

International Academy of Astronautics (IAA)  
Commission III: Space Systems and Technology Development  
**Global Space Solar Power Working Group**

**MEETING MINUTES<sup>1</sup>**

13 March 2012; 09:00 -13:00 hrs

ESA Headquarters / Paris, France

**AGENDA**

1. Welcome
2. Introductions
3. Objectives of the Meeting
4. Background: 2010-2011 IAA Study Results
5. Status of SSP Activities (from Meeting Participants)
6. Review and Discussion of Global Space Solar Power Working Group Terms of Reference
7. Future SSP Working Group Participation
8. Plan Forward for the SSP Working Group
9. All Other Business?
10. Conclusion

**MINUTES**

**1. Introduction**

Commission III (Space Systems and Technology Development) of the International Academy of Astronautics (IAA) has sponsored creation of a Global Space Solar Power (SSP) Working Group (Global SSP-WG). This is a follow-on to several recent IAA activities, including recommendations emerging from the Academy-organized Heads of Space Agencies Summit (November 2010), and two Academy reports – Climate Change and Green Systems (published in 2010 as part of the Academy’s 50th Anniversary Celebration), and Space Solar Power: the First International Assessment of SSP Opportunities, Issues and Potential Pathways Forward (published in Fall 2011).

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<sup>1</sup> Note: these minutes prepared by Mr. John C. Mankins, Global SSP WG Executive Secretary.

The vision of the Global SSP-WG is that the group will play a number of key roles, analogous to those performed by various international science organizations – e.g., the International Lunar Exploration Working Group (ILEWG), or the more recent International Space Exploration Coordination Group (ISECG). As such, participation in this new working group will be a voluntary undertaking for interested organizations and individuals. An initial meeting of the Working Group was held in Paris, France at ESA Headquarters, on Monday 13 March 2012.

## 2. Meeting Attendees

The following individuals attended the first meeting of the Global SSP WG:

NAME (Country)	ORGANIZATION(S) Represented	EMAIL ADDRESS
Alain Dupas (France)	ADIC	<a href="mailto:adupas@club-internet.fr">adupas@club-internet.fr</a>
Feng Hsu, Ph.D. (USA)	Space Energy Group	<a href="mailto:Fenghsu.1@gmail.com">Fenghsu.1@gmail.com</a>
Mark Hopkins (USA)	National Space Society	<a href="mailto:Loby4space@aol.com">Loby4space@aol.com</a>
Prof. Nobuyuki Kaya (Japan)	Kobe University	<a href="mailto:kaya@kobe-u.ac.jp">kaya@kobe-u.ac.jp</a>
Valery Korespanov (Ukraine)	Lviv Center for Space Research, Ukraine	<a href="mailto:vakor@isr.lviv.ua">vakor@isr.lviv.ua</a>
John C. Mankins (USA)	IAA; Artemis Innovation Management Solutions LLC	<a href="mailto:john.c.mankins@artemisinnovation.com">john.c.mankins@artemisinnovation.com</a>
Horst Rauck (Germany)	DLR (retired)	<a href="mailto:Horst.rauck@gmx.de">Horst.rauck@gmx.de</a>
Pierre Parrot (France)	EADS Astrium	<a href="mailto:pierreparrot@astrium.eads.net">pierreparrot@astrium.eads.net</a>
Matthew Perren (France)	EADS Astrium	<a href="mailto:Matthew.perrent@astrium.eads.net">Matthew.perrent@astrium.eads.net</a>
Giuseppe Reibaldi (Italy)	IAA; European Space Agency / ESA Hq	<a href="mailto:Giuseppe.Reibaldi@esa.int">Giuseppe.Reibaldi@esa.int</a>
Prof. Susumu Sasaki (Japan)	ISAS / JAXA	<a href="mailto:sasaki@isas.jaxa.jp">sasaki@isas.jaxa.jp</a>
Leopold Summerer (Austria)	European Space Agency / Advanced Concepts Team	<a href="mailto:Leopold.summerer@esa.int">Leopold.summerer@esa.int</a>
Massimiliano Vasile, Ph.D. (Italy / UK)	Strathclyde University	<a href="mailto:Massimiliano.vasile@strath.ac.uk">Massimiliano.vasile@strath.ac.uk</a>

Figures 1 and 2 on the page following present photographs of the working group meeting participants.

