

# SunSat Corporation

By Darel Preble  
*Chair, Space Solar Power Workshop*  
[darel.preble@comcast.net](mailto:darel.preble@comcast.net)

<http://www.sspi.gatech.edu>

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*Abstract — Strategic energy alternatives have assumed new importance due to rising energy costs and environmental stress largely related to rising CO. The established energy and aerospace corporations and agencies are incapable of pursuing the high risk development necessary to build a Space Solar Power System (SSPS). The best means to pursue the immense promise which SSP holds is the formation of a congressionally chartered private corporation analogous to the extremely successful COMmunications SATellite (COMSAT) Act of 1962. Just as COMSAT, with INTELSAT and INMARSAT, other congressionally chartered corporations, opened space to a hundred varieties of communication satellites, so a Sun Satellite (SunSat) Corporation Act could open space to power satellites. While COMSAT was chartered to build commercial communications, SunSat would be chartered to build commercial power satellites to collect and transmit energy to electric power grids on earth. Forty years after COMSAT's charter, the space industry had revenue in excess of \$100 Billion, primarily from the launch and operations of various communications satellites. This was due to the visionary developmental work Congress initiated through COMSAT and INTELSAT. (COMSAT Corporation was recently sold and absorbed by Lockheed, its original high purpose fully accomplished.)*

## Review of the problem

Thank you for inviting me to speak before your SPS Research Society. It is a great privilege and immense pleasure to exchange thoughts on this important technology. The oil and gas crunch; climate change, and many other escalating environmental problems traceable to rising CO, have had many “solutions” proposed that merely “nibble” at the problem -- such as windmills, bio-fuels like ethanol, ground based solar, “clean” coal and even nuclear power.

As global CO levels escalate, the ocean's increased rate of uptake of CO<sub>2</sub> is lowering global pH levels. Growing evidence suggests this will have a negative impact on sea creatures that build shells out of calcium carbonate (corals, some phytoplankton and zooplankton). As global CO<sub>2</sub> escalates, the impact on our food chain, from plankton to fish and from plants to animals is increasingly disturbing. We who have been studying these issues understand that SSP is the right solution to these thorny problems. Other pieces to this solution include energy storage for transportation. Recently a new hydrogen storage technology from Denmark further advances the promise of that technology. Hydrogen storage, improved batteries, or electric drive, of course all require a source of clean baseload energy. So how do we provide such wonderful energy?

## Introduction to the solution

There is no question SSP can be built; the question is how to build it economically – as a private company would. An engineer has been defined as someone who can build for a dime what any fool can build for a dollar. That is the task we face. When America has faced such seemingly insurmountable problems as SSP before, often a public/private corporation has been chartered – a cooperation between government and individuals. In 1862 the Transcontinental Railroad act, which spanned North America with rail, was enacted by Congress after years of debate. The Union Pacific Railroad Company was

chartered “to aid in the construction of a railroad and telegraph line from the Missouri River to the Pacific Ocean”. Let’s look at a page from that era showing the grants and subsidies specifically created for those railroads during that colorful history:

*The President of the United States received sealed bids on two points: First, within how short a time will the contractors complete the railroad? Second, at what rate per annum will the contractors carry the mails and Government freights for a period of twenty years from the date of the completion of the road?*

*The government organized and executed surveys from the Mississippi River westward to the Pacific Ocean, to ascertain the most practicable route. The chief engineer, in his 1869 report to the president said: "In 1863 and 1864 surveys were inaugurated, but in 1866 the country was systematically occupied, and day and night, summer and winter, the explorations were pushed forward through dangers and hardships that very few at this date appreciate. As every mile had to be run within the range of the musket, there was not a moment's security.*



*“Right of way was granted through public lands to the extent of 200 feet in width on each side of the track, and a grant of land in the amount of ten alternate sections per mile on each side of the road within the limits of 20 miles on each side of the road, not previously sold or reserved, at the time ...*

*“Upon the completion of each 20 consecutive miles of railroad,... title to the granted sections were to be issued.*

The Excursion Train Rounding Cape Horn At The Head Of The Great American Canon, With A View Of The South Fork Of The American River, Where Gold Was First Discovered In 1848. ...

- Frank Leslie's Illustrated Newspaper, April 27, 1878

*“It also provided for at subsidy in bonds of \$16,000 per mile between the Missouri River and the base of the Rocky Mountains; \$48,000 per mile for the distance of 150 miles through the mountain*

range;

*"In making the surveys numbers of our men, some of the ablest and most promising, were killed, and during the construction our stock (horses and cattle) were run off by the hundreds - I might add by the thousands. The lack of confidence in the project, even in the localities to be the most benefited, was so great that laborers demanded their pay in advance before they would perform a day's work.*

*These bonds were payable thirty years after date, bearing 6 per cent interest, and were in the nature of a loan of credit by the United States, and were made a second-mortgage lien on the railroad, telegraph and all appurtenances, subordinate to bonds which the companies could issue.*

So the process to create such a congressionally chartered corporation, the SunSat Act, is well understood. This was the same legislative tool used to create Comsat in 1962, one hundred years after the Transcontinental Railroad. The horse thieves, bushwhackers, vast distances and Rocky Mountains our corporation must budget to overcome may be different, but they introduce the same elements of risk. An SSP system is no less a challenge than Comsat or the Transcontinental Railroad were in their day and would also seem to dictate a public/private corporation to reduce those risks via compensating appropriate rewards.

Michael Schwaal, an energy economist with Arlington, VA-based Energy Ventures, pointed out that “there is not much enthusiasm in the U.S. government for space based solar power”, going on to point that NASA is not the best agency to take up the cause. The energy investment community and the SSPW would agree – NASA and JAXA are not chartered for commercial manufacturing or operation. The proper path to build SSP, is a congressionally chartered corporation, we call it SunSat Corporation. What is NASA’s current posture regarding SSP?

On September 9, 2005, the Office of Management and Budget published a ["Statement of Administration Policy" \(SAP\)](#) on [HR 2862](#), the appropriations bill that includes NASA. It is effectively the Administration's response to pending House and Senate appropriations committees’ actions to date on the legislation, identifying changes the Administration would like to see.

In that SAP, “The Administration strongly objects to the elimination of funding for key priorities, including the Space Station Cargo/Crew Services and [Centennial Challenges](#) programs, and urges the Senate to shift funding from lower-priority programs in the bill to restore the Administration's request.

The [Senate Appropriations Committee report](#) explained that “As NASA begins to consider another manned vehicle program, it must not repeat the mistakes of the Space Station, where poor management and lack of independent oversight resulted in major cost overruns. At this early stage in the development of the CEV, it is essential that these mistakes not happen again.

“The Committee acknowledges the desire of NASA to attempt to replicate the efforts of the X-Prize in the proposed Centennial Challenges program. The Committee is concerned that NASA is asking for a lump sum of funds for the Centennial Challenges program and only then will NASA identify the challenges and assign prize levels for completion. In future budget justifications, NASA shall identify the challenges being proposed for prize funding, and the specific amounts to be awarded for each challenge. No funding is recommended for this program. The Committee notes that unexpended balances for this program remain from last year. These balances should be applied to the Centennial Challenges program for fiscal year 2006. Finally, the Committee reiterates that no funds shall be expended for this program until it is authorized.

