

**Commercial space flight****Starship enterprise: the next generation**

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**A fleet of privately financed spaceships is emerging. It heralds a new business in space travel**

Virgin Galactic



THE way Will Whitehorn tells it, the story began in 2003 in Mojave, California, on a visit to Scaled Composites, a company with a reputation for designing and building futuristic and sometimes wacky-looking aircraft. Mr Whitehorn is one of the top brass in Sir Richard Branson's Virgin Group; and Virgin Atlantic, Sir Richard's airline, was sponsoring *Global Flyer*, a Scaled Composites creation, on a non-stop voyage around the world. On his way out of the factory Mr Whitehorn saw something unusual and asked what it was. Burt Rutan, head of Scaled Composites, told him it was a spaceship. He was building it for another customer, but he couldn't say any more.

Mr Rutan's customer turned out to be Paul Allen, one of the founders of Microsoft. When *SpaceShipOne*, as the craft was called, reached space for the second time, on October 4th 2004, it won the \$10m Ansari X Prize. The craft was taken to high altitude by *White Knight*, a more-or-less conventional aircraft, and then dropped, whereupon its engines ignited to shoot it 100km (60 miles) above the planet, and thus officially into space. After a short flight it re-entered the Earth's atmosphere and

glided down to land on a conventional runway. Manned space travel thus moved from the realm of governments to private enterprise.

However, Mr Allen was interested only in proving that the spaceship technology would work, not in exploiting it commercially himself. That left Mr Rutan with a very cool spaceship on his hands, but no way of making money from it. Mr Whitehorn and Sir Richard were intrigued. Virgin Galactic, a company in the Virgin stable and which was headed by Mr Whitehorn, decided to license the technology for *SpaceShipOne* and *White Knight*. Virgin Galactic said it wanted to offer commercial sub-orbital flights to paying passengers by the end of the decade.

Virgin Galactic has since accumulated a number of commercial rivals in the space-tourism market. One of them is Jeff Bezos, the founder of Amazon.com, who is building a competing sub-orbital spaceship at a ranch in Texas. His space company, Blue Origin, is so secretive that it will not even answer questions about its logo.

But Virgin Galactic has passed an important milestone. At an event held at the American Museum of Natural History in New York, on January 23rd, the company unveiled the design of its new generation of vehicles, and said that the first examples had almost been finished at Mr Rutan's factory. *White Knight Two* is due to begin test flights towards the middle of 2008, but may roll out of the hangar in the next few weeks. Test flights of *SpaceShipTwo* itself could start towards the end of the year.