Figure 1 IAA Global SSP Working Group Participants



Figure 2 IAA Global SSP Working Group Participants (continued)



### **3. Meeting Notes**

#### **3.1 Welcome and Introductions**

Welcoming remarks were made to the participants on behalf of the IAA by Mr. John C. Mankins, and by Mr. Leopold Summerer on behalf of ESA, at the headquarters of which the meeting was held. (Mr. Giuseppe Reibaldi, Chair of the Working Group was detailed by another Academy meeting and joined the Working Group meeting in progress.)

The meeting opened with a series of brief introductory remarks by the several participants.

#### **3.2 Objectives of the Meeting / Introduction to the Working Group**

Mr. Mankins reviewed the objectives of the meeting, as explained in the invitation email received by the participants, and provided a brief introduction to the WG. The objectives of the meeting included:

- Introduce the Global SSP WG
- Review Status of Global Activities related to SSP
- Review the Terms of Reference for the Working Group
  - Objectives
  - Operations
  - Organization
  - Participation
- Discuss the “Work Plan” Forward for the WG Going Forward
  - Identify Initial Opportunities for Cooperation / Collaboration
  - Next Meeting
  - IAC 2013

Note: the Terms of Reference (TOR) for the Working Group, referred to above, are provided in Appendix A of these minutes.

#### **3.3 Background: IAA SSP Study Group Results**

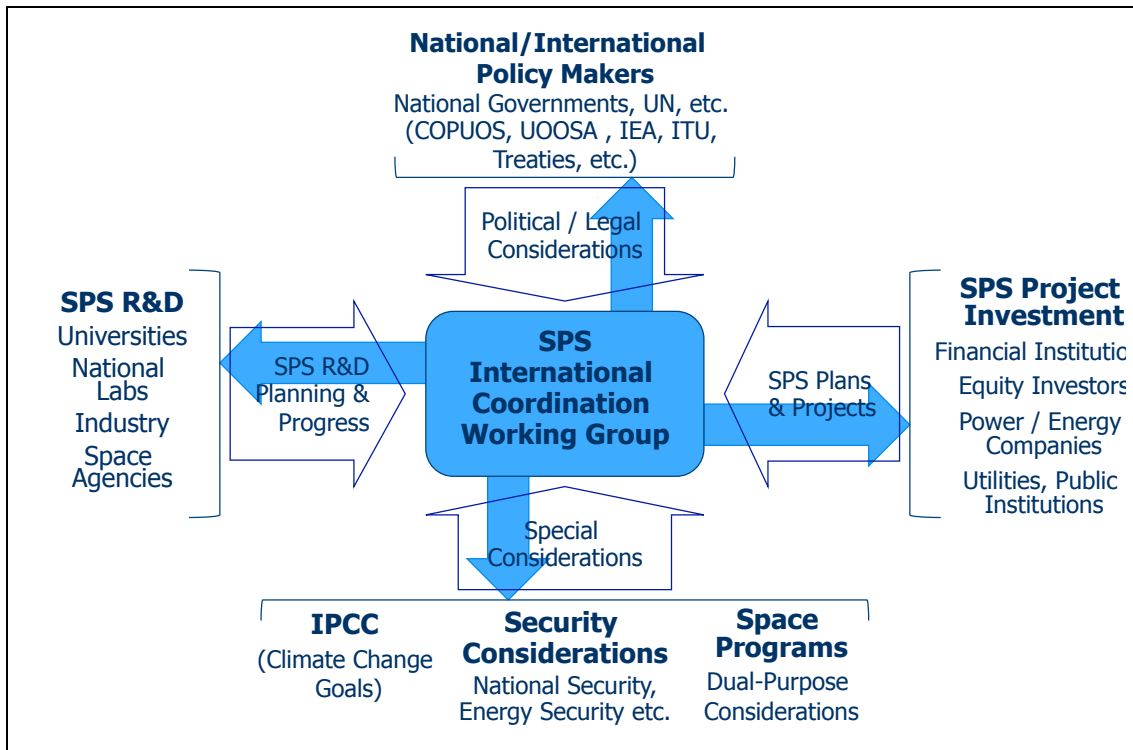
Mr. Mankins presented a series of charts that summarized the IAA context for the creation of the working group, the recently completed IAA study group on Space Solar Power, conducted during 2008-2011. A key element of this SSP study was the identification of the need to advance international cooperation related to space power, and the potential role that the IAA couple play in fostering such cooperation.