The struggle for redirecting space transportation funding priorities toward the private sector continues to be an integral part of the larger struggle to build SSP. The SSPW’s task is education -- teaching that SSP is a very large positive, even for those in the aerospace and energy business. There will be surely be job retraining required, but we all expect to retrain at least every five or ten years. As we change jobs and titles and programs this learning is part of the joy of life – like learning to ride a bicycle or trying Mexican cuisine.

My purpose in this paper is to help us to see SunSat Corp’s forest as we look at the trees ahead of us. We want to understand the new and complex business process which we must cultivate and drive. The chapters we are writing on the keys to SSP – Space Transportation, WPT, Photovoltaics (PV), etc., must be simple to understand. As teachers, we know it requires deep understanding to be able to explain a complex subject in simple terms. Naoki Shinohara is leading our effort to do this now with WPT. Let’s look at some of the key points of the draft legislation chartering SunSat corporation and initiating SSP construction.

***Sec. 1 Subchapter I - General Provisions*****(a) Policy**

The Congress declares that it is the policy of the United States to establish, in conjunction and in cooperation with other countries, as expeditiously as practicable a commercial space solar power satellite system, as part of environmentally enhanced and improved global electric power generation and networks, which will be responsive to public needs and national objectives, which will serve the growing electric power needs of the United States and other countries, and which will contribute to world peace, understanding, harmony and increased sustainable electric power generation and economic development.

**(b) Availability of electric power services**

These expanded electric power services are to be made available as promptly as possible and are to be extended to provide electric power services to additional power grids at the earliest practicable date. In effectuating this program, care and attention will be directed toward providing such services to both economically less developed countries and areas and those more highly developed; toward efficient, prudent and economical use of the electromagnetic frequency spectrum, and toward the reflection of the benefits of this new technology in quality, reliability, and charges for such services.

**(c) Private enterprise; access; competition**

To facilitate the widest possible participation by private enterprise, United States participation in the global system shall be in the form of a private corporation, subject to appropriate governmental regulation. It is the intent of Congress that all authorized electric power companies shall have nondiscriminatory access to the system; that maximum competition be maintained in the provision of equipment and services utilized by the system; that the private corporation created under this chapter be so organized and operated as to maintain and strengthen competition in the provision of baseload or throttled electric power services to national, international, public and private power grids; and that the activities of the corporation created under this chapter and of the persons or companies participating in the ownership of the corporation shall be consistent with the Federal antitrust and other trade laws.

**(d) Domestic use; additional systems**

It is not the intent of Congress by this chapter to preclude the use of power satellite systems for domestic or international energy companies or electric power companies where consistent with the provisions of this chapter nor to preclude the creation of additional or competing power satellite systems, if required to meet unique needs or if otherwise required in the national interest.

**(e) Low-cost commercial reusable space transportation systems**

It is the intent of Congress by this chapter to provide further directed support to the establishment of this power satellite corporation such that low cost commercial reusable space transportation systems are made available in concert with the need for high volumes of freight which are essential to and characteristic of the advent of full scale construction of power satellite systems. This support may take the form of launch subsidies, transportation systems developmental assistance, tax relief, insurance, and developmental bond relief, separately or in combination.

(f) Demonstration Power Satellites

It is the intent of Congress by this chapter to direct and support the design, development, construction and operation of a demonstration power satellite as rapidly as possible. The overall management of this work will be assumed by the power satellite corporation to be formed by this Act. This support may take the form of launch subsidies, transportation systems developmental assistance, tax relief, insurance, and developmental bond relief, separately or in combination. The principle purpose of this first power satellite is to improve the understanding and practice of engineering and technology essential to building efficient and reliable power satellites and related systems, including rectennas (receiving antennas). Ownership and operation of two such completed demonstration power satellites shall be with the power satellite corporation, although the rectenna shall be owned by the client electric power company receiving the power satellite feed. The debt incurred by the power satellite corporation for the development, design, and construction of two demonstration power satellites shall be ten percentum of the total construction cost of the power satellites. This debenture shall be repaid to the Congress over thirty years at a rate of 3% interest. A developmental launch cost subsidy shall be provided for ten years in the amount of one half of that portion of launch costs including insurance which exceeds \$200./lb to Low Earth Orbit (LEO).

(g) Business Focus

The power satellite corporation shall not be engaged in the development, construction, or marketing of space transportation systems or photovoltaic (PV) conversion cells or systems, except as directly required in support of corporations engaged in those businesses providing for the power satellite corporation's needs. Space transportation and PV systems shall be purchased on the open market.

(h) Reporting

The power satellite corporation shall provide full reports on its work to Congress as well as advisories concerning related topics of interest to Congress at six month intervals. The cost of preparing these reports shall be considered part of the developmental design and construction costs of the demonstration power satellites.

## ***Sec. 2. Definitions***

As used in this chapter, and unless the context otherwise requires -

(1) the term "power satellite system" refers to a system of satellites in Geo-Synchronous Orbit(GSO) or other useful orbit, whose purpose is to collect energy from the Sun and convert it to a wireless power transfer medium for the purpose of safely transferring that energy to rectennas on earth, together with such associated equipment and facilities for tracking, guidance, control, and command functions as are not part of the generalized launching, tracking, control, and command facilities for all space purposes;

(2) the term "rectenna" refers to an array of interconnected receiving antennas located on the earth's surface, operationally connected with one or more terrestrial electric power transmission and distribution systems, with necessary associated operational equipment.

(3) the term "power satellite" means an earth satellite which is intentionally used for the purpose of collecting energy from the Sun and converting it to a wireless power transfer medium for the purpose of safely transferring that energy to a rectenna on earth;

(4) the term "associated equipment and facilities" refers to facilities other than satellite terminal stations and power satellites, to be constructed and operated for the primary purpose of a power satellite system, whether for administration and management, for research and development, or for direct support of space operations;

(5) the term "research and development" refers to the conception, design, and first creation of experimental or prototype operational devices for the operation of a power satellite system, including the assembly of separate components into a working whole, as distinguished from the term "production", which relates to the construction of such devices to fixed specifications compatible with repetitive duplication for operational applications; and

(6) the term "wireless power transfer" means any transmission, emission or reception of electromagnetic energy by radio, optical, or other electromagnetic systems for the purpose of providing electrical energy to an electric power company.

(7) the term "electric power company" refers to any corporation governed by the Federal Energy Regulatory Commission under the Energy Act of 1964, as amended, or comparable Acts in other countries who are engaged in the reception, transmission, marketing and/or distribution of electrical power to its customers;

(8) the term "corporation" means the corporation authorized by subchapter III of this chapter.

(9) the term "Administration" means the National Aeronautics and Space Administration; and

.....(10) the term “energy company” includes any corporations engaged in the development, production, marketing, or sale of coal, oil, gas, or nuclear materials from natural resources; or electric power generation from these sources.

