SPACE ELEVATOR CONFERENCE

The Museum of Flight, Seattle

**Welcome to the**

# 2012 Space Elevator Conference

**Presented by**

## The International Space Elevator Consortium

ISEC

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# Technical Program Agenda

## Friday Evening, August 24, 2012

4:00 PM - 6:00 PM - ISEC Board of Directors Meeting (ISEC board members only)

5:45 PM - 6:00 PM - Check in, Red Barn Gallery

6:00 PM - 8:00 PM - **Evening Mixer** in the Red Barn Gallery at the Museum of Flight (included with paid registration)

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## Day 1 – Saturday, August 25, 2012 – View Lounge

8:00 AM - *Check in,* ***Breakfast*** (provided)

9:00 AM - Conference Opening and Welcome, David Horn
9:15 AM - Space Elevator Overview, Dr. Bryan Laubscher
10:00 AM - Space Elevator Operations Concept (CONOPS) - Skip Penny
10:30 AM - *Break*

**Technology Session (CNTs)**
10:45 AM - Nanotube Detangler - Dr. Bryan Laubscher
11:15 AM - Colossal Carbon Tubes as Tethers for a Space Elevator - Gaurav Sharma / Andrew Meulenberg

12:00 PM - ***Lunch*** (provided)

**Technology Session**
1:00 PM - Alternate Launch Options - Martin Lades
1:45 PM - Stratolaunch: Unique Launch Systems Enabler - Dr. Bryan Laubscher
2:15 PM - Two Stage Tether to Orbit Launch System - John Carpinelli
2:45 PM - *Break*
3:00 PM - High Stage One - John Knapman, Ph.D.

4:00 PM - Youth Robotics Competition Finals or explore Museum of Flight

5:00 PM - Explore Museum of Flight

6:00 PM - 8:00 PM - ***Dinner Banquet*, Skyline Room**

# Technical Program Agenda

## Day 2 – Sunday, August 26, 2012 – View Lounge

8:00 AM - *Check in,* ***Breakfast*** (provided)

**Technology Session**

9:00 AM - A study on the ring-shaped counter-weight (RCW) Space Elevator and the feasibility of a bootstrap RCW using non-metallic material - Dalong An
9:45 AM - Effect of Waviness on the Variation of Nonlinear Fundamental Natural Frequency of Single Wall Carbon Nanotube by Using Multiple Harmonic Balance Method - Hamed Samandari
10:30 AM - *Break*
10:45 AM - Space Elevator Technology for Other Space Ventures - Martin Lades

11:30 AM - The International Space Elevator Consortium - Ted Semon

12:00 PM - ***Lunch*** (provided)

**Legal Session**

1:00 PM - The Relationship of Space Elevator to the Law of the Sea and the Sky - Professor Sunao Kai

**Business and Operations Session**

1:45 PM - Architectural Vision of Space Elevator Infrastructure - Dr. Peter Swan
2:30 PM - *Break*
2:45 PM - Statistical Model of Space Elevator Operations - Aidan Shaffer
3:30 PM - Operations For Space Elevator Research? - Martin Lades
4:00 PM - Space Elevator Justification and Role in Transportation Infrastructure Incentivized by Lunar Helium-3 Mining Operation – Glenn Graham
4:30 PM - Demand Pull for Space Elevators - Dr. Peter Swan

# Technical Program Agenda

# Day 3 – Monday, August 27, 2012 – Skyline Room

8:00 AM - *Check in,* ***Breakfast*** (provided)

9:00 AM - **Guest Presentation** - Thinking Unlimited - Jeff Slostad

**Outreach Session**
9:45 AM - The Space Elevator as Textbook of Physics - Minoru Sato
10:15 AM - *Break*
10:30 AM - Why go to space? (and get there using a space elevator?) - Benjamin Sibelman
11:00 AM - Social Media Outreach for Liftport Lunar Elevator - Michelle Cadieux
11:30 AM - High Lift Screenplay - Dr. Bryan Laubscher

12:00 PM - ***Lunch*** (provided)

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|---|---|
| 1:00 PM - Shotgun Science Session (5-minute presentations open to all) | 1:00 PM - Cosmic Study Workshop - Space Elevator Feasibility |
| 2:30 PM - Space Elevator Games - Ben Shelef | |

3:00 PM - *Break*

3:15 PM - 2013 Conference Theme - Ben Shelef

3:30 PM - Conference Closing - David Horn

4:30 PM - *End of 2012 conference*

## Guest Speaker

**Jeff Slostad**
Vice President of Engineering
Tethers Unlimited, Inc.

**Education**
M.S. Aeronautics & Astronautics, University of Washington, 1993;
B.S. Aeronautics & Astronautics, University of Washington, 1992

**Experience**
Jeff Slostad has 24 years of experience in flight systems development, project management, and hardware, electronics, and software design and testing, including over one and a half hours of microgavity aircraft testing and an Antarctic expedition. Mr. Slostad joined Tethers Unlimited in February 2001, and has since led the planning and testing efforts on numerous programs and technology developments.

From early 2000 to February 2001 Mr. Slostad was Chief Engineer at BlastOff! Inc., a "stealth mode" commercial venture led by Peter Diamandis, developing a lunar rover mission, where he led the surface operations team.

From 1993 to 2000 Mr. Slostad worked at the Jet Propulsion Laboratory. From 1995 to 2000 he was responsible for the design, development, testing, and operations of the Robotic Arm on the Mars Polar Lander. As Chief Engineer for the entire Mars Volatiles and Climate Surveyor science payload, he also led the assembly, test, and launch operations for the remainder of the science instruments on the lander. From 1993 to 1995 Mr. Slostad, as Deputy Project Scientist, integrated numerous science instruments and technology demonstration payloads onto the NASA operated SR–71 Blackbird.