Mr. Mankins presented the group with a diagram for such cooperation (modified from a version originally developed by Ms. Janet Verrill (member and

Treasurer of the Sunsat Energy Council, an US NGO focused on promoting SPS).<sup>2</sup>  
See Figure 3 below.

It was noted that the formation of the Global SSP WG by IAA Commission 3 is an implementation of the related recommendation of this idea by the IAA SSP study group's final report.

Figure 3  
Diagram of the Potential Role of a Working Group in Promoting International Cooperation on Space Solar Power



### 3.4 Status of SSP Activities (from Meeting Participants)

*Mr. Mark Hopkins (USA).* Mr. Hopkins summarized the objectives of the National Space Society (NSS), a Non-Governmental Organization (NGO) based in the US, which has an international membership and plans increased international activities in the future. He commented that the past leadership of the NSS has included various individuals of note, including Lori Garver (past NSS Executive Director, and current NASA Deputy Administrator), George Whitesides (past NSS Executive Director and current CEO and President of Virgin Galactic), and Dr. Scott Pace (a space advisor to 2012 US Presidential candidate Mitt Romney).

Mr. Hopkins also described the long-standing interest of the NSS in space solar power (SSP). In that light, he mentioned that the annual NSS Conference, the

<sup>2</sup> Ms. Verrill was invited to the Global SSP WG meeting but was unable to attend; she indicated that she wishes, however, to be a member of the new Working Group.

International Space Development Conference (ISDC) has included a track on SSP for the past several years. In addition, the NSS has helped to organize several media events related to SSP during recent years, including (in cooperation with SPACE Canada, a Canadian-based NGO<sup>3</sup>) a Press Conference in November 2011 to announce the publication of the IAA's study report on SSP, "*Space Solar Power: the First International Assessment*", edited by J. C. Mankins.

Hopkins also mentioned NSS support for US SPS studies in the 1970s and the 1990s. He also mentioned potential future NSS activities, including interest in a possible future SSP initiative that has been jointly planned between the NSS and former President of India, Dr. A. Kalam, and plans for a meeting at the upcoming May 2012 ISDC in Washington, D.C.

*Prof. Nobuyuki Kaya (JAPAN).* Prof. Kaya noted that he had been working in the field of SSP and wireless power transmission (WPT) for more than 30 years. He briefed the meeting on various significant technical activities in Japan concerning SSP and WPT using both video recordings and a presentation. These included (1) tests in the state of Hawaii in the US between the islands of Maui and Hawaii (first in 2008 with sponsorship from the Discovery Channel, and then in 2010); (2) a 2009 demonstration in Toronto, Canada at an international symposium (SPS 2009), sponsored by SPACE Canada (an NGO supporting international dialog on SSP) and the IAA Commission III SSP study group.

He mentioned highlights of his recent work, involving research on radio propagation at a frequency of 2.45 GHz and the Japanese Engineering Test Satellite ETS-VIII to evaluate possible effects on WPT by the ionosphere.

*Leopold Summerer (AUSTRIA).* Mr. Summerer recounted that the European Space Agency's Advanced Concepts Team (ACT) had been conducting various SSP related activities for the past 10 years, beginning in 2002-2003 with a series of four focused comparisons of space solar power and ground solar power. Those studies culminated in an international conference (SPS 2004), held in Granada, Spain. The principal finding of those studies was that while SSP was promising, it not yet sufficiently mature.

Mr. Summerer also described SSP-related research that the ACT supported in cooperation with Japan (Kobe University, Prof. Kaya, and University of Tokyo, Prof. Nakasuka) to implement an ambitious sounding rocket experiment in 2006. This experiment included a small crawling robot from the Vienna University of Technology.

He described several more recent activities. These included additional research on mesh structural systems deployment using centripetal acceleration, and a 2012 call for ideas that had just closed at the date of this meeting. Mr. Summerer noted that the results from that call were in the process of evaluation. In addition,

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<sup>3</sup> Mr. George Dietrich, President of SPACE Canada was invited to the Global SSP WG meeting but was unable to attend; he has indicated that he wishes, however, to be identified as a member of the new Working Group.

ACT has a current post-doc on the staff who is addressing space solar power. He observed that there has been some discussion of trying to develop a new SPS reference concept for Europe, but no specific actions as yet.

