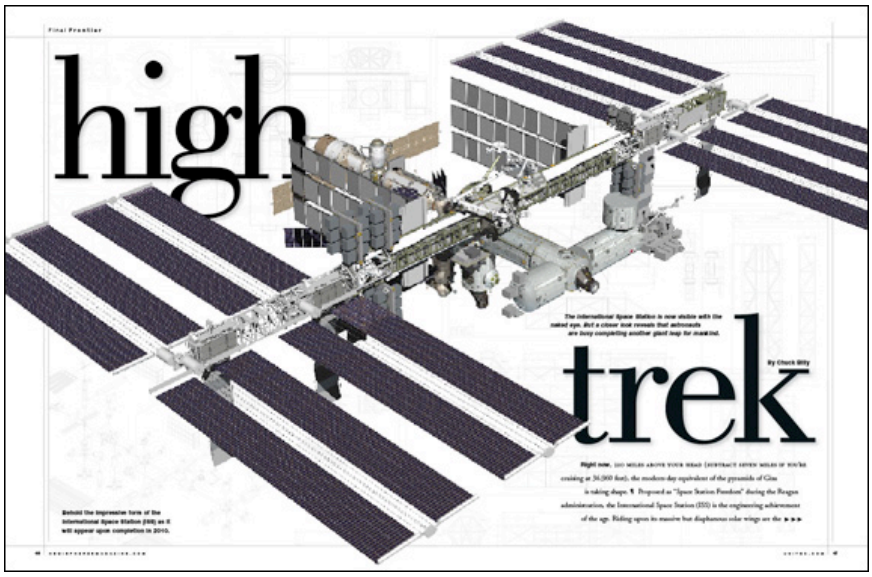

High Trek

By Chuck Billy

The International Space Station is now visible with the naked eye. But a closer look reveals that astronauts are busy completing another giant leap for mankind.

Right now, 210 miles above your head (subtract seven miles if you're cruising at 36,960 feet), the modern-day equivalent of the pyramids of Giza is taking shape.

Proposed as "Space Station Freedom" during the Reagan administration, the International Space Station (ISS) is the engineering achievement of the age. Riding upon its massive but diaphanous solar wings are the scientific aspirations of 16 countries, each counting on the logic-driven mayhem inside the crew compartments, science modules, and power plants to generate discoveries and innovations that could benefit humanity many times beyond its US$130 billion–plus price tag.

So far, the actual assembly of humanity's first international space laboratory has taken 10 years and 69 separate rocket launches. The results to date: The ISS spans 240 feet from the tip of one silicone-impregnated solar array to the other, has more interior room than a three-bedroom house, and, were it on Earth and not floating in space, would weigh just about a half-million pounds. The station is so immense you can see it from the ground with the naked eye (see Details, Details, Details).

As big as the ISS is, a flurry of huge new research modules installed in late 2007 and early this year have further increased its size. And by the completion date of 2010, the station will expand by another third. Achieving this goal will require a space shuttle and ferry craft to fly 22 more missions to the ISS, carrying new laboratories and docking cupolas, water, toilet paper, and more.

Anything and everything arriving at the ISS has to be captured, moved, stored, locked into place, and sometimes discarded. Giant mechanical arms on either the station or a visiting space shuttle move the room-size modules. Moving just about everything else requires a human touch—even if that touch is delivered through layers of Dacron, Orlon, and Beta cloth.

"Making the thermal and electrical connections between various modules and pieces of hardware requires the dexterity of a human hand," says NASA astronaut Peggy Whitson.

Whitson has been making a lot of thermal and electrical connections recently. In October, she boarded the ISS as history's first female space station commander. Whitson's arrival at the station also marks the beginning of the most complex phase of station assembly since humans first occupied the outpost seven years ago. During her stay, three shuttle flights will deliver new flight hardware from four different space agencies, requiring 14 space walks to get it all in place. While stepping outside for a little "air" will be "just another part of the job," it's a duty the veteran of a six-month stay aboard the ISS in 2002 is looking forward to.

"I had the experience of hanging on to the end of the Russian manually operated arm, about 30 feet from the station," says Whitson. "The highlight was getting to see the sunrise light up the station from the top of the structure down, and several minutes later, lighting up the Earth below. That's the most memorable moment of being in space for me. I felt so small next to this huge structure but experienced the most incredible sensation of flying, like I imagine a bird must feel flying over the Earth."

