SPACE ELEVATORS: PROVIDING SAFE, FREQUENT ACCESS TO A "GALACTIC HARBOUR"

By Michael Fitzgerald

Reliable, safe, clean, and efficient access to space without pollution or debris—this is the promise of space elevators. A space elevator could lift cargo into space like the elevators used in buildings, using a cable called a tether and an elevator compartment called a climber. The upper end of the tether is attached to a counterweight, an Apex Anchor, some 62,000 miles (100,000 km) overhead; held in place by a combination of centrifugal force and the reduced force of gravity at higher altitudes. This permanent and reusable transportation capability is closer at hand than some might think.

At the ISDC® 2018 in Los Angeles, the International Space Elevator Consortium (ISEC) explored the feasibility of building the Space Elevator Transportation System. We see this reusable infrastructure supporting the space industries that will be burgeoning in orbit by mid-century—companies that will service and repair operating satellites, manage small orbital factories, support interplanetary flights, and deliver power and materials to a crowded, resource-hungry Earth.

Space elevators may eventually replace heavy lift rockets to become the primary pathway to space. The system reviewed at ISDC® would have 14 climbers, each carrying up to 20 tons per trip to geosynchronous orbit. The climbers will move along a tether that is longer and stronger than any elevator cable ever made.

The tether material is the limiting factor for the development of the space elevator. However, recent announcements regarding revolutionary new materials with high tensile strength are an indication that the tether challenge may be met within a decade. Currently, there are three materials that are sufficiently strong at the required length for a space elevator: carbon nanotubes, boron nitride nanotubes, and continuous growth graphene. While at present no single material fully satisfies, there are alternatives that show promise. Unique engineering approaches like multi-stage elevator construction enhance the feasibility of building space elevators.

▲ Artist's concept of a space elevator node high above the Earth.

Since first discussed years ago in science fiction such as Arthur C. Clarke's 1997 book "3001: The Final Odyssey," some critics have pointed out the challenges to, and dismissed the benefits of, space elevators. ISEC has proposed controlled regions in space that would be logistically supported by space elevators it calls the Galactic Harbour. This architecture represents a transportation and commercial foundation for the growing population of our planet, currently estimated to exceed 11 billion by 2060. To support this, power, raw materials, and other resources must be found and developed in space, and a robust transportation system will be required. Just as the transcontinental railroads fueled development in the 19th century, and container shipping was the foundation of the 20th century explosion in global commerce, rapid and inexpensive access to orbit will be the driving force for space commerce in the 21st century. Space elevators could support daily departures that would carry many tons of cargo to orbit and daily arrivals of products from space.

ISEC's design, called the Space Elevator Transportation System, would be the main channel in the Galactic Harbour. On-orbit businesses would be located near transportation hubs, depending on them for services, spare parts, and customers. Geosynchronous orbit is already flourishing with hundreds of commercial and government satellites, and these satellites can be repaired, refueled, and reprogrammed inside a space elevator's reach. Space solar power generation systems can be assembled; gravity-free research and experimentation can be conducted; and interplanetary journeys can be launched using spacecraft assembled by factories within a space elevator's geosynchronous orbit region. Some governments are already moving ahead—Japan's Basic Space Law established space solar power as a national goal in 2008. China matched this with their 2015 roadmap for power delivery from space by 2050. This date coincides with the first operations date of China's Space Elevator 2045. The Galactic Harbour is the first stop to anywhere in space.

