

DREAMS OF THE NEW SPACE RACE

When it was trying to catapult satellites into orbit the private launch business didn't get very far. Can it do better now that it's focused on giving the rich the ride of their life, asks **David Chandler**.

In the 1990s, the 'new space' vision was simple. Constellations of communications satellites in low-Earth orbit would require launch systems that could pop up little replacement satellites easily and cheaply. Small entrepreneurial companies would be able to meet the demand better than conventional launch providers such as Lockheed Martin, Boeing, Arianespace or even the cheaper options from the post-Soviet states. Unfortunately, the vision didn't get very far. The would-be contenders were short of capital, and the technological challenges were greater than appreciated. Worst of all, the vast expected market did not materialize.

In the past couple of years, however, the new-space sector has been booming, thanks to a change in its business model. Private spaceflight has always been a business for dreamers, and now one group of dreamers — the people building the spacecraft — has realized that another, much larger group of dreamers might be willing to pay a lot to ride on those spacecraft even if they can't do useful things such as get into orbit or launch satellites.

A company called Space Adventures, based in Vienna, Virginia, pioneered the marketplace for space tourism. Since 2001, it has sent five private individuals into orbit on Russian

spacecraft, at US\$20 million a trip. Then, in 2004, Scaled Composites of Mojave, California, became the first venture to build and launch a privately funded piloted rocket up to the edge of space. Entrepreneur Richard Branson immediately signed on. Starting in 2009, Virgin Galactic, a US subsidiary of the Virgin Group founded by Branson, plans to offer sub-orbital trips with a three-minute ride in weightlessness and an out-of-this-world view of black skies and curved horizons. At 1% of the fee for flying to the International Space Station, the trips are cheap only in a relative sense — but the number of people with \$200,000 to spend on such an adventure is growing, and the company says that it has taken at least \$25 million in advance bookings.

Dream teams

Numerous companies are now working on similar projects — a big change from the days of satellite dreams (see 'Private spaceflight: the different approaches'). "It's a very different situation now," says former space-shuttle astronaut Jeffrey Hoffman, now a professor

of astronautics at Massachusetts Institute of Technology in Cambridge. Even traditional industry giants, such as Paris-Based Astrium and Northrop Grumman in Los Angeles, California, are joining the game.

But these developments do not mean that the business will be an easy one, or risk free.

"You really have to be able to take a lot of punches before you make it through the door."

— Robert Zubrin

On the morning of 26 July, a loud blast ripped through the Mojave desert in southern California as a routine propellant test at Scaled Composites triggered an explosion. Three people died and three others were injured. But the industry as a whole seems not to have been badly shaken by the accident. For one thing it was not a problem with the spacecraft that Scaled Composites is developing for Virgin — SpaceShipTwo — nor with its engines, but with gas storage. For another, the companies are all working with very different technologies. And for a third, most of the leading companies have relatively few investors to chase away — they tend to be dependent on the interest and investment of a particular multimillionaire or billionaire. As long as a small number of investors keeps the faith, the boom can continue.

ADRIAN DENNIS/AFP/GETTY IMAGES

Scaled Composites has a clear lead over the rest of the competition. No other company has yet managed to emulate the feat with which its SpaceShipOne, a small rocketplane launched from beneath a larger carrier jet, won the \$10 million Ansari X-prize. Scaled Composites is “the main chance here” for succeeding with a passenger-carrying rocket, says Robert Zubrin, an aerospace engineer from Colorado who in the 1990s worked to develop spaceplanes to serve the satellite market. Actually getting a vehicle into space, Zubrin says, “is a very tough thing. You put all this money in, and then something fails for the most trivial reason. You really have to be able to take a lot of punches before you make it through the door.”

