Why fly when you can take the space elevator?

The space elevator concept is not a new one. There are conflicting arguments concerning the origination of the idea, however we can be sure that humans have considered catching a lift to space for more than a century. But just how feasible is the concept? Majarat investigates the space elevator, which may appear to some to be nothing more than a constituent of an intriguing science fiction novel. But there is a huge group of highly intelligent advocates across the world, for whom it's not only a reality, but the future of space exploration. Our investigation is guided by Dr Peter Swan, President of the International Space Elevator Consortium, who falls into the latter category.

It would be the largest structure ever built, involving thousands upon thousands of construction workers, billions of dollars and a great deal of precision, but the space elevator concept has never before been more readily considered and more widely acknowledged as feasible. Much of this is due to the work of Dr Peter Swan, who holds the position as President of the Space Elevator Consortium, an organisation that lobbies around the world for governments and space agencies to take the idea seriously.

It's been a long journey for Dr Swan, one that began back in 1984 when he initially read about the idea. But his belief in the feasibility came a lot later, as he tells us.

"I became very involved, and started believing in the concept in 2003 when I realised I had missed the first Space Elevator Conference held in 2002.

"As I was a travelling professor, I had time on my hands and jumped into the development of the space elevator concept. I first read Brad Edwards' book, "Space Elevators, a Revolutionary Earth-to Space Transportation System," and discovered that the concept had indeed moved from science fiction, through scientific investigation, to the edge of engineering achievability.

"I then realised that I had a passion for this topic and immediately started working on the project, on a voluntary basis. I was first focusing upon the architectural aspects and figuring out how we would get started on a mega-project.

"My first four activities were to contact Dr Brad Edwards and have discussions, to then go to the 2003 Space Elevator Conference, to initiate a series of space elevator sessions within the International Academy of Astronautics (IAA) activities at the yearly International Astronautical Federation's (IAF) Congresses, and finally to write a book with my wife, Dr Cathy Swan, entitled "Space Elevator Systems Architecture".

It is the architecture that provides the fascination. The space elevator will extend for 100km, equivalent to about 120 Burj Khalifas. It is a feat of engineering that, if accomplished, would comfortably eclipse any human endeavour in engineering history, but how do we know that humans could even build something that high? And even if we could, we must remember that it will leave the Earth's atmosphere, meaning that while the base is anchored on the ground, the majority of the structure will be hurtling through space at 17,500mph as the Earth rotates. Dr Swan explains the idea behind the architecture, and how building a structure that high is actually not what it seems.

"The question is not about height, but about length. The space elevator could be constructed by a tether being released from a large deployment satellite at geosynchronrous altitude in both downward and upward direction. It would be impossible to raise a material against gravity without something holding it up. One of the original thinkers covering space elevators was Konstantin Tsiolkovsky when he saw the Eiffel Tower in Paris.

"He had been contemplating the trade-off of gravity forces and centrifugal forces and where they would be equal on a mass in orbit. He then thought that if one could raise an Eiffel Tower towards geosynchronous (GEO) [36,000 km altitude], he could achieve his satellite that would be synchronous with the rotation of the Earth. He was the first to put space elevators into physical terms."

In effect this means that a satellite will be placed into an orbit that mirrors the exact speed of the rotation of the Earth, meaning it will not actually be in an orbit at all, rather an equilibrium. This will act as the anchor from which a tether will be attached all the way down to the ground. And the building can begin. Sounds complex, but countless studies have been conducted to ascertain that the feasibility is well within the realms of possibility.

There are of course many significant challenges to face even once the tether is attached to the perfectly inserted satellite and to the ground. But first, we ask Dr Swan what the advantages of a space elevator

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really are? Surely now SpaceX and the others have made moves towards making space more accessible, is there really a need for the elevator? Dr Swan is adamant that there is.

"Absolutely there is (a need)! There are inherent problems with space launch vehicles, the basic issues being cost, pollution, shake-rattle-roll, potential for explosion, scarcity of launches (less than 85 global launches to space in 2014), limitation of payloads, and risk of failure. To get to GEO and beyond, the payload is well below 3% of the mass of the system on the launch pad. Compare this to the launch from space elevators when they become routine: 60% payload each lift-off, three times daily (about 1,000 per year), cost less than $100/kg for mass to GEO altitude, each lift-off with 14 metric tons of payload, almost no pollution, and extremely safe. The advantages of space elevators go well beyond cost. The space elevators open up CIS-Lunar space and our solar system with safe routine access.

"The essence of the project is that it will leverage one technology and enhance the human condition by opening up its reach to orbit and into the solar system. It is no exaggeration to say that the following characteristics support this claim:

"Space will become routine with daily lift-offs, the price for a payload to be delivered to GEO will be below $100/kg. The current figure is around $20,000/kg, so the clientele will expand for space lift-off and open entrepreneurial businesses that are not even considered today. Elevators have inherent safety in comparison with the dangerous practice of mounting valuable payloads on top of huge tanks of high explosives (rockets).

