

Proposal for Forming an IAA Study Group - SG 3.24

Title of Study:

Road to Space Elevator Era

Proposer(s):

Mr. Akira Tsuchida (CM 2)

Primary IAA Commission Preference:

Commission 3 Space Technology & Systems Development

Secondary IAA Commission Interests:

Commission 4 Space Systems Operations & Utilization

Commission 6 Space and Society: Culture and Education

Members of Study Team

Chair(s): Mr. Akira Tsuchida (CM 2),

Co-chairs: Peter Swan, Ph.D. (M 4), & David Raitt, Ph.D. (M 4),

(Must be member(s) of the Academy, M or CM)

Secretary: Ms. Sakurako Takahashi

Other Members:

(Open to members and non- members of the Academy)

Brij N. Agrawai, Ph.D. (CM 2), Setsuko Aoki (CM 4), Vladimir Aslanov, Ph.D., Yoshio Aoki, Ph.D., Yevgeny Baranov, Stephen Cohen, Hironori Fujii, Ph.D., Yoji Ishikawa, Ph.D., Sunao Kai, Ph.D., John Knapman, Ph.D., Olexandr Kushnar`ov, Shen Lin, Arun Misra, Ph.D. (M 2), Shuichi Ohno, Gennadiy Osinovyv, Robert "Skip" Penny, Minoru Sato, Cathy Swan, Ph.D. (M 4), and Yoshiki Yamagiwa, Ph.D.

The members of this Commission III Study Group are the representatives of a vast array of space expertise and will act as liaison with other international organizations having similar goals. The Study Group is also open to all persons interested in using this platform to exchange ideas and experiences according to the scope of the Study. The IAA Study Group on Space Elevators is a stand-alone cross-Commission committee which will report to the respective IAA Commission III dealing with far future activities.

As one can see, the study group proposed makeup is very international. The largest number of members is from Japan [10], with Canada [2], China [1], Finland [1], Russia [1], UK [2], Ukraine [3], and US [3].

Short Description of Scope of Study

Overall Goal:

(Expected scientific or practical benefit of the study group's efforts)

Summary

This SG is the follow-up of the SG3.13 "Assessment of the Technological Feasibility and Challenges of the Space Elevator Concept" with the same baseline design assumptions.

Development of a unique space transportation system of the future, called a space elevator, should be accomplished with more international cooperation and should contribute to the overall development of space science and systems development. To accomplish these desires, projects are identified that can be accomplished in the near future leading to risk reduction and engineering enhancements. Specifically, the following practical on-orbit verification projects could be planned and promoted through this study group's activity.

- (1) Promotion of ISS (International Space Station) utilization and leveraging of Small Satellite (Cube, Micro, etc.) concepts to accomplish on-orbit verification; such as, advanced material research (ex. material exposure experiment) and development while extending tether technology development.
- (2) Promotion of space technology spin-out into industrial application (and vice versa) by the collaboration with civil engineering, architectural engineering, and space engineering experts.
- (3) Plan and execute precursor missions, leveraging existing technology, to demonstrate prototype space elevator segments. (ex. Marine Node for sub-orbital rocket launch; tether satellites for dynamics of deployment; movement around Earth-space with low thrust, high efficiency rocket motors demonstrating start-up activities.)

Overview

It is the intention of the IAA Study Group on the Road to Space Elevator Era to support any activities in connection with the topic; and, to bring within the reach of every country the opportunity to understand the potential, design approach, and benefits/issues with a developmental program. In this context, the Study Group supports all activities to develop and promote concepts and processes by all user communities to conduct or participate in space elevator research and development. For instance, the design of materials to ensure space elevator infrastructures mature must be refined from global efforts dealing with carbon nano-tube potential. Novel types of delivery to GEO and beyond with routine, daily, \$500/kg, and soft rides will be proposed ensuring that future commercial visions can be accomplished. The exploitation of space elevators to initiate space based solar power is an initial focus that will demonstrate the possibilities available to humanity. The deployment of a space elevator transportation infrastructure will change the space arena and significantly improve the human condition through expansion into space. The Study Group should be an observatory of the required technology evolutions and their readiness for incorporation into the Space Elevator. The twice a year status will include a Prediction Feasibility Index based upon the required critical technologies progress during the year. The status will be published twice each year, at a fixed point in time, and made available using the web page created by the Study Group.

