

# Jumping-Off

FRANK MORRING, JR./SOUTHAMPTON, PA.

*Sometime in the next year or two, a Virgin Galactic SpaceShipTwo will drop from its unique carrier aircraft, fall to a safe distance and fire up its hybrid rocket engine to take eight humans on a brief excursion beyond the atmosphere. Two of them will be pilots, and the rest will be paying customers.*

*Like the mature commercial satellite industry, the nascent commercial spaceflight industry will rely on the U.S. government as its first and most important customer. Hoping that will change are the dreamers, ideologues and entrepreneurs who are trying to*

*get in on the ground floor of businesses that ultimately will have nothing to do with the ground.*

*Right now, Virgin is on track to be the first purely commercial company to sell rides to space. There is a growing field of businesses lining up behind the spinoff from Richard Branson's Virgin Group that is looking for profits off the planet, many with no government involvement whatsoever.*

*Some of them already have established a toehold in space, and may even be profitable. Others continue to make money on the ground, bending metal on space hardware, building in-*

*frastructure, and preparing would-be space travelers for the day when government takes a step back and really opens the space frontier to private enterprise. Some examples:*

- *In Japan's Kibo pressurized module on the International Space Station (ISS), astronauts are starting to plug in cubesat-level experiments on small payload accommodations developed, built and marketed by a company that did not exist when Kibo was launched in September 2009. The "nanoracks" are so inexpensive that high schools are starting to buy space on them for their students.*

**T**hey tend to whoop once it's over, but going into the centrifuge at the National AeroSpace Training And Research (Nastar) center here in the Philadelphia suburbs, would-be suborbital space travelers usually are a bit subdued. After two days of classroom work, some preparatory "flights" and an unpleasant session in the high-altitude chamber, they have a better understanding of how a real flight—and their bodies' reactions to it—could go wrong.

But once they are done with a state-of-the-art simulation of flight in the Virgin Galactic SpaceShipTwo, a little exhilaration is unavoidable.

Exhilaration is growing across the commercial spaceflight field, as policy changes in Washington and progress on a wide range of commercial-space ventures feed anticipation that the terrestrial economy is about to leap into low Earth orbit. "Excitement" is a political buzzword these days, often overused in some work-a-day speeches written at the White House and NASA. But here in the trenches it is palpable.

So far, more than 240 students have trekked to the nondescript conglomeration of light-industry buildings that includes the Nastar Center. The center is a 2007 spinoff from Environmental Tectonics Corp. (ETC), which builds pressure chambers for a variety of military and medical applications at the same facility.

A painted wooden sign at the entrance to the crowded parking lot shows the promise—and hope—riding on the commercial space industry. It says "Help Wanted," and lists "immediate" employment available for several types of skilled workers.

"Our investment in Nastar Center has been fruitful in several areas," says ETC founder, president and CEO William F. Mitchell of the \$50 million his company has invested in hard-

ware, facilities and technology. "Nastar Center has provided an ideal opportunity to conduct R&D to implement the latest technologies and to robust the training capabilities of ETC's products. [It] has become a world-class commercial research facility. We have done numerous research projects for FAA, NASA, [the U.S. Navy], as well as several internal research projects. Nastar Center has expanded our training capability, first for commercial space-traveler training and then for upset recovery training for commercial aviation."

Nastar is a harbinger of things to come in commercial space. The big money remains focused on launching government cargos and crews to the International Space Station (ISS) on for-hire spacecraft built with at least some private investment. The outlook there remains uncertain, but getting amateurs ready to fly to the edge of space is starting to generate some return on investment.

Most spaceflight students here pay \$6,000 for a three-day class built around the Virgin Galactic simulation. In one classroom Gregory P. Kennedy, a former National Air and Space Museum curator who is the center's director of education services, takes a pair of scientists through some preflight "wellness" training. Andrew J. Dombard and Jon Boley both hope to conduct experiments in space someday, Dombard as a University of Illinois-Chicago researcher and Boley as an "Astronaut4Hire."

