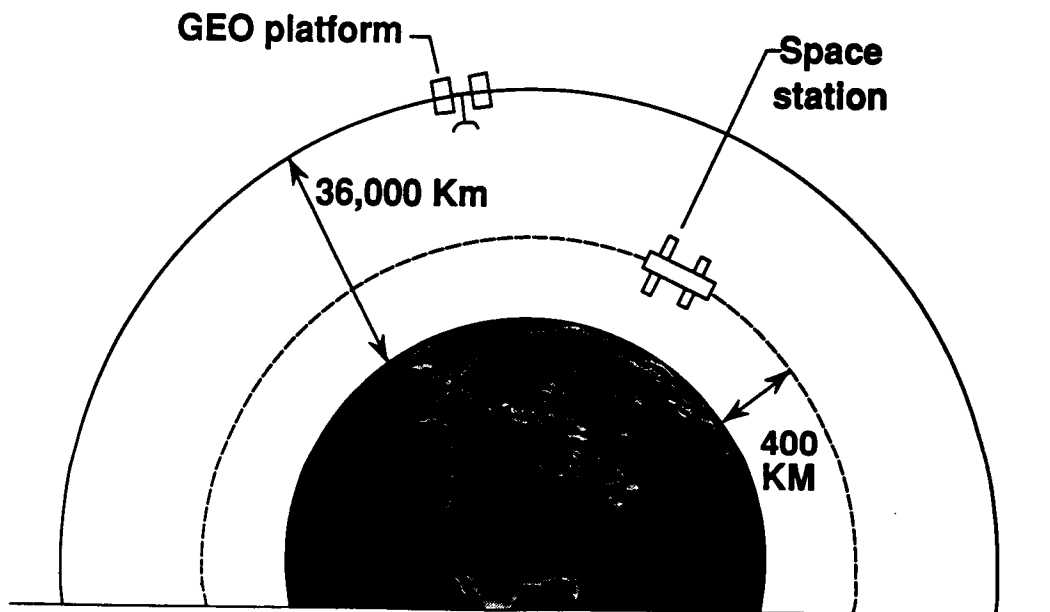# Beamed Laser Power in Support of Near-Earth Missions

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Reference Missions
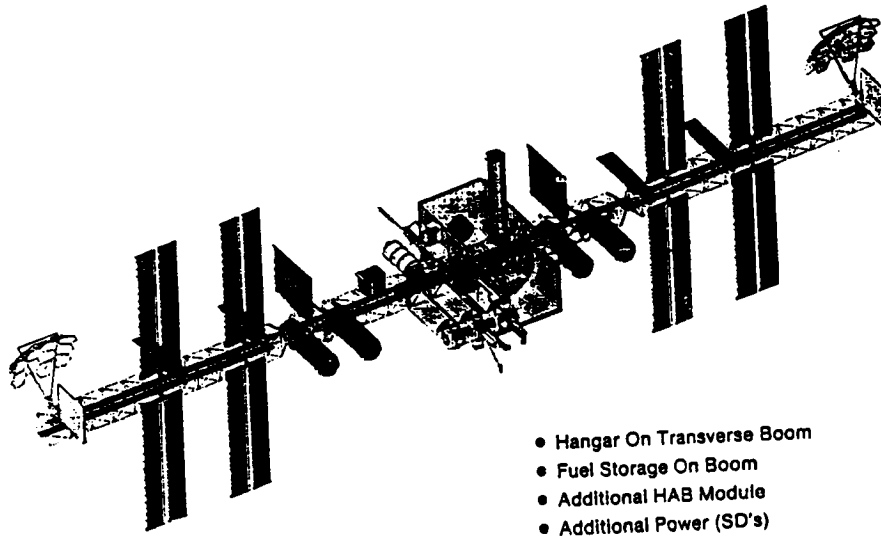
BEAMED LASER POWER IN SUPPORT
OF NEAR EARTH MISSIONS
Reference Missions

GEO platform

Space station

36,000 Km

400 KM

420

125 KW SPACE STATION
(Lunar Observatory Accomodation)
(75 KW PV +50 KW SD)
(NASA TM-4750)

- Hangar On Transverse Boom
- Fuel Storage On Boom
- Additional HAB Module
- Additional Power (SD's)

LASER-BEAMED POWER VS. CONVENTIONAL POWER

Conventional Technologies

- Photovolatic power generators (including batteries) and mass and produce atmospheric drag. This drag requires space station to be reboosted.

