SPECIAL REPORT

Science lines up for seat to space

The advent of commercial trips could open up research opportunities.

Earlier this month, when US President Barack Obama cancelled NASA's Constellation programme — a system of rockets and capsules meant to return astronauts to the Moon — he cleared the field for a host of private companies eager to sell seats aboard their space vehicles. And to back it up, he offered a US$6-billion incentive, to be doled out over 5 years, to "spur the development of American commercial human spaceflight vehicles".

Tourists eager for a few minutes at the edge of space and astronauts needing a ride to orbit will be lining up for trips. But so will scientists, who foresee unprecedented opportunities to send up research payloads on anything from a suborbital trip of a few minutes to a sojourn lasting several weeks on a commercial space station. "We have never had a capability like this in 50 years of human space exploration," says planetary scientist Alan Stern of the Southwest Research Institute in Boulder, Colorado. Stern is a former science chief for NASA and is helping to organize the first meeting dedicated to research opportunities in suborbital space, to be held on 18–20 February in Boulder.

Suborbital rockets such as Virgin Galactic's SpaceShipTwo, slated to begin flying possibly by next year, could offer researchers frequent access to space and a few minutes of near-weightlessness, neither of which is in easy reach today (see table). Sounding rockets, which carry research instruments only, are opportunities that cannot be repeated frequently or at short notice, and parabolic flights aboard 'vomit comet' aircraft offer up to only 30 seconds of microgravity conditions.

In time, commercial carriers might give scientists and their projects cheaper and more reliable access to orbit than the ageing space shuttle can offer. They could also provide a better platform for experiments than the International Space Station (ISS), where astronauts had little time to attend to experiments after crew numbers temporarily fell from six to three for several years after the Columbia space-shuttle disaster in 2003. "You can't do good science when you're focusing on keeping the ISS from falling out of the sky," says Mike Gold, director of operations at the Washington DC office of Bigelow Aerospace of Las Vegas, Nevada, which aims to build a commercial space station.

Stern argues that science will turn out to be a bigger customer for commercial spaceflight than tourism. "Tourists will typically fly once or twice — they're going to buy tickets in small numbers. But when governments or industry buy tickets they will buy them by the dozens or hundreds," he says. "The prices are now down in the range of single-investigator grants." Seats aboard SpaceShipTwo go for $200,000.

> **"We have never had a capability like this in 50 years of human space exploration."**

But in the long run, the success of tourism will determine whether scientists can buy access to space on commercial flights, says Carissa Bryce Christensen, co-founder of the Tauri Group, a defence and space consultancy in Alexandria, Virginia. The notion of researchers banding together to buy a flight on a platform such as SpaceShipTwo "hinges on a huge 'if'," she says — that is, "if there are going to be routine tourism flights". Market projections are optimistic, she says, and individual investors such as Virgin Galactic's Richard Branson and Elon Musk of SpaceX, in Hawthorne, California, remain the main source of funding.

Some companies, such as Masten Space Systems in Mojave, California, are eschewing tourism and targeting the research and education market from the start. Masten plans to launch an unmanned vertical-take-off vehicle that can travel 120 kilometres into space, providing up to 1 minute 20 seconds of microgravity time. Late last year its technology passed a major test when a spacecraft took off, ascended 50 metres and landed to win a $1-million prize sponsored by Northrup Grumman. Masten promises that it will fly any payload "into space and back for $250 per kilogram", starting in 2011.

Part of the draw of such suborbital flights is the ability to regularly sample a relatively poorly studied part of the atmosphere where key processes take place, including the seeding of high-altitude clouds by meteor debris. David Siskind, an atmospheric scientist at the Naval Research Laboratory in Washington DC, says that any access to these altitudes would be an enormous boon. Sounding rockets sample only every 6 months or so; more regular flights would allow researchers to monitor changes much more frequently.

Up and away

Getting above Earth's atmosphere could also benefit astronomers. Luke Sollitt, a physicist at The Citadel, a military college in Charleston, South Carolina, is interested in flying a commercially available telescope on a suborbital trip such as that offered by Virgin Galactic. In those 4 minutes at the edge of space, he says, scientists could take spectroscopic measurements of stars without interference from the water in Earth's atmosphere, or position themselves to observe objects such as asteroids and comets that are too close to the Sun for other space telescopes to observe safely.

