SP-100 GES PROJECT
Civilian and Military Missions
SP-100
Preliminary User Requirements

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National Aeronautics and
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JPL

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CIVILIAN AND MILITARY MISSIONS

SP-100

PRELIMINARY USER REQUIREMENTS

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1.0 Introduction

1.1 Purpose

This document defines the top level requirements of potential users of a space based nuclear electric power supply. This provides the SP-100 Project the information required to design the modular (10-1000 KWe) space power systems to meet the needs of most potential users.

1.2 Document Organization

This document is organized in four sections with the Introduction in Section 1 and Applicable Documents in Section 2. Sections 3 and 4 contain the Background and Requirements, respectively.

1.3 Document Precedence

This document is the controlling document for the generation of all SP-100 functional requirements. In the event of a conflict between this document and the requirements of the Global Positioning System (GPS), Orbital Transfer Vehicle (OTV) or the Space Based Radar (SBR), the latter shall prevail.

In the event of conflict between documents referenced herein and the contents of this document, this document shall take precedence.

2.0 Applicable Documents

The documentation listed below forms a part of this set of user requirements. Only the most recent version of the documents shall be used

2.1 JPL Documents

- 2.1.1 SP-100 SBR Study Final Review, Ross M. Jones, Jet Propulsion Laboratory, July 16, 1985
- 2.1.2 SP-100 Project, Nuclear Reactor Power for a Space Based Radar, L. Jaffe et. al., Jet Propulsion Laboratory Publication 86-47, August 31, 1986
- 2.1.3 SP-100 Project, Nuclear Reactor Power for a Reusable Orbital Transfer Vehicle, L. Jaffe et. al., Jet Propulsion Laboratory October 25, 1986
- 2.1.4 Civil Mission Applications of Space Nuclear Power, J. Mankins, J. Olivieri, A. Hepenstal, Jet Propulsion Laboratory, Publication D-3547, October 1, 1986

2.2 Other Agency Documents

- 2.2.1 Space-Based Radar Configuration Design, M. D. Pope, M.I.T. Lincoln Laboratory, Lexington, Massachusetts, (no date)
- 2.2.2 Space Radar Technology Program Review, Massachusetts Institute of Technology Lincoln Laboratory, Lexington Massachusetts, November 29,30 1983.
- 2.2.3 Statement of Work for System Development Contract, Exhibit I, Technical Specification for the SP-100 SRPS, Rev. 6, V.C. Truscello, February 2, 1987.
- 2.2.4 Meteoroid Damage Assessment, NASA Space Vehicle Design Criteria (Structures), NASA SP-8042, May, 1970.
- 2.2.5 Design Guidelines For Assessing and Controlling Spacecraft Charging Effects, NASA Technical Paper 2361, September, 1984.
- 2.2.6 Shuttle Orbiter/Cargo Standard Interfaces, JSC 07700, Vol. XIV, Att 1, (ICD 2-19001) May, 1983.
- 2.2.7 Electromagnetic Compatibility Requirements for Space Systems, MIL-STD 1541 (USAF).
- 2.2.8 Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference, MIL-STD 461, April, 1980.
- 2.2.9 Measurement of Electromagnetic Interference characteristics, MIL-STD 462.
- 2.2.10 US Standard Atmosphere, 1976, NOAA-S/T76-1562, Oct., 1976.

3.0 Background

User requirements are obtained by working with the known potential users (GPS & SBR) as well as for any newly identified potential users to develop a set of specific needs of each potential user. These needs consist of a negotiated set of requirements for each potential user that are technically feasible requirements on an SP-100 (Space Power - 100 KWe Project) space reactor power system. The negotiated needs for each potential user are then combined into a single set of user requirements to best meet the needs of all identified potential users and still be achievable by an SP-100 space nuclear power system. This combined set of requirements are then submitted to each of the individual users and the SP-100 project office for concurrence and thus form the basis for the SP-100 space nuclear power system detailed system requirements.

The missions identified in this document are selected from civilian and military applications mission models. Most of the missions are in the advanced planning phase, and the conceptual system designs are no more than

strawman designs. A number of the missions still identify a number of technology and design options of which SP-100 is one. Therefore, in most cases, the requirements can not be defined in any great depth, other than, very top level.

3.1 SP-100 Description

Most spacecraft today have a power source which is solar photo voltaic. These are relatively inexpensive systems of proven technology with no cause for consideration of safety and are thus today's logical choice for those systems requiring low power and operating near the sun. Missions not falling into this category must use an alternative power source. In most cases, this is a nuclear power source for which the SP-100 program is being developed. These missions are for deep space probes and near earth civilian and military users requiring power levels high enough to require power sources other than photo voltaic to be attractive. Although power level is the primary attribute considered when attempting to determine the desirability of an alternative power source, there are secondary characteristics which must be considered. These secondary characteristics include solar wind effects, structures, radar cross section, drag, survivability, resistance to natural radiation, gravity gradient considerations, solar array pointing problems, continuously available power in both sun light and darkness and control system dynamics problems associated with large solar arrays. Many of the future spacecraft programs will be of such a design that both the primary concern of power level as well as these secondary characteristics will be issues which must be resolved in order for the programs to be successfully implemented. The need for spacecraft power sources with characteristics that fit those of nuclear reactor systems has existed for many years and is continuing to grow as new spacecraft are developed. SP-100 is being developed to fill this growing need.

The SP-100 project is developing a space based electric power supply which develops 10 to 1,000 KWe power outputs by using a compact nuclear reactor as the heat source and thermoelectric converters to convert the heat to electricity. As part of the definition and design of SP-100, it is required that the users and their respective power requirements be determined. Applications Engineering will determine this set of users and their requirements to provide that direction to the design and development of the SP-100 power supply which will cause SP-100 to be of use to several users.

3.2 GPS OTV Description

The Global Positioning System (GPS) consists of two constellations of 18 each satellites. Each satellite broadcasts a coded signal containing its ephemeris data. By receiving the coded signals from four GPS spacecrafts, a vehicle can calculate its position at any given time. Being a navigation system, GPS is required to provide uninterrupted service over many years. This service requirement imposes the need to perform maintenance and

modifications on the deployed satellites. GPS may use an Orbital Transfer Vehicle (OTV) to retrieve the deployed satellites from their operational orbit and return them to a lower orbit for servicing. Potentially, an Electric Propulsion System for the OTV may either be Ion propulsion or an Arc Jet with the early electric power being photovoltaic. However, the Van Allen belts severely limit the useful lifetime of these photovoltaic systems and thus makes the use of a nuclear power source a viable option. SP-100 is a nuclear power source which can be used for the OTV.