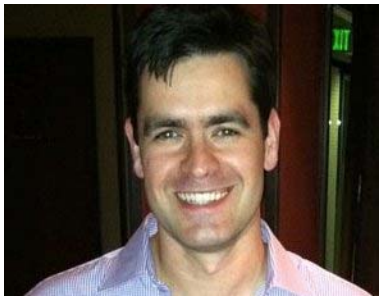
From 1988 until 1993 Mr. Slostad oversaw the development of a Get Away Special Payload to develop and test a Liquid Droplet Radiator and Centrifugal Fluid Collector. In September 1992, the experiment was successfully flown aboard the Space Shuttle "Endeavor" on Flight STS-47.

# Conference Speakers

In Alphabetical Order

### Dalong An (安大龙)

Dalong An, an independent researcher for large-scale space transportation system and a science fiction writer, is currently in pursuit his master's degree in mathematics in University of Texas at Tyler. Firmly believing this century being the age of discovery for the space, his research interest has been mainly focused on the feasibility of an economically and technically doable large scale space transportation system in the near future.



### John Carpinelli

John is a project manager for a major technology company in Silicon Valley. He has degrees in Electrical Engineering and Computer Science from the University of Melbourne, Australia. His previous employers include BHP Billiton, Exxonmobil and private aviation startup, XOJET. In 2010, he created the web site, electrictakeoff.com, with the goal of promoting tethered electric aviation and space launch.

## Glenn K. Graham

Glenn K. Graham is the author of "Sowers of God: The Holes of Mare Frigoris," Part 1 of a Sci-Fi trilogy. This novel portrays a not-too-distant future in which Helium-3 is mined on the moon, for use in fusion reactors on Earth, and a Space Elevator plays a key role in the Earth-moon transportation infrastructure.

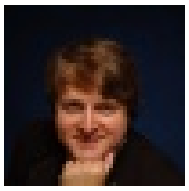
Mr. Graham earned an M.S. degree in Chemical Engineering from Montana State University and worked for many years as a Project Scientist and Process Research Leader in the Research and Development departments of Union Carbide Corporation and The Dow Chemical Company.

## Professor Sunao Kai

Professor Sunao Kai was born in Tokyo, Japan in 1948. He was a civil servant of the Board of Audit Japan from 1973 to 1993. He is currently a lecturer at the College of Law at Nihon University since 1993. His major publications include *Legal Structure of Budget and Financial Supervision of the State* and *Gap between the Theory of Human Rights*.

## John Knapman, Ph.D.

John has recently been conducting independent research into applications and variations of the Lofstrom Loop. He has published a number of papers on this topic since 2004. Prior to that, he held various posts in IBM research and development. Most of his career has been in the UK but with worldwide responsibilities. His Ph.D. was in Artificial Intelligence at the University of Edinburgh, UK, in 1976, and he still maintains interests in that field. His first degree was in mathematics at the University of Cambridge, UK, in 1969.



## Dr. Bryan E. Laubscher

Dr. Laubscher is a PhD in Physics with a concentration in Astrophysics. After a career as a project leader at Los Alamos National Laboratory that included research and development of astronomy projects, space missions, satellite instrumentation, optics, novel electrodynamic detection techniques, high power lasers, and classified projects Bryan became interested in the Space Elevator.

Bryan's current Space Elevator activities include being on the Board of Directors of the International Space Elevator Consortium, General Chairman for the annual Space Elevator Conference held at the Museum of Flight in Seattle, WA and presenting the Space Elevator and Our Future speech at various venues.

Pursuing the R&D of the Space Elevator has led him to start Odysseus Technologies, LLC a small company based in Washington state with the goal of developing high strength carbon nanotube materials. Odysseus Technologies, LLC has produced (and continues to develop) intellectual property for high strength materials and is entering a new phase of fundraising to extend its activities toward commercialization.

Bryan now lives in Olympia, WA with his wife Carla.

## Skip Penny

Skip is retired Air Force with multiple line and staff assignments in the Space arena. He spent 10 years working on Motorola's Iridium program and now consults on Iridium and other space projects.

**Mr. Hamed Samandari**

Hamed Samandari received the BSc. degree in Mechanical Engineering from Isfahan University of Technology, Isfahan, Iran, in 2008, and the MSc degrees in Automotive Power Train from the University of Tabriz, Tabriz, Iran, in 2011, where he was ranked 1st between Automotive Power Train graduate students. Currently, he is studying PhD degree at Middle East Technical University, Ankara, Turkey. He has been working as a Research Assistant at the Department of Mechanical Engineering, since spring of 2011. His Ph.D. Thesis title is “Nonlinear Free Vibration of Carbon Nanotubes”. In his thesis, he is working on the identification of the effect of nonlinearities on the natural frequencies of carbon nanotubes, and how these nonlinearities can change the characteristics of carbon nanotubes.

**Ben Sibelman**

For 40 hours of the week, Ben Sibelman is a programmer at Microsoft working on software that helps people view and manage their digital photos. The rest of his time is split between political activism, reading science fiction, playing his digital piano, making cool graphics for various purposes, and helping the SolSeed Movement with its plans to spread life across the galaxy.