Materials scientists and medical researchers interested in the effects of microgravity might like tickets, too. Aboard the space shuttle, says Mark Shelhamer, a microgravity researcher at the Johns Hopkins University in Baltimore, Maryland, "you're lucky if you get eight to ten subjects over five years, and each of those data points is really expensive". But with commercial access to space and more frequent flights, "now you're talking real statistics". Experiencing 5 minutes of microgravity aboard a rocket such as SpaceShipTwo is "not great", he says, "but it is a lot better than 25 seconds" on a vomit comet.

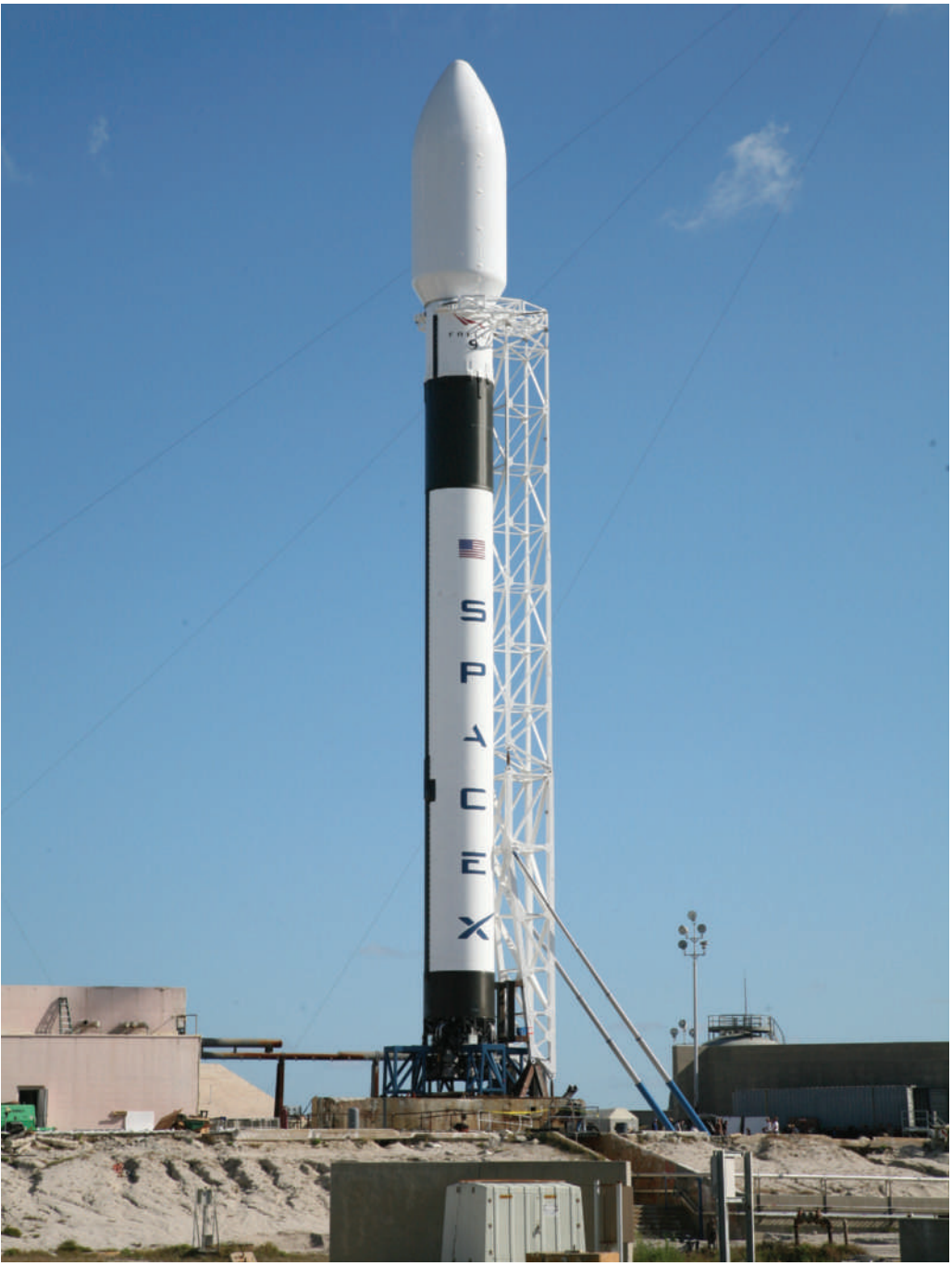
Laurence Young, a biologist at the Massachusetts Institute of Technology in