Later, each was strapped into Nastar's STS-400 "Phoenix" simulator, which is programmed to replicate for a single occupant the x- and z-axis g-loads that would be experienced on a SpaceShipTwo flight, plus a brief up-tilt to mimic the sensations felt when the rocket engine shuts down and 4-5 min. of near-weightlessness occurs—as it does when a real SpaceShipTwo arcs into space. Computer graphics projected



# Point

NASA-seeded orbital space industry needs time, but suborbital flight is almost ready to go

- In suburban Philadelphia, more than 240 space-bound scientists and would-be space tourists—"spaceflight participants," in the term originally coined for the wealthy few who could afford to pay Russia for Soyuz rides to the ISS—have taken advantage of a \$6,000 short course designed to give them an idea of what to expect on a suborbital flight in space.

- On the desert flats outside Truth or Consequences, N.M., not far from the storied White Sands test range, a new commercial spaceport is taking shape, looking for all the world like a small-town airport with a very long runway.

- In Mojave, Calif., another desert town with a legendary aerospace history, the company that won the Ansari X-Prize by demonstrating that commercial suborbital spaceflight is feasible has just cut the ribbon on the very first "spaceship factory."

- In Europe, Abu Dhabi and other space-conscious sites around the world, entrepreneurs are beginning to look for ways to get involved in the commercial space industry the U.S. is pioneering. Ideas include flights from Arctic Sweden into the bottom edge of the aurora borealis, with an overnight stay in an ice hotel as a wintertime bonus attraction.

Compared with the big bucks NASA is spending to seed a commercial industry that can take cargo and crew to the International Space Station, these beginnings are small and tentative. Once NASA's multibillion-dollar public investment bears fruit with a true, multi-destination commercial industrial complex in orbit, they may even seem quaint—like biplane barnstormers in an era of sleek jetliners. But like those barnstormers, their activities may foreshadow the emergence of a "New Space Economy" that truly does move the terrestrial economy into the heavens.



STS-134 astronauts delivered NanoRacks' commercial hardware to the ISS.

NASA





Altus Space Machines personnel test "sticky boom" technology in Zero-G parabolic flight aircraft.

Origin and Sierra Nevada Corp. in baselining the Russian-powered rocket as the launch vehicle for the human spacecraft they are developing under NASA's Commercial Crew Development effort, which has used Space Act agreements to share the cost of early-stage component and vehicle development (see p. 59).

But while the big boys are banking on government seed money and the promise of big government contracts—NASA is ready to spend \$3.5 billion with Orbital and SpaceX for 20 commercial cargo deliveries to the space station—a gaggle of smaller companies are already at work on

onto the front of the gondola display visuals of the receding WhiteKnightTwo, the climb to space, Earth from above and reentry. "We also have an Atlas V flight profile," says Brienna Henwood, Nastar director of space training and research.

The company's investment in an Atlas V simulation is a bet on orbital commercial spaceflight. Boeing recently joined Blue

spaceflight apps they believe will be pots of gold in the sky. Most of the near-term apps are necessarily based on suborbital spaceflight, but the private sector already is in business on the space station as well.

"In two years, we've designed, developed, launched, operate and market our own facilities on the U.S. National Lab,"

says Jeffrey Manber, managing director of NanoRacks, which sells cubesat-class experiment accommodation and other scientific services on U.S.-controlled ISS facilities. "We're so obsessed with the bottom line, [as] the first generation of commercial providers of goods and services in space, that we watch every penny."

NanoRacks' prices are low enough that a private California high school has paid to send student experiments into space. Other customers include EADS Astrium and Israel's Fisher Institute, which has flown twice and is preparing a third experiment.

"The average price of our contracts is \$35,000-40,000, and our goal is to increase that," says Manber, a 30-year space entre-



Virgin Galactic will fly from Spaceport America, taking shape in the New Mexico desert.

## The Next Step

FRANK MORRING, JR./WASHINGTON

**N**ASA hopes to devote \$1.6 billion in the next two years to commercial crew vehicles able to reach the International Space Station (ISS).