Leader of the pack

Scaled Composites has already taken most of those punches — cushioned in no small part by the bankroll of Paul Allen, the co-founder of Microsoft, who paid for most of the \$20-million-plus cost of SpaceShipOne. SpaceShipTwo is meant to extend the success into a business with a small fleet of rocketplanes that can each carry two pilots and six paying customers. Whether that sort of business plan can sustain itself over the long term remains to be seen; the industry, however, is banking on it. Jane Reifert, president of the adventure-travel business Incredible Adventures in Sarasota, Florida, arranges trips for people who want to fly Russian MiG jets or cage-dive among great white sharks. She says that she has a long list of customers willing to pay for suborbital space flights. “People just want to do it,” she says. “They don’t care whether they’re the first or the three-thousand-and-first.”

Incredible Adventures has a contract to sell space rides with Rocketplane Kistler in Oklahoma City, Oklahoma — a company that is happy to make money from suborbital flights, but actually has its eye on getting people all the way to orbit. In this case, though, the people are government employees, not wealthy thrill-seekers. NASA’s space shuttle is set to be retired in 2010, and its replacement — the Ares/Orion system — won’t be ready to carry cargo and astronauts to the International Space Station until at least 2015. For those five years, NASA will have to rely on the Russians for transporting people and the Russians, Europeans and Japanese for transporting cargo. It would like to be able to supplement that capability with launches by private companies.

So the agency has set up a Commercial Orbital Transportation Services (COTS) programme. In the first phase of this programme NASA is providing up to \$500 million in the form of matched funds to private investments in two companies — Rocketplane Kistler and



The Falcon 1 rocket has yet to reach orbit.

Space Exploration Technologies (SpaceX) of El Segundo, California. The idea is to develop systems that can take supplies and, further down the line, crew members to the space station. In a major departure from the way NASA has always done business, the agency is specifying the end result but leaving design choices and related trade-offs to the companies; the companies will end up owning the technology and charging NASA, and others, for their services.

Of the two, SpaceX seems to be the most likely to make it. “Most knowledgeable people think SpaceX has a reasonable chance of success,” says John Logsdon, an expert in space policy at George Washington University in Washington DC. SpaceX was founded in 2002 by Elon Musk, who by the age of 30 had made hundreds of millions of dollars through Internet start ups, most notably PayPal. SpaceX has developed a small, single-engine rocket called Falcon 1, which has so far been launched twice: the first launch, in 2006, careened into the ocean; the second, earlier this year, soared to an altitude of 200 kilometres — well into space — but didn’t make it into orbit. The problem was traced to fuel sloshing in a second-stage tank. But all the most difficult parts of the mission — rocket ignition, liftoff, guidance, second-stage ignition and separation — worked without a hitch.

With the sloshing fixed, SpaceX plans to place a satellite into orbit with its third test flight in early 2008. And by the end of 2008, Musk hopes to launch a nine-engine, 54-metre-

high version that will ultimately be capable of carrying a crew of seven to the space station; on return, the crew capsule would parachute down to the ocean.

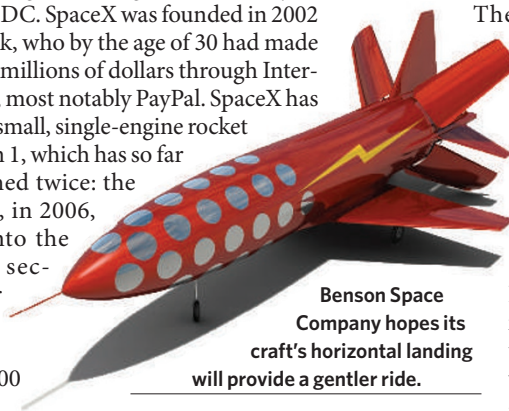
Musk hopes to get into orbit for about a tenth of the \$200 million cost of launching the similar-sized Atlas V, which is sold by a joint venture between Lockheed and Boeing. A key to making things cheaper, says Musk, is optimizing efficiency in every possible way. The Falcon craft has been designed from scratch, and every component — the propulsion, ground operations, electronic systems and overhead — has been streamlined as much as possible. “We’ve made substantial improvements that would be considered breakthroughs in all those areas,” says Musk. “There’s no one thing that is really the fundamental improvement.” To achieve all the cost savings he thinks possible, though, Musk will also need to find ways to reuse the rocket engines by bringing the spent booster stages safely back to Earth.