*Alain Dupas (FRANCE).* M. Dupas, an independent consultant, noted that he has provided assessments of space solar power several European companies. He also participated in the peer review process for the IAA SSP study group report.

He observed that there is still no significant interest in SSP among energy companies in Europe, and that the key issue remains launch to orbit. However, he also stated that the major energy companies will be investing during the next 30 years many times more resources that are spent on space activities.

M. Dupas state that it is hope to win the support in the future of at least one energy company to investigate space solar power.

*Prof. Susumu Sasaki (JAPAN).* Prof. Sasaki described a range of SSP related research and development activities in Japan. He noted that there are two basis approaches to SSP in Japan: top-down (from government-led programs) and bottom-up (from the research community). He presented a number of charts (in Japanese) that were shown at a small satellite symposium in Japan earlier in the month.

He mentioned that there are two microwave solar power satellite (SPS) concepts under consideration in Japan: the basic model (without reflectors), and the advanced model (with reflectors to provide constant power during the orbit of the satellite around Earth). Sasaki described Japanese efforts to complete a major ground demonstration of WPT. This \$10 million project should be completed in 2-3 years (c. 2014), and will involve the transmission of about 2 kilowatts over a distance of about 50 meters with beam control of  $\pm 2$  degrees. The Mitsubishi Electric Company (MELCO) is the prime contractor for the project.

Prof. Sasaki explained also that JAXA hopes to being in 2012 an SSP orbiter flight experiment pre-project that would result in a flight in approximately four years. The cost for the WPT instrument on this orbit experiment is anticipated to be about \$10 million, and the total cost of the project is estimated to be about \$30 million. The objectives of this technology flight experiment (TFE) would be to demonstrate WPT beam control and to evaluate ionosphere beam interactions.

He also described one possible programmatic approach to the TFE project. There is an ongoing small-sat program in JAXA for which three individual projects are being pursued. One of these is going forward successfully, while the second has had some difficulties. However, a call for proposals has been issued for the third small-sat project; the SSP/WPT orbiter TFE project could be selected for this mission. He mentioned that there are multiple teams competing for the mission, including a lunar lander concept and a solar electric propulsion concept. Despite the competition, there is considerable interest in SSP among various engineering groups in Japan.

Prof. Sasaki noted that there will be a change in leadership of JAXA's SSP program in the near future. He is retiring at the end of March 2012. However, there

is a young researcher at ISAS who may become the SSP lead this coming year; if this occurs, he will probably attend the IAC 2012 in Naples, Italy.

*Mr. Horst Rauck (GERMANY).* Mr. Rauck is the former chair of IAA Commission III. Although he knows of no current activities in Germany concerning SSP, he indicated to the group that he would try to communicate the existence of the WG and build some interest there.

He recommended that the working group should also consider the possible impact and interaction of new energy options on society. For example, the planned shut-down of all nuclear power in Germany by 2050 represents an opportunity for new energy options, such as SSP.

*Dr. Massimiliano Vasile (Scotland, UK).* Dr. Vasile observed that there are a variety of activities at the University of Strathclyde related to energy. His organization, the Space Studies Laboratory is pursuing various activities related to SSP, including how space solar power might contribute to global energy. (These studies include a near-term comparison of wind with other options.)

Strathclyde is conducting specific research into the topic of space structures (including mesh deployment options via a sounding rocket experiment sponsored by the ESA ACT). Other topics include fractionated spacecraft.

*Pierre Parrot (FRANCE).* Mr. Parrot explained that EADS Astrium has been examining SSP from a strategic standpoint for a number of years. He expressed the view that SSP should not be compared with existing / conventional technologies, but should be compared with other new energy options – in particular, deep geothermal and fusion. He stated that his studies have mostly involved comparisons of SSP with fusion energy.

Mr. Parrot noted that there are thousands of researchers who believe fusion can be made to work, however there are only a few hundred researchers who are working on SSP worldwide. It is hard to sell SSP to big energy at this time for commercial power. He mentioned niche applications (in the range of 10-20 kilowatts at 200-300 million Euros) as another possibility, but does not believe these are available at this time.

He identified space applications as a third option that could be more promising in the nearer term. Space industry has done well in selling information, a product that has no mass. After information, then energy, which still has no mass, could be a successful product. Where might energy in space be used? Opportunities could include: space-to-space power transmission, space-to-aircraft power transmission, and later space-to-ground transmission.