## Peter Swan, Ph.D.

International Space Elevator Consortium's Vice President is the lead editor for the International Academy of Astronautics' study "Assessment of the Technological Feasibility and Challenges of the Space Elevator Concept." His 40+ years of space systems engineering expertise helps the space elevator community reach towards the future. He has built space systems, such as the IRIDIUM constellation, and taught space systems engineering around the world. He has many publications and five books published, to include *Space Elevator Systems Architecture*. His Ph.D. studies centered around space tethers and their dynamics during the early years of excitement about asymmetric spacecraft. Over the last eight years he has contributed greatly to the space elevator community while relaxing with golf and SCUBA.

## Cathy Swan, Ph.D.

As President of SouthWest Analytic Network, she orchestrates the support to space design teams as they look at innovative and future challenges. Her Ph.D. was completed at UCLA and covered long duration space missions. She has many papers and multiple books published to include *Space Elevator Survivability, Space Debris Mitigation*. She is a full member of the International Academy of Astronautics and an active member of its Commission VI, Space and Society.

# Presentation Abstracts (In program order)

## Saturday

### Space Elevator Operations Concept: Initial Thinking

**Skip Penny** skipnjane@hotmail.com

As is the case for development of any major space program, day to day operation of the Space Elevator must be addressed early on so that Operations-derived requirements can be allocated to system components and be subject to trade studies. The Concept of Operations (CONOPS) is a tool to be used by Planners and Engineers to help define predicted Operation and Maintenance costs for Life Cycle Costing activities.

For the Space Elevator, we propose to use the model developed in Cost Effective Space Mission Operations (CESMO), 2nd Edition, edited by Squib, Boden, and Larson. CESMO defines Inputs to the CONOPS that serve as candidate sections in the document. These inputs are:

Mission Objective
Mission Description
Mission Philosophies, Strategies, and Tactics
Programmatic Considerations
End-to-End Information System Characteristics
Ground System Characteristics
Payload Characteristics and Capabilities
Spacecraft Bus Characteristics
End-to-End User Data Products

This paper will present the Initial Thinking for the CONOPS for the Space Elevator with the subject areas defined above. It will describe the operation commencing with the first completed tether (aka “ribbon”). It will include descriptions of facilities and estimates of personnel needed to man them, including notional organization charts.

# Presentation Abstracts
**Saturday (cont.)**

## Nanotube Detangler
**Dr, Bryan Laubscher** (Odysseus Technologies, LLC) skyhookbel@hotmail.com

The search for forming macroscopic, high strength materials from nanotubes is ongoing. There is a new concept, the Nanotube Detangler (patent pending), that may hold the key to treating current carbon nanotubes (CNT) structures to obtain greater tensile strength. Although the exact technique will not be described, a discussion of the problem of drawn CNT structures and the possible solutions to this problem, including the Nanotube Detangler solution will be discussed. The next step in the pursuit of this solution will be discussed as well.

## Colossal Carbon Tubes as Tethers for a Space Elevator
**Gaurav Sharma** (Indian Institute of Technology) gaurav3sharma@gmail.com
**Andrew Meulenberg** (NAv6 Center of Excellence, Universiti Sains Malaysia, Penang) mules333@gmail.com

The most important component of a Space Elevator is the tether which is fixed to a base on earth and extends beyond the geostationary orbit. A lot of papers discussing the feasibility and materials to be used for a tether have been published. This paper reports the use of a new type of carbon material – colossal carbon tubes (CCTs) for the construction of a strong and light tether. Colossal carbon tubes outshine the much discussed use of carbon nanotubes (CNTs). Compared with CNTs, CCTs have a much bigger size, high specific strength, high characteristic length and a low taper ratio. Tenfold stronger than one of the strongest CNTs (T1000), CCTs also offers a low Linear Density and the weight of counterweight to be installed at the top of the tether reduces by a factor of ten. Further CCTs possess impressive mechanical and electrical properties, hence making colossal carbon tubes a deserving candidate to be used in the design of space elevator tethers.

# Presentation Abstracts
**Saturday (cont.)**

## Alternate Launch Options
**Martin Lades** (ISEC) martin.lades@isec.org

As Space Elevator technology moves forward, we also see other promising affordable launch options evolve. With an eye to the bottom line, the talk discusses a roundup of several other launch options: SpaceX and other chemical rocket variants, beamed power launch, nuclear katyusha launch, aerovator, etc. These launch options frame the competitive landscape for the space elevator. Only very few of these options will be realized and the hurdle to construct one is challenging. The space elevator needs be competitive in development and operations.

## Stratolaunch: Unique Launch Systems Enabler
**Bryan Laubscher** (Odysseus Technologies, LLC) skyhookbel@hotmail.com

Stratolaunch has recently been announced by Vulcan, Inc. a Paul Allen company. The purposes stated in the press releases describe only its use as a launcher of expendable chemical rockets in direct analogy to Orbital Sciences' Pegasus rocket system. In this presentation, the Stratolaunch system as designed and its professed uses are discussed. Then the author develops "out-of-the-box" uses for the Stratolaunch system that enables unique launch systems. One of these uses is an enabling technology for a Space Elevator precursor – the Skyhook. The Skyhook will be described and the enabling relationship to Stratolaunch will be discussed.

# Presentation Abstracts
**Saturday (cont.)**

## Two Stage Tether to Orbit Launch System

**John Carpinelli** (JPC Professional Services) jfcarpinelli@gmail.com

A two stage orbital launch system is proposed. The system can be constructed using commercially available tether materials. The lower tether is propelled by electric tow aircraft powered by grid electricity. The end of the lower tether is travelling at 3 km/s with a radius of 400km. The upper stage is an orbiting electrodynamic tether powered by solar electricity. The payload ascends the lower tether using hub mounted winches and then accelerates due to centripetal force. The payload transfers to the upper ether using a grappling mechanism and then accelerates to orbital velocity using momentum transfer.