Off target

Rocketplane Kistler, the other potential COTS beneficiary, also hopes to make things affordable by making its stages fully reusable. Every part, including the crew capsule, is designed to parachute down to dry land for recovery. The struggling company could be at the end of its rope financially, however. It has missed several target dates for securing private financing, and the *Wall Street Journal* reported in late August that the firm had not been able to line up the institutional investors it needed to continue operations.

The company was formed in 2006 through the merger of Kistler Aerospace, which had been developing a two-stage orbital system similar to SpaceX’s, and Rocketplane, which had been working on a suborbital rocketplane similar to Scaled Composites’ K-1 design, a traditional multi-stage rocket not that unlike the SpaceX design, is the work of a space veteran — George Mueller, who was

head of NASA’s Apollo programme in the 1960s and lead designer of the space shuttle in the 1970s. K-1 also uses veteran rocket motors, albeit in a new configuration — Russian NK-33 and NK-43 engines, developed in the 1960s for the Soviet Union’s planned heavy-lift N-1 Moon rocket. The company’s chairman and chief executive officer, George French, disputes reports of its financial woes, telling *Nature*: “We will continue to pour in



Benson Space Company hopes its craft’s horizontal landing will provide a gentler ride.

SPACEX

BENSON SPACE COMPANY

PRIVATE SPACEFLIGHT: THE DIFFERENT APPROACHES

Company	Project	Launch type	Fuel/oxidizer	Seats	Notable for
Armadillo Aerospace	Pixel (prototype)	Vertical take-off and landing	Ethanol/liquid oxygen	2	Entry in NASA Lunar Lander challenge
Blue Origin	New Shepard	Vertical take-off and landing	High-test peroxide	4	Preliminary test flights
Benson Space Company	X-1	Vertical take-off, horizontal landing	Hybrid (rubber/nitrous oxide)	6	Designed to produce lower <i>g</i> -forces than other systems
Interorbital Systems	Neptune	Vertical take-off, straight to orbit	Unspecified hypergolic hydrocarbons	6	Fuel mix does not require ignition system
Rocketplane Kistler	K-1	Vertical take-off, straight to orbit	Kerosene/liquid oxygen	5	Fully reusable orbital system
	XP	Horizontal take-off and landing	Kerosene/liquid oxygen	4	Jet engines for take-off, then rocket to reach space
SpaceX	Falcon/Dragon	Vertical take-off, straight to orbit	Kerosene/liquid oxygen	7	Test flight in March highest ever for private craft
Virgin Galactic/Scaled Composites	SpaceShipTwo	Horizontal take-off and landing	Hybrid (rubber/nitrous oxide)	8	SpaceShipTwo's predecessor, SpaceShipOne, was first civilian spacecraft
EADS Astrium	Astrium spaceplane	Horizontal take-off and landing	Methane/liquid oxygen	5	Jet engines for take-off, then rocket to reach space
Xcor Aerospace	Xerus	Horizontal take-off and landing	Kerosene/liquid oxygen	2	Rocket motors for take-off and to reach space

our blood, sweat and money until the funding is secured.”

Many more companies are working on suborbital approaches. Although most are interested in rocketplanes, two are using an approach familiar to watchers of science-fiction movies but never before used for operational spacecraft: the same engine system for a vertical take-off and a vertical landing.

Straight up and down

Perhaps the most ambitious of these designs comes from Jeff Bezos, founder of Amazon.com and owner of a space company called Blue Origin, based in Kent, Washington. With a personal fortune estimated at more than \$3 billion, Bezos has the resources to develop a serious vehicle, and his company's motto — *gradatim ferociter*, “step by step with spirit” — suggests that he is in for the long haul. So does his choice of a vertical take-off, vertical landing design. Such an approach works best in vehicles with orbital and near-orbital performance, when the ability to slow down with rockets rather than with heat shields could be very handy.