## ***Subchapter II - Federal Coordination, Planning, and Regulation***

### ***Sec. 721. Implementation of policy***

In order to achieve the objectives and to carry out the purposes of this chapter -

(a) Executive functions; execution of national program; review; agency coordination; supervision of foreign relationships; foreign participation; use for general governmental purposes; separate systems; compatibility with domestic and foreign facilities the President shall -

(1) aid in the planning and development and foster the execution of a national program for the establishment and operation of global and lunar commercial power satellite systems;

(2) provide for continuous review of all phases of the development and operation of such systems, including the activities of a power satellite corporation authorized under subchapter III of this chapter;

(3) coordinate the activities of governmental agencies with responsibilities in the field of electric power generation and transmission, so as to insure that there is full and effective compliance at all times with the policies set forth in this chapter;

(4) exercise such supervision over relationships of the corporation with foreign governments or entities or with international bodies as may be appropriate to assure that such relationships shall be consistent with the national interest and foreign policy of the United States;

(5) insure that timely arrangements are made under which there can be foreign participation in the establishment and use of power satellite systems;

(6) create a Power Satellite Commission to provide necessary governmental coordination, as required in the national interest; It shall meet quarterly or as often as required; it shall be composed of these members to be named by:

- (a) the power satellite corporation
- (b) Federal Energy Regulatory Commission
- (c) Federal Communications Commission
- (d) Department of State
- (e) Department of Commerce
- (f) Department of Energy
- (g) The Congress
- (h) Space Transportation Association
- (i) The Chairman of the Power Satellite Commission shall be named by the power satellite corporation.

(7) so exercise his authority as to help attain coordinated and efficient use of the electromagnetic spectrum and the technical compatibility of the system with existing electric power companies both in the United States and abroad.

(b) Administration functions; technical advice to Commission; cooperation in research and development and technical consultation with corporation; assistance and launching, associated services and other services to corporation on reimbursable basis the National Aeronautics and Space Administration shall -

- (1) advise the Commission on technical characteristics of the power satellite system;
- (2) cooperate with the corporation in research and development to the extent deemed appropriate by the Commission in the public interest;
- (3) assist the corporation in the conduct of its research and development program by furnishing to the corporation, when requested, on a reimbursable basis, such services as the Administration deems necessary for the most expeditious and economical development of the power satellite system;
- (4) consult with the corporation regarding technical characteristics of the power satellite system;
- (5) furnish to the corporation, on request and on a reimbursable basis, associated services required for the establishment, operation, and maintenance of the power satellite system approved by the Commission;

(c) Commission functions; competitive bidding; consultation with Small Business Administration; discrimination; just and reasonable charges, classifications, practices, regulations and other terms and conditions; allocation of facilities; establishment of power to particular foreign point; technical compatibility of system and stations; accounting; rates; technical approval; construction and operation authorizations; financing of corporation; additions; rules and regulations of the Federal Energy Regulatory Commission, in its administration of the provisions of the Public Utility Regulatory Policy Act of 1978, as amended (<http://www.ferc.fed.us/intro/acts/purpa.htm>), and as supplemented by this chapter, shall -

- (1) insure effective competition, including the use of competitive bidding where appropriate, in the procurement by the corporation and associated entities of apparatus, equipment, and services required for the establishment and operation of the power satellite system and satellite terminal stations; and the Commission shall consult with the Small Business Administration and solicit its recommendations on measures and procedures which will insure that small business concerns are given an equitable opportunity to share in the procurement program of the corporation for property and services, including but not limited to research, development, construction, maintenance, and repair.
- (2) insure that all present and future authorized electric power transmission, distribution and generation corporations shall have nondiscriminatory use of, and equitable access to, the power satellite system and rectenna stations under just and reasonable charges, classifications, practices, regulations, and other terms and conditions and regulate the manner in which available facilities of the system and stations are allocated among such users thereof;
- (3) in any case where a member of the Commission, Secretary of Defense, or other authorized agency or government entity after obtaining the advice of the Administration as to technical feasibility, has advised that communication of power to a particular foreign point by means of the power satellite system and rectennas should be established in the national interest, institute forthwith appropriate proceedings as necessary;
- (4) insure that facilities of the power satellite system and rectennas are technically compatible and interconnected operationally with each other and with existing power transmission facilities;

(5) prescribe such accounting regulations and systems and engage in such ratemaking procedures as will insure that any economies made possible by a power satellite system are appropriately reflected in rates for public electric power services;

(6) approve technical characteristics of the operational power satellite system to be employed by the corporation and of the associated rectennas; and

(7) grant appropriate authorizations and guidelines for the construction and operation of each satellite rectenna station, either to the corporation or to one or more authorized construction corporations as will best serve the public interest, convenience, and necessity. In determining the public interest, convenience, and necessity the Commission shall authorize the construction and operation of such rectennas by client electric power companies or their agents, without preference;

(8) authorize the corporation to issue any shares of capital stock, except the initial issue of capital stock referred to in section 734(a) of this title, or to borrow any moneys, or to assume any obligation in respect of the securities of any other person, upon a finding that such issuance, borrowing, or assumption is compatible with the public interest, convenience, and necessity and is necessary or appropriate for or consistent with carrying out the purposes and objectives of this chapter by the corporation;

(9) insure that no substantial additions are made by the corporation or other contracting agents with respect to facilities of the power satellite system or rectennas unless such additions are required by the public interest, convenience, and necessity;

(10) require, in accordance with the Public Utility Regulatory Policy Act of 1978, as amended, that additions be made by the corporation or agents with respect to facilities of the power satellite system or rectennas where such additions would serve the public interest, convenience, and necessity; and

(11) make rules and regulations to carry out the provisions of this chapter.

### ***Subchapter III - Power Satellite Corporation***

#### ***Sec. 731. Creation of corporation***

There is authorized to be created a power satellite corporation for profit which will not be an agency or establishment of the United States Government.

#### ***Sec. 732. Applicable laws***

The corporation shall be subject to the provisions of this chapter and, to the extent consistent with this chapter, to the District of Columbia Business Corporation Act (D.C. Code, Sec. 29-301 et seq.). The right to repeal, alter, or amend this chapter at any time is expressly reserved.

### *Sec. 733. Directors and officers*

(a) Board of directors; qualifications; chairman; appointment by President; term; election by stockholders; percentage of stock ownership determining right to elect; cumulative voting; amendment of articles of incorporation; bylaws for national emergencies

The corporation shall have a board of directors consisting of fifteen individuals who are citizens of the United States, of whom one shall be elected annually by the board to serve as chairman. Three members of the board shall be appointed by the President of the United States, by and with the advice and consent of the Senate, effective the date on which the other members are elected, and serve for terms of one, two, and three years, respectively, or until their successors have been appointed and qualified, and any member so appointed to fill a vacancy shall be appointed only for the unexpired term of the director whom he succeeds. The remaining twelve members of the board shall be elected annually by the stockholders. Six of such members shall be elected by those stockholders who are not aerospace, electric power, or energy companies, and the remaining six such members shall be elected by the stockholders who are aerospace, electric power, or energy companies, except that if the number of shares of the voting capital stock of the corporation issued and outstanding and owned either directly or indirectly by aerospace, electric power, or energy companies, as of the record date for the annual meeting of stockholders is less than 45 per centum of the total number of shares of the voting capital stock of the corporation issued and outstanding, the number of members to be elected at such meeting by each group of stockholders shall be determined in accordance with the following table:

| When the number of shares of the voting capital stock of the power satellite corporation issued and outstanding and owned either directly or indirectly by aerospace, electric power company, or energy company is less than - | But not less than | The number of members which stockholders who are aerospace, electric power company, or energy company are entitled to elect shall be: | And the number of members which other stockholders are entitled to elect shall be |
|--|-------------------|---|---|
| 20 per centum  | 14 per centum     | 2   | 10  |
| 14 per centum  | 8 per centum      | 1   | 11  |
| 8 per centum   |                   | 0   | 12  |

No stockholder who is an aerospace, electric power, or energy companies, and no trustee for such a stockholder shall vote, either directly or indirectly, through the votes of subsidiaries or affiliated companies, nominees, or any persons subject to his direction or control, for more than three candidates for membership on the board, except that in the event the number of shares of the voting capital stock of the corporation issued and outstanding and owned either directly or indirectly by aerospace, electric power, or energy companies, as of the record date for the annual meeting is less than 8 per centum of the total number of shares of the voting capital stock of the corporation issued and outstanding, any stockholder who is a aerospace, electric power, or energy company shall be entitled to vote at such

meeting for candidates for membership on the board in the same manner as all other stockholders. Subject to the foregoing limitations, the articles of incorporation of the corporation shall provide for cumulative voting under section 27(d) of the District of Columbia Business Corporation Act (D.C. Code, sec. 29-27(d)). The articles of incorporation of the corporation may be amended, altered, changed, or repealed by a vote of not less than 66 2/3 per centum of the outstanding shares of the voting capital stock of the corporation owned by stockholders who are aerospace, electric power, or energy company and by stockholders who are not aerospace, electric power, or energy company, voting together, if such vote complies with all other requirements of this chapter and of the articles of incorporation of the corporation with respect to the amendment, alteration, change, or repeal of such articles. The corporation may adopt such bylaws as shall, notwithstanding the provisions of section 36 of the District of Columbia Business Corporation Act (D.C. Code, section 29-336(d)), provide for the continued ability of the board to transact business under such circumstances of national emergency as the President of the United States, or the officer designated by him, may determine, after February 18, 2010, would not permit a prompt meeting of a majority of the board to transact business.

(b) President of corporation; designation and appointment of other officers; compensation; United States citizenship of officers; dual salary prohibition

The corporation shall have a president, and such other officers as may be named and appointed by the board, at rates of compensation fixed by the board, and serving at the pleasure of the board. No individual other than a citizen of the United States may be an officer of the corporation. No officer of the corporation shall receive any salary from any source other than the corporation during the period of his employment by the corporation.

### *Sec. 734. Financing of corporation*

(a) Capital stock; amount of issue; no par value shares; voting rights; dividends; price and public distribution of initial offering; shareholder eligibility

The corporation is authorized to issue and have outstanding, in such amounts as it shall determine, shares of capital stock, without par value, which shall carry voting rights and be eligible for dividends. The shares of such stock initially offered shall be sold in a manner to encourage the widest distribution to the American public. Subject to the provisions of subsections (b) and (d) of this section, shares of stock offered under this subsection may be issued to and held by any person.

(b) "Authorized carrier" defined; shareholder eligibility; voting rights limitation of authorized carriers and other stockholders

(1) For the purposes of this section the term "authorized carrier" shall mean an aerospace, electric power company, or energy company which is specifically authorized or which is a member of a class of carriers authorized by the Commission to own shares of stock in the corporation upon a finding that such ownership will be consistent with the public interest, convenience, and necessity.

(2) Only those aerospace, electric power, or energy companies which are authorized carriers shall own shares of stock in the corporation at any time, and no other aerospace, electric power, or energy companies shall own shares either directly or indirectly through subsidiaries or affiliated companies, nominees, or any persons subject to its direction or control. At no time after the initial issue is completed shall the aggregate of the shares of

voting stock of the corporation owned by authorized carriers directly or indirectly through subsidiaries or affiliated companies, nominees, or any persons subject to their direction or control exceed 25 per centum of such shares issued and outstanding.

(3) At no time shall any stockholder who is not an authorized carrier, or any syndicate or affiliated group of such stockholders, own more than 10 per centum of the shares of voting stock of the corporation issued and outstanding.

(c) Nonvoting security issues and certificates of indebtedness; rate base

The corporation is authorized to issue, in addition to the stock authorized by subsection (a) of this section, nonvoting securities, bonds, debentures, and other certificates of indebtedness as it may determine. Such nonvoting securities, bonds, debentures, or other certificates of indebtedness of the corporation shall be eligible for inclusion in the rate base of the corporation to the extent allowed by the Commission. The voting stock of the corporation shall not be eligible for inclusion in the rate base of the carrier.

(d) Alien share ownership limitation

Not more than an aggregate of 15 per centum of the shares of stock of the corporation authorized by subsection (a) of this section which are held by holders other than authorized carriers may be held by persons of the classes described in subsection (a) and paragraphs (1) through (4) of subsection (b) of section 310 of this title.

(e) Inspection and copying rights

The requirement of section 45(b) of the District of Columbia Business Corporation Act (D.C. Code, sec. 29-345(b)) as to the percentage of stock which a stockholder must hold in order to have the rights of inspection and copying set forth in that subsection shall not be applicable in the case of holders of the stock of the corporation, and they may exercise such rights without regard to the percentage of stock they hold.

(f) Transfer and distribution of shares among authorized carriers

Upon application to the Commission by any authorized carrier and after notice and hearing, the Commission may compel any other authorized carrier which owns shares of stock in the corporation to transfer to the applicant, for a fair and reasonable consideration, a number of such shares as the Commission determines will advance the public interest and the purposes of this chapter. In its determination with respect to ownership of shares of stock in the corporation, the Commission, whenever consistent with the public interest, shall promote the widest possible distribution of stock among the authorized carriers.

## ***Sec. 735. Powers of corporation***

(a) Authorized powers

In order to achieve the objectives and to carry out the purposes of this chapter, the corporation is authorized to -

(1) plan, initiate, construct, own, manage, and operate itself or in conjunction with foreign governments or business entities a commercial power satellite system;

(2) furnish, for hire, channels of communication to United States electric power companies and to other authorized electric power companies and entities, foreign and domestic; and

(3) own and operate satellite terminal stations when licensed by the Commission under section 721(c)(7) of this title.