## **Fly me to the moon**

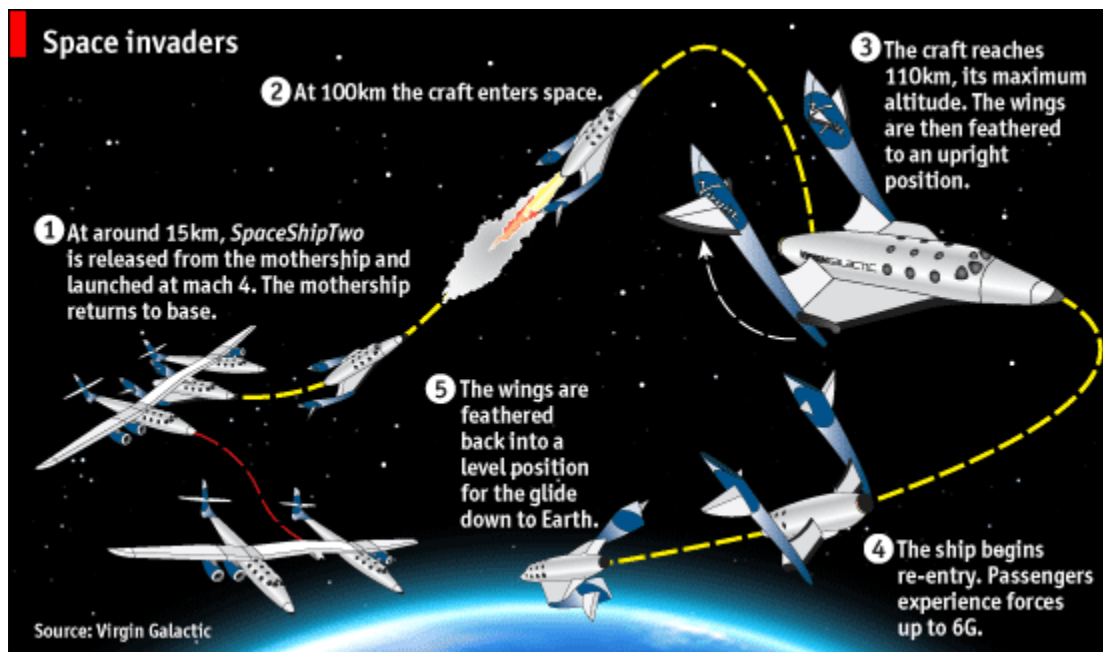
The combination of a carrier aircraft and a spaceship to get into space is akin to building a two-stage rocket. Air-launched rockets have a long history. *SpaceShipOne* and *White Knight* were, in essence, vastly improved and much cheaper versions of the X-15 rocket plane that set speed and altitude records in the early 1960s and the B-52 bomber that carried the rocket plane under its wing. But pure rockets, such as the ones that lift the space shuttle, won out because the Space Race between America and Russia emphasised speed over cost, and rockets were proven technology, having already been developed as intercontinental ballistic missiles. However, they consume a huge amount of power as they claw their way up through the Earth's thick atmosphere. By contrast a rocket lifted by a plane with wings before being launched can be made much smaller and lighter. The plane itself is light because its engines breathe air. It thus needs to carry less fuel than a rocket, and no chemical oxidant to burn that fuel, as a rocket would. Each craft—plane and rocket—can therefore be optimised for its own job, which is easier than designing a single vehicle that has to make lots of compromises to do both.

## **Lifting more**

Virgin Galactic's second generation of craft are based on *SpaceShipOne* and *White Knight*, but with plenty of differences. *White Knight Two* has been redesigned wholesale to lift a much larger spaceship with eight people on board instead of three. It has a wingspan equivalent to that of a Boeing 757, is three times larger than its predecessor and is the largest aircraft made entirely from composite materials like

carbon fibre. It is powered by four Pratt & Whitney engines. With its twin boom and long wing, it looks more like the *Global Flyer* than its predecessor. It has also been engineered to be able to treat any passengers it carries to zero-gravity swoops on the way down after they have watched the spaceship being released for its trip into space.

*SpaceShipTwo* itself will accommodate two pilots at the front and also six passengers, who will have room enough to bounce around in zero gravity. It has more of a dolphin-like nose than its prototype and more windows. It will also go a little higher than its predecessor, so that its passengers will experience five minutes or so of weightlessness before flying back to receive their astronauts' wings. But, crucially, it has the same flip-up wings. These are used when the craft reconfigures itself for re-entry into the Earth's atmosphere. The wings rotate through 90° to give it extremely high drag, which allows it to begin its slow deceleration through the atmosphere earlier and at higher altitudes than previous spaceflight re-entries.



The spaceship will be fuelled by a “hybrid rocket”—so-called because it contains both liquid and solid propellants. These rockets can be cheaper to develop and operate, and the fuel is safer to store than in purely liquid-fuelled ones. *SpaceShipOne* used rubber and laughing gas. Scaled Composites is studying alternatives to rubber that may offer better performance.

Another change in the design of the spaceship is the insertion of a flexible glass-fibre section into its composite structure. This will allow the rocket's oxidiser tank to expand when it is full. All these changes mean that when *SpaceShipTwo* does begin flight tests, the programme will last at least a year before paying customers can take to the skies.

Work will also begin soon on fitting out another factory to start making more of these craft. Virgin Galactic has ordered five spaceships and two carrier aircraft. The spaceships will take longer to refuel for their next flight than the carrier aircraft do, so—thinking just as an airline would—the firm has concluded it needs more spaceships than carriers. Each spaceship should eventually be capable of making two trips into space every day, and the launch aircraft three or four flights. Mr Rutan says they could operate from a number of airports and spaceports around the world.