3.3 SBR Description

Space Based Radar (SBR) is a constellation of 12 surveillance radars that is required to provide continuous coverage over a specific geographic area. This continuous coverage requirement implies that these radars must operate in both sunlight and darkness. The use of a photovoltaic system for the electrical power source requires the use of storage batteries to provide the required continuous coverage. However storage batteries have a life time which is too short for the planned SBR mission life when they are subjected to frequent charge/discharge cycles. This short life time of the storage batteries makes the use of a nuclear power source a viable option. SP-100 is a nuclear power source which can be used for the SBR.

4.0 Requirements

This section contains requirements that the SP-100 power system must meet in order to satisfy the needs of the users. These requirements are arranged in separate groups. The first group contains those requirements which apply to all identified users and thus form a baseline set of user requirements for SP-100. The remaining groups address those requirements which are unique to each of the identified users and thus specify the degree to which SP-100 must be tailored to meet the needs of each individual user. In addition to specifying the amount of tailoring required, these user unique requirements together with the baseline requirements form the basis for the design requirements for each of the modular components that make up the complete SP-100 system.

4.1 Generic SP-100 Requirements

The requirements stated in this section are the generic requirements for all users and thus form the baseline requirements for the SP-100 design. Any tailoring required to meet the needs of a specific user is specified in the section of this document addressing the particular user.

4.1.1 Physical Requirements and Constraints

4.1.1.1 Specific Mass

The Specific mass of the SRPS as depicted in figure 4.1.1-1 shall be, as a goal, less than 30 kg/kWe, including all

components which are deployed with the spacecraft from the orbiter vehicle.

4.1.1.2 Size/Envelope

The maximum allowable payload envelope in the cargo bay or compartment shall be as specified in JSC 07700, Vol. XIV, Att. 1 (reference document 2.2.6). The SRPS in launch configuration shall be packaged in such a way that a mission module may be included attached to the SRPS, with cross-bay dimensions filling the payload bay and a length of up to 2/3 of the payload bay.

4.1.1.3 User Mechanical Interface

4.1.1.3.1 Launch Interface

The SRPS shall be integrated mechanically to the Mission Module in the launch readiness phase. For STS launch, the SRPS will be mechanically integrated to the orbiter vehicle such that the induced X-axis launch loads are reacted through a SRPS/orbital vehicle launch interface. The induced loads in the Y-and Z-axes direction and their resulting moments at the mission module launch interface plane may be reacted through this plane to the mission module, or through Airborne Support Equipment to the orbiter vehicle. The mechanical interface with the mission module shall consist of a user plane mechanical interface and a mission module launch interface. The SRPS/launch vehicle mechanical interface shall be capable of withstanding launch loads, launch abort loads, and orbit injection loads, compatible with the STS interface standards as specified in JSC 07700, Vol XIV, Att. 1 (reference document 2.2.6).

4.1.1.2 On-Orbit Configuration Interface

The SRPS shall be attached to the mission in the on-orbit configuration at the user plane by mechanical attachment. The SRPS shall provide a dynamic environment to the mission module as specified in paragraph 4.1.3.7, in the configuration depicted in figure 4.1.1-1. The interface shall not preclude on-orbit assembly.

4.1.2 Electrical Characteristics and Constraints

4.1.2.1 Power Bus Requirements

The SRPS shall provide power to the user on both a Main and a Secondary bus.

4.1.2.1.1 Launch/Orbit Acquisition Phase Power

In the case of external power loss, the SRPS shall have the capability to provide power for SRPS internal monitoring or

Figure 4.1.1-1 Definition of Terms Concerning Physical Configuration on Orbit

control purposes. The SRPS may utilize launch vehicle supplied power, and/or upper stage supplied power so long as the total energy demands do not exceed one third of the standard launch vehicle user supply capability, and/or all of the upper stage payload supply capability, and so long as STS safety requirements are met. The SRPS shall provide all mission module power during this phase, up to the requirement as specified in 4.1.2.1.3 for post STS separation.

4.1.2.1.2 Main Bus

The main bus electrical power output capability of the SRPS shall be 100 kWe net to the user.

Main bus power shall be supplied to the user as direct current. The voltage will be fixed for the lifetime of the SRPS and may be any single value between 100 volts and 600 volts, regulated to $\pm 5\%$. Ripple amplitude on the main bus shall not exceed 1% of the nominal dc voltage value.

4.1.2.1.3 Secondary Bus

The secondary bus electrical power output of the SRPS shall be 300. We net to the user through the mission duration.

Secondary bus power shall be supplied to the user as direct current at 28 ± 7 Vdc with the ripple amplitude not to exceed 3% of the dc value.

The secondary bus shall provide power to the user immediately following separation from the STS or an upper stage, whichever occurs later, and continuing throughout the operating lifetime of the SRPS. The secondary bus shall be capable of providing power, obtained from the OV or upper stage if necessary, from liftoff through separation.

4.1.2.2. Load Following

The SRPS electrical output, both on the primary bus and the secondary bus, shall be continuously variable by user demand from 0% to 100% of rated power while maintaining voltage regulation as specified in 4.1.2.1. Load following shall be accomplished by means other than changing reactor thermal power level. Load Following shall maintain system performance while providing user load change rates to 3 kWe/ms.

Although load following shall be accomplished by other than thermal power level changes, slow response, long duration changes (consistent with paragraph 3.1.4, Reference document 2.2.3) could be accomplished by changing reactor thermal power level, with its associated change in SRPS primary electric power output.

4.1.3 System-Induced environment

4.1.3.1 User Plan Location

The nuclear, thermal, and electromagnetic (where appropriate) radiation levels specified in this document shall apply to the user plane, defined as a planar circular surface 4.5m in diameter perpendicular to and centered on the spacecraft/power subsystem axis (Figure 4.1.3-1). The user electrical power, telemetry, and command interfaces shall be located at this interface.

4.1.3.2 SRPS-Induced User Radiation Environment

Nuclear radiation from the SRPS alone, resulting from 7 years full power operation shall not exceed:

Neutron fluence: 10^{13} neutrons/cm²
(1 MeV equivalent)

Gamma dose: 5×10^5 Rads (Si)
at any point on the user plane.

4.1.3.3 SRPS- Induced User Thermal Environment

Total thermal radiation from the SRPS alone, resulting from full power operation shall not exceed 0.14 Watts/cm² at any point on the user plane.