That is extremely encouraging to those who want to see the terrestrial economy move off the planet, but it may not be the only path to commercial orbital transportation.

NASA is building on Space Act agreements under its Commercial

Crew Development (CCDev) seed-money effort to sign cost-plus contracts with at least two companies for end-to-end designs of commercial spacecraft that can get astronauts to the space station and back, including the launch vehicles, capsules or spaceplanes, and operations (AW&ST Sept. 26, p. 40).

That kind of money, which must be provided by a skeptical Congress,

will buy a lot of the work that will be needed before the terrestrial economy soars. Still, even true believers know there can be pitfalls. A strong "if you build it, they will come" mentality persists among New Space visionaries, and there is a lot of frustration among companies that are finding unfortunate similarities—ruthless competition, hidebound government bureaucracy, limited resources—between Old Space and New.

Brett Alexander has been working toward easing government out of human spaceflight since his days as



preneur who started out selling space on Russia's Mir orbital station as CEO of MirCorp.

While the continuous microgravity environment on the space station is attractive to many researchers, not all of them need that much time. Suborbital sounding rockets have long provided an interim stage between drop towers and orbit. Suborbital crewed vehicles like SpaceShipTwo and the XCOR Aerospace Lynx spaceplane may fill another niche on the scale. They allow experimenters to interact with their hardware in microgravity, and the vehicles are reusable, which means experiments can be run, modified and rerun much more quickly than experiments in orbit or on unmanned sounding rockets.

Alan Stern of Southwest Research Institute (SwRI), a former NASA associate administrator for science who is the principal investigator on the New Horizons Pluto probe, was one of the first scientists to see that vehicles built for thrill-seeking space tourists could also be used for research. In February 2010 he helped

**Nastar Center's centrifuge simulates the flight profile of a Virgin Galactic SpaceShipTwo for would-be space tourists and researchers.**

organize a conference for would-be "payload specialists" who have grown into an important market for suborbital-flight providers.

Stern and his colleagues have gone on to procure flights from both Virgin and XCOR, and have trained at the Nastar center. They chose three pre-tested experiments to check out on a suborbital mission—a biomedical harness, a "box-of-rocks" test designed to see how planetary regolith behaves in microgravity, and an ultraviolet imaging endeavor to determine how useful suborbital flight can be for astronomy and upper-atmosphere studies.

With the experience they are gaining, Stern and his fellow suborbital scientists at SwRI hope to hire themselves out to other researchers who may not have the time or inclination to perform their own experiments in suborbital space, or the ability to engineer and build them.

"Some organizations want to build their own experiment, but they don't have a way to fly," Stern says. "Just to be frank,

they have insurance concerns about flying in this early era. They're happy for somebody else to go fly it, but they don't want to [risk] their student or graduate student or professor. Others want to fly their own person, but don't know how to integrate the experiment."

Stern's group has teamed with three flight-services providers as payload integrators under a suborbital flight opportunity program through NASA's Office of the Chief Technologist—Virgin, XCOR and Masten Space Systems. Masten is parlaying vehicles it built for NASA's Centennial Challenges competitions into an unmanned reusable suborbital market niche (*AW&ST* Jan. 4, 2010, p. 46).

The SwRI group already faces competition in the inflight operations arena. A Florida-based non-profit corporation with tax-exempt status has set up as Astronauts4Hire, which plans



NASTAR CENTER

to match researchers needing payload specialists with would-be suborbital scientists like Boley, the Nastar suborbital spaceflight student.

A big hope among new-space advocates is that once there is a low-cost way to get to space—cheaper than on government-owned vehicles at the very least—there will be many new ways to make money there, just as smart-phone technology opened up a profusion of new moneymaking wireless apps.