Some clues about Blue Origin's near-term plans can be gleaned from an environmental

impact statement it had to file last year about its plans to launch from Bezos' ranch in west Texas. The company's first cone-shaped craft will be 15 metres high, automatically piloted and carry up to three passengers to heights of more than 100 kilometres. Passengers would experience about three minutes of weightlessness, and return to a landing pad just a few hundred metres from the take-off point. The company has been doing flight tests since November 2006.

Operating on a much less lavish scale, out of a warehouse near Dallas, Texas, Armadillo Aerospace was founded in 2000 by videogame designer John Carmack. Last October, the company — staffed in part by volunteers — fell just short of winning a prize NASA set up to inspire designs the agency hopes to use on the Moon, where vertical take-offs and landings are the only possibilities. The lunar landing challenge promises \$1 million to the first craft that can soar 50 metres high, hover for three minutes, land 100 metres away, and repeat the process in reverse within two and a half hours. Armadillo's small test rocket, named Pixel, has since met the requirements, but not yet under the scrutiny of judges. And, in the second ‘new space’ accident of the year, Armadillo's other vehicle, Texel, crashed and

burned during a test flight on 18 August, taking it out of the competition and leaving its twin without a back-up.

Meanwhile, another company, Benson Space Company in Poway, California, run by businessman Jim Benson, is looking at a hybrid approach — a rocketplane that takes off vertically but glides back horizontally. A survey by Incredible Adventures has shown that most potential passengers would prefer a horizontal landing of this sort, and Benson says that it will provide a gentler ride. Benson's rocket design is powered by a hybrid engine, which combines solid fuel with a liquid oxidizer. That gives it some of the stability of solid rockets, the motors of which can be stored fully fuelled for long periods, but with the controllability of liquid engines, which can be turned on and off during flight. The craft uses six hybrid motors, but needs only three to take off successfully. Parts of the hybrid engine technology developed by SpaceDev — another company founded by Benson — have already been used in SpaceShipOne, although just how much it contributed has been a bone of contention between Benson and Burt Rutan, the fabled aerospace engineer who created SpaceShipOne.

Under pressure

Another company building on previous success with rocket motors to plan a foothold in the spaceplane business is Xcor Aerospace of Mojave, California. Xcor already makes a small profit by selling rocket engines and low-altitude racing rocketplanes to other companies, and was included on *Inc Magazine's* list of the 500 fastest growing companies in the United States this August. It has plans for a simple spaceplane that would use a cluster of four such engines to take off from its runway and ascend to space.

Xcor has avoided finalizing the details of the design or timetable for its Xerus passenger



Recycling: Rocketplane Kistler hopes that its Russian engines will be fully reusable.

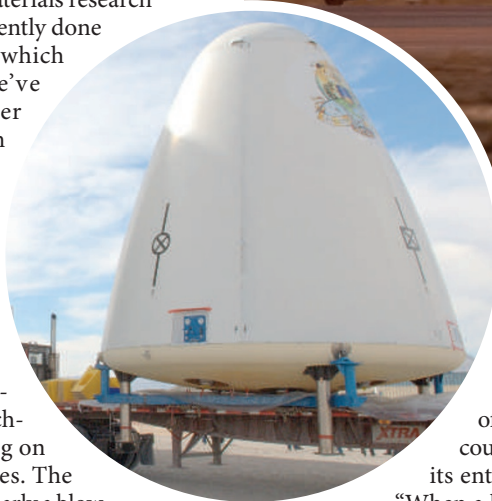
ROCKETPLANE/KISTLER

rocket, but it is expected to be lightweight and small, with room for just one passenger and a pilot. “We don’t want to feel rushed to market by tying ourselves to particular deadlines,” says the company’s president, Jeff Greason. “We never anticipated that we’d be the first to market.” The company is also planning for a suborbital research market, in which their passenger spaceship could be reconfigured as a space laboratory for short-duration scientific research — the kinds of projects in astronomy, environmental monitoring, materials research and so on that are currently done on sounding rockets, which are expensive. “We’ve already got a customer [the Southwest Research Institute in Boulder, Colorado] waiting in the wings that wants more flights than we had thought the entire market would be,” says Greason.

