

## LARGE SOLAR ARRAYS

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### MULTIHUNDRED kW SOLAR ARRAYS FOR EARTH ORBIT

The objective of the multihundred program is to evaluate a broad range of concepts for reducing the cost of photovoltaic energy in space. In order to provide a focus for the effort, an orbital power platform mission in the late 80's is being used to allow a coherent technology advancement program.

#### Specific Objective:

- Evaluate a broad range of advanced concepts for reducing cost of photovoltaic energy

#### Targets:

- Evaluate alternative approaches and produce technology development plans for the most promising by mid FY 1981.
- Complete planar array low cost blanket evaluation in FY 1982.
- Demonstrate low energy cost modules by end of FY 1982.
- Demonstrate low energy cost photovoltaic systems by end of FY 1984.

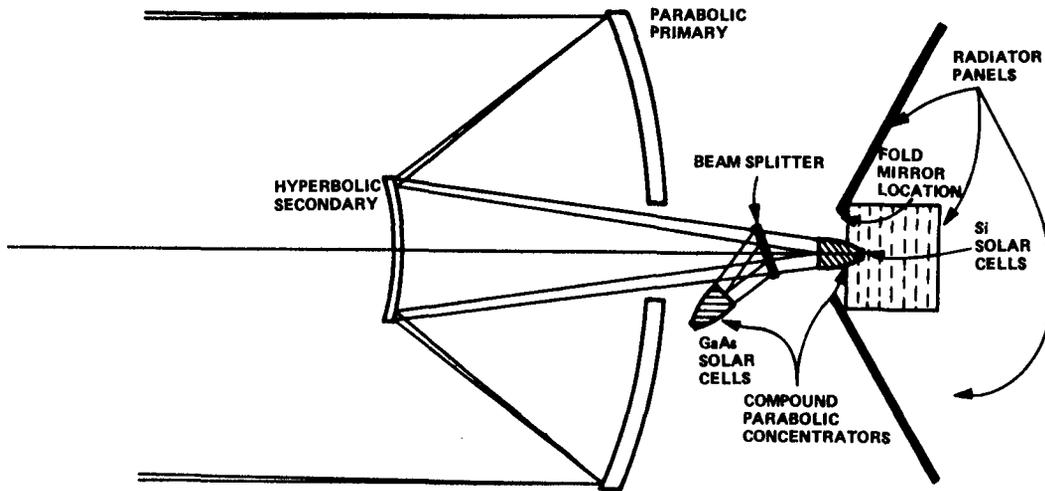
\*(Ten year life with maintenance at a captial recurring cost of \$30/watt based on 1978 dollars)

## ARRAY CONCEPTS

In keeping with the objective of evaluating a broad range of concepts, shown below are five array concepts that are being investigated. These involve a range of technology risks. The high risk technology is represented by thermophotovoltaics and spectrophotovoltaics. Each of these involves manipulation of the incoming spectrum to enhance the system efficiency, but have several unanswered technology questions, resulting in an unknown potential payback. The lowest technology risk is represented by the planar array, which has no technology risk and a moderate payback. In between the high and low risk technologies are the cassegrainian and high flux approaches.

<u>TASKS</u>	<u>PRIMARY CHARACTERISTIC</u>	<u>TECHNOLOGY RISK</u>	<u>POTENTIAL PAYBACK</u>
● SPECTROPHOTOVOLTAICS	BEAM SPLITTING	HIGH	UNKNOWN
● THERMOPHOTOVOLTAICS	SPECTRAL SHIFTING	HIGH	UNKNOWN
● CASSEGRAINIAN CONCENTRATOR	HIGH CR	MODERATE	HIGH
● HIGH FLUX	LOW CR	LOW	MODERATE
● LARGE SILICON CELL BLANKET	PLANAR	NONE	LOW TO MODERATE