NASA calls space walking "extra-vehicular activity" or EVA. EVAs have been on NASA's flight manifest since 1965, when Ed White became the first American to walk in space on *Gemini 4*. Neil Armstrong and Buzz Aldrin took EVA to a whole new level when they stepped out of their spacecraft and onto the surface of the moon during the *Apollo 11* voyage in July 1969. All EVAs (American and Russian) have been successful in that the space walker has

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Overachievers Wanted

What stellar skill set is required to repair a ripped wing of electrically charged solar panels on the International Space Station? Here's an imaginary want ad and some of the modest talents astronaut Scott

made it back alive into the comparable safety of the mother ship. But that doesn't mean all EVAs have been without peril.

"I had many problems," said Russia's Alexei Leonov during a 2000 interview. "My space suit had many problems, and I almost did not make it back inside."

Leonov became the first man to walk in space when he stepped outside the airlock of the Russian spaceship *Voskhod-2* on March 18, 1965. While he was attempting to reenter his spacecraft, his space suit ballooned to the extent that it became inflexible, and his feet and hands couldn't reach into his boots and gloves. The first man to walk in space truly could not get a handle on the situation.

With his limited air supply already halfway depleted and his respiration rate and body temperature skyrocketing, Leonov risked decompression sickness and bled air from his space suit, reducing the pressure until he could reposition his body and close the airlock hatch. Of course, that was nearly 43 years ago.

"We've come a long way since Alexei Leonov performed the first space walk," says retired NASA astronaut and EVA specialist Leroy Chiao. "We know more about the medium, and our suit technology has evolved a great deal."

As an EVA astronaut, Chiao spent much of his Earthbound time figuring out the best way to do hardhat construction "off planet." "Astronauts practice EVA in a water tank called the Neutral Buoyancy Laboratory or NBL," says Chiao. "We get into our space suits and then get put into the water. Divers add weights to our suits until we become neutrally buoyant and can simulate a space walk outside of the shuttle or the space station."

Astronauts chosen for EVA spend hundreds of hours in the NBL learning about working in outer space. Yet, lab practice, as well as the virtual-reality instruction that NASA employs for EVA training, can go only so far. Real on-the-job training requires a 450-pound jumble of umbilicals, battery packs, Beta cloth, fiberglass, Lexan, a vacuum that humankind cannot replicate in a laboratory, and 200-plus miles between you and terra firma.

"The first thing I learned in space is to conserve hand strength," says Chiao. "You don't use your legs much in a weightless environment, and since you move by pulling yourself around, you are constantly grabbing onto things. The tendency at first is to grab things tightly because on Earth, you have to hold on tight to support your body weight. But in space you learn to just lightly grasp things, maybe using only one or two fingers. When you use a wrench, you have to hold it tightly in the initial turn; then you can loosen your grip for the remainder of the turns. If you are using a power tool, you learn right away that if the drill is turning clockwise, then the tool wants to turn counterclockwise. So you learn to use your left hand, so that the tool is not pushing on the weak side of your hand and fingers but into the meaty side of your hand. If you don't do those things, about an hour into the space walk your hands are exhausted."

Exhaustion is only one of the concerns of the modern space walker. Improperly installed wiring could cause electrocution. A malfunctioning restraint system could send an astronaut spinning off into the night. A micrometeorite the size of a BB hurtling through space or a jagged piece of metal on the ISS could rip open a space suit, causing loss of consciousness in 15 seconds.

Concern for space walkers is more than simply hypothetical. In 1977, cosmonaut Yuri Romanenko became detached from the tether that held him to the Russian space station *Salyut-6*. If not for the fast actions of a fellow cosmonaut, Romanenko could have been lost in space. Just last November astronaut Scott Parazynski tore a glove while lacing together five makeshift braces of aluminum, wire, and insulating tape during a seven-hour space walk to repair a damaged solar array. This is not the high ground's first damaged glove. During a 2006 shuttle supply mission to the ISS, ground controllers ordered astronaut Rick Mastracchio back inside after he reported a hole he'd just discovered in one of his space suit's gloves.

"You have to accept that you're putting yourself at a little higher risk of anything going wrong when you get into a space suit and go outside," adds Chiao. "But we always train to optimize safety, and EVA is no exception. EVA construction is essential to get the station up and running."

To attach all the coolant hoses, electrical connections, and fiber-optic lines that will make the ISS fully operational, 165 separate EVAs will be required. By the completion of assembly, astronauts and cosmonauts will have spent an estimated 1,920 man-hours in open space assembling the laboratory—more than twice the total EVA hours of all prior U.S. space missions.

With so much work already done and a great deal still to do, the station's EVA astronauts are reluctant to highlight their accomplishments. The astronauts know that they're just a few of the 100,000 people at 500 installations around the world working to make the ISS a reality. Although they may hold back about themselves, they love to talk about their labor of love.