"If somebody else is developing the spacecraft to get there, and NASA is the anchor tenant and has a lot of the infrastructure and lessons learned from 50 years, then I can come along with an app," says Brett Alexander, until recently the head of the Commercial Spaceflight Federation. "I don't know if that

a space-policy wonk in the FAA's commercial space office under President George H.W. Bush. He sees the path as a middle ground between all-government/all-commercial that takes advantage of both. The CCDev effort may be just what is needed, he says.

"The beauty of the commercial crew program is that it's a partnership between government and industry, where NASA brings 50 years of experience, but the industry side—which is both big industry that has built every U.S. spacecraft ever flown, and entrepreneurial industry—

is able to do things in a more rapid manner, freed from the traditional government contracting and oversight processes," he says.

By all accounts, it will be difficult to close a business case with human flights to the ISS. One company willing to broach it is Boeing, with its seven-seat CST-100 capsule riding on an Atlas V. The relatively simple capsule is being built to run on batteries instead of expensive solar arrays, with a basic life-support system to sustain the crew during a maximum 60-hr. flight.

John Elbon, the new vice presi-

dent and general manager of space exploration for Boeing, says the station-only business model "isn't very exciting, to tell the truth."

The company also has a deal to provide human transport to Bigelow Aerospace, which already has flown prototypes of its inflatable space stations and is waiting for a commercial transport provider to hit its price point (*AW&ST* Feb. 21, p. 35).

"His customers are countries that want their own space program, but can't afford the infrastructure associated with that, Elbon says. ☛



app is taking pictures looking down, or it's taking pictures looking up, or if it's using microgravity for science or manufacturing or whatever. [It could be] taking "people for joy rides or religious experiences. Whatever it is, it comes at a price point and an entry point that is so much lower than it was before, and that is the way of the commercial market."

One app under development is a way for one object in space to grapple another. Altus Space Machines, a five-person start-up based north of Denver, has flown a test version of its "sticky boom" technology on a Zero-G Corp. commercial parabolic flight, and is "bootstrapping" its way toward money making technology, according to Jonathan Goff, president/CEO.

Goff, who put some of the Centennial Challenges winnings from his days with Masten Space Systems toward getting the company started, says the idea is to combine a flexible device that uses electrostatic attraction to grapple a non-cooperative spacecraft with a very long, strong boom for safety.

"We call it a mechanical tractor beam," Goff says. "The idea is being able to reach out with the long, lightweight boom, stick to any surface and be able to controllably pull it in, damp out any relative velocity and things like that. It just opens up such a wide range of capabilities, everything from orbital debris mitigation, sample capture for things like the Mars Sample Return mission, all the way to the main market we're looking at—trying to revolutionize space logistics."

In that concept, a sticky boom mounted on the ISS would pull in just-in-time deliveries sent up by relatively small launch vehicles—including suborbital launchers—to allow station users to get samples or supplies to the station in days rather than the months it takes now. The company is also developing an onboard transponder to guide an upper stage safely toward the ISS.