4.1.3.4 EMC

The SRPS shall be compatible with MIL-STD-11541 (USAF) reference document 2.2.7) and with the radiated and conducted emissions and susceptibility specifications of MIL-STD 461B (reference document 2.2.8), as verified by the methods of MIL-STD 462 (reference document 2.2.9). The design shall permit a reference to electrical ground for all metallic parts.

4.1.3.5 Magnetic Fields

Magnetic fields caused by current loops within all electrical and in the cabling between the power generation module and the interface module shall be minimized.

4.1.3.6 Electrostatic Discharge (ESD)

The SRPS shall be designed such that internal electrostatic discharge is eliminated.

Figure 4.1.3-1 User Plane Definitions

4.1.3.7 Dynamic Disturbances

The SRPS will not contain active attitude control capabilities, but will be controllable in attitude behavior by the mission module through the mechanical interface.

4.1.3.7.1 SRPS-Induced Disturbances

The SRPS shall be designed to minimize the application of static and dynamic forces and torques to the mission module. Residual unavoidable force and torque application shall be characterized as functions of direction of application and frequency at the user interface.

4.1.3.7.2 SPS Response to Disturbance Input

The SRPS shall be designed to withstand reasonable application of forces and torque through a displacement at the user interface, while maintaining performance as specified.

The SRPS shall have no resonant structural frequency under 1 Hz, and the number of resonant frequencies under 10 Hz should be minimized. Each resonant frequency shall be suitably damped.

4.1.3.7.8 Fission Product Containment

SRPS-produced fission products shall not be released to space.

4.1.4 Externally Imposed Environments

The SRPS shall meet performance requirements throughout the mission lifetime while in the natural and space debris environments specified in the following sections.

4.1.4.1 Space Debris

The SRPS shall operate while in the space debris environment as specified in Table 4.1.4-1, which corresponds to an orbit altitude of 1100 km. Debris shall be assumed to consist of spherical fragments of aluminum impacting the SRPS at a speed of 10 km/sec.

The total number of debris impacts of mass [M] or greater over the 10 year mission duration is determined by multiplying the mass fluence by the total SRPS external surface area.

TABLE 4.1.4-1: SPACE DEBRIS
MASS FLUENCE FOR IMPACTS OF DEBRIS OF MASS [M] OR GREATER

10 Year Total Fluence

MASS [M] gm.	IMPACTS/m ² (SURFACE AREA)
10 ⁻⁶	5.0
10 ⁻⁵	1.0
10 ⁻⁴	2.6x10 ⁻¹
10 ⁻³	5.0x10 ⁻²
10 ⁻²	1.0x10 ⁻²
10 ⁻¹	1.3x10 ⁻³
10 ⁻⁰	2.3x10 ⁻⁴

4.1.4.2 Meteoroids

The SRPS shall operate while in the meteoroid environment as specified in Table 4.1.4-2, for an orbit consistent with the debris environment as specified in paragraph 4.1.4.1. Meteoroid particles shall be assumed to have a mass density of 0.5 gm/cm³ and a mean impact speed of 20 km/sec.

TABLE 4.1.4-2 METEOROIDS
MASS FLUENCE OF METEOROID IMPACTS OF MASS [M] OR GREATER

10 Year Total Fluence

MASS [M] (GM)	IMPACTS/m ² (SURFACE AREA)
10 ⁻⁶	18.0
10 ⁻⁵	1.1
10 ⁻⁴	6.8X10 ⁻²
10 ⁻⁴	4.2X10 ⁻³
10 ⁻²	2.6x10 ⁻⁴
10 ⁻¹	1.6x10 ⁻⁵
10 ⁰	9.6x10 ⁻⁷

4.1.4.3 Meteoroid and Debris Damage Assessment

The SRPS shall be designed to proved at least 0.99 probability of no penetration of critical components due to meteoroid or debris impact for ten years based on a Poisson distribution. NASA SP-8042 (reference document 2.2.4) shall be used to assess damage caused by meteoroids and debris. In addition to the materials specified, the materials constants (K1) in the threshold penetration equation (SEC 4.2.2, NASA SP-8042, (reference document 2.2.4) shall be taken as 0.4 for titanium alloys and 0.6 for beryllium, both at 500 deg C. Impact normal to the spacecraft surface shall be assumed.

4.1.4.4 Low Earth Orbit Plasma

The SRPS shall be designed to operate in a low Earth orbit plasma environment, for an orbit of 500 km altitude and inclination 28 degrees, as specified in NASA TM 82478 (reference document 5). The design shall also be in conformance with NASA Technical Paper 2361 (reference document 2.2.5).

4.1.4.5 Ionizing the Nuclear Radiation

The total radiation environment is a composite due to inputs from the natural radiation environment, the reactor radiation environment, and the hostile threat environment. In addition to the reactor radiation environment the SRPS shall operate in the natural radiation environment, as specified in Tables 4.1.4-3 through 4.1.4-5.

4.1.4.6 Atomic Oxygen Interactions

The SRPS shall be designed to operate while in an environment containing atomic oxygen as specified in NOAA-S/T 76-1562 (reference document 2.2.10) for an orbit of altitude 500 km and inclination 28 degrees.

4.1.4.7 Natural Thermal Radiation Environment

The SRPS shall be designed to operate in the natural thermal radiation environment as displayed by Table 4.1.4-6, the thermal radiation environment above the Earth's atmosphere for direct solar radiation, Earth albedo and Earth Longwave Radiation (LWR).

4.1.4.8 Handling and Transportation

Shipping and storage containers and handling procedures shall be designed and utilized to ensure that neither the vibration nor shock levels experienced by the SRPS shall exceed those levels expected during launch.