- Solar Dynamic power generators produce less atmospheric drag than PV.

Approach

- Remove conventional power generators and do not carry to LEO reboost fuel.

- Place laser converter, radiator and batteries on space station.

- Provide laser power.

- Since earth-to-orbit launch is very costly ($/Kg), we will compare power options in terms of total mass taken over 10 years to LEO (TMLEO/10 yrs.) to meet the space station's power requirements.

Comparison

- Is beamed power (a) better than conventional, (b) competitive, or (c) not competitive?

- If beamed power is better, we will know what could have been gained if the technology had been developed earlier.

SPACE STATION POWER SYSTEM MASSES

(10 years, on-board power generation)
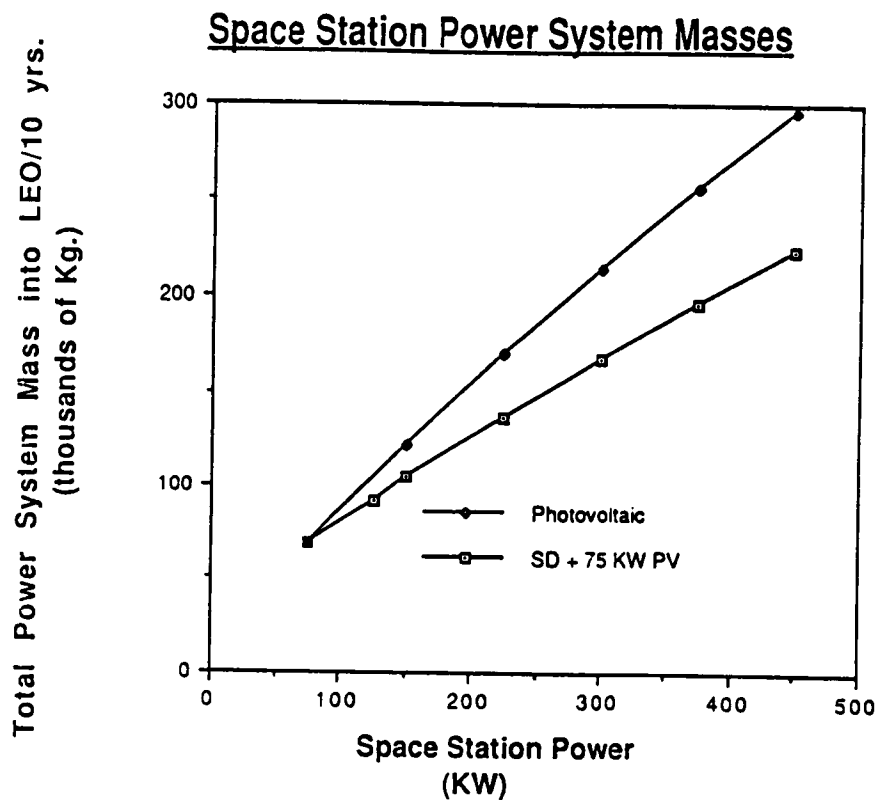
1. **All Photovoltaic Power**