## High Stage One

**John Knapman, Ph.D.** JMKnapman@aol.com

The Lofstrom Loop was originally named the Launch Loop and was designed to launch vehicles electromagnetically into orbit. Different versions and applications were developed under the name Space Cable, and some of these are suitable as stage one of the space elevator.

Stage One is the name chosen for the infrastructure below the main space-elevator tether. Past proposals base this on a ship: Marine Stage One. An alternative is to anchor the tether at 50 km altitude, the start of the mesosphere, on top of a version of the Lofstrom Loop. This is called High Stage One. It can be built using materials and technology available today. The main advantages are in dealing with winds and other atmospheric phenomena. It is calculated that strong winds in the troposphere and stratosphere could add an effective weight of 300 tons to the space-elevator tether, causing a 15-fold increase in its mass requirements. High Stage One transmits these forces down to the Earth's surface instead of up to geosynchronous orbit or beyond, thus saving this large mass requirement on the tether. In addition, tether riders stay above the stratosphere and so their fragile solar panels are protected from winds.

High Stage One consists of evacuated tubes in which rotors travel at over 3 km/sec. To keep friction to an absolute minimum, the rotors support the tubes' weight with magnetic levitation using permanent magnets stabilized by electromagnets. They also support the weight of a platform at the top. Payloads, and eventually passengers, ride up the tubes in vehicles like electric train cars. They transfer to tether riders at the platform. Passengers may want to enjoy the observation lounge before continuing their journey.

High Stage One has facilities for moving the tether to avoid space debris. Doing this above the stratosphere allows more options than at sea level. For example, it is possible to swing a mass on the bottom of the tether with virtually no air resistance and cause a 20-ton payload at altitudes of thousands of kilometres to be deflected. At the same time, High Stage One is well able to supply the much smaller force needed to accelerate a tether rider as it climbs to geosynchronous orbit.

# Presentation Abstracts
## Sunday

### A study on the ring-shaped counter-weight (RCW) Space Elevator and the feasibility of a bootstrap RCW using non-metallic material

**Dalong An** (University of Texas at Tyler) yangmingspace@yahoo.cn

In order to shorten the lifting cable of SE, an idea of lowering down the orbit of SE's counter-weight by changing it into a ring-shaped counter-weight (RCW) is studied in this paper. As an existing idea, Orbital Ring System (ORS) was the first example of RCW structure proposed by Mr. Birch. But instead of giving answers to the large scale space transportation problem, Mr. Birch find ORS extremely expensive to build, since we have to send an huge amount of mass into space, or accelerate a small amount of mass up to an extremely fast speed. In this paper we shall try to give a construction plan based on the second possible choice. With a main idea of using solar power instead of chemical fuel and an elaborated constructing plan named "sling system", a bootstrap ORS made of non-metallic material, now seems much more doable than once predicted.

### Effect of Waviness on the Variation of Nonlinear Fundamental Natural Frequency of Single Wall Carbon Nanotube by Using Multiple Harmonic Balance Method

**Hamed Samandari (**Middle East Technical University)
HAMED.SAMANDARI@metu.edu.tr
**Ender Cigeroglu** (Middle East Technical University) ender@metu.edu.tr

In recent years, the unique mechanical and chemical properties of nanomaterials have given rise to their emerging into industrial and scientific applications. Nanostructures are of great interest due to their potential to revolutionize critical technologies as well as their basic scientific richness. Nowadays, carbon nanotubes (CNTs) unique properties have been resulted in their utilization as nanosensors, nanoswitches and resonators. Recently, due to CNTs extraordinary strength, they have been recommended to be used as building blocks of cables used in space elevator application. The proposed cable is a ribbon from centimeters to meter wide and microns thick which is composed of CNTs in a composite structure. Hence, a deep understanding of mechanical performance of CNTs is required. The

mechanical behavior of CNTs can be divided in two major classes: structural behavior and dynamic behavior. In this study, dynamic behavior of CNTs is investigated.

Studying the literature, it is observed that the effect of higher harmonics on the vibrational behavior of CNTs are disregarded and it has been assumed that the vibration of CNTs can be expressed by the fundamental harmonic. However, due to large deformations and waviness, vibration of CNTs is nonlinear where the effect of higher harmonics is required to be studied as well.

In this paper, nonlinear free vibration of a curved simply supported single walled carbon nanotube (SWCNT) is investigated using harmonic balance method with multiple harmonics. Nonlinearities are due to large deflection of carbon nanotubes (geometric nonlinearity) and waviness of tubes due to their application in space elevator cables . Galerkin method is used to discretize the continuous differential equation of motion and multiple harmonic balance method is used to convert the nonlinear discretized equation into a set of nonlinear algebraic equations. An expression for the variation of nonlinear fundamental natural frequency of CNTs is derived analytically. Results show that in the presence of only large deflection, first and third harmonics should be considered to track nonlinear fundamental natural frequency of CNTs, whereas in the presence of only waviness first and second harmonics should be considered.

## Space Elevator Technology for Other Space Ventures

**Martin Lades** (ISEC) martin.lades@isec.org

As technology relevant for the Space Elevator such as tethers, dynamic tether management, fast climbers, and lasers mature they could also be used for other space ventures. The talk references options such as magsails, space tethers similar to EDDE, and energy management options including power beaming.