A special emphasis will be placed upon the tie with student activities and engineering competitions. Just this year [2014], there were space elevator "races" in Israel, Japan, and the United States. The ability to tie space elevator climber development to the engineering interests of young students and professionals is a special characteristic of this fascinating transportation infrastructure development.

Topics of Interest

The IAA Study Group on Space Elevators is in the lead to coordinate all activities related to Space Elevators within the Academy. The Committee is based upon the experiences gained from the IAA Study Group 3-13, Space Elevator Feasibility. It would cover the complete span of related topics including but not limited to:

- System of systems architectural approach

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Instructions and application form: see: "Scientific Activity" section at <http://iaaweb.org/content/view/256/393/>

- Carbon nano-tube material development for longitudinal strength,
- tether dynamics modeling,
- Risk assessment during development and in space
- Marine Node development [including High Stage One Option],
- GEO Node definition,
- Apex Anchor design,
- Tether climber design
- Developmental approach
- Legal regime layout [Land, Air, Sea and Space],
- International policy [including national vs. international, commercial vs. government, space treaties vs government policies, regional approaches, and national approaches], - research and development needs in the near future, and
- Potential customer needs and business opportunities.

General Tasks

- 1) Consolidate the successful publication of Study 3-13, "Space Elevator: Technological Feasibility and the Way Forward."
- 2) Transition from this Commission III study group to a new Commission III study group on Road to Space Elevator Era with a significant event at the Toronto IAC [Sept 2014]
- 3) Continuing the series of Space Elevator Sessions at the International Astronautical Congress, organizing similar sessions at COSPAR and relevant stand-alone conferences/symposia/workshops on behalf of the IAA; and, contributing papers about the SE in conferences not dedicated to the topic, but where some relevant sessions may be devoted to the topic or are sponsored by the Academy.
- 4) Making presentations in countries and organizations throughout the world, especially in developing countries and countries just beginning their involvement in space activities.
- 5) Making space elevator infrastructure concepts an integral part of university science and engineering curricula.
- 6) Promoting and supporting current and new IAA studies dealing with aspects of space elevator technologies and missions.
- 7) Continuing to work with the three major international associations working space elevator development:
 - o International Space Elevator Consortium [Seattle, Wash, USA]
 - o Japanese Space Elevator Association [Japan]
 - o EuroSpaceWard [Munich, Germany] and working together with other professional groups and societies to expand our knowledge base and contacts, [e. g. COSPAR, IAF, SEDs, AIAA, TBIS].
- 8) Implementing cooperation with other international organizations having similar goals, e. g., the United Nations, the International Space University, and ISPRS.

4. Specific Tasks

- Review the advancement of critical technologies required to implement the Space Elevator. This will include carbon nano-tubes, control dynamics, etc.
- Define the Space Elevator Prediction Feasibility Index (SEPMI) based upon the critical technologies identified
- Based on the SEPMI defined above, this study group makes recommendation of on-orbit verification/demonstration experiment by priority order. This priority will be determined by contribution of (1) Space Elevator (and other future space infrastructure) research progress and (2) technical progress of any space activities in the future. (Many items listed in SEPMI should be applied other space application, such as light and strong material, high efficiency energy transfer method, space debris mitigation method, etc.)
- Publish the yearly Space Elevator Feasibility Status Assessment
- Create an IAA Space Elevator web page containing all the relevant information related to the General and Specific Tasks identified in this document