With these rivals at various stages of development, many are watching to see what is going on with Scaled Composites. The explosion in July was clearly a blow, although Rutan has said the company will forge ahead. Investigations into the accident are ongoing, and formal findings have yet to be released. The other major development in the company’s fortunes is a buy-out by aerospace giant Northrop Grumman, which in July bought the 60% of the company that it did not already own. The price has not been disclosed, and the deal is still waiting for regulatory approval. But John Pike, the space and defence analyst who runs Globalsecurity.org, suggests that it might have had less to do with the space-tourism business than with the other projects Scaled Composites works on. The company has several patents and designs, including pilotless aircraft, that Northrop Grumman could benefit from. “It has basically bought a skunk works,” says Pike, referring to the secretive, advanced-design companies pioneered by Lockheed Martin’s famed ‘skunk works’ in California. “That kind of agility is hard to develop, so you buy it.” It’s even conceivable, he speculates, that Northrop could float off the personal spaceflight business as a separate company.

Growth spurt

Rick Tumlinson, cofounder of the Space Frontier Foundation in Nyack, New York, says that the acquisition could signal that traditional businesses are becoming more familiar and



Different directions: unlike SpaceShipOne’s (above, with its carrier) horizontal positioning, New Shepard takes off and lands vertically.

respectful of the fledgling space-tourism industry. But he worries that a full buy-out of Scaled Composites could dampen some of its entrepreneurial spirit. “When a big aerospace company comes in and takes over one of these startups before the frontiers have been opened,” he says, there’s a risk that “the old-school mentality will suffocate [the new industry] even before it gets born.”

Tumlinson and other advocates of a new approach to spaceflight are also concerned about the other big player entering the field: Astrium, part of the European Aeronautic Defense and Space Company. Astrium announced in June that it hopes to raise €1 billion (\$1.3 billion) to develop a rocketplane that would take off and land on a runway. It would use a single vehicle with two propulsion systems, conventional jet engines to take off and climb to the cruising altitude, and a rocket to soar into space. Charles Lurio, an aerospace engineer based in Boston, Massachusetts, and publisher of an insider newsletter on the new-space movement, says the announcement shows that “the field’s become serious enough that even a company such as Astrium feels like it has to offer a competing vision.

Astrium concedes that its plans depend on raising outside funding, hopefully from private loans and regional development funding, but says that it is serious and expects to go ahead. Jeremy Close, the company spokesman, says

that its technology could also be developed into vehicles that could go beyond the space tourism market. “There’s a possibility of point-to-point travel — for example, from Europe to Australia at significantly reduced travel times,” he said.

The extra mile

The fact that supersonic passenger planes never got farther than the massively subsidized Concorde project of the 1960s suggests there might not be much of a civilian market for such things. But if Astrium really does manage to develop such a vehicle, it will probably catch the attention of the armed forces. The US

military, for instance, plans to use scramjet engines, which use jetplane-like intakes to extract oxygen from the air to ignite their fuel, rather than carrying a supply of oxidizer as rockets do. Codenamed Blackswift, the planes being studied would be unmanned

fighter-like craft that can reach any point on Earth within a few hours. Although the technological approach is different, Astrium’s spaceplane, with its similar capabilities, might have military applications.

With so many businesses and technological approaches to achieving similar goals for private spaceflight, many analysts have a positive outlook for the industry. There’s a good chance that the robust competition between these players will help to hone the systems and drive down the costs. And Logsdon adds, “I hope one or more of these folks will succeed. A little competition could be a good thing.” ■

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