Private launch plans aim higher

New prizes and the success of SpaceShipOne have boosted hopes for making private spaceflight a commercially viable industry

by **Ben Iannotta**
Contributing writer

Aerospace companies in the U.S. and abroad are competing with fresh vigor to build privately funded space launch vehicles that would be capable of carrying people. Some hope to capitalize on the suborbital tourism market presumably opened by the successful manned flights of Burt Rutan's SpaceShipOne last fall. Customers would pay still-to-be-determined fees to experience weightlessness and glimpse the planet from altitudes over 330,000 ft before returning to Earth. Other companies, however, are working on vastly more powerful vehicles that would launch satellites and cargo to orbit as well as human explorers. These companies expect to serve spacefaring governments as well as wealthy private explorers, should that market develop.

SpaceShipOne's victory in the Ansari X Prize competition has infused both sides of the fledgling industry with not only some new capital but, just as important, a new attitude, company officials say. U.S. regulators are now working with them to find ways of operating private space launch vehicles over U.S. territory without endangering aircraft in the skies or people on the ground.

"There is a new attitude among the agencies. Instead of, 'Let me tell you all the reasons you can't do it,' the attitude is, 'Let's go look at this and see if there's a way to do it,'" says Randy Brinkley, CEO of Kistler Aerospace of Kirkland, Wash. The company has added manned launches as a possible new market for the fully reusable K-1 rocket it is building.

Eyes on more prizes

Some companies plan to keep the momentum going in the suborbital market by participating in a successor to the X Prize competition won by SpaceShipOne. This new effort, called the X Prize Cup, will begin in October with a technology exposition in Las Cruces, N.M. Other companies, including Kistler, plan to reach even higher by competing for a new, $50-million manned space launch award called America's X Prize, underwritten by hotel mogul Robert Bigelow. Although his holdings range from budget hotels to oil refineries, his biggest dreams are

SpaceShipOne's victory in the X Prize competition has generated some new capital for the industry and a new attitude among regulators.

taking shape at Bigelow Aerospace, a company he founded.

Engineers at Bigelow, which has locations in Las Vegas, Washington, D.C., and Houston, are brainstorming an orbiting space hotel that would be made of inflatable modules. For the idea to make sense, Bigelow will need rockets capable of launching guests at least 250 mi. into space. His America's X Prize promises $50 million to the first contestant to launch a crew of five to that altitude, not once but twice, before the contest deadline of January 10, 2010.

SpaceShipOne and the other X Prize contestants were not designed to reach that altitude. Pilot Mike Melvill flew the rocket-powered plane to a height of 63.92 mi. on September 29, 2004, and Brian Binnie followed with a flight to 69.59 mi. on October 4, 2004, to win the X Prize for the team.

Among the companies vying to bridge the gap between manned suborbital flights and flights to orbit are SpaceX of El Segundo, Calif., and Kistler of Kirkland, Wash.

Kistler has emerged from Chapter 11 bankruptcy to restart work in phases on the K-1. The vehicle will resemble an expendable rocket, except that its two stages will be recovered with parachutes and airbags.

Kistler plans to conduct its first launches from Woomera, Australia, and later from the U.S., at a site yet to be determined. U.S. launches would require approval from the FAA, and possibly from NASA and the Air Force, depending on the location. "In terms of being able to launch and recover the K-1 in the United States, [the X Prize] certainly had some positive impact on us," Brinkley says.

Kistler had settled on the Nevada Test Site but, given the new attitude among regulators, is considering other venues, adds Brinkley. Company officials plan to launch the K-1 for the first time from Woomera in early to mid-2007.

Meanwhile, SpaceX, founded by Internet mogul Elon Musk, has an agreement in principle with Bigelow Aerospace to launch a one-third-scale inflatable module to test the feasibility of the space hotel concept. The late-2006 launch would be the first for the company's forthcoming Falcon 5 partially reusable launch vehicle, which might someday vie with the K-1 for unmanned, and eventually manned, launches.