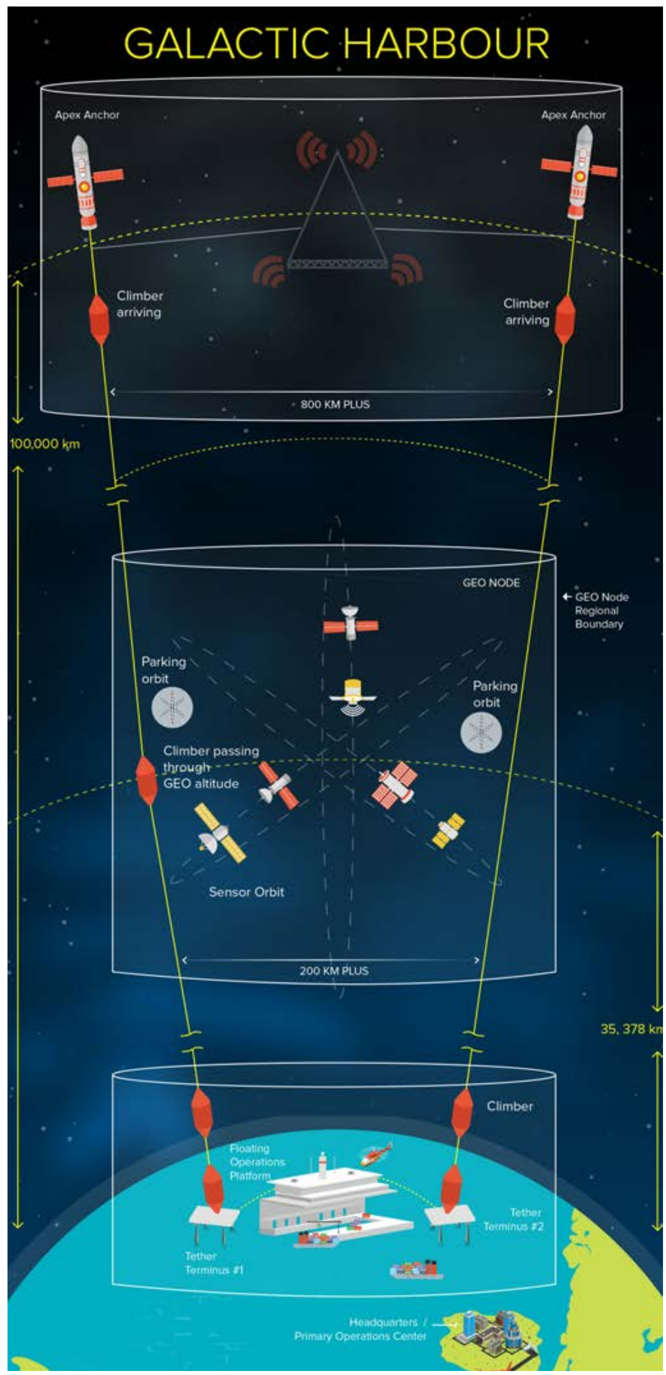
One of the principle ways to enable operational space elevators is effective customer utilization. A Galactic Harbour could represent the unification of transportation and enterprise. Cargo would enter the Galactic Harbour at a port on Earth where it would be placed inside carriers called climbers. These would then proceed up the elevator's tether. The exact point of delivery can be adjusted along the tether according to a customer's requirements. Many customers will specify geosynchronous orbit, the elevator's terminal node.

The Galactic Harbour concept encompasses two tether terminals on the ocean surface, located near a central operating platform where incoming and outgoing ships, helicopters, and airplanes would operate. These would handle cargo, as well as housing crews and support services. The elevator would operate from the Earth Port, climbing up 62,000 miles (100,000 km) to what ISEC calls an "apex anchor," which is effectively the counterweight on the far end of the tether, carrying cargo and personnel from point-to-point or anywhere in-between.

When near the apex anchor, spacecraft that are released from the tether would have enough energy (derived from centripetal force and the diminished effect of Earth's gravity) to travel beyond Mars. Departing spacecraft would be "tossed" toward their destinations, with propulsion required for trajectory correction only. Travel to the Moon, Mars, resource-rich asteroids, and a variety of other destinations would be routine.

According to many futurists and engineers, space elevators will eventually be built because they make so much sense. They represent clean and inexpensive access to the resources of the solar system, and a route to cislunar space and beyond.

Space elevators may become a transformational transportation system that is more efficient than today's launch systems for leaving the deep gravity well of Earth. Once matured, they are likely to be very safe—much more so than chemical rockets—environmentally friendly, and most importantly, affordable (estimated at $50 to $100 per kilogram versus today's $1000's per kg). This should enable activities in space that we can only dream of today. ISEC's goal is to champion the space elevator's effectiveness for the development and settlement of space, moving humanity one large step closer to its destiny beyond our planet.



▲ Image credit: International Space Elevator Consortium (ISEC).