    $$Pss_1 (N) = N * 75: \ KWe$$
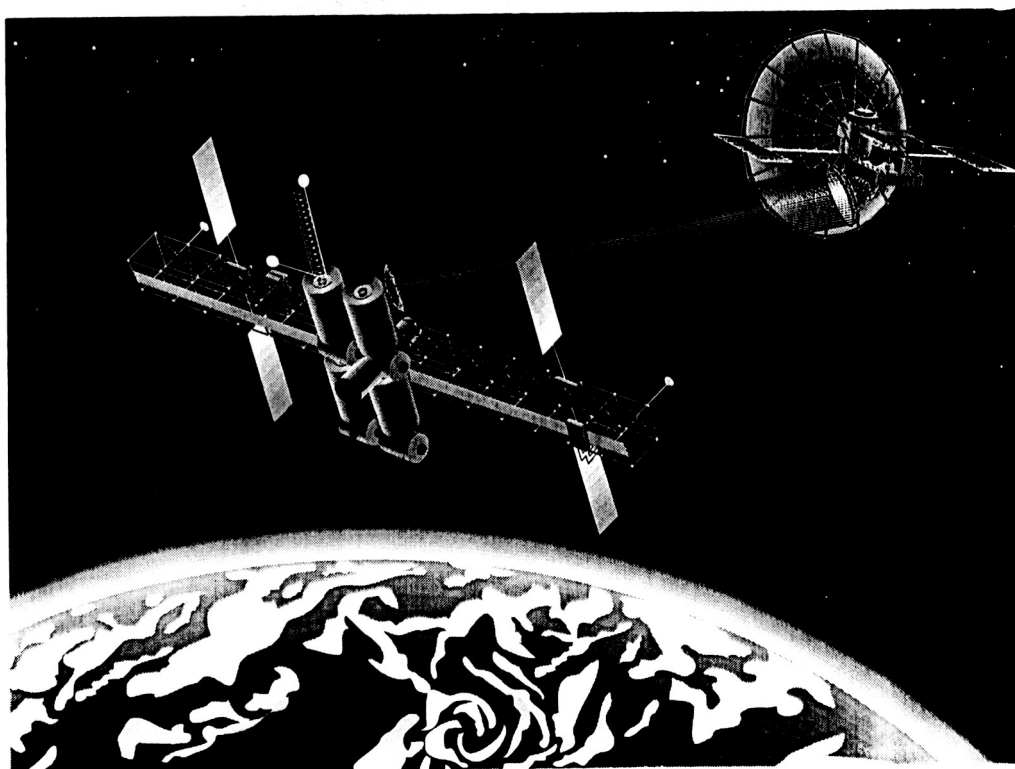
    $$M_1 = N * M \ (75 \ KW \ PV) + M \ (FUEL_1): \ Kg$$

2. **75 KW PV + Solar Dynamic**

    $$Pss_2 (N) = 75 + N * 25: \ KWe$$

    $$M_2 (N) = M \ (75 \ KW \ PV) + N * M \ (25 \ KW \ SD) + M \ (FUEL \ 2): \ Kg$$

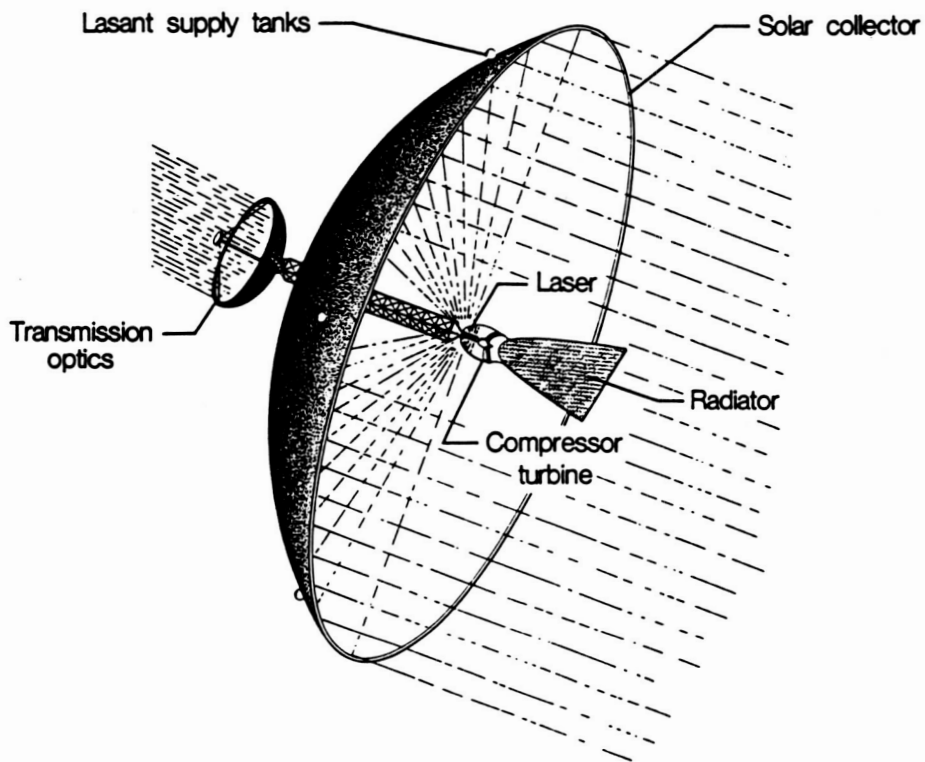### Space Station Power System Masses
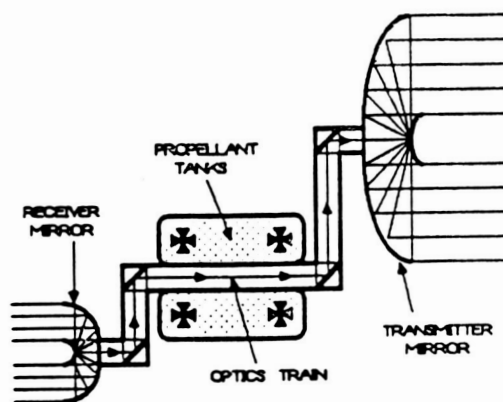
SPACE STATION POWERED BY SOLAR-PUMPED LASER

