Private spaceflight

Rocket renaissance

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The era of private spaceflight is about to dawn

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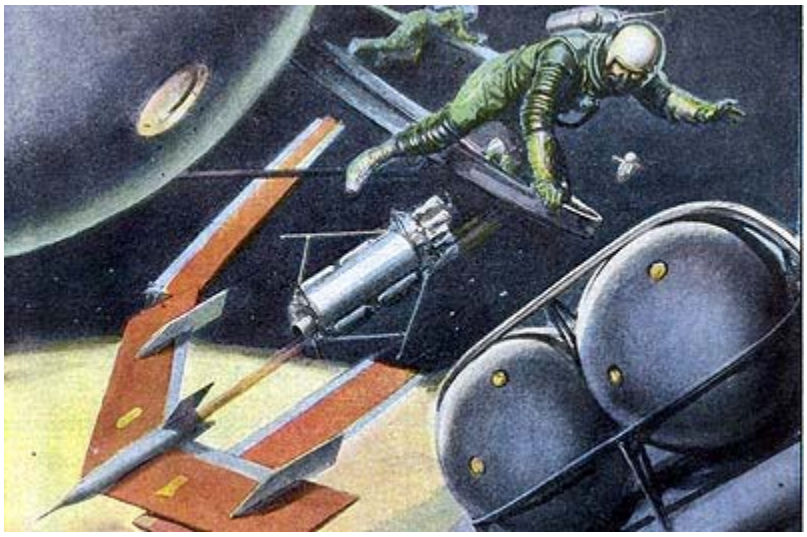

TWO years ago next month space travel underwent its Wright-brothers moment with the first flight of *SpaceShipOne*. The roles of Orville and Wilbur were played by Burt Rutan, who designed the craft, and Mike Melvill, who flew it—although they were ably assisted by Paul Allen, one of the founders of Microsoft, who paid for it. Of course, history never repeats itself exactly. Unlike the brothers Wright, who were heirs to a series of heroic failures when it came to powered heavier-than-air flight, Messrs Rutan and Melvill knew that manned spaceflight was possible. What they

showed was that it is not just a game for governments. Private individuals can play, too.

Now, lots of people want to join in, and most of them have just met up at the International Space Development Conference in Los Angeles, to engage in that mixture of camaraderie and competition that characterises the beginnings of a new technology. And, as might be expected, they are brimming with two of the necessary ingredients of success: ideas and money.

First, the money. So far, more than $1 billion is known to have been committed to building private spaceships and the infrastructure to support them. For example, Mr Rutan's follow-up vehicle, *SpaceShipTwo*, is expected to cost its backers, Virgin Galactic, $240m for a fleet of five. The spaceport in New Mexico from which these are intended to fly will account for another $225m, although New Mexico's government is planning to raise this money itself.

These are not small sums, of course. On the other hand, Virgin Galactic has already banked $14m of deposits towards the $200,000 fare from people who want to travel on *SpaceShipTwo*, even though it has yet to be built, let alone flown.

All this suggests that spaceflight, if not exactly entering the age of the common man, is at least entering the age of the moderately prosperous enthusiast. For entrepreneurs, it is no longer necessary to have billions of dollars to get into space; millions will now do. And for those who merely wish to travel there, and have a few hundred thousand in the bank, reality beckons—provided that at least one of the ideas actually works.

Chocks away

As with aircraft a century ago, a plethora of designs are competing with each other, and there is no certainty about which will prevail. The initial goal is to build a "suborbital" vehicle. This will not have to develop the tremendous speed needed to go into orbit around the Earth. Instead, it will travel briefly into space, offering a short thrilling ride out of the atmosphere, a few minutes of weightlessness, and a spectacular view of the planet from about 100km. Four important criteria are how you take off, what fuel you use, what your craft is made of, and how you come back.

Most people's vision of a rocket launch is straight up from the ground. But, of the five vehicles most likely to be developed (see table), two will actually be launched from the air. *SpaceShipTwo* will be carried to high altitude by a purpose-built aircraft known as *Eve* before its rocket motor is ignited. And *Explorer*, a vehicle being designed by Space Adventures, will be launched from the top of a high-altitude Russian research plane called the M-55X, according to Eric Anderson, the firm's president and chief executive.

As Dennis Jenkins, a consultant engineer at NASA, America's space agency, points out, this is similar to using a two-stage rocket to get into space, with the aircraft acting as the first stage. However, a plane offers several advantages over a throw-away booster rocket. First, it can be used again. Second, it uses oxygen from the air, rather than having to carry its own oxidant, which saves weight. Third, it is lifted by

wings. That means the atmosphere is an advantage, rather than a hindrance. All this means that the spacecraft itself can be lighter and cheaper.

Not everyone wants to run two vehicles, though. Jeff Greason, president of XCOR Aerospace, a firm based in Mojave, California, is developing a two-person, ground-launched suborbital rocketplane called *Xerus*. Launching from the ground, says Mr Greason, is more difficult than air launching, but he reckons that in this case it has significantly lower operating costs.

AFP

SpaceShipOne leads the way

The second important design choice is the type of fuel. Unlike a jet engine, a rocket carries its own oxidant. This is why it can operate in space. Sometimes that oxidant is oxygen itself, in liquid form. In that case the fuel, too, is usually liquid—either kerosene or liquid hydrogen—and the two liquids are stored in separate tanks until they meet in the rocket's combustion chamber. Alternatively, both fuel and oxidant are solid, and are loaded pre-mixed, like the propellant of a firework rocket.

SpaceShipTwo, though, follows the design of *SpaceShipOne* and is powered by a hybrid of the two. The combustion chamber of a hybrid is partly filled with solid fuel but no oxidant. However, the fuel is coated round the inside of the chamber, leaving a hole through the middle into which a liquid or gaseous oxidant can be pumped, and out of which the exhaust emerges. In *SpaceShipOne*, the fuel was rubber and the oxidant a liquefied gas called nitrous oxide.