# FINAL OPTICAL SYSTEM DESIGN SCHEMATIC

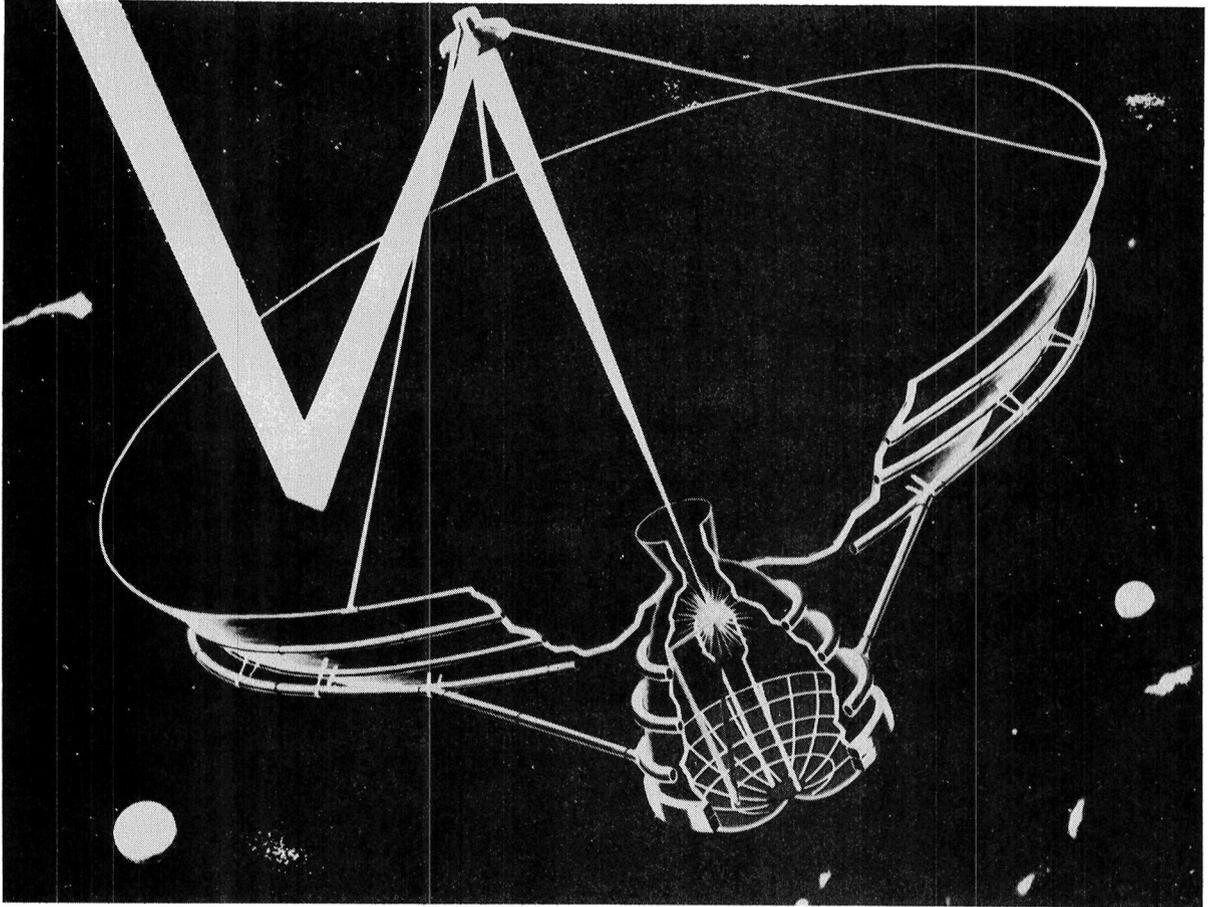


## SPECTROPHOTOVOLTAIC CONVERTER

It consists of a primary parabolic mirror and a hyperbolic secondary mirror which concentrate the sunlight. The light then passes through a beam splitter (dichroic mirror) or a number of beam splitters depending upon the design. The beam splitter splits the spectrum, sending a portion of it to a solar cell which is designed to convert the energy in that spectral region and the remainder of the spectrum is passed, eventually either being split again or going intact to another solar cell. In the particular concept shown, one beam splitter is used to split the spectrum sending part of it to a GaAs solar cell and passing the remainder to a silicon cell. The concept shown also uses compound parabolic concentrators at the cell as well as radiator panels for thermal dissipation. Of particular concern with spectrophotovoltaic converters is the tradeoff between efficiency and the number of cells required since the cost of developing new cells is generally prohibitive. Another major technology concern is spectrophotovoltaic converter sizing which has an impact on concentrator development, radiator weight, packaging and the maintainability philosophy, all of which are legitimate technology concerns in their own right.