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- Organization of the yearly IAA Sessions on Space Elevator within the Far Future Symposium D-3, for the International Astronautical Congress. This would primarily consist of identification of the proposed sessions including scope, chairs and rapporteurs, proposals for joint sessions with other symposia, proposals for Keynote Lectures within the Congress, and Highlight Lectures in the more general IAC frame.
- Coordination of the Academy sponsorship, participation and contribution to selected relevant conferences dedicated to Space Elevators, such as the annual ISEC International Space Elevator Conference in August in Seattle.
- Identification of potential studies on Space Elevator Infrastructure or Development within Commission III and coordinated with any other Academy Commission. This would naturally lead to submission of a proposal of another Cosmic Study based upon the Permanent Group's concepts.
- Dissemination of information among the members of the Study Group, mainly during regular meetings taking place twice a year, before the IAC and during the IAA March meetings in Paris. During these meetings, general information concerning past activities at the international level on Space Elevators will be shared amongst members, including debriefings from past conferences and major related actions (for instance ISEC, COSPAR). Practical aspects of the preparation of the upcoming Conferences, Symposia, Sessions are also dealt with during these meetings.

The Committee is based upon the experiences gained from the IAA Study Group 3-13, Space Elevator Feasibility. Some new ideas have surfaced that will ensure more international flavor:

(A) Japan Society for Aeronautical and Space Science made committee for SE feasibility study.

(B) "Science Council of Japan" defined Space Elevator project as one of master plan for large research projects - 2014. It is the first step of starting very small research but recognized Space Elevator as "National Project".

(C) Shared meeting with International Space Elevator Consortium.

(D) Study Group must be a new approach to energize other activities of IAA (each SG, etc.) with such ideas as "What will your focus become where there is really low cost access to space?" Can we do Nuclear Waste Disposal?

Intermediate Goals:

- Review the advancement of critical technologies required to implement the Space Elevator. This will include carbon nano-tubes, control dynamics, etc.
- Define the Space Elevator Prediction Feasibility Index (SEPMI) based upon the critical technologies identified
- Publish the yearly Space Elevator Feasibility Status Assessment
- Conduct IAA sponsored SPace Elevator Challenge (SPEC) and conference in the world
- Making presentations in countries and organizations throughout the world, especially in developing countries and countries just beginning their involvement in space activities.
- Making space elevator infrastructure concepts an integral part of university science and engineering curricula.

Methodology:

(Email works, workshops, stand alone conferences, interim publications, etc.)

- Email and face to face meeting twice per year (IAC and Paris)
- Workshops around the world (In USA, in Japan, etc) with IAA Sponsorship if possible

Time Line:

(Cannot exceed three years)

1st Meeting Oct 2, 2014 Toronto – to establish study group

2nd Meeting: March 2015 in Paris– to discuss progress, identify action items

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Meetings:	Each March and Sept at IAA events
Scheduled:	Mar 2017 at IAC – summarize conclusions and recommendations
Scheduled:	Sept 2017 at IAC – Final Document published and presented

Final Product (Report, Publication, etc.):

Academy Publication entitled:
International Academy of Astronautics Report on the Road to Space Elevator Era
This includes the following research result:
- Space Elevator Prediction Feasibility Index (SEPMI)
- Pilot project proposal with first level system engineering details

Target Community:

Major space faring nations and organizations wishing to have inexpensive access to space: Mars/Moon program, Life in space believers, geosynchronous satellite owners (communications, solar power satellites, etc.), planetary defense organizations, commercial satellite builders, space tourism companies, and governments.

Support Needed:

Minimal at the present time

Potential Sponsors:

Space agencies, Mars/Moon programs, planetary defense organizations, commercial space organizations, future human habitats and world governments.

To be returned to the IAA Secretary General Paris

by fax: 33 1 47 23 82 16 or
by email: sgeneral@iaaemail.org

Date: September 27, 2014

Name: signed Akira Tsuchida

(No Signature required if document authenticated).

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Follow-up Section for IAA use only

Initial Phase

Application received:

Commission Approved:

SAC Approved:

Web Site Section opened:

Members Formally Appointed by IAA:

Final Phase

Peer Review by Commission Completed:

Recommended by the Commission:

Final Report Received:

SAC Approved:

BOT Accepted:

Publisher Selected:

Study Published: