



**International Academy of Astronautics (IAA)
Commission III Study Group - Solar Energy From Space**

**International Academy of Astronautics (IAA)
Commission III (Space Systems and Technology) / Study Group 3.11
International Assessment of Solar Energy From Space**

**A WORKSHOP ON SOLAR ENERGY FROM SPACE (SPS 2009)
AS PART OF AN INTERNATIONAL FORUM ON SOLAR ENERGY FROM SPACE
SEPTEMBER 9-10, 2009**

WORKSHOP PROGRAM

WEDNESDAY, 9 SEPTEMBER 2009

- 8:00 AM Workshop Opening – Plenary Session 1**
This session will provide an overview of the workshop, including its objectives, agenda, and logistics. The session will also present recent international SSP study results. The session will present the SSP scenarios being used to organize the IAA study, and will conclude with a charge to workshop participants for Day 1.
CO-CHAIRS: J. Mankins; N. Kaya
Catalytic Presentations including:
- IAA Study Group Background (J. Mankins, N. Kaya)
 - Recent Studies of Space Solar Power at the US Naval Research Laboratory (P. Jaffe)
 - USEF Activities in the Development, and the Logical Steps Toward Realization of SSPS (*Ijichi, S. Mihara*)
 - Solar Electric Power Plants In Space: Potential Bedrock for Sustaining India's High Economic Growth Track (*Gopalaswami, invited*)
 - ESA Activities Regarding SSPS (*L. Summerer, via Videoconference*)
 - Workshop Overview & Charge to Participants (J. Mankins, N Kaya)
- 9:30 AM BREAK (Coffee & Snacks)**
- Walk-through and Technical Discussion of WPT Demo at SPS 2009 (N. Kaya, J. Mankins)
- 10:00 AM SPS Systems Architectures – Plenary Session 2**
This session will involve discussions of various Solar Power Satellite concepts (past and present) – with the focus on the overall architecture for the approach. The session discussions will include identifying



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overall characteristics of various systems concepts and/or architectures when viewed in the context of the several SPS scenarios around which the IAA study has been organized. In addition, the session will address key challenges associated with SPS realization, including spectrum management related topics.

CO-CHAIRS: J. Mankins/ N. Kaya

Catalytic Presentations including:

- SPS Systems Architectures Overview (J. Mankins)
- Japanese concept of microwave-type SSPS (S. Sasaki)
- Laser WPT SPS Architectures (J. Penn)
- Future Plans and Directions for “Smart Grid” Development and the Integration of Solar Energy from Space (T. Sidhu)
- The Production of Chemical Fuels From Space Solar Power (R. Wegeng)
- Spectrum Management Challenges for SPS (K. Hashimoto)

10-15
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Plus... some preliminary discussion of architecture level issues.

12:00 PM LUNCH

1:00 PM **SPS Major Systems / Technology Challenges – Plenary Session 3**

This session will involve discussions of various specific systems elements and infrastructure challenges for Solar Power Satellite concepts (past and present) – with the focus on the technology-related details of each area. The session discussions will include identifying strengths, weaknesses, technology requirements, and technology readiness levels for each of the architectures / concepts when viewed in the context of the several SPS scenarios around which the IAA study has been organized.

CO-CHAIRS: R. Dickinson / R. Wegeng

Catalytic Presentations including:

- SPS Technology Challenges Overview (J. Mankins)
- Retrospective: SPS/WPT Technologies of the 1970s (R. Dickinson)
- Retrodirective Phased Array WPT – Technology Development and Demonstrations (N. Kaya)
- Technology Challenges and Opportunities for Very Large In-Space Structural Systems (K. Belvin)

Plus... some preliminary discussion of technology challenges issues.

3:00 PM BREAK (Drinks & Snacks)



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3:30 PM

SPS Systems & Technologies Breakout Sessions – Series A

This series of Sessions will involve discussions of key systems and technologies that are necessary to support the future deployment and operation of Solar Power Satellite concepts. The session discussions will include identifying strengths and weakness, technology requirement and readiness for each of the supporting systems areas when viewed in the setting of the several SSP scenarios being used to organize the IAA study.