## SPECTROPHOTOVOLTAIC CONVERTER

- TECHNOLOGY NEED:
  - LOW COST HIGH PERFORMANCE SOLAR ARRAYS IN LATE 80's
  
- CONVERTER COMPONENTS
  - CONCENTRATORS - CASSEGRAINIAN AND CPC
  - BEAM SPLITTER - DICHROIC MIRROR
  - SOLAR CELL - SILICON AND GaAs
  - HEAT REJECTION - RADIATOR
  
- TECHNOLOGY CONCERNS
  - CELL DEVELOPMENT
  - CONCENTRATOR DEVELOPMENT
  - MODULE SIZING
  - MAINTAINABILITY PHILOSOPHY
  - RADIATOR WEIGHT
  - PACKAGING



## THERMOPHOTOVOLTAIC CONVERTER

A thermophotovoltaic converter operates as follows: Solar energy is collected and focused on a "black body" absorber within a cavity. The absorbed energy is re-emitted from the converter with a 3000 K "black body" spectrum. The inside of the cavity is covered with solar cells which are irradiated with the 3000 K spectrum energy. Ideally the cells convert the energy in the 0.5 to 1.0  $\mu$  wavelength band into electricity and reflect the energy at wavelengths greater than 1.0  $\mu$  back to the "black body" where it is absorbed and then re-emitted with the 3000 K spectrum. The overall result is that the incoming spectrum is shifted to one which the solar cell would rather see.

The thermophotovoltaic converter has technology questions in the same areas as the spectrophotovoltaic converter although the concerns themselves are different. Major ones are briefly as follows: What size should the converter be? Can existing cells and concentrators be used or is cell and concentrator development required? Will radiator weight be prohibitive? Can the converter or a sufficient number of converters be packaged in the space shuttle? And what should be the maintainability philosophy?

## THERMOPHOTOVOLTAIC CONVERTER

### ● TECHNOLOGY NEED

LOW COST HIGH PERFORMANCE SOLAR ARRAYS IN LATE 80's

### ● CONVERTER COMPONENTS

- CONCENTRATOR - CASSEGRAINIAN
- CAVITY - PORTION OF A SPHERE
- ABSORBER - TUNGSTEN
- SOLAR CELL - SILICON
- HEAT REJECTION - RADIATOR

### ● TECHNOLOGY CONCERNS

- CELL DEVELOPMENT
- CONCENTRATOR DEVELOPMENT
- MODULE SIZING
- MAINTAINABILITY PHILOSOPHY
- RADIATOR WEIGHT
- PACKAGING

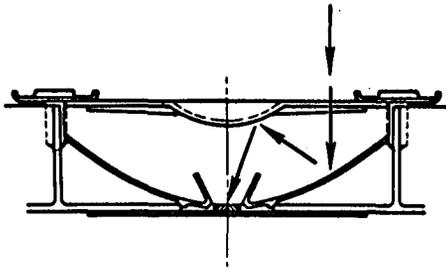
## CASSEGRAINIAN CONCENTRATOR

Below is shown a sketch of a cassegrainian concentrator concept for a multihundred kW solar array application.

The cassegrainian concept shown would make up an array which would deploy as a planar array and would provide 940 kW per shuttle launch using an advanced concentrator solar cell. It uses a concentration ratio of 125.