TABLE 4.1.4-3
ELECTRON FLUENCE-ENERGY SPECTRA
EXTERNAL ENVIRONMENT
SOLAR MINIMUM PERIOD

ENERGY (MEV)	FLUENCE (PARTICLES/Cm ² -DAY)
1.0x10 ⁻¹	5.5x10 ⁺¹²
2.0x10 ⁻¹	2.1x10 ⁺¹²
3.0x10 ⁻¹	9.5x10 ⁺¹¹
4.0x10 ⁻¹	5.2x10 ⁺¹¹
5.0x10 ⁻¹	2.9x10 ⁺¹¹
6.0x10 ⁻¹	2.0x10 ⁺¹¹
7.0x10 ⁻¹	1.4x10 ⁺¹¹
8.0x10 ⁻¹	1.0x10 ⁺¹¹
9.0x10 ⁻¹	7.8x10 ⁺¹⁰
1.00	6.0x10 ⁺¹⁰
1.25	3.8x10 ⁺¹⁰
1.50	2.4x10 ⁺¹⁰
1.75	1.6x10 ⁺¹⁰
2.00	1.1x10 ⁺¹⁰
2.25	7.6x10 ⁺⁰⁹
2.50	5.2x10 ⁺⁰⁹
2.75	2.0x10 ⁺⁰⁹
3.00	7.4x10 ⁺⁰⁸
3.25	2.1x10 ⁺⁰⁸
3.50	6.2x10 ⁺⁰⁷
3.75	1.8x10 ⁺⁰⁷
4.00	5.3x10 ⁺⁰⁶
4.25	1.5x10 ⁺⁰⁶
4.50	4.4x10 ⁺⁰⁵
4.75	1.2x10 ⁺⁰⁵
5.00	0
5.50	0
6.00	0
6.50	0
7.00	0

TABLE 4.1.4-4
PROTON FLUENCE-ENERGY SPECTRA
NATURAL RADIATION ENVIRONMENT

ENERGY (MEV)	FLUENCE (PARTICLES/Cm ² -DAY)
1.0x10 ⁻⁰¹	2.8x10 ⁺¹⁰
2.0x10 ⁻⁰¹	2.8x10 ⁺¹⁰
5.0x10 ⁻⁰¹	2.7x10 ⁺¹⁰
1.00	2.6x10 ⁺¹⁰
2.00	2.5x10 ⁺¹⁰
3.00	2.3x10 ⁺¹⁰
4.00	2.1x10 ⁺¹⁰
5.00	1.9x10 ⁺¹⁰
6.00	1.8x10 ⁺¹⁰
8.00	1.4x10 ⁺¹⁰
1.0x10 ⁺⁰¹	1.1x10 ⁺¹⁰
1.5x10 ⁺⁰¹	6.4x10 ⁺⁰⁹
2.0x10 ⁺⁰¹	3.9x10 ⁺⁰⁹
2.5x10 ⁺⁰¹	3.1x10 ⁺⁰⁹
3.0x10 ⁺⁰¹	2.6x10 ⁺⁰⁹
3.5x10 ⁺⁰¹	2.3x10 ⁺⁰⁹
4.0x10 ⁺⁰¹	2.1x10 ⁺⁰⁹
4.5x10 ⁺⁰¹	1.9x10 ⁺⁰⁹
5.0x10 ⁺⁰¹	1.7x10 ⁺⁰⁹
5.5x10 ⁺⁰¹	1.6x10 ⁺⁰⁹
6.0x10 ⁺⁰¹	1.5x10 ⁺⁰⁹
7.0x10 ⁺⁰¹	1.3x10 ⁺⁰⁹
8.0x10 ⁺⁰¹	1.2x10 ⁺⁰⁹
9.0x10 ⁺⁰¹	1.1x10 ⁺⁰⁹
1.0x10 ⁺⁰²	9.4x10 ⁺⁰⁸
1.5x10 ⁺⁰²	5.3x10 ⁺⁰⁸
2.0x10 ⁺⁰²	3.0x10 ⁺⁰⁸
3.0x10 ⁺⁰²	1.1x10 ⁺⁰⁸
4.0x10 ⁺⁰²	4.0x10 ⁺⁰⁷
5.0x10 ⁺⁰²	1.4x10 ⁺⁰⁷

TABLE 4.1.4-5
ELECTRON FLUENCE-ENERGY SPECTRA
NATURAL RADIATION ENVIRONMENT
SOLAR MAXIMUM PERIOD

ENERGY (MEV)	FLUENCE (PARTICLES/Cm ² -DAY)
1x10 ⁻⁰¹	1.2x10 ⁺¹³
2x10 ⁻⁰¹	5.9x10 ⁺¹²
3x10 ⁻⁰¹	2.6x10 ⁺¹²
4x10 ⁻⁰¹	1.0x10 ⁺¹²
5x10 ⁻⁰¹	3.9x10 ⁺¹¹
6x10 ⁻⁰¹	2.5x10 ⁺¹¹
7x10 ⁻⁰¹	1.6x10 ⁺¹¹
8x10 ⁻⁰¹	1.1x10 ⁺¹¹
9x10 ⁻⁰¹	8.2x10 ⁺¹⁰
1.00	6.0x10 ⁺¹⁰
1.25	3.8x10 ⁺¹⁰
1.50	2.4x10 ⁺¹⁰
1.75	1.6x10 ⁺¹⁰
2.00	1.1x10 ⁺¹⁰
2.25	7.6x10 ⁺⁰⁹
2.50	5.2x10 ⁺⁰⁹
2.75	2.0x10 ⁺⁰⁹
3.00	7.4x10 ⁺⁰⁸
3.25	2.1x10 ⁺⁰⁸
3.50	6.2x10 ⁺⁰⁷
3.75	1.8x10 ⁺⁰⁷
4.00	5.3x10 ⁺⁰⁶
4.25	1.5x10 ⁺⁰⁶
4.50	4.4x10 ⁺⁰⁵
4.75	1.2x10 ⁺⁰⁵
5.00	0
5.50	0
6.00	0
6.50	0
7.00	0

TABLE 4.1.4-6
THERMAL RADIATION ENVIRONMENT

ENVIRONMENT	LEVEL
Earth Direct Solar Radiation	135.3 +/- 4.7 mW/cm ²
Earth Albedo[a]: Annual Mean	0.30 +/- 0.02
Antarctic Region Mean	1/20.6
Arctic Region Mean	0.45 to 0.6
Equatorial Region Mean	0.2
Earth Long Wavelength Radiation (LWR) Annual Mean =	23.7 +/- 0.7 mW/cm ²
Mean Sunlit Antarctic Regions (LWR) =	14.0 mW/cm ²
Mean Sunlit Arctic Regions (LWR) =	16.0mW/cm ²
Mean Sunlit Equatorial Regions (LWR) =	27.0 mW/cm ²
Maximum Diurnal Variation =	3.6 mW/cm ²

ENVIRONMENT	RANGE
Direct Solar	0[b] to 140 mW/cm ²
Albedo	0[b] to 0.32
LWO	[b] to 27.0 mW/cm
Earth Effective Black Body Temperature Te	206 K to 262 K

[a] Note when albedo is a maximum, long wavelength radiation is a minimum.

[b] Due to the orbital orientation, a surface may not see direct solar, earth albedo or Earth (LWR).

4.2 OTV Specific Requirements

The OTV is a space transportation system that is reusable and operates between Low Earth Orbit (LEO) and High Earth Orbit (HEO). The requirements stated in this section are those which are unique to the OTV.