Proponents of hybrids say they are safer than either pure solid or pure liquid rockets. George Whittinghill, Virgin Galactic's chief technologist, says that they are safer than solid rockets because the flow of oxidant can be controlled, and combustion halted, if there is a problem. Solid rockets, like the fireworks they resemble, cannot be stopped until they run out of fuel. On the other hand liquid-fuelled engines, though they can be shut down, are complex and temperamental. As Mr Whittinghill observes, "they have pumps, seals, valves and lines everywhere, and there is a lot that potentially could go wrong."

All this rather irks those working on liquid propulsion. Richard Pournelle, head of investor relations at XCOR Aerospace, says the comparison is unfair. Liquid propulsion is routine in rocketry while hybrids are still rare. Numbers alone,

therefore, mean that liquid-fuelled rockets blow up more often. That, Mr Pournelle argues, does not prove that they are inherently unsafe. Chuck Lauer, vice-president of business development for Rocketplane, another firm going down the liquid-fuelled route, agrees and argues that kerosene is widely used as aviation fuel and nobody complains that it is unsafe.

Product launches

Leading private manned spaceships

Name	Status	Finance	Seats	Launch method	Propellant
SpaceShipOne	Completed	Paul Allen	3	Air	Hybrid
SpaceShipTwo	In development	Virgin Galactic	8	Air	Hybrid
Rocketplane XP	In development	Private/state	4	Ground	Liquid
Xerus	In development	Private investors	2	Ground	Liquid
Explorer	Design	Ansari family	6	Air	*
New Shepard	In development	Jeff Bezos	*	Ground (VTOL)†	Liquid

Source: *The Economist*

*Not known †Vertical take-off and landing

Nor is safety the only issue. For, while hybrids may be cheaper to develop, they are more expensive to run. That is because they need to have new fuel-lined combustion chambers fitted after each flight. By contrast, liquid refuelling is so easy that XCOR plans that its ships will make four trips a day. In addition, according to Mr Pournelle, rubber fuel is five times more expensive than the kerosene that it and Rocketplane plan to use. Liquid fuel is also more powerful and burns more evenly.

As to what the craft are made of, composites have been the most popular choice, because they are light, strong, easy to work with and able to cope with the heat of re-entry. One notable exception, though, is Rocketplane's entry, the XP, which is an extensively converted Learjet.

At first sight, the notion of converting an executive jet into a spaceship might seem rather dangerous. However, as Mr Lauer explains, there is very little left of the original aircraft except the fuselage. "Starting with the existing Lear gave us a frame of reference to be able to build from and saved us a year in terms of schedule," he says. The craft has a new delta wing and a new v-tail. Wind-tunnel studies show it has "natural stability" on re-entering the atmosphere, according to Mr Lauer.

Which leads to the fourth crucial design feature: a safe landing. *SpaceShipOne* solved the problem of stability on re-entry by flipping its wings in half. Mr Lauer claims the XP's natural stability, means it has no need for such reconfiguration—though some of his critics are sceptical about this. Finally, the XP's wings, tail and nose cap are made of titanium, a heat-resistant metal, and the rest of the structure is covered with a thermal-protective paint to enable the aluminium it is made of to cope with high temperatures. The next step, says Mr Lauer, is to test the XP to destruction—to find out how and when it fails.

That leaves Blue Origin, a firm backed by Jeff Bezos, the founder of Amazon.com. Unlike everybody else's crafts, Blue Origin's *New Shepard* spaceship is designed for vertical take-off and landing (VTOL). And that is weird.

To infinity and beyond

Like the other craft under development, *New Shepard* is, according to its backers, intended for suborbital flights. However, if this is really all that Mr Bezos is interested in, a VTOL vehicle is about the most difficult way of going about it.

One way of explaining this curious design choice would be if Mr Bezos ultimately intended to produce an orbital vehicle. He wouldn't be alone. Elon Musk, a co-founder of PayPal, is hoping to do the same thing by first creating a satellite-launching business around a new, unmanned rocket, the *Falcon*. And Armadillo Aerospace, based in Mesquite, Texas, and backed by John Carmack, a rich game-designer, is tinkering with a VTOL suborbital vehicle design in the hope of building an orbital vehicle one day.

These VTOL suborbital designs might reap some monetary benefits sooner than their backers had thought. This week, while researchers were bemoaning the forthcoming slashing of NASA's scientific budget in favour of the agency's manned programme, yet more riches were coming forth for human spaceflight. A prize of $2m was announced for NASA's Lunar Lander Analogue Challenge. It will go to a vehicle with the energy and accuracy (though obviously not the overall spaceworthiness) needed to land on the surface of the moon. This will need a VTOL spaceship, which can take off, hover and land on a rocky site.

The first competition for this prize will be held in Las Cruces, New Mexico, in October this year during an event called the X-Prize cup. This is a series of about 30 rocket races that will be held on a three-dimensional track in the sky—like Formula 1 racing on steroids. It is the brainchild of Peter Diamandis, the founder of the X-Prize, a $10m purse won by *SpaceShipOne* as the first reusable suborbital vehicle. Mr Diamandis's long-term goal is for his rocket racers to race right into space. On the way to this goal, he hopes that this annual event—like the Formula 1 races which inspired it—will make a great deal of money.

He also reckons that a “Darwinian explosion” of suborbital designs is emerging. Each design, it seems, has its own merits. Several are expected to start test flights soon. Which will be first to market is unclear. Some may run out of funding. But with spaceships now costing less than a Formula 1 racing car, and having the interest of a variety of deep-pocketed investors, it shouldn't take that long.