PRELIMINARY CONCEPT STUDY
OF
SOLAR-PUMPED LASER POWER
BEAMED TO SPACE STATION
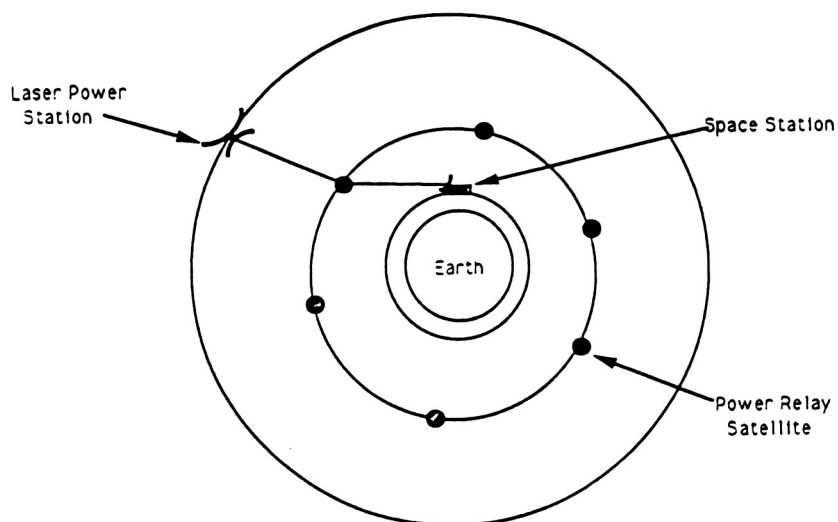
ONE MEGAWATT IODINE SOLAR PUMPED
LASER POWER STATION

Lasant supply tanks — Solar collector

Transmission optics —

Laser

Radiator

Compressor turbine

POWER RELAY SATELLITE
(JPL D-1919)