4.2.1 Physical Requirements

4.2.1.1 The mass of the OTV, exclusive of the power source, will be 1,136 KG.

4.2.1.2 The GPS OTV will be cylindrical in shape with a length of 2.77 meters and a diameter of 2.62 meters.

4.2.1.3 The OTV is required to transport from 1 to a maximum of 4 GPS satellites from low earth orbit (LEO) to their operational orbit of 10,898 nm when all transported satellites are in the same plane.

4.2.1.4 The OTV is required to transport the GPS satellite(s) payload from the 28.5 degree LEO parking orbit to their 55 degree inclination operational orbit in less than 90 days.

4.2.2 Performance Requirements

4.2.2.1 The OTV will require between 100 to 300 KWe of Power.

4.2.3 Interface Requirements

TBD

4.2.4 Operational Requirements

TBD

4.2.5 Reliability Requirements

4.2.5.1 The GPS OTV system, including SP-100, shall have a reliability greater than 0.96.

4.3 SBR Specific Requirements (5,600 nmi Orbit)

SBR is a constellation of 12 surveillance radars that is required to provide continuous coverage over a specific geographic area. The requirements stated in this section are those which are unique to the SBR operating at an orbital altitude of 5,600 nautical miles.

4.3.1 Physical Requirements

- 4.3.1.1 The mass of the SBR, exclusive of the power source, will be 8,774 KG.
- 4.3.1.2 The SBR will be rectangular in shape with dimensions of 32 meters by 64 meters.
- 4.3.1.3 The SBR requires that there be no devices at or protruding beyond the antenna plane or outside the 32 X 64 meter rectangle.
- 4.3.1.4 The SBR is required to be shielded from the SP-100 radiation. Its maximum permissible dosage from SP-100 over its operating life is 100,000 Rad.
- 4.3.1.5 The SBR is required to have a pointing accuracy of 0.2 degrees in all axes.
- 4.3.1.6 When deployed, the SBR must not be subjected to an acceleration of more than 0.1 g.
- 4.3.2 Performance Requirements
 - 4.3.2.1 SBR requires 300 kWe of power.
 - 4.3.2.2 SBR requires the following voltages for its operation:
 - 15-30 vdc
 - 100-200 vdc
 - 28 vdcThese voltages will be generated by the SBR power system from the SP-100 power busses of 28 vdc and 200-600 vdc.
 - 4.3.2.3 The SBR requires the SP-100 to supply power which is regulated to 0.5 percent. All additional regulation required by SBR will be performed by SBR.
 - 4.3.2.4 The SBR requires that SP-100 be able to track its power load which will vary by a factor of 2 to 1 over a 0.001 second period of time.
 - 4.3.2.5 The SBR requires power at a constant voltage with power level changes being reflected in the current level. The SP-100 is required to accommodate this voltage-current characteristic to the maximum extent possible.
- 4.3.3 Interface Requirements
 - 4.3.3.1 Mechanical Interface Requirements
 - 4.3.3.1.1 The SBR and SP-100 must be mechanically connected into a single integral unit capable of being maneuvered with an attitude

control system.

- 4.3.3.1.2 The integrated SBR/SP-100 shall be designed to prevent the overheating of the SBR by the SP-100's radiator.

- 4.3.3.2 Electrical Interface Requirements

- 4.3.3.2.1 SBR shall receive its electrical power from an external power source which is capable of continuously delivering the power.

- 4.3.3.2.2 SBR requires that the power source provide it with housekeeping data which contains information about the operational state of the power source.

- 4.3.4 Operational Requirements

- 4.3.4.1 The integrated SBR/SP-100 is required to have the capability to perform orbit maintenance maneuvers.

- 4.3.5 Reliability Requirements

- 4.3.5.1 SBR requires a power source which is capable of providing continuous rated power for a period of at least 10 years.

- 4.3.5.2 SBR requires that the power source be capable of operating over its planned lifetime when its subjected to those same natural and hostile environment conditions experienced by SBR.

- 4.4 SBR Requirements (600 nmi Orbit)

SBR is a constellation of 12 surveillance radars that is required to provide continuous coverage over a specific geographic area. The requirements stated in this section are those which are unique to the SBR operating at an orbital altitude of 600 nautical miles.

- 4.4.1 Physical Requirements

- 4.4.1.1 The SBR will have an antenna size of 8 X 16 meters. The antenna will be composed of 9,000 modules.

- 4.4.1.2 The SBR will have the following weight allowances:

Radar	12,250 lb
Power System	4,500 lb
Available for hardening	1,250 lb
Total	<hr/> 18,000 lb

Of the total of 18,000 lb, there is an 800 lb. contingency.

- 4.4.1.3 The SBR requires that SP-100 be located at a distance of 25 meters from the spacecraft to meet the SBR radiation requirements.
- 4.4.1.4 The SBR requires the radiation dosage be less than 1,000,000 Rad.
- 4.4.1.5 The SBR requires that the SP-100 heat radiator be changed from a conical frustrum to a cylinder to fit the SBR package.
- 4.4.2 Performance Requirements
 - 4.4.2.1 The SBR requires 65 kWe primary power.
- 4.4.3 Interface Requirements
 - TBD
- 4.4.4 Operational Requirements
 - 4.4.4.1 The SBR will operate at an orbital altitude of 600 nautical miles and an inclination of 61 degrees.
 - 4.4.4.2 The SBR will be deployed as constellation of 8 to 14 satellites.
- 4.4.5 Reliability Requirements
 - 4.4.5.1 The SBR is required to have an operational life of a minimum of 5 years and a desired life of 10 years.
 - 4.4.5.2 The SBR is required to be survivable against man made radiation, ASAT's, and laser weapons.

4.5 Civil Missions Requirements

Requirements stated in this section are those which apply to users that are performing missions within the civilian sector. Civilian missions are categorized as science and exploration, space operations, or commercial utilization. Missions identified in each of these three categories are at present only in the planning phase so that the detailed requirements of each user are not available. However, the high level requirements for these missions have been determined and they do provide a basis for assessing whether SP-100 is suitable as a power source. These known requirements are contained in the following sections of this document.

4.5.1 Science And Exploration Missions

Science and exploration missions consists of those missions designed to gather data for basic space science and research.