# Presentation Abstracts
**Sunday (cont.)**

## The Relationship of Space Elevator to the Law of the Sea and the Sky

**Professor Sunao Kai** (College of Law at Nihon University)
kaisunao@mpd.biglobe.ne.jp

The United Nations Convention on the Law of the Sea is often called as the "Constitution for the oceans". So, if we intend to establish a ground base of the space elevator on the sea, we must search the possibility within the framework of the Convention of the sea.

Alike to it, relationship to the Law of the sky, we must consider the problem of space elevator under the framework of Convention on International Civil Aviation (Chicago Convention).

## Architectural Vision of Space Elevator Infrastructure

**Pete Swan, Ph.D.** (International Space Elevator Consortium) dr-swan@cox.net
**Cathy Swan, Ph.D.** (SouthWest Analytic Network, Inc.)

The mature arena of space elevators will be a robust environment with routine, safe, inexpensive and environmentally friendly movement of cargo to geosynchronous orbit and beyond. The purpose of this vision is to establish the "big picture" and propose a future for space elevator businesses and user communities. The strength of the space elevator infrastructure revolves around the high demand for cargo to GEO and beyond as well as the unique aspects of the transportation complex to include: safe, routine [7 climbers started each week], inexpensive [$ 500/kg to GEO], no shake rattle and roll of launch or thrust, opening up design space for space systems, little impact upon the environment, no consumption of fossil fuel [solar cells will drive the motors for lift], and does not leave space debris in LEO MEO orbits. This paper will reach beyond the concept of building one space elevator to an environment where business is booming and the space infrastructure is in place.

# Presentation Abstracts
**Sunday (cont.)**

## Statistical Model of Space Elevator Operations
**Aidan Shaffer** (UNM) aidanshaffer@unm.edu

The logistics of shipping a purpose built device from the assembly floor to a port of call than onto the spaceelevator base station at the equator will be examined. The spaceelevator operations will be evaluated statistically using Poisson distribution as a single point of service with multiple queues. The time interval of the mission will be approximately one month and one week in duration starting when the equipment is received at the spaceelevator base station. The logistics will be examined to discern the channel suppliers and shipment channels that will feed into the spaceelevator. The nature of cargo and differences between static and dynamic cargo will be developed. The most important factor is customer satisfaction with a focus on quality of shipment. It will be assumed that a shipment contract exists and implies a single use of the spaceelevator which consists of a round trip.

## Operations For Space Elevator Research?
**Martin Lades** (ISEC) martin.lades@isec.org

It is the age of social networks and international collaborations around the clock. How can the Space Elevator Community with its limited means improve the development of its long term effort. What options are available to connect global expertise to accelerate R&D without introducing a hype cycle. The talk presents options and raises questions referencing other long term efforts such as the Icarus project, the 100 year starship project, etc.

# Presentation Abstracts
**Sunday (cont.)**

## Space Elevator Justification and Role in Transportation Infrastructure Incentivized by Lunar Helium-3 Mining Operation

**Glenn Graham** (Independent Author) graham@suddenlink.net

In “Sowers of God: The Holes of Mare Frigoris,” Part 1 of a Sci-Fi trilogy, the author of the book and this paper envisions a scenario, in the not-too-distant future, in which most of the Earth’s power is generated by fusion reactors fueled by Helium-3 extracted from the moon. A Space Elevator is the key component of the novel’s transportation infrastructure, which also includes a revolving Space Station attached to the Space Elevator shaft at the geosynchronous orbital level, a fleet of Lunar Transport spacecraft that travel between the moon and the Space Station, and a world-wide, high-speed, evacuated-tube, maglev train system. In this paper, these concepts from the novel were employed to consider a realistic Helium-3 acquisition system. The construction of a Lunar Mining Base for the purpose of extracting Helium-3 for use in Helium-3/Deuterium fusion reactors on Earth was considered, with an emphasis on how multiple Space Elevators could benefit such an operation, the amount of mass that would need to be transported from the surface of the Earth to the moon, and estimated costs for the endeavor. The Helium-3 acquisition infrastructure that was considered includes a Lunar Mining Base, Robotic Regolith Miners and related equipment, a Volatiles Refining Operation, several Lunar Transports (for transportation between the Earth and the moon), and several Earth-based Space Elevators. The design calculations were based on the replacement of one-half of the Earth’s fossil fuel consumption, currently worth about $2.1 trillion annually, with energy produced by the fusion reaction of Helium-3 with Deuterium. The Helium-3 was assumed to have an average concentration on the moon of 8.3 ppb. The total mass of equipment and personnel that would need to be transported to the moon was estimated to be 983,000 metric tons, and 16,600 employees would be required to be stationed at the Lunar Mining Base. If the transportation and construction of the Lunar Base and mining-related equipment were to be carried out over a period of 31 years, a total of 42 Earth-based Space Elevators and 34 Lunar Transports would be required. It would be critical to generate hydrogen and

oxygen from water produced on the moon for use as propellant in the Lunar Transports to avoid using most of the Space Elevators' lift capacity for fuel. The use of Lunar Space Elevators could provide a solution to this problem, by significantly reducing fuel requirements, and have the possibility of shortening the time required to implement this project by 5-10 years. Lunar Space Elevators should, therefore, be included in more detailed evaluations, even though they are not part of the Helium-3 acquisition infrastructure described in this paper. The total estimated cost for this project is $2.9 trillion, if Earth-based Space Elevators are utilized, but $27 trillion if conventional rocket technology were to be used instead. The estimated cost to build the fusion reactors is $39 trillion (this assumes the same cost per watt as for fission reactors).