It was observed during the discussion that research into fusion energy also benefits from the strong historical connection with the military-industrial-academic community. This provides a large and clear organizational structure that is capable of spending a lot on fusion R&D. However, it was noted in the conversation that fusion technology is still very immature and is years, if not decades away from break-even. It was unclear to the group whether the comparison of SSP with fusion was useful or not. However, there was general agreement on the value of space applications of SSP



– for example in the development of solar electric propulsion (SPE) in furthering the development of this technology.

*Matthew Perren* (FRANCE). Mr. Perren (also of EADS Astrium) drew some general conclusions from the comments made by Mr. Parrot. He noted that there is no large scale investor at this time for SSP. As a result, in its planning Astrium chose to focus on a demonstration of the key functions of space solar power – both ground based and space-to-ground transmission using an existing technology laser components with power up to a few kilowatts. This concept requires an emphasis on R&D to achieve more efficient lasers and higher efficiency in-space solar energy conversion.

*Feng Hsu, Ph.D. (USA)*. Dr. Hsu explained that after a career with NASA, in 2009 he left the agency and joined an SSP start-up company, The Space Energy Group. His interest in space solar power stems from his past work with the Advanced Technology Working Group (ATWG), and the 1990s NASA Fresh Look Study.

Dr. Hsu described his participation in a 2007-2008 project to define a microwave ISS-based SSP experiment that would have demonstrated space-to-ground WPT technologies. This effort involved NASA Johnson Space Center (JSC), NASA Goddard Space Flight Center (GSFC) and the NASA Glenn Research Center (GRC). However, the project was never funded; the experiment definition effort was terminated by Dr. Mike Griffin, then NASA Administrator before his departure from the space agency.

Also, as a member of the NSS, Dr. Hsu supported the NSS-Kalam SSP initiative (mentioned earlier in the meeting by Mr. Hopkins). He stated that there was some success in framing a potential US-India SSP study project, but noted that it has not yet succeeded in making the connection between the two countries. The Space Energy Group has organized two “summit meetings” on energy/SSP in China during the past three years, including a meeting in Chengdu in 2010 and one near Beijing in 2011. There has been a considerable increased in activity related to space solar power in China during recent years.

He also mentioned the “Solar High” SSP study group, of which he is a member. This group comprises mostly retired individual subject matter experts (SMEs) with experience in the 1975-1980 studies of solar power satellites. The Solar High study should be published by summer 2012. Dr. Hsu show several charts from the Solar High study, including one addressing Earth-to-orbit (ETO) costs and another concerning ETO cost drivers.

He noted that this group has spent a lot of time discussing ETO for SSP, and that it is the group’s view that low cost ETO transportation is achievable – at less than \$400 per kilogram is achievable in the nearer term (before 2030), and at less than \$150 per kilogram in the farther term (after 2030). He also indicated that the group advocates the need for radical advances in technology for SSP, including thin film PV, high temperature superconductors, light space structures, and others.

*Mr. John C. Mankins (USA)*. Mr. Mankins reviewed for the group a currently ongoing US project sponsored by the NASA Innovative Advanced Concepts (NIAC)

program, entitled “SPS-ALPHA’ (SPS by means of Arbitrarily Large Phased Array). He is the principal investigator for the NIAC Phase 1 project for which Prof. Kaya and Dr. Vasile are co-investigators. Mr. Mankins described the details of the current study project and noted the call for Phase 2 project proposals would be released by NASA in the coming several weeks. He invited various participants in the WG meeting to consider discussing possible participation in this next proposal.

*Mr. Giuseppe Reibaldi (ITALY).* Mr. Reibaldi apologized for his unavoidable late arrival at the meeting and offered both some introductory remarks on the overall meeting, as well as his personal views of space solar power. He noted that the technical community outside of SSP circles are not yet convinced that space solar power can be competitive with power systems on the ground. In fact, he observed, there can be a predisposition against SSP within such circles.

He also suggested that among other goals the SSP WG should try to find a more compelling rationale for space solar power – one that could convince technical people that SSP can be competitive. In his remarks, Mr. Reibaldi mentioned the idea of focusing discussion within the working group on a particular topic of interest each year. In particular, he mentioned that during the coming year there will be an intense effort to prepare for the next IAA Heads of Space Agencies summit meeting (to be held in November 2013). A key question, Reibaldi observed, is how to convince the technical community within the space agencies.