They consist of asteroid sample return, comet sample return, mars sample return, saturn ring rendezvous, far outer planets probe/explorer thousand astronomical unit (TAU) explorer and large array lunar observatory. User requirements relating to power for each of these missions are contained in the following:

4.5.1.1 Asteroid Sample Return Mission Requirements

The asteroid sample return mission will visit up to four main-belt asteroids, taking from five to nine years for rendezvous and return to earth. The spacecraft will carry a reusable scientific lander to a selected target asteroid where it will land, collect the sample and return to the rendezvous spacecraft. When all targeted asteroids have been sampled, the spacecraft will return to earth. The concept in this mission is for the SP-100 to be the power system for the electric propulsion system. User requirements relating to power for the asteroid sample return mission are listed below.

4.5.1.1.1 Physical Requirements

- 1) The asteroid sample return mission requires sufficient shielding to protect the instruments and electronics from radiation damages.
- 2) The asteroid sample return mission requires that it be shielded from excess heat from the power supply that would cause damage to or degrade the operation of its payload or electronics

4.5.1.1.2 Performance Requirements

- 1) The asteroid sample return mission requires a power level of approximately 80 to 100 Kwe.

4.5.1.1.3 Interface Requirements

TBD

4.5.1.1.4 Operational Requirements

TBD

4.5.1.1.5 Reliability Requirements

- 1) The asteroid sample return mission requires a power supply to support an operational life of approximately 5 to 9 years.

4.5.1.2 Comet Sample Return Mission Requirements

The comet sample return mission requires travels to a short

period comet where it lands on the surface. Upon landing, it will anchor itself to the surface and remain there for one Heliocentric orbit of the comet. During this one orbit period, it will collect core samples and other comet surface data which are telemetered to earth. It will then return to earth with the core samples. The concept in this mission is for the SP-100 to be the power system for the electric propulsion system. User requirements relating to power for the comet return mission are listed below.

4.5.1.2.1 Physical Requirements

- 1) The comet sample return mission requires sufficient shielding to protect the instruments and electronics from radiation damages.
- 2) The comet sample return mission requires that it be shielded from excess heat from the power supply that would cause damage to or degrade the operation of its payload or electronics.

4.5.1.2.2 Performance Requirements

- 1) The comet sample return mission requires a power level of approximately 80 to 100 Kwe.

4.5.1.2.3 Interface Requirements

TBD

4.5.1.2.4 Operational Requirements

TBD

4.5.1.2.5 Reliability Requirements

- 1) The comet sample return mission requires a power supply to support an operational life of approximately 12 to 18 years.

4.5.1.3 Mars Sample Return Requirements

The Mars sample return mission consists of a spacecraft system composed of three primary components. These components are the main spacecraft which remains in orbit about Mars, the lander/ascent vehicle, and a rover vehicle. The rover will collect samples which it transfers to the lander/ascent vehicle for delivery to the orbiter and eventual return to earth. The concept in this mission is for the SP-100 to be the power system for the electric propulsion system. User requirements relating to power for the Mars sample return mission are listed below.

4.5.1.3.1 Physical Requirements

- 1) The Mars sample return mission requires sufficient shielding to protect the instruments and electronics from radiation damages.
- 2) The Mars sample return mission requires that it be shielded from excess heat from the power supply that would cause damage to or degrade the operation of its payload or electronics.

4.5.1.3.2 Performance Requirements

- 1) The Mars sample return mission requires a power level of approximately 80 to 100 Kwe.

4.5.1.3.3 Interface Requirements

TBD

4.5.1.3.4 Operational Requirements

TBD

4.5.1.3.5 Reliability Requirements

- 1) The Mars sample return mission requires a power supply to support an operational life of approximately 4 to 5 years.

4.5.1.4 Saturn Ring Rendezvous Mission Requirements

The Saturn ring rendezvous mission will orbit the planet Saturn and maneuver amid the rings to allow its instruments to determine the three dimensional structure of the rings as well as their magnetic, physical and chemical characteristics. The concept in this mission is for the SP-100 to be the power system for the electric propulsion system. User requirements relating to power for the Saturn ring rendezvous mission are listed below.

4.5.1.4.1 Physical Requirements

- 1) The Saturn ring rendezvous mission requires sufficient shielding to protect the instruments and electronics from radiation damages.
- 2) The Saturn ring rendezvous mission requires that it be shielded from excess heat from the power supply that would cause damage to or degrade the operation of its payload or electronics.

4.5.1.4.2 Performance Requirements

- 1) The Saturn ring rendezvous mission requires a power level of approximately 80 to 100 Kwe.

4.5.1.4.3 Interface Requirements

TBD

4.5.1.4.4 Operational Requirements

TBD

4.5.1.4.5 Reliability Requirements

- 1) The Saturn ring rendezvous mission requires a power supply to support an operational life of approximately 9 to 13 years.

4.5.1.5 Far Outer Planets Probe/Explorer Missions Requirements

The far outer planets probe/explorer missions consist of voyages to the far outer planets; Uranus, Neptune, and Pluto for the purpose of studying their atmospheres, magnetospheres, compositions, and satellites. The concepts in these missions is for the SP-100 to be the power system for the electric propulsion system. User requirements relating to power for the far outer planets probe/explorer missions are listed below.

4.5.1.5.1 Physical Requirements

- 1) The far outer planets probe/explorer missions require sufficient shielding to protect the instruments and electronics from radiation damages.
- 2) The far outer planets probe/explorer missions require that it be shielded from excess heat from the power supply that would cause damage to or degrade the operation of its payload or electronics.

4.5.1.5.2 Performance Requirements

- 1) The far outer planets probe/explorer missions require a power level of approximately 80 to 100 Kwe.

4.5.1.5.3 Interface Requirements

TBD

4.5.1.5.4 Operational Requirements

TBD

4.5.1.5.5 Reliability Requirements

- 1) The far outer planets probe/explorer missions require a power supply to support an operational life of approximately 8 to 11 years.

4.5.1.6 Thousand Astronomical Unit (TAU) Explorer Requirements

The TAU explorer mission consists of a spacecraft utilizing electric propulsion to achieve the extreme required distance in a reasonable period of time. The purpose of the TAU mission is to investigate the distance scale and age of the universe as well as the structure of the galaxy. User requirements relating to power for the TAU mission are listed below.

4.5.1.6.1 Physical Requirements

- 1) The TAU mission requires sufficient shielding to protect the instruments and electronics from radiation damages.
- 2) The TAU mission requires that it be shielded from excess heat from the power supply that would cause damage to or degrade the operation of its payload or electronics.

4.5.1.6.2 Performance Requirements

- 1) The TAU mission requires a power level of approximately 300 to 1,000 Kwe.