### 500 kW<sup>†</sup> MINIATURIZED CASSEGRAINIAN CONCEPT

STUDY OF MULTI-KW SOLAR ARRAYS  
FOR EARTH ORBIT APPLICATIONS  
NAS8-32986



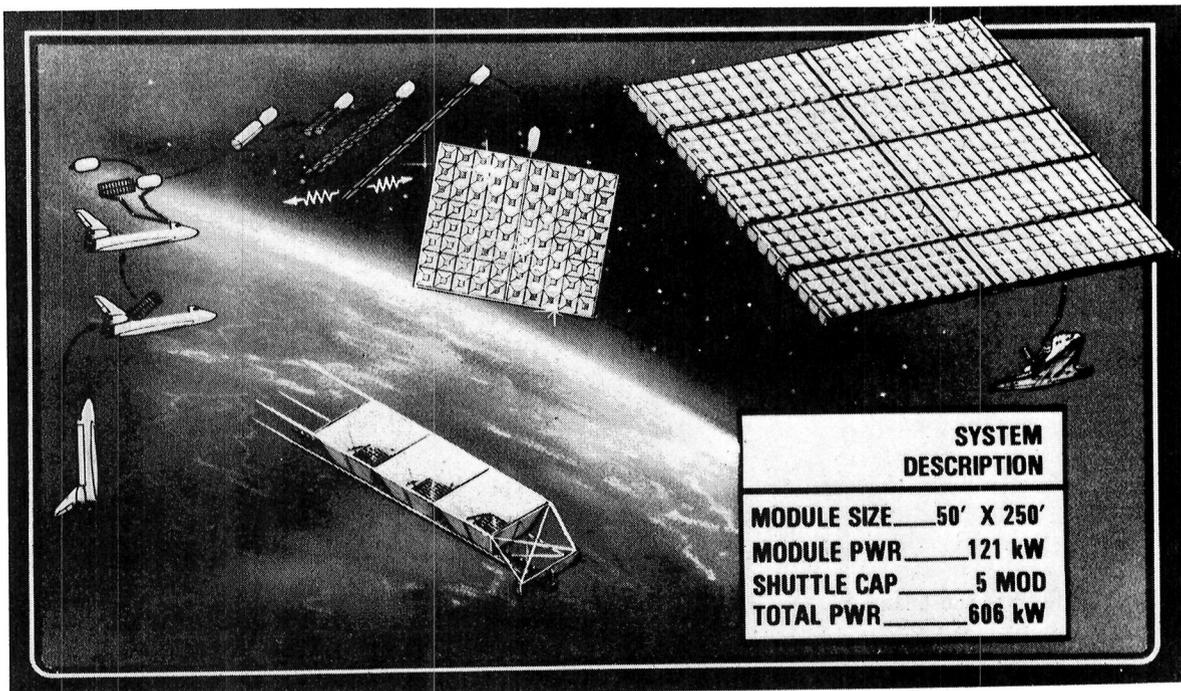
- 12 mm THICK PANELS OF CONCENTRATORS DEPLOY AND OPERATE IDENTICALLY TO PLANAR ARRAY CONCEPT
- FOLDING MIRROR SYSTEM UNIFORMLY ILLUMINATES 4 x 4 mm CELL AT 125 SUN INTENSITY
- CONE-TERTIARY REFLECTOR PROVIDES OFF-POINTED CAPABILITY TO ~4 DEGREES TO ACCOMMODATE MISALIGNMENT AND FIGURE CONTROL
- CELLS COUPLED TO PASSIVE RADIATORS
- 15<sup>\*</sup>W/kg, 75<sup>\*</sup>W/m<sup>2</sup>, 325<sup>\*</sup> - 500<sup>\*\*</sup> kW/LAUNCH
- MAINTENANCE AT 1 kW LEVEL BY EVA AND WITH AN ON-ORBIT STORAGE OPTION

† PER ORBITER LAUNCH

\* BASED ON 12% CELL EFFICIENCY AT 100<sup>0</sup>C

\*\* 18% GaAs CELL

## LOW-CR CONCENTRATOR CONCEPT



## HIGH FLUX CONCENTRATOR

The high flux concentrator concept shown in the previous artist's concept is known as a truncated pentrahedral concept. Its basic building block is a five faced figure with four reflectors arranged to form a rectangle with the reflectors tilted to reflect the sunlight into the bottom of the rectangle which contains solar cells.

The concept is capable of providing a total beginning of life power of 606 kW with one shuttle launch by carrying five (5) modules (module power 121 kW, module dimensions 50 ft x 250 ft) the concept has a geometric CR of 5 and can utilize silicon or GaAs solar cells. (The power numbers are for GaAs cells.)

