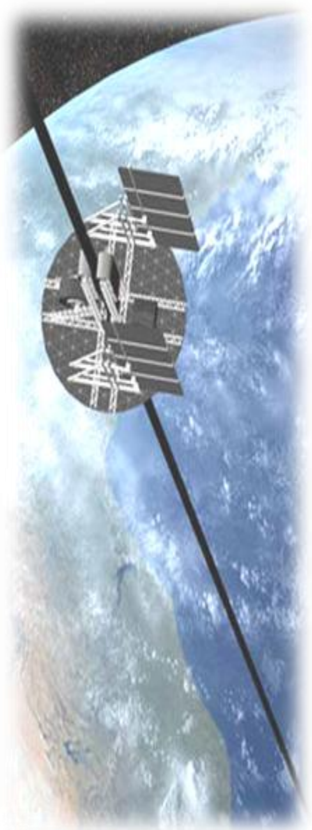
ISEC

The International Space Elevator Consortium

The Space Elevator Fact Sheet

What is a Space Elevator?

A Space Elevator (SE) can be thought of as a vertical railroad into space. A cable (Tether) stretches from the ground to a Counterweight 100,000 km up/out in space. Elevator cars (Climbers), powered by electricity travel up and down the Tether and carry cargo and eventually humans to and from space.



Why build a Space Elevator?

- Cargo Capacity: Using a Tether that is just 2.5 inches in diameter could support the lifting of three complete International Space Stations per day, the highly scalable nature of the elevator allow this capacity to be expanded almost infinitely.
- Cost: Shipping cargo into space will be significantly reduced in price to the realm of dollars per kilogram compared with over $20,000 per kilogram today
- Safety: Though much slower than a conventional rocket, the ride is much smoother, akin to riding on a high-speed railway line, this means there are no high-g forces or explosives

What are the main components of a Space Elevator?

- The Tether: This is the ‘railway’ that stretches from the earth to orbit, about 100,000 km into space. Made from carbon nanotubes, it will be stronger than any construction material today.
- The Ground Station: This structure serves to anchor the Tether to Earth and as the loading and unloading station. It will be located on or very near the earth’s equator.
- The Counterweight: This is a large mass located at the outer end of the Tether to keep the Tether taut.
- The Climbers: These are the ‘elevator cars’ traveling up and down the Tether, carrying cargo and eventually humans into orbit.
- The Power Sources for the Climbers: A combination of lasers and the sun will illuminate solar cells on the Climbers, giving them the energy necessary for the week long journey into space.

What will a Space Elevator look like?

The Tether will stretch straight up 100,000 km from the Ground Station to the Counterweight. Someone looking at this from the earth’s surface will see an impossibly thin cable standing straight up from the Ground Station and quickly vanishing into the sky above. Several lasers will shine up from the base of the Tether like giant pillars of light to provide power for the Climbers that can also be seen slowly working their way up to space. From farther away, the only proof that the Tether is there at all will be a slight glint from the sun as the light is caught at just the right angle.

How will a Space Elevator work?

Periodically a Climber carrying cargo or people will be attached at the Ground Station. The Climbers will ascend the Tether, quickly leave the atmosphere and begin to make their way past Low Earth Orbit, between 160 and 2000 km up. While passing through this zone, cargo can be jettisoned to enter its own orbit around the earth. After four to five days, the Climber will reach Geosynchronous Orbit where more cargo will be detached. The cargo that remains on the tether above Geosynchronous Orbit will be moving faster than required to stay in orbit and can be detached and sent to destinations such as the Moon or Mars. The Climbers will then ascend to the end of the Tether where they will become part of the Counterweight.

709-A N. Shoreline Blvd, Mountain View, CA 94043 / 630-240-4797 / inbox@isec.info / www.isec.info

Several Climbers will be on the Tether at all times, each carrying their own small propulsion systems to 'move' the Tether out of the way of orbiting satellites and large space debris. Smaller space debris will be allowed to impact the Tether with the resulting damage taken care of by the Maintenance Climbers. Maintenance Climbers will be a constant companion of the Tether. They will travel the tether, continuously inspecting it and making repairs.

What makes the Space Elevator Tether 'stand up straight' into outer space?

Imagine you are holding a rope with a weight attached to the end. If you swing the rope in a circle at a sufficient speed, the rope will become taut, revolving about your hand. The force pulling the rope taut is known as centrifugal force. This same centrifugal force, generated by the rotation of the earth, will pull the Space Elevator Tether upwards into space (outwards from the earth).

Who Invented the Space Elevator?

The idea of a Space Elevator can be attributed to several different visionaries spread over more than one hundred years. In 1895 a Russian scientist named Konstantin Tsiolkovsky first proposed a tower into space. In 1959 another Russian scientist, Yuri Artsutanov came up with the idea of a tensile structure, something being pulled away rather than built up, to get into space. This idea used a satellite in Geosynchronous Orbit (GEO) to send a Tether down to the earth. In 1966 the idea moved in the U.S. with four American scientists writing an article about their "sky-hook" in the journal Science. American Jerome Pearson independently 'discovered' the idea of a Space Elevator and, in 1975 published his concept of the "Orbital Tower". By 1979 the concept was being spread to a larger audience by Arthur C. Clark in his novel The Fountains of Paradise.

How will the Space Elevator be built?

