73.034	73.034	74.339	74.339	80.65	80.65	545.84	363.16	242.54

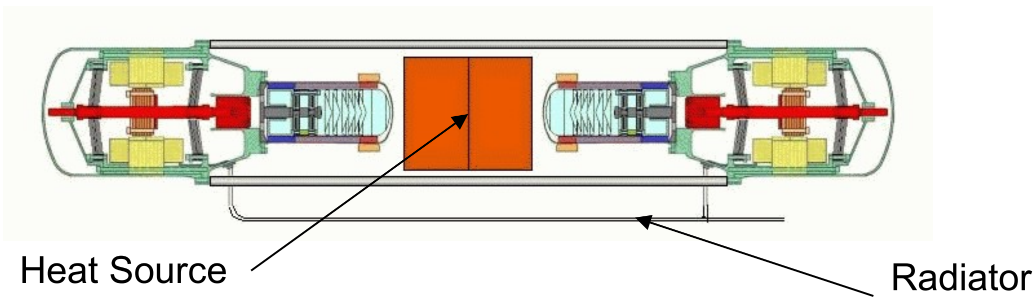
Power Systems Options

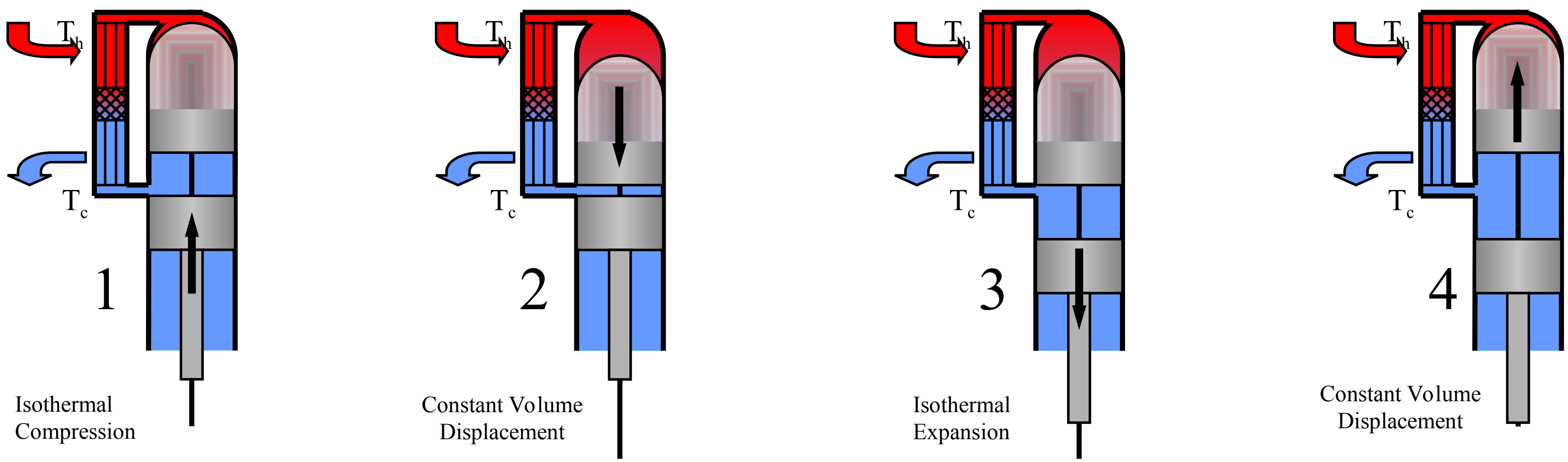
Results:

- RTG only option lowest mass option if PV operation degraded in Anti-umbra
- Benefit to keeping PV array on secondary manifests only in an Advanced PV environment with no degradation - Further investigation of PV arrays at this location not recommended
- PV option lightest if advanced arrays used in non-degraded environment
- Minimal number of RTG units better choice than lowest mass due to required support structure