(b) Specific corporate activities

Included in the activities authorized to the corporation for accomplishment of the purposes indicated in subsection (a) of this section, are, among others not specifically named

(1) to conduct or contract for research and development related to its mission;

(2) to acquire the physical facilities, equipment and devices necessary to its operations, including power satellites and associated equipment and facilities, whether by construction, purchase, or gift;

(3) to purchase satellite launching and related services from commercial providers;

(4) to contract with authorized users, foreign or domestic, including the United States Government, for the services of the power satellite system; and

(5) to develop plans for the technical specifications of all elements of the power satellite system.

(c) Specifically excluded corporate activities

The power satellite corporation shall not engage in the manufacture, marketing, or sales of space launch vehicles, photovoltaic conversion devices, wiring or cables, or any major electrical or mechanical systems and/or components not related to and/or part of the power satellites. The power satellite corporation is to contract for these services and components as necessary.

(d) Usual powers of stock corporation

To carry out the foregoing purposes, the corporation shall have the usual powers conferred upon a stock corporation by the District of Columbia Business Corporation Act (D.C. Code, Sec. 29-301 et seq.).

### ***Sec. 736. Foreign business negotiations of corporation; notice to Commission***

Whenever the corporation shall enter into business negotiations with respect to facilities, operations, or services authorized by this chapter with any international or foreign entity, it shall notify the members of the Power Satellite Commission of the negotiations, and they shall advise the corporation of relevant foreign policy and regulatory considerations. Throughout such negotiations the corporation shall keep the Power Satellite Commission informed with respect to such considerations. The corporation may request Power Satellite Commission members to assist in the negotiations, and they shall render such assistance as may be appropriate.

## ***Sec. 737. Sanctions***

### **(a) Petition of Attorney General for equitable relief; venue**

If the corporation created pursuant to this chapter shall engage in or adhere to any action, practices, or policies inconsistent with the policy and purposes declared in section 701 of this title, or if the corporation or any other person shall violate any provision of this chapter, or shall obstruct or interfere with any activities authorized by this chapter, or shall refuse, fail, or neglect to discharge his duties and responsibilities under this chapter, or shall threaten any such violation, obstruction, interference, refusal, failure, or neglect, the district court of the United States for any district in which such corporation or other person resides or may be found shall have jurisdiction, except as otherwise prohibited by law, upon petition of the Attorney General of the United States, to grant such equitable relief as may be necessary or appropriate to prevent or terminate such conduct or threat.

### **(b) Punishment, liability or sanction under other provisions**

Nothing contained in this section shall be construed as relieving any person of any punishment, liability, or sanction which may be imposed otherwise than under this chapter.

### **(c) Duty of compliance with provisions of chapter and rules and regulations**

It shall be the duty of the corporation and all aerospace, electric power companies, or energy companies to comply, insofar as applicable, with all provisions of this chapter and all rules and regulations promulgated thereunder.

## ***Sec. 738. Reports to Congress***

The corporation shall transmit to the President and the Congress, annually and at such other times as it deems desirable, a comprehensive and detailed report of its operations, activities, and accomplishments under this chapter.

## **Subchapter V - International Solar Power Rectenna Owners Organization**

### ***Sec. 751. Congressional declaration of policy and purpose***

(a) Development and operation of rectennas and their associated electrical grid interconnection machinery, regulatory and environmental needs to serve power satellite downlink needs of the United States and member foreign countries

The Congress hereby declares that it is the policy of the United States to provide for the participation of the United States in the International Solar Power spAce ReCtenna Owners Organization (hereinafter in this subchapter referred to as “SPARCO”) in order to develop and operate power satellite rectennas. SPARCO shall promote power frequency allocations consistent with sound environmental regard for both the successful transmission of clean solar power and the environment through which this transmission takes place

(b) Corporate participation; private entity status; non-Government agency

It is the purpose of this subchapter to provide that the participation of the United States in SPARCO shall be through the power satellite corporation established pursuant to subchapter III of this chapter, which constitutes a private entity operating for profit, and which is not an agency or establishment of the Federal Government. Additional participation by aerospace, electric power, or energy companies is encouraged.

### ***Sec. 752. Corporation's status as designated operating entity***

(a) Statement of purpose; signature authorization

(1) the power satellite corporation established pursuant to subchapter III of this chapter is hereby designated as the initial organizing entity of the United States for participation in SPARCO , for the purpose of facilitating and encouraging improved understanding of power satellite downlink construction, operational, environmental and regulatory issues and services.

(2) The corporation may participate in and is hereby authorized to sign the operating agreement or other pertinent instruments of SPARCO as the initial designated operating entity of the United States.

(b) Powers of corporation

The corporation -

(1) shall advise, consult and facilitate as required in the design, construction and operation of satellite earth rectennas downlink stations and associated electrical power grid interconnections to local, national or other electric power grids public or private with the owners and operators of those electric power grids;

(2) shall interconnect such stations with the supplying power satellite to provide system integrity and assure continuous power flow, except as may be required for biannual or other maintenance, and as authorized by the Commission;

(3) shall provide for the common operational and system security of such rectennas and the power satellite transmitting to their rectenna partner, and with power relay equipment servicing other electric power grids, as requested, unless SPARCO or the Commission finds that such interconnection will not serve the interests of the electric power grid;

(c) Financial obligation

The corporation shall be responsible for fulfilling any financial obligation placed upon the corporation as a signatory to the operating agreement or other pertinent instruments, and any other financial obligation which may be placed upon the corporation as the result of a convention or other instrument establishing SPARCO. The corporation shall be the United States' organizing representative in the managing body of SPARCO.

(d) Ownership or/and operation of power satellite and rectennas for training of personnel pursuant to authorization of responsible executive department or Commission:

(1) Any person, including the Federal Government or any agency thereof, may be authorized, in accordance with paragraph (2) or paragraph (3), to be the sole owner or operator, or both, of any power satellite or rectenna if such satellite or rectennas is used for the exclusive purposes of training personnel in the use of equipment associated with the operation and maintenance of such satellite or rectennas, or in carrying out experimentation relating to various power satellite services.

(2) If the person referred to in paragraph (1) is the Federal Government or any agency thereof, such power satellite or rectenna shall have been authorized to operate by the executive department charged with such responsibility.

(3) In any other case, such power satellite or rectenna shall have been authorized by the Commission.

(e) Additional noncorporation ownership of power satellite or rectenna for enhancement of power satellite services in the public interest

The Commission may authorize ownership of power satellites or rectennas by persons other than the corporation at any time the Commission determines that such additional ownership will enhance the provision of electric power services in the public interest.

(f) Operational arrangements for interconnection of power satellite or rectenna and facilities with other electric power grids, power systems or components for extension of electric power services:

The Commission shall determine the operational arrangements under which the corporation shall interconnect its satellite earth terminal station facilities and services with United States electric power companies, other than any electric power companies, system, or other entity in which the corporation has any ownership interest, and private electric power systems when authorized pursuant to subsection (b)(3) of this section for the purpose of extending electric power services within the United States and in other areas.

SPARCO shall work with international developmental agencies to identify nations, states, power corporations and/or regions that are developmentally close to being capable of supporting an electric power grid of sufficient size to accept a share of rectenna downlinked SSP power. SPARCO shall work with these agencies to share in fostering subsidization of completion of these new downlinkable grid segments. In no case will the power satellite corporation take any share in title of the rectenna.