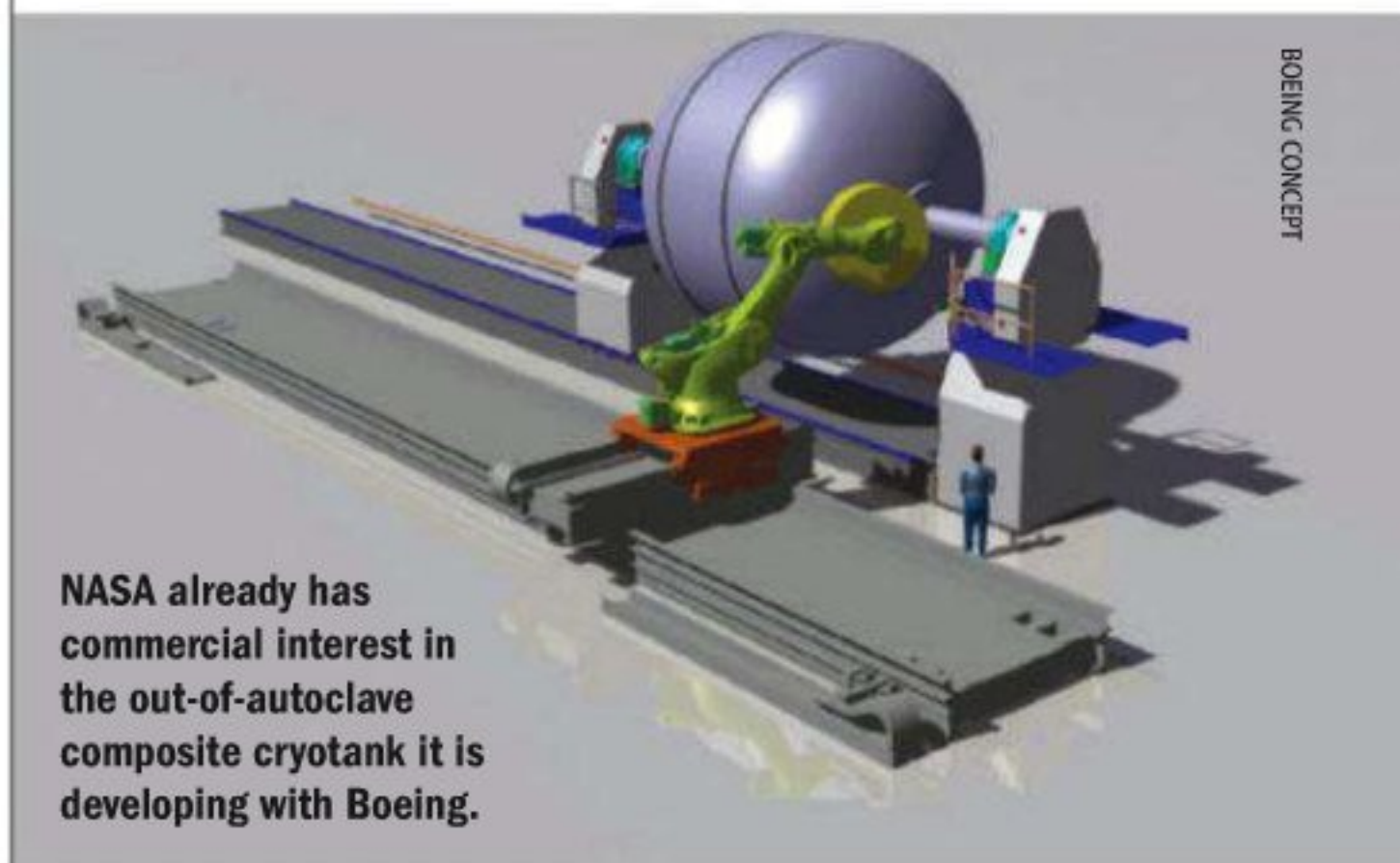
To finance the work, Altus takes on a mix of commercial and government contracts, and has raised about \$60,000 in addition

to the capital Goff brought into the venture. The company is also working with the Space Angels Network, a spinoff of the Space Adventures travel agency that has booked tourist flights to the ISS. The network matches space entrepreneurs with investors who are willing to take the risk in the hope of a big payout.

Recently the network matched LaserMotive Inc. with network member Brad Fleury, director of Edge Consulting, for undisclosed financing to help bring the Kent, Wash., company's expertise in laser-power beaming to market in remotely powered unmanned vehicles and, eventually, space-based apps.

"What we've seen from the Space Angels Network are companies that are trying to take advantage of the infrastructure that's either already there or is going to be there shortly," says Joe Landon, Space Angels managing director.

Like Masten Space Systems, LaserMotive started out as a Centennial Challenges winner, collecting NASA prize money for



BOEING CONCEPT

NASA already has commercial interest in the out-of-autoclave composite cryotank it is developing with Boeing.



XCOR developed a rocket engine for its Lynx spaceplane because no one manufactured one that met its specifications.



powering a simulated space-elevator climber. The agency also is developing generic technology that has commercial potential.