PROPELLANT TANKS

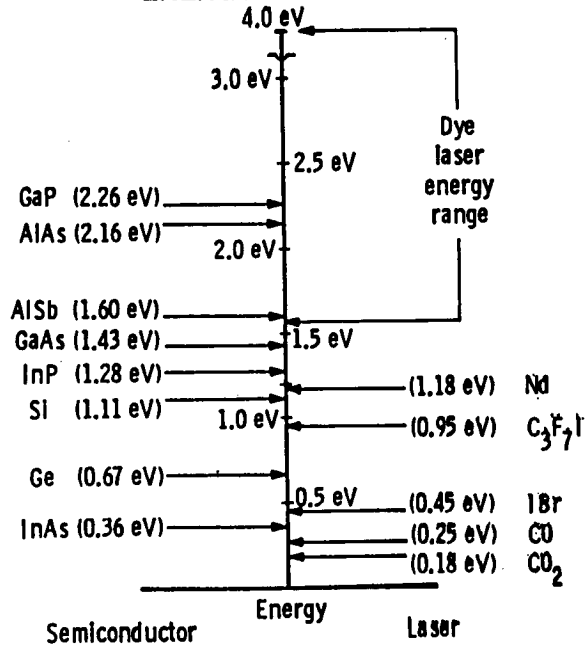RECEIVER MIRROR

OPTICS TRAIN

TRANSMITTER MIRROR

ACTIVE COOLING

ACS SIZED FOR
10 YEARS

ADAPTIVE OPTICS
(30 kg/m^2)

LASER ENERGY-SEMICONDUCTOR BAND GAP ENERGY COMPARISON

4.0 eV

3.0 eV

2.5 eV

Dye laser energy range

GaP (2.26 eV)

AlAs (2.16 eV)

2.0 eV

AlSb (1.60 eV)

GaAs (1.43 eV) — 1.5 eV

InP (1.28 eV)

SI (1.11 eV)

1.0 eV

(1.18 eV) Nd

(0.95 eV) C_3F_7I

Ge (0.67 eV)

0.5 eV

(0.45 eV) IBr

InAs (0.36 eV)

(0.25 eV) CO

(0.18 eV) CO_2

Semiconductor   Energy   Laser

SCHEMATIC DIAGRAM OF CONVERTER LASER BEAM

m

| Coverglass |
| η P η P |
| Diamond substrate |
| Heat pipe |
| Aluminum plate |
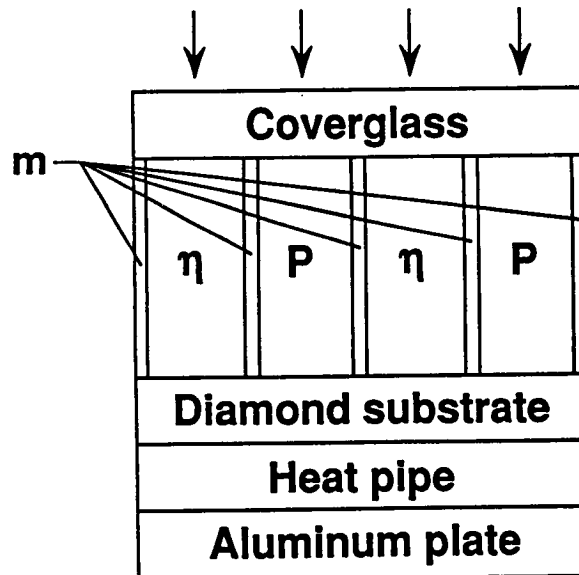
LASER PHOTOVOLTAIC CONVERSION SYSTEM

Laser Converter

Power

Radiator
for Converter
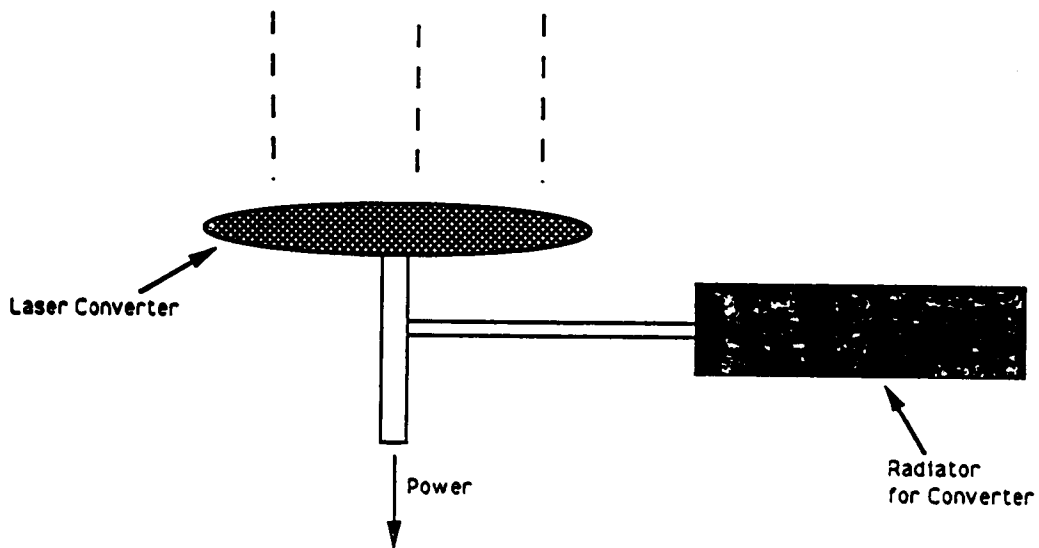
Relative Subsystem Masses
for
Laser Power Beamed to Space Station