Stirling Converter

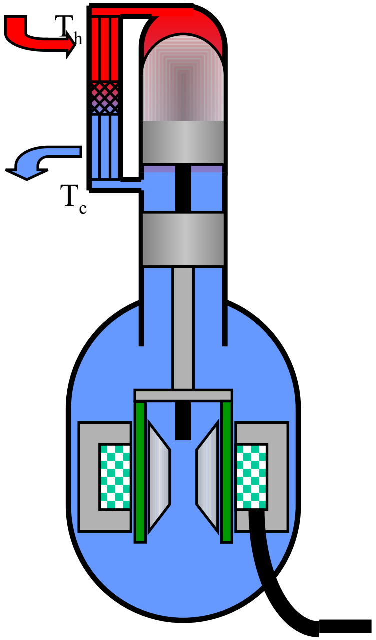
Dual opposed engines coupled to heat source





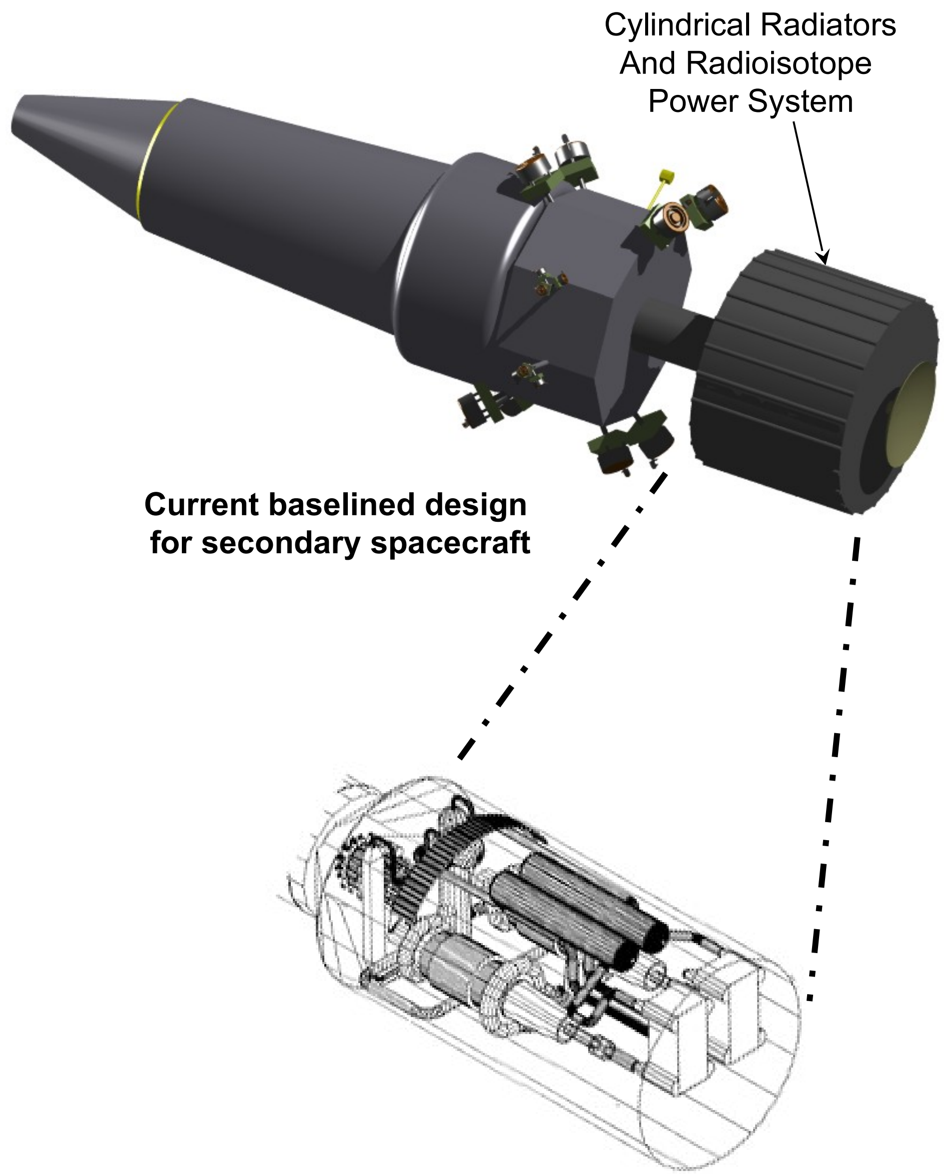
Basic Stirling Operation

- Heat energy is supplied to to heater head (Th) typically via isotope, solar or reactor energy.
- This energy is converted to the oscillating motion of a “free motion” piston/alternator generating electricity.
- Radiators provide the sink for waste heat removal.



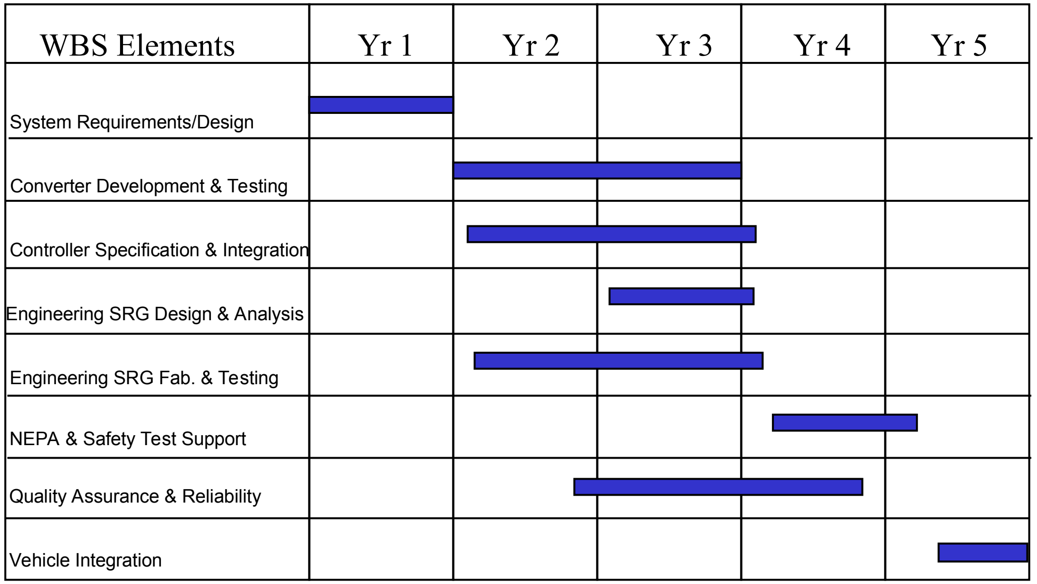
Power Systems Issues

- RPS selected as best option for primary and secondary spacecraft
  - RPS designs incorporated into spacecraft design
    - Primary & Secondary
- Issues:
  - Size of photovoltaic array makes integration difficult and interferes with secondary spacecraft. Array on primary spacecraft interferes with thruster operation.
  - Increases in power requirements can result in significant changes in RPS design decision
    - Stirling and Brayton RPS should be investigated.
  - If power requirements escalate for thruster operation, free-flying reactor system may become option due to increased usage of isotope material (current 3 kWe design uses same amount of fuel as Cassini mission).



Stirling Radioisotope Roadmap

1 kWe Stirling Radioisotope Unit



Assumes development of Stirling Radioisotope Generator 110 Unit

Technology Roadmaps

- Main technologies required for Power

- Power conversion engine
- Heat source/conversion interface
- Light weight radiators

* Many of these technologies are currently under development in NASA sponsored programs

Recommendations

- High efficiency power converters to reduce isotope needed
  - Stirling(scale up from SOTA)
  - Brayton(scale down from SOTA)
  - High efficiency thermoelectrics (TRL 2)
- Higher temperature materials to reduce radiator size and mass
- Light weight radiator materials
- Light weight thruster power processing unit