One example is ongoing composite cryotank development work. NASA has awarded Boeing a \$24 million contract to an earlier design effort by building a 10-meter-dia. (32.8-ft.) out-of-autoclave cryotank and testing it at Marshall Space Flight Center. NASA hopes to save 30% on weight and 25% on cost compared with aluminum tanks.

Both are attractive in large launch vehicles and in orbiting fuel depots touted by the Augustine commission on the future of human spaceflight as a possible commercial alternative to heavy-lift launchers. NASA down-selected to Boeing based on Phase 1 work that also included ATK, Lockheed Martin and Northrop Grumman.

"We've talked to almost all of the commercial companies

that are competing for the launch services," says John Vickers, NASA's cryotank demo project manager.

XCOR CEO Jeff Greason sees "a lot of triumphalism" in new-space circles, and says he expects at least some of the suborbital companies to make it. The key to a working new space economy has always been affordable access to space, he says, and the key to that is the reusability that the suborbital systems soon will be offering.

"There's a lot of encouraging, but still-early steps toward getting new kinds of vehicles [into] the marketplace," says Greason, who was a member of the Augustine panel. "Many things are being tried. That's a good thing. They won't all work, and as long as the ones that don't are allowed to fail, and the ones that do are allowed to thrive, this will all work out very well." ☼

## Future Markets

FRANK MORRING, JR./WASHINGTON

**G**eorge Whitesides is a long-time advocate of commercial human spaceflight. He helped shift NASA's post-shuttle policy to reliance on commercial spaceflight as NASA's chief of staff at the beginning of the Obama administration, and he is now working to make his dreams a reality as CEO of Virgin Galactic.

Like his XCOR counterpart Jeff Greason, Whitesides sees his company moving from suborbital spaceflight to orbital some day, as long as the shift is profitable. And just as with \$200,000 suborbital spaceflights, one key to orbital profitability will be the cost savings reusable spacecraft provide. Given the shortage of orbital destinations in the near future (see p. 56), Whitesides and his boss—British tycoon Richard Branson—are looking for a richer field of spacecraft destinations.

"The thing that we're probably most interested in is actually not going to the ISS, but doing point-to-point travel, which is very similar to the orbital problem," he says. "We think the market for that is much bigger, ultimately."

Instead of flying spacecraft to orbit, Virgin might make suborbital hops from the state-owned Spaceport America in the New Mexico desert that it will use initially, to similar facilities around the world.

"[It's not] that interesting to create a capability that exists already . . . and gain some marginal piece of that pie," Whitesides says. "What's interesting is are there any areas where we can have, as I think the company promises to have in space tourism, a transformational impact."

Another "transformational" area where commercial-space visionaries are starting to operate is the Moon. An

Alabama-based entry in the Google Lunar X Prize competition plans to pay for its ride to the Moon by selling piggy-back rides to low Earth orbit and perhaps lunar orbit, using an evolved expendable launch vehicle secondary payload adapter (ESPA) ring to mount paying payloads alongside its planned lunar X Prize rover (AW&ST Oct. 18, 2010, p. 39).

"For the Earth-departure stage we've stretched an ESPA ring; we call it a tug, or whatever you want to call it," says Tim Pickins, chief propulsion engineer and commercial space adviser for Dynetics, a corporate team member on the Rocket City Space Pioneers entry.

Ultimately the Moon could provide a big enough destination to sustain a commercial transportation industry, provided the world's govern-

**Rocket City Space Pioneers hope to fund a lunar landing with this "rideshare" payload that would drop off paying customers en route.**

ments set up an outpost there, according to former NASA Administrator Michael Griffin, who has prepared an analysis of the idea for the International Astronautical Congress in Cape Town, South Africa, this week.

"The ISS market is too limited, but in the absence of

a serious commitment to any credible subsequent effort it is "the only game in town," Griffin writes. "If there is to be a viable commercial spaceflight industry, an anchoring public enterprise of significantly larger scope is necessary. In the author's opinion, development of an international lunar base provides the best near-term option for such a program. To be effective, public policy makers must heed the old investment advice—go big or stay home." ☼