### 3.5 Review and Discussion of Global Space Solar Power Working Group Terms of Reference (TOR)

The meeting reviewed and discussed the terms of reference (TOR) for the Global SSP Working Group. (The Global SSP WG TOR is provided in Appendix A of these minutes.)

Goal and Objectives. The goal of the working group is to facilitate and accelerate the development of key SSP technologies, the application of those technologies in future space systems, and the eventual implementation of solar power satellites (SPS). In accomplishing that goal, the objectives of the WG are to:

- Establish an ongoing forum for technical communication and coordination among subject matter experts with an interest in SSP and related topics;
- Facilitate discussions among various interested individuals and organizations related to SSP and related program/project activities, including potential cooperative efforts;
- Facilitate and organize consideration of key policy issues related to SSP (e.g., spectrum allocation for WPT);
- Define pilot projects aiming to advance the development of SSP Foster the involvement of non space organizations interested in energy matters;
- Set-up a global roadmap to federate already existing initiatives for the development of SSP and define future milestones;
- Foster Outreach activities aiming to inform the public and policy makers of potential of SSP as a Green energy system; and,

- Create of a dedicated web page to exchange information. Produce an yearly report of the WG activities.

Technical Topic Areas. A series of technical topic areas for the working group were identified in the TOR; these included both technology R&D areas of interest, and prospective system/mission application areas of interest; both of these are listed below:

- Technology R&D Areas of Interest
  - Solar Power Generation
  - Wireless Power Transmission
  - Power Management and Distribution
  - Thermal Management Systems
  - Structures and Materials
  - Space Robotics and Construction, and others
- Systems / Mission Application Areas of Interest
  - Role of Human Space Flight in Supporting SSP R&D and Demonstrations
  - Solar Power Satellites (SPS); i.e., space solar power for terrestrial markets
  - Future Mission Applications of Space Solar Power technologies and systems, including human missions and robotic missions
  - Commercial Space Applications of Space Solar Power technologies and systems
  - Space Launch and In-Space Transportation Systems Aspects related to SSP, and others.

Operations. In general, it was stated that the Global SSP WG will operate by means of (1) regularly scheduled face- to-face meetings; (2) periodic teleconferences; (3) email communications; and, (4) occasional conferences or workshops. This will include the following means of communications:

- *Meetings.* Two working meetings per year are anticipated, organized to coincide with IAA meetings at the annual International Astronautical Congress (IAC) and before the annual IAC preparatory meeting of the International Program Committee (IPC); the former occurring in the fall and the latter in the spring of each year.
- *Teleconferences.* The working group will organize, as appropriate teleconferences among the members of the group. Typically these will be scheduled in advance of face-to-face meetings to facilitate planning for these events, but may also be scheduled for discussions of focused topics as needed.
- *Email Communications.* The general mode of communications among working group members will be by means of email communications.
- *Conferences and/or Workshops.* Activities may involve organizing or participating in various international meetings (e.g., the International

Astronautical Federation (IAF) annual Space Power Symposium. In addition, the Global SSP-WG will promote and facilitate the formation of effective international public-private partnerships to advance space solar power.

Discussion. There were a number of comments as well as discussion from the meeting participants concerning the initial TOR. Highlights included the following:

- The WG should attempt to formulate and advance market entry strategies for SSP (Parrot).
- The WG should pursue, where practical, some approach to federation of global resources focused on SSP so that progress may be achieved more rapidly than by single countries working in isolation (Hsu).
- The WG should examine potential impacts of SSP and/or other energy choices on society. (Summerer / Rauck)

It was also noted that the SSP WG should leverage, not compete, with the resources available through the International Astronautical Federation (IAF). This should include emphasizing the “added value” of the engagement of the IAA in the global discussion of SSP. In this the role of the Academy is to look beyond current major programs and problems to the longer-term future of global astronautics.

In pursuing this, it was noted that to be fully successful the IAA SSP WG can – and must – draw people from outside the current SSP community of interest.

The idea of forming sub-groups within the WG was raised, but there was a strong feeling that it is pre-mature to take such a step.

Actions from this discussion are summarized below.