### **Sec. 753. Implementation of policy**

(a) Administrative functions; agency coordination; use for general governmental purposes; separate systems; spectrum and orbital space use; compatibility with domestic and foreign facilities; interests and needs of ultimate users; Federal views on utilization and user needs The Secretary of Commerce shall -

(1) coordinate the activities of Federal agencies with responsibilities as an electric power company (other than the Commission), so as to ensure that there is full and effective compliance with the provisions of this subchapter;

(2) take all necessary steps to ensure the availability and appropriate utilization of the power satellite services provided by SPARCO for general governmental purposes, except in any case in which a separate electric power company is required to meet unique governmental needs or is otherwise required in the national interest;

(3) exercise his authority in a manner which seeks to obtain coordinated and efficient use of the electromagnetic spectrum and orbital space, and to ensure the technical compatibility of the space segment with existing earthbound power transmission facilities in the United States and in foreign countries; and

(4) take all necessary steps to determine the interests and needs of the ultimate users of the electric power company foreign and domestic and to communicate the views of the Federal Government on utilization and user needs to SPARCO.

(b) Executive functions; supervision and instructions for foreign relationships and activities

The President shall exercise such supervision over, and issue such instructions to, the corporation in connection with its relationships and activities with foreign governments, international entities, and SPARCO as may be necessary to ensure that such relationships and activities are consistent with the national interest and foreign policy of the United States.

(c) Commission functions; institution of proceedings; recommendations for issuance of executive instructions; public space segment channel, construction, operation and other authorizations; review; rules

The Commission shall -

(1) institute such proceedings as may be necessary to carry out the provisions of section 752 of this title;

(2) make recommendations to the President for the purpose of assisting him in his issuance of instructions to the corporation;

(3) grant such authorizations as may be necessary under title II and title III of the Communications Act of 1934 (47 U.S.C. 201 et seq., 301 et seq.) and the Public Utility Regulatory Act of 1978 as amended to enable the corporation -(A) to provide to the public, in accordance with section 752(c)(2) of this title, space segment orbital locations from their owner; and title II and title III of the Communications Act of 1934 to carry out to the provisions of this subchapter;

(5) establish procedures to provide for the continuing review of the power satellite activities of the corporation as the United States signatory to the operating agreement or other pertinent instruments; and

(6) prescribe such rules as may be necessary to carry out the provisions of this subchapter.

(d) Commission regulatory instructions; conflicting and prevailing instructions of President

The Commission is authorized to issue instructions to the corporation with respect to regulatory matters within the jurisdiction of the Commission. In the event an instruction of the Commission conflicts with an instruction of the President pursuant to subsection (b) of this section, the instructions issued by the President shall prevail.

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## **The business planning process**

While the SunSat Act is derived from the Comsat Act of 1962, there are important differences to remember. In 1962, space was an entirely new field for communications. Space transportation and PV were in their infancy. Today these technologies are very mature. Then there was *no private* space transportation, PV, telerobotics or other space infrastructure provider.

Either you built government launchers or you didn't go. Much technology simply did not exist. Virtually everything that Comsat needed to do business in space, we take for granted as available to SunSat today – we just need to bring the costs down. The employees of Comsat had to invent it as they went along.

The persons and/or corporate groups who choose to compete to form SunSat Corporation would assemble business plans in consultation with their component manufacturers and service providers and submit these in response to a Request For Proposal from the government. The Japanese “Implementation Plan Evaluation Type” may be similar to typical US government “Integrated Master Plan Events”. In both cases, potential bidders are required to submit in advance their implementation plans for the project so that their technical qualification can be examined and approved for the bidding process.

To begin *our* SSP business plan or proposal we would examine every aspect of SSP design, construction, marketing, operations, etc., and meet with possible providers for all component technologies. Among the key technologies that have been identified include

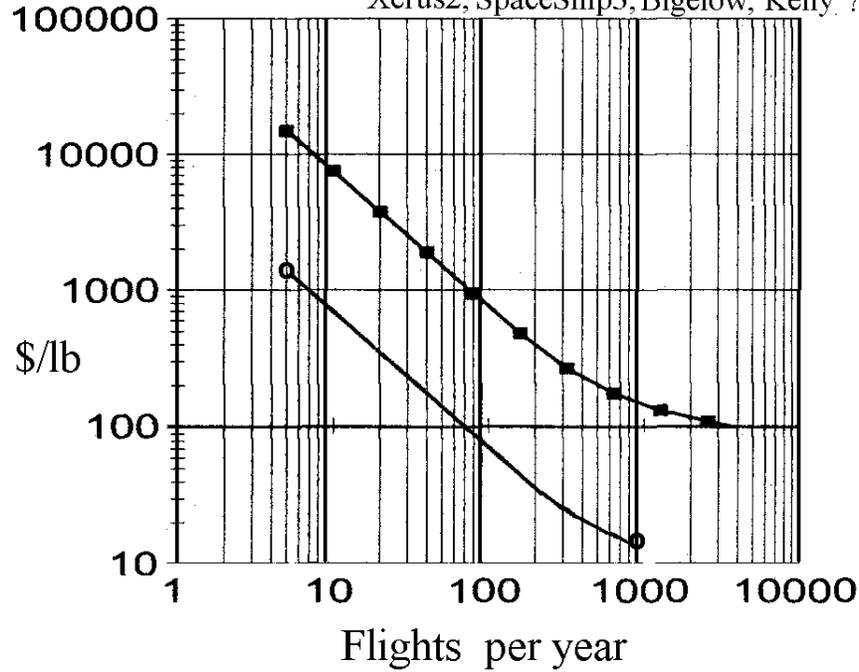
1. Space transportation
2. Thin-film PV fabric solar array designed for likely high voltage operation even in solar storm conditions.
3. WPT – transmitting antenna & rectenna
4. Telerobotic assembly and nearly autonomous operation
5. Advanced SunSat flight control operations and satellite geometries
6. Superconducting cables
7. Terrestrial environmentally-positive rectenna construction, marketing, development and regulatory procedures (SPARCO interfaces)
8. Asteroid defense and cis-lunar (off earth) mining and manufacturing

As the graph below shows, two companies' launch vehicles – SpaceX' Falcon and Kosmotras' Dnepr – have surged into the lead of a new generation of low cost commercial spacecraft.

