Roping the Stars

By Glenn Fishbine

We cannot swing up on a rope that is attached only to our own belt.

--William Ernest Hocking

As I stated in the first column, it is my hope to entertain, educate, and enrage in a manner that leads to thoughtful and productive discussions. Picture if you will, a rope stretching from the surface of the earth, 22,000 miles straight up into geosynchronous orbit. Engineering analysis suggests that if such a rope can exist, you could climb it. In fact, there have been a number of serious studies that have outlined the mechanics and physics of such a device. These studies have even indicated that a rope braided out of carbon nanotubes would have sufficient strength to make such a rope actually physically possible. The concept has the generic name "space elevator."

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The dynamics of a space elevator are relatively simple. You bolt one end of a rope at a location on the equator (Ecuador comes to mind), and the other end passes through a location in space 22,000 miles overhead (plus additional distance for counterweights). This permits you to have a stationary object, or tower, that stretches from the surface of the earth to orbit at 22,000 miles. Along the way, you would pass through the inner Van Allan Belt and reach the fringes of the outer Van Allan Belt, so you would have to wear your lead underwear for the trip. You would also hope that the carbon fibers would have self-healing capabilities every time they encountered an oncoming 10 MEV particle. Lastly, you would pray that elevator music has finally evolved into an endurable state of being. These minor issues aside, one calculation I saw indicated that the rope that reaches the required distance, just to sustain itself (i.e. no payload) based on continuous strands of carbon nanotubes, would weigh about 34 million pounds. Using the current Payload Assist Module (PAM-A: 4,400 pound payload) getting that bulk of carbon fibers into geosynchronous orbit would take about 7,700 space shuttle launches. At a rate of 10 launches per year, this could be done in about 700 years at a cost of perhaps 924 billion dollars (assuming no inflation). Redeeming frequent flyer miles would reduce the cost somewhat. Obviously some intermediate technology is required just to get the rope (or even part of the rope) in place. Equally obviously, it is not going to be a crash priority for the Bush administration.

While the cooler heads are thinking about heavy lift vehicles and non-geosynchronous staging areas, there is the minor problem of coming up with aligned carbon nanotubes of sufficient length to braid into a rope longer than, say 1 millimeter. At least we know how to put something into geosynchronous orbit. Now lets think about those nasty little carbon nanotubes. Well the state of the art isn't too good right now. There may be a few labs kicking around that have created a few fibers as long as a millimeter. Of course, getting a weaver's bundle together by picking out the long ones using an atomic force microscope is a sorting activity that can take, on a good day, an hour per fiber. The fact is, however, that unlike hemp, carbon nanotubes would rather slide against each other rather than stick together, so there is an implicit requirement that any space cables should be fabricated out of single strands about 3,872,000,000 times longer than those that have been previously fabricated. The alternative is a self-unraveling rope, which wouldn't stay together long enough to be of any value. Not to worry, we are not going to start shuttle launch operations any time soon.

So, where might we focus our R&D efforts on carbon nanotubes? Well, I happen to like IBM. They have a near-term product focus. In April 2001, they published a report describing how to make arrays of carbon nanotube based transistors. ***Arrays***, not just one—in other words, bulk processing. Now the downside is that the arrays weren't any smaller than those produced with conventional lithography techniques, and the performance of the transistors didn't set any speed or amplification records. But, it did demonstrate that a concerted affordable effort using a nanomaterial could result in a practical and usable technology. Only one-step away from being a product! It only missed the cost-effective element.

Next time, I'll explore another concept in nanomaterials. In particular, should we use buckyballs to create storage energy systems of unprecedented density, or simply just mix them with paint?

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