### 3.6 Future SSP Working Group Participation and Organization

As a portion of the discussion of the WG TOR, the group examined planning for the organization and participants in the Global SSP WG was discussed. It was noted that the General Secretary of the IAA has “blessed” the working group. The types of individuals who are potential members of the group include:

- Interested members of the International Academy of Astronautics
- Space Solar Power subject matter experts (SMEs)
- Representatives from interested organizations (including international space agencies, commercial firms, academic institutions, and non-governmental organizations)
- Individuals from appropriate and interested non-space organizations

Mr. Giuseppe Reibaldi will be the first chair of the WG. Mr. John C. Mankins will be the Executive Secretary of the Group. The organization of the WG calls for a vice-chair, as well as a chair. Prof. Nobuyuki Kaya was nominated and elected to serve as the vice-Chair of the Global SSP Working Group. The current plan is that the leadership of the WG will rotate among members, with changes occurring once

every two years (on the off-years when changes in IAA Commission membership are not made).

### 3.7 All Other Business

Spectrum for WPT Research. An additional topic that was discussed during the meeting of the WG was that of spectrum allocation for SSP / wireless power transmission (WPT) research and development. It was noted that the existing question before the International Telecommunications Union (ITU) concerning WPT (originated by NASA) may be removed from consideration during the coming months and that this is a matter of urgent concern for the international SSP community. All members of the Global SSP WG were asked to raise this issue with relevant members of the ITU Working Party 1A and urge that the current question should continue.

## 4. ACTIONS / Plan Forward for the Global SSP Working Group

The discussion during the first meeting closed with a quick review of the plan forward for the working group. This included:

- Action to participants to provide comments on Draft TOR, etc.
- Action to attendees to assist in identifying potential Additional Participations
- Planning for the Next WG Meeting: IAC 2012 in Naples, Italy
- Action to further the Definition of the WG Identity
  - e.g., creation of a website
- Planning for IAC 2013
  - Goal of cooperation with IAF Power Committee Symposium (C3.1)
  - Idea of a new session that is dedicated to the SSP WG activities (D4.2)
  - But, must assure clear distinctions and no duplication of content
- Action to Identify Initial Opportunities for Cooperation / Collaboration
- Future Space Solar Power-Related Conference Planning (e.g., “SPS 20XX”)
- Action to WG members to address the immediate Issue concerning the ITU and Spectrum allocation for WPT R&D and support continuation of the existing ITU Working Party 1A Question

## Appendix A

### Global SSP Working Group Terms of Reference

The following are the Terms of Reference (TOR) for the Global SSP Working Group. These were reviewed and approved by the participants in the 13 March 2012 first meeting of the group.

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Global Space Solar Power Working Group

#### TERMS OF REFERENCE

Version 3.0 / 23 February 2012

#### 1.0 Introduction

Commission III (Space Systems and Technology Development) of the International Academy of Astronautics (IAA) is sponsoring creation of a Global Space Solar Power (SSP) Working Group (Global SSP-WG). This is a follow-on to several recent IAA activities, including recommendations emerging from the Academy-organized Heads of Space Agencies Summit (November 2010), and two Academy reports – *Climate Change and Green Systems* (published in 2010 as part of the Academy's 50<sup>th</sup> Anniversary Celebration), and *Space Solar Power: the First International Assessment of SSP Opportunities, Issues and Potential Pathways Forward* (published in Fall 2011).

The vision of IAA Commission III is that the Global SSP-WG will play a number of key roles, analogous to those performed by various international science organizations – e.g., the International Lunar Exploration Working Group (ILEWG), or the more recent International Space Exploration Coordination Group (ISECG). Participation in this new working group would be a voluntary undertaking for interested organizations and individuals.

#### 2.0 Goals and Objectives

##### 2.1 Goals

The principal goal of the Global SSP-WG will be to facilitate and accelerate the development of key SSP technologies, the application of those technologies in future space systems, and the eventual implementation of solar power satellites (SPS).

##### 2.2 Specific Objectives

The following are selected specific objectives of the Global SSP-WG:

- Establish an ongoing forum for technical communication and coordination among subject matter experts with an interest in SSP and related topics.
- Facilitate discussions among various interested individuals and organizations related to SSP and related program/project activities, including potential cooperative efforts.
- Facilitate and organize consideration of key policy issues related to SSP (e.g., spectrum allocation for WPT).
- Define pilot projects aiming to advance the development of SSP

- Foster the involvement of non space organizations interested in energy matters
- Set-up a global roadmap to federate already existing initiatives for the development of SSP and define future milestones
- Foster Outreach activities aiming to inform the public and policy makers of potential of SSP as a Green energy system.
- Create of a dedicated web page to exchange information.
- Produce an yearly report of the WG activities

### 2.3 Technical Topic Areas

The following are the technical topic areas that will be within the scope of the Global SSP WG; they comprise two general types of topics: technology R&D-oriented topics, and systems / mission applications-oriented topics.