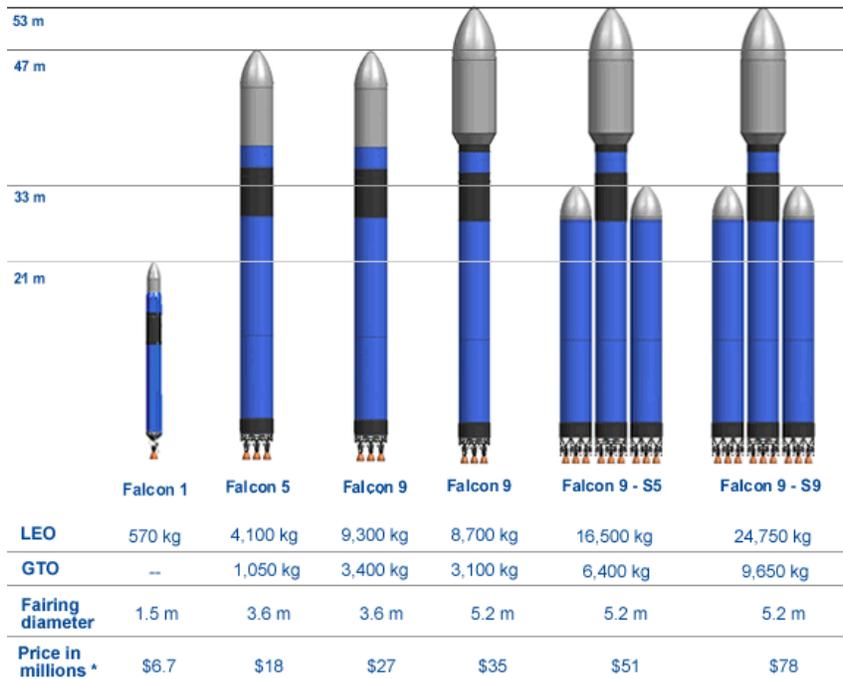
## Low Cost Potential

■ Loss 0.0001 Rate 200 Life 1000 Labor 200

○ New vehicles - Falcon, Dnepr, Xerus2, SpaceShip3, Bigelow, Kelly ? .



Increases in Flights per year lowers the per flight costs.



\* Prices are all inclusive of launch range, third party insurance and standard payload integration costs.

We note that SpaceX has not yet launched anything (first launch scheduled for October, 2005 at the earliest) and Dnepr Kosmotras' rockets are not technically new, they are converted ICBMs. Regardless, both these companies are now operating on the new-improved (lower) price per flight curve. The old price per flight, the upper curve, was defined by the expendable launch vehicles you are familiar with -- Delta, Atlas, Titan, Ariane, shuttle, etc.

At the new price performance curves being quoted by Mr. Musk and Kosmotras, in an admittedly thin market, we project the price would fall below \$10/lbm (\$22/kg) at over 3,000 flights per year – once the requisite flight volume and appropriate spacecraft are realized. Prices would likely fall well below these estimates once the market volume was established. *Many* other enterprises would then be enabled.

Space transportation costs are an exquisitely important key to SSP. Without the vast market expansion SSP offers, however, it may be many years before the costs for space transportation can be pushed low enough to enable SSP. They are interdependent. Without favorable launch costs, SSP is not possible.

*We suggest separate legislation to provide a 75% launch subsidy to **new** private or public/ private businesses, such as SunSat Corp, which are contracting for space transportation and 25 % launch subsidy to established businesses contracting for space transportation. These funds would go to those businesses buying launch services, as vouchers, not directly to space transportation companies. Other reasonable requirements in this legislation might be that the launch must be to LEO or higher.*

The space transportation industry is undergoing a metamorphosis toward commercial launch with many in the US advocating that NASA should leave LEO and other launch segments to commercial providers, even replacing the CEV with commercial providers such as Mr. Robert Bigelow's America's Prize promises to do. Establishing a dialog with potential providers and establishing a presence as a major customer is the beginning.

Significant work must be done to develop the SSP marketplace which will require very low cost and massive quantities of PV thin-film fabric solar arrays, in addition to high volume cargo transport to GSO. Working with all these manufacturers' flexible estimates of the working subsidies necessary to develop groups of competing providers will be required. Some of these will share common demand cycles, technologies and customer bases with related technology providers which can ameliorate the risk and lower the cost of building these markets to levels required for full SSP construction.

Continuing the global PV development race, numerous developments make clear our readiness to begin SSP construction. For example, United Solar Ovonic's triple-junction modules, originally developed for terrestrial applications, were deposited on a 5-mil flexible stainless steel substrate. "By utilizing a polymeric substrate rather than stainless steel, new space cells will be developed that have a specific power density greater than 1,000 watts per kilogram (W/kg). The radiation hardness and superior high-temperature performance of amorphous silicon make it an attractive material for space application."

Hewlett Packard's "Solar City" factory design would produce 2.1 – 3.6 GW of solar panels per year. This "Solar City" can produce solar panels at \$1.00 per peak watt [terrestrial – e.g. US, Japan, Germany,.. or \$0.10 peak watt at GSO – SSPW] This breakthrough in the price of solar energy comes without the need for any significant new invention. It comes entirely from the manufacturing scale of a large plant and the cost savings inherent in operating at such a large manufacturing scale. HP expects further optimizations will lead to further improvements in cost.

*Concomitantly, we would suggest separate legislation to provide a 75% subsidy to **new** private or public/ private businesses, such as SunSat Corp, which are contracting for space photovoltaic arrays and 25 % subsidy to established businesses contracting for space photovoltaic arrays. These funds would go to those businesses buying space photovoltaic arrays as vouchers, not directly to space photovoltaic arrays companies. Other reasonable requirements in this legislation might be that the launch must be to LEO or higher.*

Coordinated planning of the nascent SSP market segments will thus be required in a wide variety of technologies — from thin-film solar array fabric and WPT components to high volume cargo transport to GSO. Working with many manufacturers, flexible estimates of the working subsidies necessary to develop groups of competing providers will be required. Some of these will share common demand cycles, technologies and customer bases with related technology providers which can ameliorate the risk and lower the cost of building these markets to levels required for full SSP construction.

As you know, WPT is perhaps the key technology which is both most central to SSP and least well developed in the commercial or private world. Just as Comsat Corp also created a space communications laboratory as part of the legislation, so SunSat Corp should also create a space communications laboratory as part of the enabling legislation. Comsat International through its subsidiaries still has many such laboratories from Latin America to Turkey. These WPT laboratories would be an integral part of SunSat Corp and its customers. Technologies which those laboratories developed would be shared in various contractual arrangements with customers, just as Comsat Corp. did.

### Related activities

A SunSat Corporation has no business reason to and should not be permitted to pursue off-target enterprises and endeavors.

Its first task would be to design and build an SSP demonstration satellite. SunSat's single focus should be developing SSP -- its market and associated technology, such as WPT. However, an appropriate encapsulation of SunSat's risk into forms which would work for the mutual public and private benefit of many could begin with the formation of a Lunar Development Authority (LDA).

Some space analysts have concluded that if some preliminary lunar development were subsidized, as is planned by several nations including President Bush's "Moon, Mars and Beyond" plan, photovoltaic cells could be provided to an SSP development at lower cost than the earth could provide these. This may be important, as most of the weight of an SSP system would be photovoltaic "fabric".

Considering that high purity silicon for PV manufacturing is becoming significantly more expensive and hard to obtain on earth and electric power in space seems to be declining in price, making PV from lunar silicon may be a very desirable product for an LDA to sell under contract to a SunSat Corp.

These cells, manufactured primarily from lunar regolith would be useful to moon development, as well. Rather than lift such large masses of components, such as photovoltaic cells, the primary component by weight of SSPs, from earth to GSO, it may be shown to be more profitable to collect raw materials from the lunar surface, and even from asteroids and comets in convenient orbits.