WEIGHING UP THE OPTIONS

	Commercial suborbital	Sounding rockets	Parabolic aeroplane flights
Cost	$200,000 per seat	$500,000–$1.2 million per flight	$8,000 per seat
Time in microgravity (continuous)	4 minutes	20 minutes	Up to 30 seconds
Launch frequency	Multiple flights per day possible	Once every six months	Multiple flights per day possible
Altitude	100 kilometres	50–1,500 kilometres	10 kilometres
Maximum *g* force	2–4*g*	20*g*	2–4*g*

MORALS DON'T COME FROM GOD
Study shows religion scarcely influences moral intuition.
go.nature.com/FIpnkJ

MICHELANGELO BUONARROTI/TOMISTI



SPACEX

The Falcon 9 rocket could be the first to launch commercial orbital flights.

Cambridge, says that a few minutes is sufficient to monitor the human body's response to changes in gravity, and the transition from microgravity to zero gravity. And John Pojman, a polymer scientist at Louisiana State University in Baton Rouge, says that "3 minutes is long enough" to conduct his experiments on how microgravity affects liquids that mix together on Earth.

On more ambitious trips, all the way to orbit, at least one company is hoping to turn its tourist customers into amateur scientists, doing experiments for researchers on the ground. Excalibur Almaz, based in the Isle of Man, UK, aims to offer week-long experiences in space in a refurbished Almaz vehicle from Russia, for $35 million a seat by 2013. "We would anticipate that folks up there will want something to do," says the company's executive vice-president, former NASA astronaut Leroy Chiao. Excalibur Almaz is also talking about carrying payloads for researchers and possibly even funding the development of experiments.

Bigelow Aerospace already has two inflatable test platforms in orbit, and hopes to build an inflatable space station. SpaceX is developing DragonLab, an unmanned reusable vehicle for experiments slated to be ready by early next year. "Some markets and experiments don't lend themselves to the space station, especially if there are safety concerns," explains Max Vozoff, SpaceX's senior mission manager.

Go for launch

Research platforms in orbit will be of no use, however, unless commercial space companies can develop a reliable way to get there, a much taller order than for suborbital flight. Hopes for orbital transportation are pinned on Falcon 9, a launch rocket being developed by SpaceX. NASA has signed a deal with SpaceX to use Falcon 9 to service the ISS once the shuttle retires next year, and its first test is scheduled for the next few months. Bigelow is also looking at how to transport passengers. Together with Boeing Aerospace, it received $18 million of a $50 million NASA fund, announced on 1 February, to develop crew-carrying technologies.

Researchers who wish to send their experiments on such flights might also start branching out from the traditional sources of space funding, such as NASA, and instead apply for other basic funding.

In Europe, researchers might be able to escape the European Space Agency's mission structure and instead apply for funding through the seventh and eighth Framework programmes for research, says Jeremy Curtis from the British National Space Centre in Swindon.

In the United States, NASA has an initiative, started by Stern in 2007, called the Commercial Re-usable Suborbital Research Program. Still in its preliminary stages, it aims to start a dialogue between NASA and commercial providers, and between scientists and companies. It recently called for information about possibilities for suborbital experiments. Other funding could potentially come directly from the National Science Foundation or the National Institutes of Health.

Wherever the money comes from, many researchers are looking forward to where the new world of commercial spaceflight might take them. Time will tell which of the companies survive, but, says Gold, "the advancement of commercial spaceflight is crucial for scientists". ■

Katharine Sanderson

See Editorial, page 709.