18 Breakout Session A.1: Wireless Power Transmission

This Session will address SPS technology challenges and opportunities in the functional area of Wireless Power Transmission, including both RF (i.e., microwave) power transmission and laser power transmission; the scope of discussion will comprise both key figures of merit for this functional area as well as a discussion of the readiness and risks associated with various specific technology options.

CO-CHAIRS: N. Kaya / J. McSpadden

Catalytic Presentations including:

- Advances in RF Wireless Power Transmission (J. McSpadden)
- Technology Development and Demos for Retrodirective WPT (N. Kaya)
- Strategies for SPS Technology Demos and Applications (R. Dickinson)
- Concepts for Near-Term Point-to-Point Ground-based Wireless Power Transmission Demonstrations & Applications (K. Carroll)
- Space based Solar Power Using RF Technology: A Clean and Safe Energy Design (R. Simons)
- Radio Science and Wireless Power Transmission (M. Davis)

Plus... some preliminary discussion of technology challenges issues.

10 Breakout Session A.2: SPS Markets, SPS Ground Energy Systems and Economics

This Session will comprise discussions of the prospective markets for solar energy from space. The Session will also examine the potential economics of SPS in the context of alternative “green energy” solutions – particularly comparison of ground and space solar power. The Session will also examine potential non-SPS applications of space solar power technologies and systems.

CO-CHAIRS: A.C. Charania / P. Eckert

Catalytic Presentations including:



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- The Economics of Space Solar Power: Searching for Cost and Financial Viability (A.C. Charania)
- Commercial Space Solar Power: Principles and Precursors (P. Eckert)
- Base Load Power from Earth and Space (J. Strickland)
- Global Markets for Space Solar Power at the 10 MW Level and Above: Opportunities and Lessons from the SPS 2000 Project (P. Collins)
- Megawatt SEPS & Mars Exploration (H. Brandhorst)

Plus... some preliminary discussion of technology challenges issues.

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Breakout Session A.3: In-Space Resources & Manufacturing

This Session will address SPS Supporting Systems concepts in the topic area of In-Space Resources and Manufacturing, including both lunar resources and asteroid materials, as well as in-space materials processing and systems component fabrication; the scope of discussion will comprise both figures of merit for this type of SPS supporting systems as well as identification of key technologies.

CO-CHAIRS: R. Wegeng / A. Ignatiev

Catalytic Presentations including:

- Hypothesis: Lunar Resources can be used to Reduce the Cost of Space Solar Power (R. Wegeng)
- Opportunities to Employ Lunar Surface Materials in a Future Space Solar Power Economy (A. Ignatiev)
- Low Cost Lunar Launch Concepts – A Novel Option (J. Mankins)

Plus... some preliminary discussion of technology challenges issues.

5:30 PM END OF DAY 1

DAY 2 (THURSDAY, 10 SEPTEMBER 2009)

8:00 AM **Workshop Day 2 Opening – Plenary Session 2**

This session will provide an overview of the results of Day 1 of the workshop, including its objectives, agenda, and logistics. The session will conclude with a charge to workshop participants for Day 2.

CO-CHAIRS: J. Mankins; N. Kaya

Catalytic Presentations including:

- Breakout Session Reports (Chairs / Members)



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- Commercial Space Solar Power: Principles and Precursors (P. Eckert)
 - WPT Technology Demonstration Options at USEF (S. Mihara)
 - Charge to Workshop Participants (J. Mankins, N. Kaya)
- Plus...* some preliminary discussion of technology challenges issues.

9:30 AM BREAK (Coffee & Snacks)

10:00 AM **Finding the Path Forward for SPS: Challenges and Opportunities
Breakout Sessions – Series B**

This series of Sessions will focus on several of the most critical technology areas that are required to achieve economical solar energy from space for Earth, including Wireless Power Transmission, Power Generation and Management,

Breakout Session B.1: Space Transportation for SPS

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This Session will address SPS Supporting Systems concepts in the broad topic area of Space Transportation, including both low-cost Earth-to-Orbit Transport, as well as affordable In-Space Transport; the scope of discussion will comprise both figures of merit for this type of SPS supporting systems as well as identification of key technologies.