"Space elevators will have vibrations in the region of cycles per day and shock loads equivalent to petals dropping into a pond instead of the explosive potential and violent rock and roll experienced during rocket lift offs. And finally, think about the environment. Operations of a space elevator will decrease environmental damage and virtually eliminate the creation of new space debris.

"Each space elevator would be similar to other transportation infrastructures – permanent and reusable."

But now to the challenges, and there are many. One of the most difficult to manage is the potential for collision in orbit, with the huge amount of space debris currently flying through space, as well as more than 2,500 active satellites.

"As one who has developed numerous space systems, I know many have faced similarly

daunting projects. Everyone who takes on mega-projects recognises that we must incrementally approach each risk item and develop a plan to lower all risk and enable the project.

"In Dr Edwards' book, and his work with NASA's Innovative Advanced Concepts office, he outlined the challenges and then methodically approached each one with a proposed risk reduction activity. His answer was that a space elevator could be built and that it would be available ten years after initial funding. The IAA study and the Obayashi project report (two other studies into space elevator feasibility) agree with him. Each book identifies the problems and then proposes solutions.

"We have almost 60 years of understanding space operations and the environment. One key problem that everyone jumps on is the orbital space debris issue. The International Space Elevator Consortium (ISEC) approached this problem with a yearlong activity that included an engineering study. The conclusion from the study report, "Space Elevator Survivability, Space Debris Mitigation," was that the issues are serious; but there are methods to make the risk acceptable.

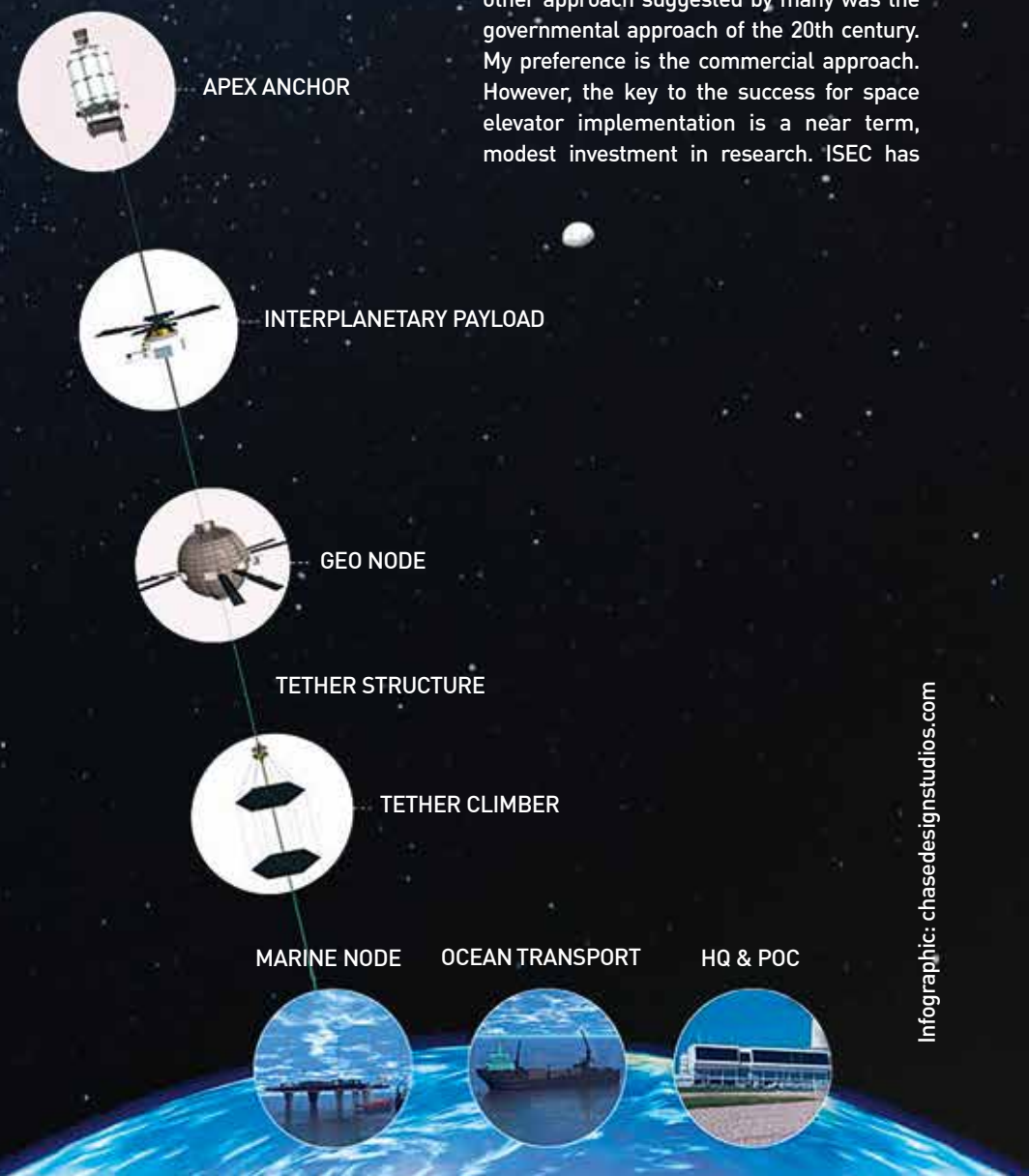
"These boil down to deliberate movement of the tether to move out of the way of large debris [ISS being one of those] and design of the tether to accept periodic "hits" by small debris. The numbers were based upon information from NASA's Debris Office in Houston, and the approach was one developed and used since the late seventies. There are many other challenges, but the engaged organisations are approaching each of these systematically to address them so that the construction can begin as soon as the material is developed and the funding is ready."