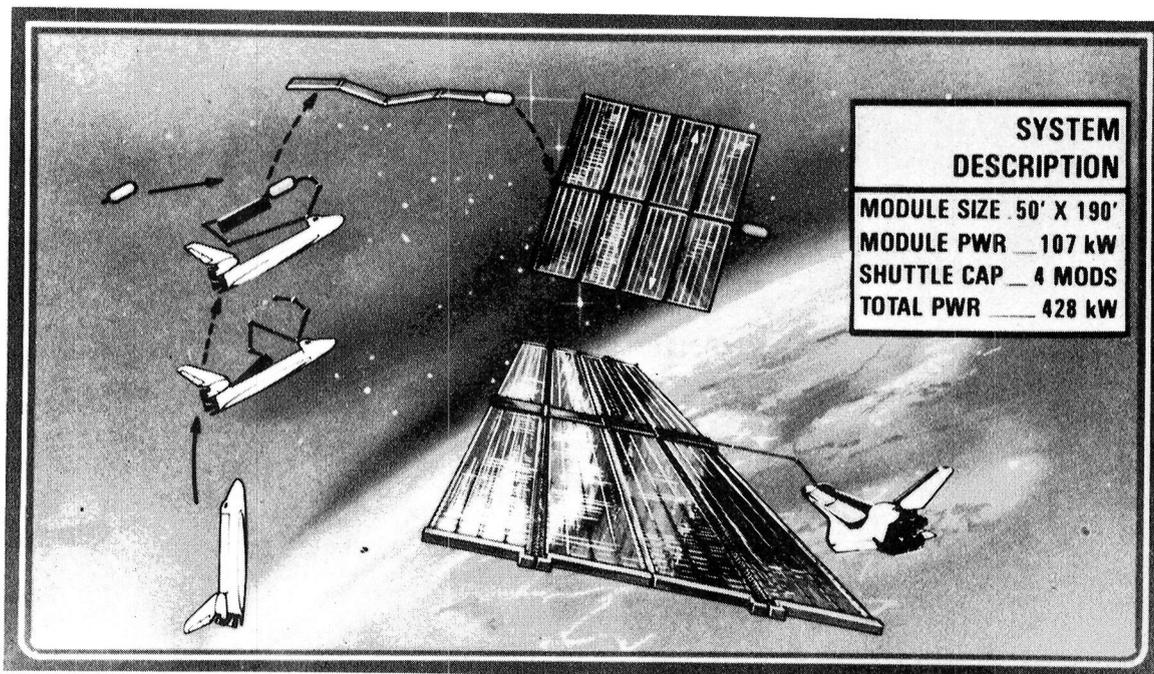
## HIGH FLUX CONCENTRATOR

### TRUNCATED PENTAHEDRAL CONCEPT

- GEOMETRIC CR-5
- MODULE SIZE - 50' X 250'
- MODULE PWR - 121 kW
- SHUTTLE CAPACITY - 5 MOD
- TOTAL PWR - 606 kW BOL
- SOLAR CELLS - GaAs\*

\*CONCEPT ALSO ALLOWS USE OF SILICON CELLS

## SELF DEPLOYABLE PLANAR CONCEPT



## PLANAR ARRAY

The planar array concept for multihundred kW Earth orbital applications shown in the previous artist's concept would produce 428 kW total power at beginning of life. This would be attainable using one shuttle launch and carrying four modules (module power of 107 kW and dimensions of 50 by 190 ft). It would use large silicon solar cells (6 by 6 cm).

## PLANAR ARRAY

- MODULE SIZE - 50' X 190'
- MODULE PWR - 107 kW
- SHUTTLE CAPACITY - 4 MODS
- TOTAL PWR - 428 kW BOL
- SOLAR CELLS - SILICON

## SUMMARY

In summary, the multihundred kW solar array program is pursuing three discrete efforts.

The thermophotovoltaic, spectrophotovoltaic, and cassegrainian approaches will be pursued because it is believed that they have a high potential payback; however, due to the fact that they have high technology risk, the funding will be at a low sustaining level.

Due to the lack of technology risk involved in planar silicon arrays, it is felt that even a potential moderate payback justifies pursuing this area; therefore, a two-year effort to investigate the cost of large/terrestrial cells and cell blanket technology will be undertaken.

It is believed that the high flux array approach presents only a moderate technology risk and yet a high potential payback; therefore, this is planned as the multihundred kW centerline program.

The above is felt to be a balanced, flexible approach to meeting the need for high and low risk technology options and allows emphasis to be shifted as necessitated by future advancements and needs with minimum risk and dilution of effort.

## SUMMARY

### ● THERMOPHOTOVOLTAIC; SPECTROPHOTOVOLTAIC; CASSEGRAINIAN

- HIGH TECHNOLOGY RISK
- HIGH POTENTIAL PAYBACK
- PURSUED AT LOW SUSTAINING LEVEL

### ● PLANAR SILICON ARRAY

- INVESTIGATE COST EFFECTIVENESS OF LARGE/TERRESTRIAL CELL
- MODERATE PAYBACK POSSIBLE
- TWO YEAR BLANKET TECHNOLOGY PROGRAM PLANNED

### ● HIGH FLUX ARRAY

- MODERATE TECHNOLOGY RISK
- HIGH POTENTIAL PAYBACK
- PLANNED AS CENTERLINE PROGRAM