CO-CHAIRS: J. Howell / J. Penn

Catalytic Presentations including:

- Achieving Low Cost Launch: the Systems Challenges & Requirements (J. Penn)
- Achieving Low-Cost Access to Space: Results of NASA's Highly Reusable Space Transportation Study (J. Howell, J. Mankins)
- Reusable Launch Vehicle for Space-Based Solar Power (R. Nansen)
- Maglev Launch – An Ultra Low Cost Way to Deploy Space Solar Power Systems (J. Powell & G. Maise)
- Economical Launch Systems As A Prerequisite For SPS (J. Coopersmith)

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Plus... some preliminary discussion of technology challenges issues.

Breakout Session B.2: Advanced Space Systems: Platform Systems, In-Space Assembly, Maintenance & Servicing

This Session will address various advanced space systems and concepts in the broad topic area of Advanced In-Space Operations, including platform systems, in-space assembly, maintenance and servicing of SPS and related systems; the scope of discussion will comprise both figures



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of merit for this type of SPS supporting systems as well as identification of key technologies. The session will also address SPS technology challenges and opportunities in the functional areas of Solar Power Generation and related Power Management and Distribution (PMAD), including conventional solar arrays, concentrator solar power generation, thin-film power generation, and solar dynamic power generation.

CHAIR: D. Bienhoff / H. Brandhorst

Catalytic Presentations including:

- Future Directions for Large Thin-Film Space Systems (P. Spampinato)
- Low-Cost Concentrator PV Systems (H. Brandhorst)
- The Role of Cryogenic Propellant Depots and Supporting Space Infrastructure in Future Space-based Solar Power (D. Bienhoff)
- Innovative Orbits for SPS – non-Eclipsed Options (V. Werhle)

Plus... some preliminary discussion of technology challenges issues.

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Breakout Session B.3: SPS Policy and Regulatory Issues

This Session will examine various policy and regulatory issues involved in the development, deployment and operation of future Solar Power Satellites, including topics such as spectrum management and frequency allocation, international cooperation, and safety requirements.

CO-CHAIRS: P. Eckert / A.C. Charania

Catalytic Presentations including:

- Policy and Financial Considerations and Prospects for Space Solar Power (E.-J. Lark)
- Perspectives on International Cooperation and the Implementation of Space Solar Power (J. Verrill)
- Spectrum Management Challenges for SPS (K. Hashimoto)

Plus... some preliminary discussion of technology challenges issues.

12:30 PM LUNCH

1:30 PM **Crossing Cutting Topics and Integration: Plenary Session – 4**

This Session will involve discussions of various cross cutting topics that affect the potential future viability of Solar Power Satellites, as well as the integration of results for the IAA study. The session discussions will include technology assessments, markets, policy and regulatory matters and various non-SPS applications of space solar power systems



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and technologies. This Session will include discussions of technologies necessary to support the future deployment and operation of Solar Power Satellite concepts.

The session discussions will include integrating results from earlier sessions during the workshop, and will attempt to frame the technology requirements and readiness levels, and technology risks for each of various SPS and supporting systems areas.

CO-CHAIRS: J. Mankins / N. Kaya

Catalytic Presentations including:

- Reports from Day 2 Breakout Sessions (Chairs / Members)
- ISS –Experiment / Laser Wireless Power Transmission Experiment Option (F. Steinsiek)
- Concepts for Near-Term Point-to-Point Ground-based Wireless Power Transmission Demonstrations & Applications (K. Carroll)
- SSP/SPS Technology Pathways: R&D to Demonstrations (J. Mankins, N. Kaya)

Plus... some preliminary discussion of technology challenges issues.

- 3:00 PM BREAK (Drinks & Snacks)
- 3:30 PM **Workshop Closing Session – Plenary Session on Study Integration**
This discussion during this final session will comprise three topics: (1) systems analysis; (2) the path forward; and, (3) the workshop summary and closing discussion.
CO-CHAIRS: J. Mankins; N. Kaya
- 4:30 PM **END OF WORKSHOP**