Despite the growing attention on privately funded orbital flight, a handful of X Prize also-rans are continuing to pursue suborbital flight for space tourism. Says Peter Diamandis, president of the X Prize Foundation, "Out of the remaining 25 teams, two-thirds are not doing anything, but eight or 10 are."

One of those is Rocketplane (formerly Pioneer Rocketplane) in Oklahoma City. Its vehicle, called XP Rocketplane, will be built on the fuselage of a Lear 25 passenger plane. New delta-shaped wings and a rocket engine will be installed, says Dave Urie, the firm's vice president and program manager.

Urie says the mood at the company has been upbeat, in part because of the media frenzy surrounding the X Prize.

In addition to ventures such as Rocketplane, cash-strapped smaller companies have not given up on suborbital tourist flights. In the U.K., for instance, former X Prize competitors Steve and Adrienne Bennett of Starchaser Industries in Hyde continue to work on their new 15-ton Churchill Mk 3 engine with funds raised by educational visits to schools. The engine would power their Thunderstar rocket and crew capsule to an altitude of over 62 mi. Bennett says she is talking with officials from New Mexico's Southwest Regional Spaceport about the equipment that would be needed to launch Thunderstar from the site at a date to be determined.

Diamandis envisions the new X Prize Cup evolving into competitions in a variety of categories. "The prizes will allow the teams to continue development of their space ships in different directions," he says. "You'd have one team focusing on how many times a day can you fly? Another team focusing on how high can I get? Another team focusing on what's my cross-range? How far can I travel from one location to another?"

Kistler on the rise

Kistler emerged from bankruptcy on April 29 by giving its unpaid contractors 20% ownership of the company. Executives plan to build two fully reusable vehicles by 2007, although a backup craft is not required for the first flight, says Will Trafton, the company's president and chief operating officer. Once revenues begin rolling in, Kistler will build three more vehicles for a fleet of five K-1s.

Aerojet modified the NK-33 to become the AJ26-58 and a restartable AJ26-59 for Kistler's K-1 rocket.

Work on the program will resume with a "warm restart" that will include completing tests of the rocket's engines, says Brinkley.

"We'll be moving from limited financing to support a warm start, to permanent financing and completion of the first two vehicles. We'll be able to do that all in time to meet the first launch in the first quarter of '07," he says.

The heart of the Kistler K-1 is its engines, which were built more than 30 years ago at Samara State Scientific and Production Enterprise-NK Engines in Russia for the N-1 Moon rocket. The Soviet Union abandoned the N-1 program in 1974 and placed about 100 NK engines in storage. Aerojet of Sacramento later reached an agreement with Samara to acquire some of these. Forty-six arrived at Aerojet in 1997 for use on the K-1.

The engines were imported before enactment of the Iran Nonproliferation Act, which restricts U.S. business dealings with entities in Russia because of that country's relationship with Iran. For this and other reasons, the trade restrictions in the act have not impacted the K-1 program, says Debra Lepore, Kistler's vice president of business development.

Aerojet modified the powerplants to make them reusable and renamed them to emphasize that they are now U.S. engines. The NK-33 became the AJ26-58, and a restartable version became the AJ26-59; the NK-43 became the AJ26-60 (although engineers still sometimes refer to them by their original names). The engine tests will certify the modified versions for use on the K-1, says chief engineer Dick Kohrs.

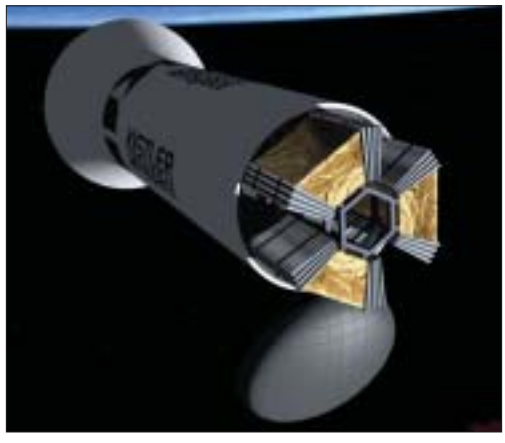
Three NK-43 engines will boost the K-1's first stage, and a single NK-43 will power the upper stage. According to Aerojet, the modified engines have a 99.5% reliability rating and 125:1 thrust-to-weight ratio. New U.S. components include a gimbal system for vehicle steering, a solid propellant gas generator, electrically operated valves, and new main combustion chamber igniters.