"Politically, the ISS is demonstrating what can be accomplished, peacefully, as a partnership of our world's people," says Whitson. "Philosophically, you have to see the ISS as a key steppingstone that will take us one step further in our quest to go beyond this place we call Earth."

Right now, very important things are happening that will directly affect how you, your children, and your children's children will live. Right now, men and women are walking in space, working in space, making the dream of humanity's exploration and permanent habitation of space a reality. Right now, that dream is in progress, taking big and inspiring shape hundreds of miles above your head.

Details, Details, Details / For more about NASA Human Spaceflight, visit **spaceflight.nasa.gov**. Find out when to spot the ISS from your city by clicking on "Station" and "Realtime data."

Chuck Billy *is a former Navy fighter pilot. He's currently a practicing attorney in Long Beach, California, and a commander in the Navy Reserve.*

Parazynski drew on to complete the longest and riskiest space walk ever (November 2007) to repair the ISS.

Your new job requires:

- An international education. (His global studies took him to junior high in Senegal and Lebanon and high school in Iran.)
- Science degree from an elite university. (Parazynski got his biology degree at Stanford.)
- Medical degree from an elite university. (Stanford again, M.D. Oh yeah, with honors.)
- Must possess the skills and composure of an emergency room doctor. (22-month residency in emergency medicine, Denver, Colorado.)
- Ideal candidate would be a widely published academic researcher on space topics. (Parazynski is a recognized expert on space physiology.)
- Candidate must demonstrate outstanding reputation in the scientific community. (Honored with awards from the National Institutes of Health, Stanford Medical School, NASA, and Wilderness Medical Society.)
- Position demands the stamina of a world-class mountaineer. (Parazynski climbed Chile's Aconcagua, the highest mountain outside Asia.)
- Must be a recognized leader in a competitive, team-oriented environment. (He was an Olympic luge coach.)
- Pre-eminent experience in space flight required. (He's logged more than 1,000 hours in space and 20 hours of extra-vehicular activity (space walking) and has traveled more than 17 million miles.)
- Must have demonstrated skill at adapting to challenges of living in space. (Parazynski helped design exercise devices for long-duration space flight and studied the correlation between space flight and the aging process.)

Even with these skills, a good luck charm doesn't hurt—Luke Skywalker's Jedi light saber was aboard the *Discovery* mission with Parazynski, who woke up to the *Star Wars* theme the morning of the repair. Given his extraordinary qualities and a son named Luke, Parazynski is right at home quoting *Return of the Jedi*: "Luke, I am your father."

New Horizons

From Space Hops to Space Hotels

Private space flight came closer to going mainstream last April when the Federal Aviation Administration initiated regulations for commercial "joy rides." The rules mandate training and medical fitness evaluations for crew members, preflight testing, and other steps that space companies must take before getting their licenses to take passengers where few paying customers have gone before. The first tentative steps are bringing space tourism to the upper atmosphere, and those with enough bucks can become tomorrow's Buck Rogers. Here are some key players in the high-stakes, high-altitude business of space tourism.

Virgin Galactic / Led by British billionaire Richard Branson, Virgin Galactic plans to begin offering suborbital space flight (any craft that reaches 62 miles above sea level) aboard its *SpaceShipTwo* in 2009 for US$200,000 a ticket. Replete with flat-screen TVs and reclining seats, SpaceShipTwo will carry six passengers and two crew members to an altitude of 87 miles. During the flight they will travel at four times the speed of sound, endure up to seven times the force of gravity, and experience an estimated five minutes of weightlessness. ***virgingalactic.com***

Space Adventures / Although putting a paying customer on the moon is out of reach for the time being, Space Adventures already has two passengers with $100 million of spare change willing to take a ride around the moon in a Russian spacecraft. Launch date is TBD. ***spaceadventures.com***

Bigelow Aerospace / Using inflatable, balloonlike modules, Bigelow Aerospace plans to provide a low-cost, low-Earth-orbit space complex that is accessible to the private sector for commercial activities. Though no date is firm, the company has already successfully orbited two technology demonstrators called Genesis I and Genesis II. ***bigelowaerospace.com***

Galactic Suite / Billing itself as "the first space hotel," Galactic Suite promises to deliver 15 sunrises and sunsets in a single day (the craft orbits the Earth 15 times a day) to adventure travelers who are up for the experience. A three-day stay in one of Galactic Suite's "pods" will run you about $4 million. The grand opening of the high ground's first hotel is in 2012. ***galacticsuite.com***

SpaceX / This company has already received $250 million from NASA to develop a low-cost reusable rocket and the Dragon spacecraft that can support up to seven passengers for Earth-orbital missions. The first unmanned space flight of Dragon has been scheduled for fall 2008. ***spacex.com*** —C.B.