And these are the two challenges that must be overcome before we even consider the operational issues once it is built. Securing the huge level of funding and appropriating the right materials and technology in the vast amounts required are pivotal stumbling blocks that Dr Swan is working methodically to find ways to overcome.

"There is quite a lot of interest in the concept around the world, and there is significant justification for having space elevators for routine, inexpensive and safe access to space with low environmental impact. However, the funding is almost non-existent. The initial investments, such as NASA support, the Japanese Space Agency (JAXA) support for on-orbit experiments and the Obayashi Corporation initial studies have all expired. The next step is an investment of modest funds into research activities to look at the key risk items.

"But the real constraint is that the ribbon material for a 100,000km long, extremely strong tether is beyond current production capabilities. After four years of studying this issue in the IAA study, the report estimated that the material would be available, in multiple metre length, during the middle of this decade. Significant investment into material research is being made around the world. The hope inside the space elevator community is that the carbon nanotube promised strengths and lengths are produced soon. This is the main stumbling block for commitment towards a robust space elevator infrastructure.

"In relation to funding, of course the users will pay for the space elevator as fees for access to space. In the IAA book, the concept was to raise investment for the development of an access to space infrastructure that would be used continuously instead of being thrown away after each launch. That study's approach showed a sizable profit relatively soon after operations begin. The other approach suggested by many was the governmental approach of the 20th century. My preference is the commercial approach. However, the key to the success for space elevator implementation is a near term, modest investment in research. ISEC has



Infographic: chasedesignstudios.com

It is expected that a space elevator will be built and operational by 2036 (Source: IAA)

outlined how to proceed by listing research topics on their website."

So while there is still research to be conducted and financing to be sourced, there are three modern day space elevator designs and proposals on the table, and each has a timeline. First is the aforementioned Dr Edwards, who estimates his space elevator will become operational 10 years after funding begins (the current best estimates for the costs of constructing this mega-structure are around $6.2 billion).

The International Academy of Aeronautics (IAA) expect a space elevator to be constructed and operational by 2036, while the third company, Obayashi of Japan, predict theirs will become operational in 2050, capable of carrying people and massive payloads. But, for now, as Dr Swan tell us: "The current status is that we are waiting for funding to conduct near-term research to lower technological risks. This would enable investors to aggressively jump into the project one step at a time. First research, then a prototype pathfinder in orbit, and then major investment into the space elevator itself."

Before the interview ends, Dr Swan re-emphasises some of the main points raised, and some of his central beliefs pertaining to space exploration and the space elevator's role in that. "The space elevator seems feasible in all the credible studies that have been carried out, the space elevator is NEEDED for expansion into the solar system, the next step is funding for major research, and ISEC is ready to implement and assist in this activity. And also let me tell you that currently ISEC is working on a voluntary model of activity and would welcome others to participate – go to our website and jump in."

ISEC is a voluntary organisation for which Dr Swan is the President, and it predominantly promotes the development, construction and operation of a space elevator, which it believes would revolutionise space travel. While $6.2 billion is quite an investment, in the short term much smaller amounts are required to conduct the necessary research on matters relating to the elevator concept, such as the carrying of large payloads through the Earth's atmosphere and the space debris issue, however we are edging nearer to the space elevator becoming a reality, thanks to the commitment of Dr Swan and his organisation. Who will take the leap and place their full backing behind it? Will it be a nation, a singular organisation or a consortium? And who will build it? There are many unanswered questions, but Dr Swan leaves us with a final thought: "Who will build the space elevator, I do not know. The IAA study was structured around a commercial venture, similar to a new toll bridge, with expectation of profit from the transportation tolls. However, we all know that big governments dominate today in launching satellites and we realise, to quote Philip Ragan, co-author of Leaving the Planet by Space Elevator - the first country to deploy a space elevator will have a 95% cost advantage and could potentially control all space activities."

For more information on the International Space Elevator Consortium, you can visit www.isec.org ■