Virgin Galactic believes the fleet it has ordered should be large enough to furnish its space-tourism business in the early years. Trips are expected to cost some \$200,000 each to start with. Hundreds of people have put down a total of \$30m in deposits. However, as the firm also made clear at the announcement in New York, the new craft may one day do a lot more than ferry day-trippers to the edge of space and back. Stephen Attenborough, Virgin Galactic's commercial director, says the spaceship is revolutionary because it is able to take not just people into space, but other payloads too.

## **Up, up and away**

What those other things will be is still unclear, but satellites are a possibility. Virgin Galactic says it thinks it could launch small satellites in the range of 50-100kg into low-Earth orbit using an unmanned rocket hung from *White Knight Two* for less than \$2.5m. The market for launching small satellites is presently only partly served by the Pegasus rocket, which is launched at high altitude by a commercial jet aircraft. But a launch using Pegasus would cost many times the price that Virgin is talking about. If costs are brought low enough it could make even tiny satellites financially viable. These could be sent up by all sorts of organisations, including universities for research projects.

An air launch is constrained by the weight the carrier aircraft can lift, so big rockets blasting off from the ground will, for the time being, remain the only way to get the heaviest payloads into space. It is possible for small satellites to hitch a ride along with big payloads, but that can be difficult to arrange and is much more restrictive than having a dedicated low-cost launch vehicle like *White Knight Two*. Virgin Galactic is already having discussions with a company interested in creating a rocket that would launch satellites from *White Knight Two*.

Launching at high altitude has many advantages for space tourists and commercial loads alike. Using an aircraft to take up a rocket can avoid the numerous weather-induced delays—and costs—that get in the way of rockets fired from the ground. Aircraft can climb above bad weather to a more suitable launch position. Nor do they need specially built, reinforced launch pads. Any suitable runway will do.

In addition, an air launch promises a lot more scope to find a good “launch window” to get the spacecraft into orbit. Launching from the ground can mean waiting for the Earth to rotate until the launch window is accessible. But an aeroplane carrying a rocket can fly to the window instead.

Air launches are also a greener way of getting into space, because they avoid igniting rockets in the lower atmosphere. Earlier this month Virgin Atlantic said it

would fly one of its Boeing 747s using biofuel during a demonstration flight in February. Mr Attenborough says this has "implications" for *White Knight Two*, which indicates that the company is also looking at greener fuels for the carrier aircraft.

## **Who knows if the moon's a balloon?**

In the longer term Virgin Galactic's system could also be used to launch hypersonic vehicles, which could dash from one side of the world to the other in a few hours. In 2005 and 2006 *White Knight* test-launched the American government's experimental X-37 hypersonic plane. America's space agency, NASA, has signed an agreement with Virgin that covers co-operation on the planes. The company is also said to be discussing a third, more powerful generation of spaceships, designed to make longer sub-orbital journeys rather than just poking their noses into space in the way that *White Knight Two* will.

Mr Whitehorn and Mr Rutan have made no secret of their desire to see later generations of carrier aircraft and rocketry that can put people into orbit. Some within the industry are sceptical that Mr Rutan can develop such vehicles, which will have to travel many times faster than a sub-orbital plane and must have tougher heat-shielding in order to survive harsher re-entry. Nevertheless, business is taking an increasing interest in the possibilities and last year Northrop Grumman, a big aerospace and defence contractor, increased its 40% stake in Scaled Composites to 100%. Mr Rutan expects Scaled Composites to build 40-50 launch aircraft. He thinks that at least 15 will be used for space tourism, with the rest used for satellites and other payloads.

As the new generation of craft emerges, so will new ideas about their capabilities and potential. With some \$70m already spent and another \$130m still to come, Mr Attenborough says that Virgin Galactic expects to break even in 2014. Reducing the price of a trip into space to attract more customers is also part of the plan, as is exploiting every possible form of additional income, such as selling media rights.

Finding new markets for its carrier ship will help Virgin Galactic make money faster. Mr Whitehorn believes that wider use of the vehicle will ultimately come with lifting payloads and satellites into space. Although the customers for such launches are not yet putting down their deposits, the progress to commercial space flight—complete with a business plan and a profit goal—is nonetheless remarkable. There are surely easier and safer ways for businessmen like Sir Richard, Mr Bezos and others to make money. Then again, commercialising space is a venture for the unconventional.