Subsystem Mass
(thousands of Kg.)

■ Laser Power Station
■ (6) Power Relay Satellites
■ On-board Space Station

200

100

0

75   450

Space Station Power, KW
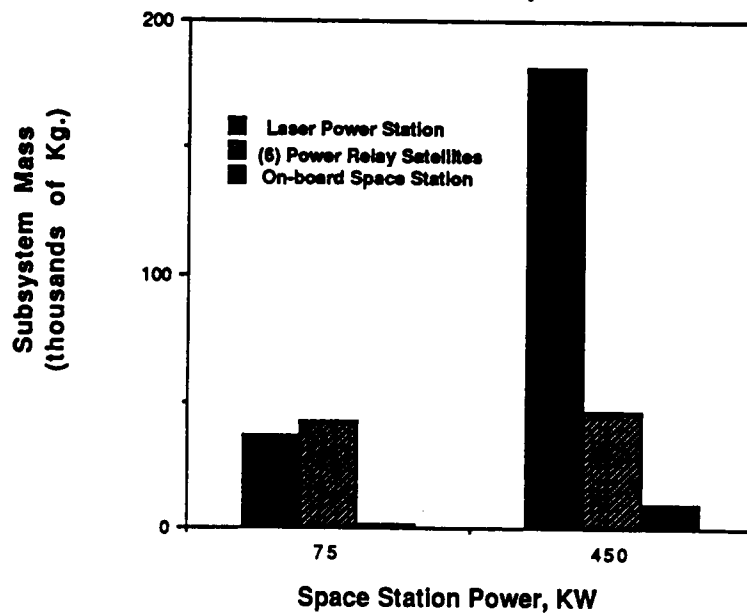
Space Station Beamed-Power-System Mass

Total Power System Mass into LEO/10yrs. (thousands of Kg.)

300

200

100

0

Photovoltaic
SD + 75 KW PV
Solar-Pumped Laser Power

0   100   200   300   400   500

Space Station Power
(KW)
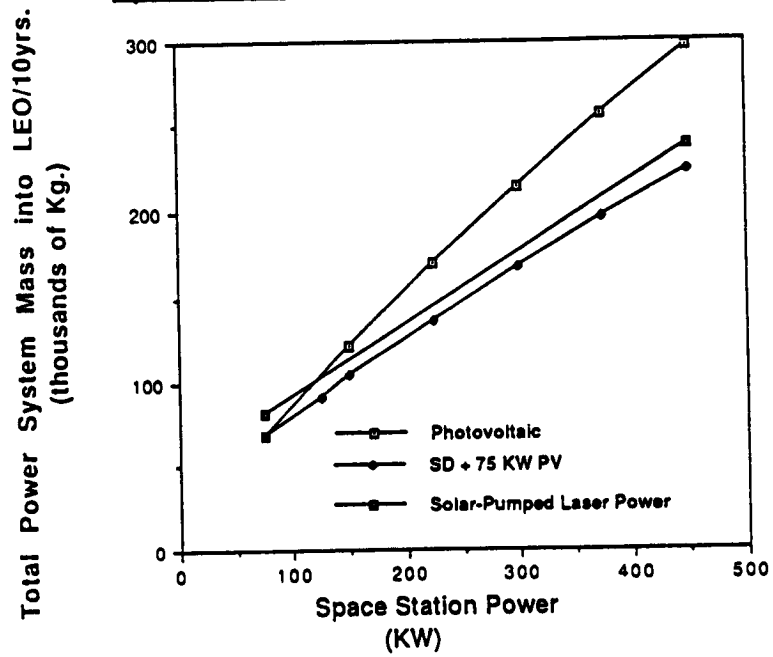
TWO CONVENTIONALLY POWERED SPACE STATIONS