## Demand Pull for Space Elevators

**Pete Swan** (International Space Elevator Consortium) dr-swan@cox.net

Establishing a market projection is normally a process of looking into the future and using past data to estimate future business opportunities. This process works extremely well when future business resembles past businesses. In the case of space elevators, the ability to supply routine, safe, and frequent access to GEO and beyond is not linearly extrapolated from launch vehicles with their infrequent launches, caustic propellants, violent liftoffs, potential for explosion, vast support infrastructure and extreme prices. A space elevator creates a phenomenal opportunity for new satellites to have design flexibility and cost significantly less. The future demand will be projected and will surprise the traditional space systems engineer.

# Presentation Abstracts
## Monday

### The Space Elevator as Textbook of Physics
**Minoru SATO** (Tokai University) minoru@tokai.ac.jp

A space elevator is technically unrealizable yet. However, the principles of the space elevator are understandable. It is not difficult for high school students and undergraduates who studied mechanics, electromagnetism, and thermodynamics. Therefore, a textbook of physics on the theme of the space elevator was written for high school students and undergraduates, and was published in Japan. The textbook was written for problem-based learning of which the theme was the space elevator. The students can learn the space elevator and physics at the same time by using this textbook. In this paper, it introduces the content of the textbook, and proposes the curriculum that uses the textbook.

### Why go to space? (and get there using a space elevator?)
**Benjamin Sibelman** (SolSeed Movement) ben@solseed.org

If we want to get a space elevator built, it is vitally important to understand what would motivate people to tackle this massive project. This paper will present a brief survey of the many reasons for wanting to go to space, presented in the framework of a two-dimensional emotional spectrum whose axes are fear/hope and self-interest/altruism, and attempting to show how each motive relates to the space elevator. It will also describe the outlook of the SolSeed Movement, which prefers to focus exclusively on hope in our advocacy for “giving birth to new living worlds,” although we are also interested in working with many of the other constituencies elsewhere on this emotional spectrum.

# Presentation Abstracts and Summaries
**Monday (cont.)**

## Social Media Outreach for LiftPort Lunar Elevator

**Michelle Cadieux** (Liftport) liftportgroup@gmail.com
**Michael Laine** (LiftPort) laine@liftport.com
**Charles Radley** (LiftPort) charles.radley@liftport.com
**Adam Glickman** (Liftport) Adam.Glickman@liftport.com
**Thomas Marshall Eubanks** (AmericaFree.TV) marshall.eubanks@gmail.com

As a new startup LiftPort has had the chance to utilize a lot of different social media technology to do space elevator education. By using STE(A)M, and putting the arts in Science, Technology, Engineering, and Math education we are working on reaching many different parts of society. We'd love to share our success with facebook, startup competitions, and more for developing community, mobile apps, educational programs, and more. Come join us and get some ideas about our programs and how you can use them. We will talk about our outreach with Mobile apps and development with @space apps challenge, and some of the many competitions and resources we have found useful.

## High Lift Screenplay

**Bryan Laubscher** (Odysseus Technologies, LLC) skyhookbel@hotmail.com
**Victor Cummings** victorcummings@gmail.com

High Lift, featuring in its plot the Space Elevator, has won the grand prize in Script Vamp's ScriptVamp 2011 Dream Quest: Feature Screenwriting Competition for the Action/Adventure and Science Fiction/Fantasy categories. It has taken over 3 years, many rewrites, professional reviews, layman reviews, plot tweaks and a great deal of work! Now the authors, Victor E. Cummings and Bryan E. Laubscher are moving forward to try to sell the screenplay as a feature production. This presentation will outline the past, present and possible future of the High Lift screenplay. The popularization of the Space Elevator concept through popular media can be an important part of Space Elevator development and High Lift may be a breakthrough into feature movies.

The paper includes contest scoring and updates to the marketing strategy.

# Conference Menus

**Evening Mixer** – Friday from 6pm to 8pm

- Crudités: Broccoli Florets, Carrots, Radishes, Cauliflower & Celery with Roasted Red Pepper Dip & Bleu Cheese Dip
- Blueberry & Hazelnut Torta with a variety of Crackers
- Warm Spinach & Roasted Onion Dip with Herb Crostini
- Northwest Wild Mushroom & Rondele Pinwheel
- Italian Sausage & Parmesan stuffed Mushrooms
- Orange Soy glazed Salmon Skewers
- Herb roasted Turkey Breast with mini Rolls, Orange Aioli, Whole grain Mustard &Cranberry Sauce

Cash Bar

- Premium Cocktails
- Premium Wine
- Assorted Beers to include Domestics, Microbrews & Imports
- Soft Drinks, Bottled Water, Mineral Water & Juices

**Saturday Banquet**

- Spinach Salad with Mushrooms, Spiced Pecans, Red Onion & Sherry Vinaigrette
- Seasonal Fruit
- Caprese platter with Basil, Tomatoes, Mozzarella & Balsamic Vinaigrette
- Rustic Breads with Sweet Cream Butter
- Parslied New Potatoes
- Oven Roasted Salmon with Lemon & Shrimp Sauce
- Sautéed Chicken Breast in Wild Mushroom & Leek Essence on a bed of Quinoa Rice
- Confetti Pilaf

Dessert

- Warm Northwest Berry Cobbler with Chantilly Cream
- Coffee, Decaf & Hot Tea

Cash Bar

- Premium Cocktails
- Premium Wine

- Assorted Beers to include Domestics, Microbrews & Imports
- Soft Drinks, Bottled Water, Mineral Water & Juices