The project will start with an initial 'seed' ribbon, about 80 tons of material, which will be lofted into orbit with conventional rockets. The parts will be assembled in Low Earth Orbit and then boosted to GEO to a point above the Ground Station. Once stable in GEO the seed ribbon will be built both upwards and downwards to maintain equilibrium at the center of mass of the structure. Since the Tether being built away from the Earth is being pulled by less gravity the longest part of the Tether will stretch away from GEO. Once the ribbon reaches the Ground station, it will be captured and downward deployment will cease.

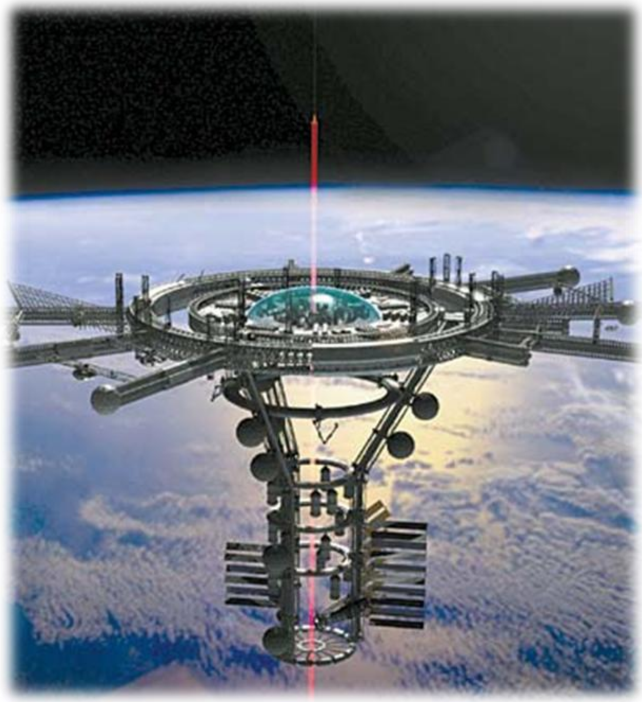
With this basic 'seed' ribbon is in place it will be possible to add more Tether material to increase carrying capacity. A Tether just 7 cm thick would be able to lift more than 1000 tons of material per day. In other words, the International Space Station that the entire world has spent over a decade building could be lifted to orbit in less than one day.

How strong does the Tether have to be?

The first important term for this question is Specific Strength. A spider web might not seem very strong but it has a high Specific Strength because of what it can hold versus its thickness. This is very important for a Space Elevator because all of the material will have to be lifted into space and because the Tether will have to be able to hold itself together over a great distance. The standard unit of measurement for Specific Strength is stress/density or Pascal/(kg/m^3), for our purposes this can be adjusted to be GPa-cc/g (1Gpa-cc/g = 1 million Pascal/(kg/m^3)). For simplicity ISEC has adopted the measurement scale of Yuri's, named after Yuri Artsutanov, where 1 MYuri is equal to 1 GPa-cc/g. Steel wire has a specific strength of about .5MYuri.

Now we enter the realm of what is technically needed to build a Tether into space versus what is required to make a practical Space Elevator. A Tether with a specific strength of 25MYuri could be built but it would require a lot of mass and would not really be able to lift much. In the *Space Elevator Feasibility Condition*, Ben Shelef discusses this problem in detail and shows how several factors enter into the question. The bottom line is that stronger is better with 30-40 MYuri's being the best bet for a practical Space Elevator, well within the predicted limits for carbon nanotubes. Less initial material and more payload to orbit will increase the rate at which a Space Elevator becomes a profitable venture.

Current R&D efforts in Space Elevator development:



There are many technologies for the SE that will be of general use for several other industries as well. Carbon nano-tubes are being researched by government agencies, corporations and academic institutions all around the world. Laser technology is constantly being investigated for many different purposes and industries. However, there are also several research efforts aimed specifically at the creation of a Space Elevator.

- Tether: The Spaceward Foundation sponsors an ongoing competition for anyone who can make a Tether that is at least 50% stronger than the “House” material. Winning teams will win $2,000,000 (provided by the NASA Centennial Challenges program) but no one has yet been able to meet the challenge.
- Climber: The Spaceward Foundation also sponsors an ongoing Power Beaming/Climber competition. Since its inception in 2005, the requirements to win a prize have been made more difficult while the prize purse (again, provided by the NASA Centennial Challenges program) has been increased. It now stands at $2,000,000. In 2009 the LaserMotive team won $900,000 for climbing a 1 km steel cable at an average speed of 3.9 m/s. There is still $1.1 million left in the prize pool and this will be awarded to the team(s) that can climb this steel cable at an average speed of at least 5 m/s.
- Similar challenges occur at the Robo-games and at the Japanese Space Elevator Technical and Engineering Competition.

What is ISEC’s role in its development?

ISEC is a central organizing force for the Space Elevator. We sponsor academic prizes for research, contribute to conferences and seek partnerships with international groups to assist in our goals. ISEC is also developing a library of papers and articles on the SE to provide a ready source of material for research use. With it’s “Four pillars” (Technical, Legal, Business and Outreach), ISEC is working to answering all the questions and solving all of the problems necessary to make this concept a reality.

709-A N. Shoreline Blvd, Mountain View, CA 94043 / 630-240-4797 / inbox@isec.info / www.isec.info