4.5.1.6.3 Interface Requirements

TBD

4.5.1.6.4 Operational Requirements

TBD

4.5.1.6.5 Reliability Requirements

- 1) The TAU mission requires a power supply to support an overall operational life of approximately 55 years.
- 2) The TAU mission requires a power supply to support a propulsion phase of approximately 10 years.

4.5.1.7 Large Array Lunar Observatory Requirements

The large array lunar observatory mission will consist of an unmanned observatory on the lunar surface. This observatory

will be implemented as a large scale array of approximately 500 meters in diameter. It will be used for observations of extra-solar planetary systems within a distance of approximately 10 parsecs (33 light years) of the solar system. User requirements relating to power for the large array lunar observatory mission are listed below.

4.5.1.7.1 Physical Requirements

- 1) The large array lunar observatory mission requires sufficient shielding to protect the instruments and electronics from radiation damages.
- 2) The large array lunar observatory mission requires that it be shielded from excess heat from the power supply that would cause damage to or degrade the operation of its payload or electronics.
- 3) The large array lunar observatory mission requires sufficient radiation shielding to protect periodic access by manned maintenance crews.

4.5.1.7.2 Performance Requirements

- 1) The large array lunar observatory mission requires a power level of approximately 130 Kwe.

4.5.1.7.3 Interface Requirements

TBD

4.5.1.7.4 Operational Requirements

TBD

4.5.1.7.5 Reliability Requirements

- 1) The large array lunar observatory mission requires a power supply to support an indefinite operational life.

4.5.2 Space Operations Missions

Space operations missions are those which support an ongoing activity in space. They consist of a space station complex, materials processing factory, lunar settlement, libration point base, cargo-ITV, Mars settlement and Phobos station. User requirements relating to power for each of these missions are contained in the following:

4.5.2.1 Space Station Complex Requirements

The space station complex will consist of a manned orbiting platform that serves as a base for scientific studies as well as commercial endeavors such as manufacturing in space. These uses of the station and the need to provide for a man rated environment impose requirements for power. User requirements relating to power for the space station are listed below.

4.5.2.1.1 Physical Requirements

- 1) The space station complex requires sufficient shielding to protect the instruments and electronics from radiation damages.
- 2) The space station complex requires that it be shielded from excess heat from the power supply that would cause damage to or degrade the operation of its payload or electronics.
- 3) The space station complex requires sufficient radiation shielding to provide protection for a permanently manned facility.

4.5.2.1.2 Performance Requirements

- 1) At Initial Operational Capabilities (IOC), the space station complex requires a power level of approximately 75 Kwe. Those components of this power requirement are:

A) Habitat Module	15
B) Laboratory Module	35
C) Attached Payloads	10
D) Servicing Facilities & Systems	5
E) Systems (GN&C, C&T, etc)	10
- 2) The space station complex requires that the power source be capable of growth to a power level of approximately 470 Kwe.

4.5.2.1.3 Interface Requirements

TBD

4.5.2.1.4 Operational Requirements

TBD

4.5.2.1.5 Reliability Requirements

- 1) The space station complex requires a power supply to support an operational life of a minimum of 15 years.

4.5.2.2 Materials Processing Factory Requirements

The materials processing factory will utilize the growth space station as a base for processing materials in a environment which is available only in space. This processing will place power requirements on the space station which are above those required for normal operation. User requirements relating to power for the materials processing capability are listed below.

4.5.2.2.1 Physical Requirements

- 1) The materials processing factory requires sufficient shielding to protect the instruments and electronics from radiation damages.
- 2) The materials processing factory requires that it be shielded from excess heat from the power supply that would cause damage to or degrade the operation of its payload or electronics.
- 3) The materials processing factory requires sufficient radiation shielding to provide protection for a permanently manned facility as well as any biological material in the processing facility.

4.5.2.2.2 Performance Requirements

- 1) The materials processing factory requires a power level of approximately 160 Kwe.

4.5.2.2.3 Interface Requirements

TBD

4.5.2.2.4 Operational Requirements

TBD

4.5.2.2.5 Reliability Requirements

- 1) The materials processing factory requires a power supply to support an indefinite operational life.

4.5.2.3 Lunar Settlement Requirements

The lunar settlement consists of several manned lunar bases which together form a lunar based settlement. This settlement

would grow from an initial base to its final set of bases composing the settlement. Each lunar base will require its own power source. User requirements relating to power for the lunar settlement are listed below.

4.5.2.3.1 Physical Requirements

- 1) Each lunar base in the lunar settlement requires sufficient shielding to protect the instruments and electronics from radiation damages.
- 2) Each lunar base in the lunar settlement requires that it be shielded from excess heat from the power supply that would cause damage to or degrade the operation of its payload or electronics.
- 3) Each lunar base in the lunar settlement requires sufficient radiation shielding to provide protection for a permanently manned facility.
- 4) The lunar settlement requires that its shielding be configured in a manner which permits safe access to the settlement by manned spacecrafts.

4.5.2.3.2 Performance Requirements

- 1) The lunar settlement requires an initial power source for a single lunar base at a power level of 35 Kwe.
- 2) The lunar settlement requires an initial power level of 25 Kwe for materials processing.
- 3) The final lunar settlement requires a power source capable of supporting a total of six lunar bases at a power level of 240 Kwe.
- 4) The final lunar settlement requires a total power level of 360 Kwe for materials processing which is performed at the various lunar bases.

4.5.2.3.3 Interface Requirements

TBD

4.5.2.3.4 Operational Requirements

TBD

4.5.2.3.5 Reliability Requirements

- 1) The lunar settlement requires a power supply to support an operational life of a minimum of 4 years.

4.5.2.4 Libation Point Base Requirements

The libation point base will be a manned space facility located at the "L1" earth/moon libation point. It will consist of a complex of three large habitation modules, one laboratory module, two logistic modules, and a variety of spacecraft assembly and servicing facilities. User requirements relating to power for the libation point base are listed below.

4.5.2.4.1 Physical Requirements

- 1) The libation point base requires sufficient shielding to protect the instruments and electronics from radiation damages.
- 2) The libation point base requires that it be shielded from excess heat from the power supply that would cause damage to or degrade the operation of its payload or electronics.
- 3) The libation point base requires sufficient radiation shielding to provide protection for a permanently manned facility.
- 4) The libation point base requires that its shielding be configured in a manner which permits safe access to it by manned spacecrafts and those crews supporting its operation.

4.5.2.4.2 Performance Requirements

- 1) The libation point base requires a power level of approximately 160 Kwe.