The K-1 will measure 36.9 m high when equipped with its extended payload module. The first stage, called the Launch Assist Platform, is 18.3 m high and will generate 4.54 MN (1,020,000 lb) of thrust at liftoff, according to Kistler. The second stage, which includes the extended module, is called the orbital vehicle and measures 18.6 m. In addition to a single NK-43 engine for primary propulsion, it will have a LOX-ethanol-fueled orbital maneuvering system that will perform the critical task of precisely positioning the vehicle for reentry.

Kistler has designed a family of payload modules for the K-1. "What we do is change our payload module with either a standard payload module, an extended payload module, a cargo module—pressurized or unpressurized—or an active dispenser module, whatever we think will meet the needs," Kohrs says. The pressurized module would carry cargo to the International Space Station or to Bigelow's space station.

On each launch, the K-1 will soar to an altitude of 135,000 ft in 121 sec, where the first stage will separate from the orbital vehicle. The center engine of the three AJ26 engines (formerly NK-33s) on the first stage will restart to send the stage on a controlled return trajectory. At 10,000 ft, six parachutes will deploy. Just prior to touchdown, four airbags will inflate to cushion the landing so the first stage can be recovered and readied for its next launch.

In the meantime, the orbital vehicle's single NK-43 engine will have ignited to boost the payload toward orbit. After dispensing a satel-



Kistler plans to build two fully reusable K-1 vehicles by 2007.

Rocketplane engineers would build the XP from the fuselage of a Lear 25 passenger jet.

lite, for example, the orbital vehicle will make a controlled descent, protected by space shuttle-derived thermal tiles and blankets, says Kohrs.

After proving its reliability in a series of unmanned commercial flights, the K-1 then would be adapted to carry people to compete under the Bigelow-sponsored America's X Prize. Though the rocket was not originally conceived to carry people, Brinkley notes that George E. Mueller, the K-1's original vehicle architect, headed NASA's Apollo program through the second Moon landing in 1969. The requirements Mueller set for the K-1 were "very similar to those that would drive the development of a human-rated vehicle," Brinkley says.

"If there is a real market for space tourism and the space hotel, I believe the K-1 is well positioned to be able to compete for transportation to and from the space hotel or any other commercial activity," Brinkley says.

SpaceX: It's all about the engines

The SpaceX Web site notes that most launch failures are caused by three factors, the most common of which is engine trouble. Thus much of the company's work focuses on the Kestrel and Merlin engines it is building for the Falcon 1 and Falcon 5 launch vehicles. SpaceX plans to recover the first stages of its rockets by parachuting them to the ocean after separation. Technicians will recover the engines and attempt to refurbish them.

Kistler is planning to build two reusable engines by 2007, the Kestrel (below) and Merlin (right).

Deciding whether to purchase existing engines or develop their own was an easy one, says Gwynne Shotwell, vice president for business development. They chose to develop new ones, because "if you use heritage components, what inevitably comes with that are the heritage costs," she says.

Reflecting the philosophy that using fewer engines reduces the odds that one of them will be faulty, Falcon 1 will rely on just two. A single Merlin engine delivering 75,000 lb of thrust will power the first stage. The second stage will be boosted by a single Kestrel engine delivering 7,000 lb of thrust, says Shotwell.

Powering the larger Falcon 5 will be five Merlin engines on its first stage and probably a single Merlin on its second stage, though engineers are still considering alternatives. "It looks like we're leaning more toward a Merlin engine for the upper stage for Falcon 5," Shotwell says.

The five-engine configuration is a departure from the philosophy of using as few engines as possible. However, their arrangement will be similar to that of the engines on the Saturn 5 Apollo rocket, to maximize reliability. "The vehicle is capable of sustaining an engine failure at any point in flight and still successfully completing its mission," according to the company Web site.