**Breakfast** – Saturday, Sunday, and Monday from 8am to 9am

- Morning Bakery Basket to include Breads, Pastries, Muffins & Bagels with Cream Cheese, Butter & Jam
- Seasonal Sliced Fruit
- Fruit Juices
- Coffee, Tea, Decaffeinated Coffee

**Lunch** – Saturday, Sunday, and Monday from 12pm to 1pm

- Already Built Sandwiches: Turkey & Smoked Cheddar on Whole Wheat, Roast Beef & Gouda on Rustic Roll, Tuna Salad on Whole Wheat Bun, BLT Wrap, & Vegan Portobello Veggie
- Tim's Potato Chips
- Salad
  Saturday: Mixed Field Greens with Balsamic Vinaigrette
  Sunday: Spinach Salad with Mushrooms, Red Onion & Sherry Vinaigrette
  Monday: Traditional Caesar Salad with Parmesan, Croutons & Creamy Garlic Dressing

**Afternoon Break** – Saturday, Sunday, and Monday around 3pm

Saturday: Chocolate Walnut Brownies
Sunday: Chocolate Dipped Hazelnut Airplane Cookies
Monday: Lemon Bar Cookies


## The International Space Elevator Consortium

**http://www.isec.org**

Formed at the end of 2008, the International Space Elevator Consortium (ISEC) represents the coming-together of a number of organizations and individuals who want to see a Space Elevator built and are working together to help make it happen.

Our mission statement says it all:

***ISEC promotes the development, construction and operation of a Space Elevator as a revolutionary and efficient way to space for all humanity***

The Board of Directors includes members from EuroSpaceward, the Spaceward Foundation, the Space Engineering and Science Institute and the Space Elevator Blog, as well as a number of other individuals with a long history in promoting this revolutionary concept. We also maintain a cordial and working relationship with the Japan Space Elevator Association (JSEA).

ISEC was founded on the concept of the "*Four Pillars*", four segments of society that must be brought on board for any mega-engineering project (such as the Space Elevator) to succeed. These four pillars are;

- Technical / Scientific Pillar: - If it can't be built, then all discussions about the benefits of a Space Elevator are just intellectual exercises. The Technical Pillar addresses the science and engineering of the Space Elevator.

- Business Pillar: - Space today is dominated by government business, but shipping and air travel isn't. The Space Elevator may be built for reasons of security or national pride, but its capacity can only be satisfied by a real space-based economy. The Business pillar examines the economics of the Space Elevator.

- Legal Pillar: - The Space Elevator is going to break new legal ground. Existing Space Treaties will need to be amended. New Treaties may be needed. International cooperation may be sought. Insurability will be a requirement. The Legal Pillar examines how each of these issues will be addressed.

- Public Outreach Pillar: - People need to be sold on the idea of a Space Elevator. The public needs to be educated as to how a Space Elevator works and why it is needed and they need to be convinced that a Space Elevator will make their life better. Societal institutions; government, media, corporations, unions, the educational system, etc. must all be convinced that at the very least, this is not a project to oppose and, hopefully, one to

support. The Social Pillar provides a blueprint of a PR campaign in support of the Space Elevator and coordinates the resulting activities.

ISEC is all this and more. Each year, we select a topic of Space Elevator research and make it our yearly theme. Most of our activities for the year are centered on this theme. For 2012, the theme is "*Operating and Maintaining a Space Elevator*".

We sponsor and prepare an "ISEC Report" each year; a definitive report on the yearly ISEC theme.

We will announce the topic for the 2013 Artsutanov and Pearson prizes at this year's Conference.

We publish a yearly Journal (**C$^{L}$IMB**) containing the best of Space Elevator writing for the year and also publish a yearly poster based on the yearly ISEC theme.

This year, we are the sponsors of the yearly American Space Elevator Conference.

What we need is YOU. We need your enthusiasm, your ideas, your skills and your membership dollars to help us achieve the goal of building a Space Elevator.

Come and join us – you'll participate in one of the signature projects of this century, will make a lot of new friends and will have a lot of fun along the way.

And, in cooperation with this year's Space Elevator Conference, we are offering a one-year new or renewal membership to ISEC for all paid conference attendees at a discounted price of $40.00. The normal one-year Professional-level membership fee is $68.00, so take advantage of the fact that you are here and join us!

Yes, I want to take advantage of this offer and purchase a 1-year Professional-level membership in ISEC for only $40.00! I confirm that I am a paid conference attendee.

First Name: _____ Last Name: _____

Email Address: _____

Postal Address: _____

_____

(Please print clearly and legibly – and welcome to ISEC!)

Members joining or renewing at the 2012 conference receive the ISEC e-Newsletter, the 2012 ISEC Space Elevator Poster, and the 2012 issue of **C$^{L}$IMB**, the ISEC Space Elevator Journal (the preliminary electronic version will be available and the conference and the printed version will be sent to you when it becomes available).

**Come join us and help make a Space Elevator happen!**

PRESS RELEASE – Space is the Answer – For immediate release

**Leeward Space Foundation** has announced plans to establish an international system of local chapters to be known as "Space is the Answer" chapters. The purpose of establishing this network of local chapters is twofold. Firstly, the local chapters will support the mission of Leeward Space Foundation by promoting the idea that the development of space and space resources can provide many, if not all the answers to Mankind's most pressing concerns. "Most people know that Human Civilization faces some very difficult challenges ahead such as; climate change, industrial pollution, developing clean energy, eliminating poverty and many others ", said John Lee, Executive Director of Leeward Space Foundation, "but few realize that there are permanent solutions to these problems to be found by developing nearby space resources".