125 KW (75 PV + 50 SD)

450 KW (75 PV + 375 SD)
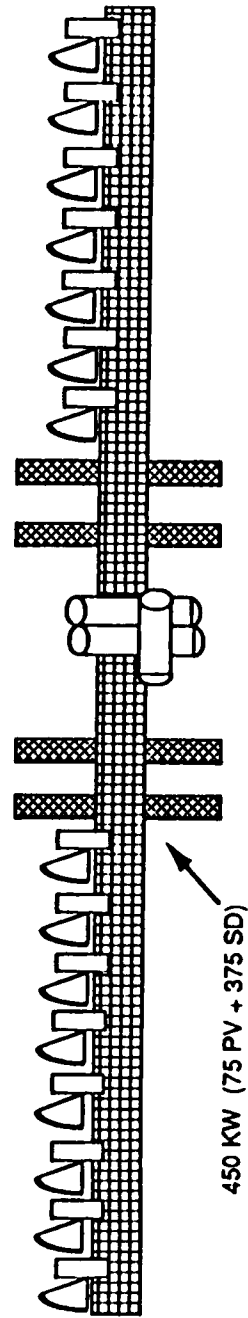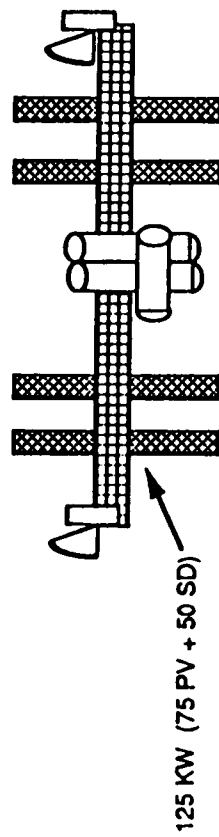
A Laser Supported Space Station Concept
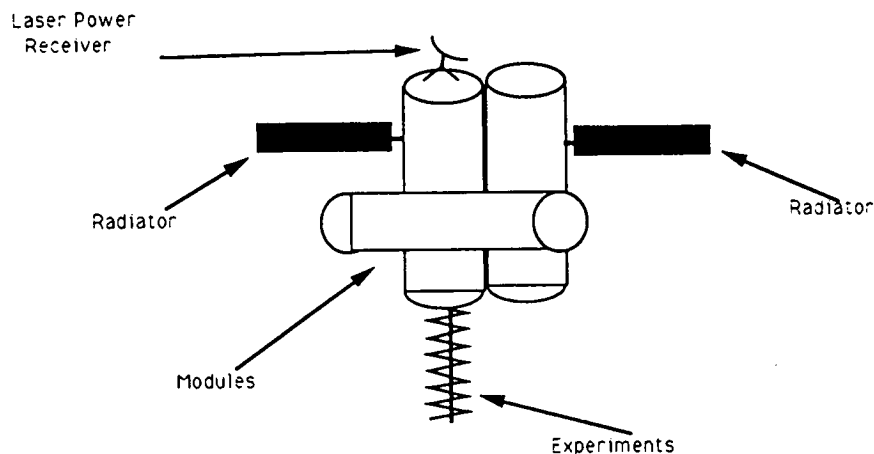
SUMMARY

- Solar-pumped laser-beamed power:

  - Lighter than photovoltaic for power requirements of 150 KWe and above;

  - Competitive with combined photovoltaic/solar-dynamic over the entire power range investigated.

- Space Station supported by laser-beamed power:

  - Can be a lower-g facility (reduced drag) than with PV or PV + SD power;

  - Has greater freedom of orientation (small receiver moves rather than large arrays or concentrators);

  - Requires less structure (arrays, alpha joints, booms) permitting easier control and fewer vibrational modes.

CONCLUSION

- Laser power beaming offers a revolutionary concept for planing, designing, and powering large orbiting spacecraft.