"The Falcon 5 has about 10 times the [payload] capacity of Falcon 1," Shotwell points out. "That'll cover a lot of missions. GPS missions, for instance, and commercial payloads. That's the more documented market. We're sort of creating the Falcon 1 market," she explains. As for manned flights, "I think the market is much farther out—probably by the end of the decade or beginning of [the] next."

The company's first launch is tentatively scheduled for late this month or, more likely, August. SpaceX must wait for the Air Force's last Titan 4 rocket to clear the launch site at Vandenberg AFB before launching Falcon 1.

The rocket will carry the Defense Dept.'s small Tactical Microsatellite Experiment (TACSat-1). Conceived by DOD's Office of Force Transformation and the Naval Research Laboratory (NRL), TACSat-1 will test the ability of commanders to control imaging satellites from the

After taking off down a runway, the XP pilot will climb to 20,000-25,000 ft, flip a switch to ignite the rocket engine, and pull up the nose to ascend at an angle of 70°.

battlefield, according to an NRL document describing the mission.

Falcon 5's first launch is meant to occur about a year after that of Falcon 1 and will carry a one-third-scale test element for Bigelow's space hotel, Shotwell says.

Rocketplane: Souping up a Learjet

SpaceShipOne was designed to win the X Prize rather than to carry paying passengers. Executives at Rocketplane plan to go straight to their operational vehicle, and for that reason they never expected to win the prize. "We wanted to support the process," says Urie, the company's vice president and program manager. "Scaled Composites' winning it has had an enormous benefit for us in focusing public interest."

In April, Rocketplane's board of directors, including retired Gen. Merrill "Tony" McPeak, former Air Force chief of staff, met at an Oklahoma City hotel and approved the preliminary design for the 43-ft-long suborbital XP.

If the plans hold, engineers will build the XP from the fuselage of a Lear 25 passenger jet. Starting as soon as 2007, two to three passengers will be whisked to a maximum altitude of 330,000 ft inside the Lear's pressurized cabin.

The XP is not unlike that of the Learjet from which the vehicle is derived.

"We're going to remove the tail and cut off the last few frames of the rear fuselage," says Urie. Engineers will install propellant tanks inside the fuselage and graft a single kerosene/liquid oxygen-powered rocket engine onto it. They'll add delta-shaped wings to create what Urie calls a "classical, tailless delta design." Rocketplane officials are in talks with Boeing Rocketdyne to acquire an RS-88 Bantam rocket engine for use on the XP. "We're going to take off the turbo pumps and feed it directly from our pressurized tanks to generate 30,000 lb of thrust," Urie says.

The XP will retain the Lear's two General Electric CJ610 jet engines for low-altitude flight but will replace the aluminum inlets with more heat-tolerant stainless steel.

On each flight, the XP will take off down an old B-52 runway that is soon to become part of the Oklahoma Spaceport. The pilot will climb to an altitude of 20,000-25,000 ft, flip a switch to ignite the rocket engine, and pull up the nose to ascend at an angle of 70°. The climb will impart 3 *g*s of force on the passengers, Urie says.

The engine will shut down 70 sec later at 175,000 ft, and the XP will coast silently to its peak altitude, presumably with thrilled passengers staring out the windows. "We're putting in smaller windows and more of them," says Urie.

The temperatures during the descent at Mach 3.5 will be benign compared to those Urie dealt with as the Lockheed manager for the SR-71 spy plane program, he says. "We'll put on a stainless steel nose cap. We'll make sure the doors are properly sealed, and we'll use a thermal protection paint called PCC, which stands for Protective Ceramic Coating. It's essentially a quartz paint," he says.

✈✈✈

For his part, Diamandis says he intentionally chose an achievable goal for the X Prize as a first step toward human activities well beyond suborbital flight. He predicts the new X Prize Cup and America's Space Prize will draw more sponsors and rich entrepreneurs into the market, giving engineers the real-world experience they will need to make travel to orbit and beyond a commercially viable prospect.

Says Diamandis, "It's just a matter of bridging that gap, and I am sick and tired of waiting for it to happen through government means."