Secondly, the network of local chapters will help Leeward develop a Scholarship program for High School Seniors or equivalent and a separate scholarship for college level. Each local school or community chapter can sponsor a graduating senior or college student who will then present a paper to Leeward concerning how he believes developing space resources will provide an answer to a particular concern facing humanity. The best papers will earn their composers scholarship grants and will be published on http://www.Space-Is-The-Answer.Org Lee also said, "We must make the next generation aware of the huge potential of space development, for they are the ones who will build the infrastructure that will grow Human Civilization out into the Solar System". The first year's scholarships will be $1000, but plans are to grow the top scholarship to $10,000 and to offer four other lesser grants.

The application process to become a "Space Is The Answer" local chapter is very easy: simply send an email to chapters@LeewardSpaceFoundation.Org with your location and the group to be represented. There are no national dues or donation requirements, though each chapter may charge local membership dues. Each chapter must actively participate in as many of Leeward Space Foundation's fundraising activities as possible. The activities are listed at: http://www.LeewardSpaceFoundation.Org/id21.html.

# Space Elevator Conferences

## What we all can do to help support them

Every year at this time we are called upon to help support the next Space Elevator Conference. Listed below are some things that we all can do at little or no cost beyond what we would be spending anyway. These items helped make it possible for Leeward to sponsor the Jerome Pearson prize. Help us do better next year.

The table below assumes that there are at least 200 people at this conference who are serious about supporting the next one. It is also assumed that each of us can influence at least 5 other friends, family or neighbors to do the same as we do to support the conferences. The 1st three items are sponsored by GoodSearch and GoodShop where we earn a donation of 1 cent for each search we make online and an average of 3% of whatever we spend when we shop online. GoodSearch uses the Yahoo search engine, so you Google fans will be upset; but there are four other ways to help support the conferences. At GoodShop there are over 1300 online stores ranging from Amazon to WalMart to shop from at no extra cost to the shopper. Under the subheading of "Travel" at GoodShop all the major online travel companies are included. Why not let all of our traveling support the Space Elevator effort. Collecting cell phones and gift cards is as easy as asking a few friends or neighbors (everybody has a few old ones around the house collecting dust). You may send them to Leeward Space Foundation or bring them to the next conference. If you collect a large number of phones, email or call me with your name and address and I will send you a prepaid FedEx mailing label to ship them to the recycler. You may go to: http://www.GoodSearch.com/?charityid=879255 or http://www.GoodShop.com/?charityid=879255 to download the search bar or to shop online. Our Capital One credit card will earn 2% of gas and grocery purchases and 1% of all other purchases, plus Capital One will donate $50 to the Foundation the 1st time you use the card.

| # of people | What they do | How much they earn |
|---|---|---|
| 1000 | 1000 x 2 searches/day x 365days x $0.01 | $7,300 |
| 1000 | 1000 x $500/yr spent online x 0.03 | $15,000 |
| 1000 | 1000 x 3 trips/yr x $15/trip | $45,000 |
| 1000 | 1000 x 10 cell phones x $1each | $10,000 |
| 1000 | 1000 x 5 gift cards x 10each | $50,000 |
| 1000 | 1000 x $50 plus $4,000/yr C. Card Use x 0.01 | $90,000 |
| Total | | $217,300 |

It's not what one person does that matters so much, but what we all do together that counts.

# Call to Action & Credits

## Call to Action

This conference is the result of too few people volunteering countless hours over the past several months. Don't let them have all the fun next year – you too should be involved! Seriously, we can make this conference bigger, better, and more effective with your help. If you are serious about making the Space Elevator a part of humanity's future, then you should be serious about making this conference a part of your future.

## Credits

These volunteers made this conference possible. Let's add your name here for next year. Get involved!

**General Chair** – Bryan Laubscher

**Technical Chair** – David Horn

**Family Science Fest Chairs** – Carolyn Davids

**Microsoft Chair** – Maurice Franklin

**Robotics Challenge Chair** – David Schilling

**Publicity Chair** – Peggy Alonso

**Family Science Fest Poster** – Claire Mitchell(art) & Sarah Westfall(graphics)

**Technical Sessions Poster** – Peggy Alonso(concept) & Greg Thorburn(art/graphics)

**Conference Planning Committee** – David Horn, Bryan Laubscher, Ted Semon, Maurice Franklin, Peggy Alonso, Phil Richter, and Ruth Richter

These sponsoring organizations also contributed valuable planning and organizing efforts in addition to funding.

**Microsoft –** Conference advertising, robotics challenge prizes

**Leeward Space Foundation (and John Lee)** –Registration raffle prizes

# Space Elevator Links

## Space Elevator References

- The Space Elevator Reference - http://www.spaceelevator.com/
- Space Elevator Wiki - http://spaceelevatorwiki.com/
- Wikipedia article - http://en.wikipedia.org/wiki/Space_elevator
- How Stuff Works - http://science.howstuffworks.com/space-elevator.htm

## Space Elevator Organizations

- The International Space Elevator Consortium (ISEC) - http://www.isec.org/
- The Japanese Space Elevator Association (JSEA) - http://www.jsea.jp/
- The European Spaceward Foundation (EuroSpaceward) - http://www.eurospaceward.org/
- LiftPort Group - http://www.liftport.com/
- The Spaceward Foundation - http://www.spaceward.org/
- 2009 Space Elevator Games - http://www.spaceelevatorgames.org/

## Online Social

- The Space Elevator Blog - http://spaceelevatorblog.com/
- 2012 Space Elevator Conference event on Facebook - https://www.facebook.com/#!/events/399448556742038/
- Space Elevator Architects group on Linkedin - http://www.linkedin.com/groups?gid=111756