- Technology R&D Areas of Interest
  - Solar Power Generation
  - Wireless Power Transmission
  - Power Management and Distribution
  - Thermal Management Systems
  - Structures and Materials
  - Space Robotics and Construction
  - Etc.
- Systems / Mission Application Areas of Interest
  - Role of Human Space Flight in Supporting SSP R&D and Demonstrations
  - Solar Power Satellites (SPS); i.e., space solar power for terrestrial markets
  - Future Mission Applications of Space Solar Power technologies and systems, including human missions and robotic missions
  - Commercial Space Applications of Space Solar Power technologies and systems
  - Space Launch and In-Space Transportation Systems Aspects related to SSP
  - Etc.

### 3.0 Operations

The Global SSP-WG will operate by means of (1) regularly scheduled face-to-face meetings; (2) periodic teleconferences; (3) email communications; and, (4) occasional conferences or workshops.

*Meetings.* Two working meetings per year are anticipated, organized to coincide with IAA meetings at the annual International Astronautical Congress (IAC) and before the annual IAC preparatory meeting of the International Program Committee (IPC); the former occurring in the fall and the latter in the spring of each year.

*Teleconferences.* The working group will organize, as appropriate teleconferences among the members of the group. Typically these will be scheduled in advance of face-to-face meetings to facilitate planning for these events, but may also be scheduled for discussions of focused topics as needed.

*Email Communications.* The general mode of communications among working group members will be by means of email communications.

*Conferences and/or Workshops.* Activities may involve organizing or participating in various international meetings (e.g., the International Astronautical Federation (IAF) annual Space Power Symposium. In addition, the Global SSP-WG will promote and facilitate the formation of effective international public-private partnerships to advance space solar power.

#### **4.0 Organization**

The Global SSP Working Group will be organized as follows:

- Chair
- Co-Chair
- Executive Secretary
- General Membership

The leadership and membership of the working group will change over time. The initial leadership of the working group will comprise Giuseppe Reibaldi as Chair, and John C. Mankins as Executive Secretary. Details of processes and timing for future development of the leadership and membership will be provided in an updated version of this document.

#### **5.0 Participants**

Participants in the Global SSP-WG are anticipated to include

- (1) Interested members of the International Academy of Astronautics;
- (2) Space Solar Power subject matter experts (SMEs);
- (3) Representatives from interested organizations (including international space agencies, commercial firms, academic institutions, and non-governmental organizations); and,
- (4) Individuals from appropriate and interested non-space organizations.

#### **4.0 Glossary and Acronyms**

##### **4.1 Glossary of Terms**

For purposes of the working group communications, the following working definitions of important terms are assumed:

*Space Solar Power.* The term “space solar power” encompasses both systems and technologies related to the harvesting, distribution and use of solar power in space, including those related to the delivery of such power to remote locations via wireless power transmission.

*Space-based Solar Power.* The term “space-based solar power” refers to systems and technologies related to the collection of solar power in space and the delivery of such power to the Earth via wireless power transmission.

*Solar Power Satellite.* The term “solar power satellite” refers to a space systems concept the purpose of which is to collect solar power in space and deliver it to Earth.

*Wireless Power Transmission.* The term “wireless power transmission” refers to the use of electromagnetic energy (including microwaves, millimeter waves, visible and near visible light, etc.) to transfer energy from one location to another without the use of wires, fiber optics or other physical connections.



#### 4.2 Selected Acronyms

The following are selected acronyms commonly used in discussing the topic of space solar power.

<b>ETO</b>	Earth to Orbit (transportation)
<b>GEO</b>	Geostationary Earth Orbit
<b>IAA</b>	International Academy of Astronautics
<b>IAC</b>	International Astronautical Congress
<b>IAF</b>	International Astronautical Federation
<b>IPC</b>	International Program Committee
<b>LEO</b>	Low Earth Orbit
<b>NGO</b>	Non-Governmental Organization
<b>SME</b>	Subject Matter Expert
<b>SSP</b>	Space Solar Power
<b>WG</b>	Working Group
<b>WPT</b>	Wireless Power Transmission