The energy cost to transport a pound of cargo to GSO from the moon is twenty times smaller than the energy costs to transport a pound from earth. So if shipping costs from earth to GSO were \$100 per kilogram; *once the infrastructure is in place on the moon*, shipping costs from the moon to GSO would approach \$5 per kilogram. Of course, first developing such an industrial capacity on the moon, primarily through telerobotics, would first be required, probably through another public / private LDA corporation. Telemining and even telesurgery have been fully demonstrated on the earth.

A publicly chartered LDA would share and subsidize the cost of infrastructure needed by cis-lunar businesses to facilitate the rapid development of all. Separating this infrastructure development would reduce the risk attached to each and make a massive undertaking manageable. Candidate infrastructure areas might include:

|              |                                    |
|--------------|------------------------------------|
| transport,   | power supply,                      |
| water,       | meteorite defense,                 |
| air,         | photovoltaic cell production       |
| shelter, ... | legal other services & commodities |

These infrastructure support contracts would support the nascent cis-lunar commercial manufacturing and other services. Under such special circumstances a separate lunar photovoltaic material manufacturer may very well be chartered to become a PV provider to a SunSat type corporation(s).

## *Conclusion*

It has been wonderful to meet so many scientists and engineers here in Japan actively working on WPT and SSP this week. The closest related work we have in the US appears may be Space Based Radar(SBR) -- a classified research area similar to WPT. In fact, the SBR Innovative Space-based Radar Antenna Technology(ISAT) antenna is similar in design to Japan's proposed SPS-2000.

“The Association for the Study of Peak Oil & Gas (ASPO), a group of petroleum geologists formerly with major oil companies (e.g. BP, Amoco) has recently revised their forecasted date for global peak oil production forward from 2010 to 2008. ...

“ExxonMobil expects 80% of additional global demand for energy up to 2020 to come from the developing countries (see ExxonMobil, A Report on Energy Trends, February 2004, p.3). In the worst-case scenario, the already emerging widening of supply/demand gap could trigger a shortage shock leading to price crisis. This would also impact world economic development.”

The SSPW takes no position on these date predictions. In a recent report prepared for the Department of Energy's National Energy Technology Laboratory (NETL), lead author Robert Hirsch states that

*“whatever the peak year turns out to be, 2005 is the time to get moving on energy policy. ... strong action must be taken at least 10, and preferably 20 years before we reach a world oil peak, if we are to avoid a long period of significant economic hardship worldwide. Under normal conditions, replacing half our automobile fleet would require 10-15 years; replacing half our light trucks, 9-14 years. Waiting until world conventional oil production peaks before implementing crash program mitigation leaves the world with a significant liquid fuel deficit for two decades or longer.” )*

It is crystal clear that the time to begin building SSP is here. The longer we delay making substantial improvements to our energy policy, centered on building SSP, the greater the danger to our environment, our energy supply and our world.

## *Endnotes*

1. "Ocean acidification due to increasing atmospheric carbon dioxide", <http://www.royalsoc.ac.uk/document.asp?id=3249> and "Global warming? Scientists seeing more dead birds, fewer fish on Pacific Coast" <http://www.sun-sentinel.com/news/nationworld/sfl-81-global-warming,0,3557815.story>
2. A summary of the massive global work being done in these studies can be found at Chapter two "Climate Change-Weather Impacts " explains and explores the escalating impact of forced climate change " <http://www.sspi.gatech.edu/weatherchg.pdf>
3. The idea for SSP may be traced back to Peter Glaser, Nicola Tesla and others. The earliest mention may, however be David, the author of Psalms 19:4-5. Perhaps even the design for the Japanese flag may be traced to that same rising sun of King David.
4. Recently a new hydrogen storage technology from Denmark claims to exceed the DOE goals for 2015 for safe hydrogen storage. AMMINEX A/S hydrogen storage technology has an Energy density of 13.0(MJ/1) versus the US-DOE Goal of 9.0 AMMINEX A/S is a start-up company founded by researchers at the Technical University of Denmark (DTU). [http://www.amminex.com/index\\_files/Page344.htm](http://www.amminex.com/index_files/Page344.htm)
5. "Annual Report Of The Commissioner Of Railroads To The Secretary Of The Interior, For The Year Ending June 30, 1883 " [http://cpr.org/Museum/Construction\\_1883.html](http://cpr.org/Museum/Construction_1883.html) last accessed 8/27/05
6. The SunSat Corporation Act [http://www.sspi.gatech.edu/sunsat\\_act.html](http://www.sspi.gatech.edu/sunsat_act.html)
7. "Japanese Scientists, Politicians Support Space Solar Power, by Stew Magnuson, *Space News* March 18, 2002, page 15
8. <http://www.whitehouse.gov/omb/legislative/sap/109-1/hr2862sap-s.pdf>
9. "Statement of Administration Policy [NASA Excerpt] H.R.2862, Depts of Commerce and Justice, Science, and Related Agencies Appropriations Bill, FY2006," <http://www.spaceref.com/news/viewstr.html?pid=18024>
10. "United Solar Ovonic Receives Contract from the Air Force Research Laboratory to Continue Further Development of the UNI-SOLAR(R) Cells and Modules for Airship and Space Applications", August 16, 2005 <http://www.renewableenergyaccess.com/rea/market/business/rinewstory?id=35455>
11. "Study of Potential Cost Reductions Resulting from Supper-Large-Scale Manufacturing of PV Modeles", By M.S.Keshner and R.Arya *Hewlett Packard, Palo Alto, California*, Final Subcontract Report October 2004 • NREL/SR-520-36846
12. "Silicon PV cell production on the Moon as the basis for a new architecture for space exploration", by Michael B. Duke, Alex Ignatiev, Alex Freundlich, Sanders D. Rosenberg, and Darby Makel, 2001 *Space Technology and Applications International Forum-AIP Conference Proceedings Vol. 552(1) pp.19-24.*

February 2, 2001 and

“First demonstration of photovoltaic diodes on lunar regolith-based substrate”, by C. Horton, C. Gramajo, A. Alemu, L. Williams, A. Ignatiev, A. Freundlich, pp. 537-545 ACTA

ASTRONAUTICA, Volume 56 no. 5,

March 2005 <http://www.iaanet.org/publicat/last.html>

13. SBR is developing new technologies that enable huge radar antennas, many times larger than anything deployed in space before. These enormous radar antennas will enable the continuous life-to-death tracking of high-value ground targets, anywhere, anytime.

14. Articles from K. Aleklett and C.J. Campbell at ASPO Newsletter No.49-January 2005

<http://www.peakoil.net/Newsletter/NL49/newsletter49.pdf> last accessed 1/21/05

15. “Peaking of world Oil Production: Impacts, Mitigation and Risk Management”, by Robert L. Hirsch et al.,

March 7, 2005, by Science Applications International Corporation (SAIC)

<http://www.energybulletin.net/4638.html> last accessed 4/5/05