4.5.2.4.3 Interface Requirements

TBD

4.5.2.4.4 Operational Requirements

TBD

4.5.2.4.5 Reliability Requirements

- 1) The libation point base requires a power supply to support an indefinite operational life.

4.5.2.5 Cargo-ITV Requirements

The cargo-ITV (Interplanetary Transit Vehicle) will be a transportation system which will orbit the Earth/Mars system for the purpose of transporting support material to a manned Mars base and returning material to earth. When near the earth, an earth based spacecraft rendezvous' with it for transfer of material between it and earth. The cargo-ITV will require power to support its magneto-plasma-dynamics thrusters required for orbit maintenance. User requirements relating to power for the cargo-ITV are listed below.

4.5.2.5.1 Physical Requirements

- 1) The cargo-ITV requires sufficient shielding to protect the instruments, electronics, and cargo from radiation damages.
- 2) The cargo-ITV requires that it be shielded from excess heat from the power supply that would cause damage to or degrade the operation of its instruments, electronics, or cargo.

4.5.2.5.2 Performance Requirements

- 1) The cargo-ITV requires a power level of approximately 7,000 Kwe.

4.5.2.5.3 Interface Requirements

TBD

4.5.2.5.4 Operational Requirements

TBD

4.5.2.5.5 Reliability Requirements

- 1) The cargo-ITV requires a power supply to support an indefinite operational life.

4.5.2.6 Mars Settlement Requirements

The Mars settlement will consist of a colony of several independent bases similar to those of the lunar settlement. As with the lunar settlement, each base of the Mars settlement will require its own power source. User requirements relating to power for the Mars settlement mission are listed below.

4.5.2.6.1 Physical Requirements

- 1) The Mars settlement requires sufficient shielding to protect the instruments and electronics from radiation damages.

- 2) The Mars settlement mission requires that it be shielded from excess heat from the power supply that would cause damage to or degrade the operation of its instruments or electronics.
- 3) The Mars settlement requires sufficient radiation shielding to provide protection for a permanently manned facility.
- 4) The Mars settlement mission requires that its shielding be configured in a manner which permits safe manned access to the settlement.

4.5.2.6.2 Performance Requirements

- 1) The Mars settlement requires an initial power level of 30 Kwe.
- 2) The final Mars settlement requires a power source capable of supporting 12 habitation modules, 4 laboratories, 8 logistics modules, and associated operational hardware at a total power level of 280 Kwe.
- 3) The final Mars settlement requires a power level of 450 Kwe for materials processing.

4.5.2.6.3 Interface Requirements

TBD

4.5.2.6.4 Operational Requirements

TBD

4.5.2.6.5 Reliability Requirements

- 1) The Mars settlement requires a power supply to support an indefinite operational life.

4.5.2.7 Phobos Station Requirements

The Phobos station will be a single manned base for the purpose of exploring the Mars moon. It will require power to support scientific studies as well as to provide for a human habitable environment. User requirements relating to power for the Phobos station mission are listed below.

4.5.2.7.1 Physical Requirements

- 1) The Phobos station requires sufficient shielding to protect the instruments and electronics from radiation damages.
- 2) The Phobos station requires that it be shielded from excess

heat from the power supply that would cause damage to or degrade the operation of its instruments or electronics.

- 3) The Phobos station requires sufficient radiation shielding to provide protection for a permanently manned facility.
- 4) The Phobos station requires that its shielding be configured in a manner which permits safe access to the settlement by manned spacecrafts.

4.5.2.7.2 Performance Requirements

- 1) The Phobos station requires a power level of approximately 150 Kwe.

4.5.2.7.3 Interface Requirements

TBD

4.5.2.7.4 Operational Requirements

TBD

4.5.2.7.5 Reliability Requirements

- 1) The Phobos station requires a power supply to support an indefinite operational life.

4.5.3 Commercial Utilization Missions

Commercial utilization missions are those space based missions which are operated for the benefit of the commercial sector of the economy. They consist of geosynch communications platform(s) and air traffic control radar station(s). User requirements relating to power for each of these missions are contained in the following:

4.5.3.1 Geosynch Communications Platform(s) Requirements

The geosynch communications platform will address the problem of crowding in the geosynch locations that are desired for communications satellites. It will provide a platform with its own power, signal processing, and attitude control system which would be available as a host platform for several individual communications stations in place of the presently required individual communications satellites. User requirements relating to power for the geosynch communications platform are listed below.

4.5.3.1.1 Physical Requirements

- 1) The geosynch communications platform requires sufficient shielding to protect the instruments and electronics from radiation damages.
- 2) The geosynch communications platform requires that it be shielded from excess heat from the power supply that would cause damage to or degrade the operation of its payload or electronics.

4.5.3.1.2 Performance Requirements

- 1) The geosynch communications platform requires a power level of approximately 15 Kwe to 150 Kwe.

4.5.3.1.3 Interface Requirements

TBD

4.5.3.1.4 Operational Requirements

TBD

4.5.3.1.5 Reliability Requirements

- 1) The geosynch communications platform requires a power supply to support an operational life of approximately 7 to 10 years.

4.5.3.2 Air Traffic Control Radar(s) Requirements

Space based air traffic control radar would be deployed in a manner which augments the coverage area of the existing earth based radar system. This augmentation would allow for the positive control of aircraft over ocean routes and thus provide for safer and more efficient aircraft operations. User requirements relating to power for the space based air traffic control radars are listed below.

4.5.3.2.1 Physical Requirements

- 1) The space based air traffic control radar requires sufficient shielding to protect the instruments and electronics from radiation damages.
- 2) The space based air traffic control radar requires that it be shielded from excess heat from the power supply that would cause damage to or degrade the operation of its payload or electronics.

- 3) The space based air traffic control radar will have the following weights:

Subsystem	Weight (lb)
Phased Array	6,950
Power System	5,200
Structure	1,400
Processors	600
Housekeeping	400
ACS & Propulsion (Dry)	500
Propellant	2,350
Contingency (5%)	850
Total	18,250

- 3) The oceanic route air traffic control SBR will have an antenna array with dimensions of 8 x 16 meters.

4.5.3.2.2 Performance Requirements

- 1) The space based air traffic control radar requires a power level of approximately 40 Kwe to 200 Kwe.

4.5.3.2.3 Interface Requirements

TBD

4.5.3.2.4 Operational Requirements

- 1) The oceanic route air traffic control SBR will operate at an orbital altitude of 600 nautical miles and an inclination of 61 degrees.

4.5.3.2.5 Reliability Requirements

- 1) The space based air traffic control radar requires a power supply to support an operational life of approximately 7 to 10 years.