

FOCUS

GUEST EDITED BY
Richard Branson

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WHAT TO PACK
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James Dyson
Father of the cyclonic vacuum, the Airblade and now the Air Multiplier, Sir James helps judge the Focus awards for the best inventions of 2009 – see p26.

Julia Tizard
With a PhD in cosmochemistry, Julia is no stranger to space. She's now Operations Lead for Virgin Galactic and explains how you can fly in space on p47.

Fred Pearce
An award-winning environment writer, Fred's books include *Confessions of an Eco Sinner*. On p54, he presents the ultimate guide to climate change.

Elon Musk
Founder of PayPal and Tesla Motors, Elon has a habit of setting up good things. On p50, he tells how he started private space-launch company SpaceX.

Burt Rutan
Burt is the maverick US aerospace engineer who built Virgin Galactic's space fleet. He tells of his dreams for orbital tourism on p44.

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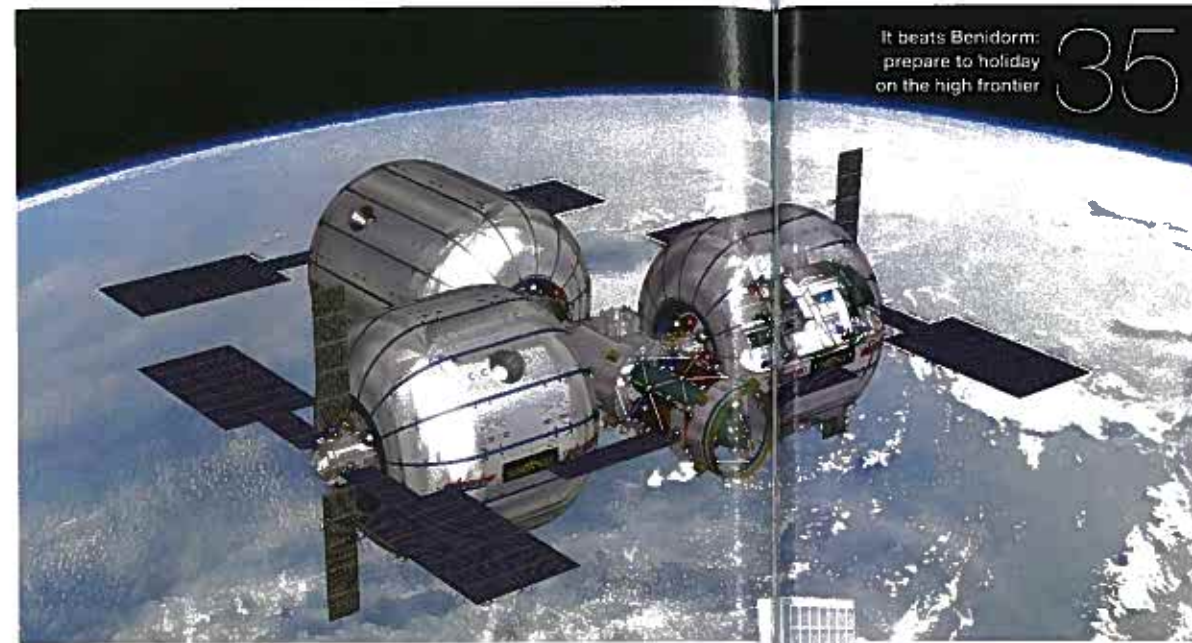
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It beats Benidorm: prepare to holiday on the high frontier 35

Welcome

from guest editor **Richard Branson**



Welcome to a slightly different edition of Focus. Different because Jheni has invited me to be the guest editor. This isn't a first for me, as I edited and published a student mag in the Sixties, but that was 40 years ago!

This issue's lead feature looks at space tourism, and why we need it. The answer lies in the history of space exploration. To date, most launch vehicles have been government owned. Although the tech that governs what we can do in space has moved forward leaps and bounds, the tech that gets us there hasn't changed much since Wernher von Braun's V-2 missiles rained terror on London in 1944. Every shuttle launch costs around \$1 billion. Even a relatively small 200kg low-Earth orbit satellite (the size of a washing machine) can cost at least \$30 million to get into space. This price is massively limiting our ability to use space for industrial purposes.

This is where space tourism comes in. Virgin Galactic, along with Burt Rutan, has developed a low-energy, low-environmental-impact, low-cost launch system. By being suitable for space tourism and launching small satellites into orbit, it has the potential to revolutionise the cost of getting to

space. It's not the only such system being developed. A friend of mine, Elon Musk, is currently developing a new, ground-based rocket that will revolutionise the economics of getting to the ISS.

We need these sorts of ventures if we're going to find the solutions to the two looming problems of the 21st century: population growth and climate change, as space holds some of the keys for managing both.

Virgin also has several other initiatives to try and find the answers to these challenges. One is the Carbon War Room, which has been set up to harness the energy, influence, and resources of some of the world's top entrepreneurs to help revolutionise the carbon economy. The other is the Virgin Earth Prize, where the best solution for taking carbon out of the atmosphere will be awarded \$25m.

Staying on the green theme, we have this issue's all-you-need-to-know guide to climate change (p54). And the winners of the inaugural Focus innovation awards are revealed (p26). Inventors like these might go on to solve the problems facing Earth, or even become the next Burt Rutan! Enjoy the issue...

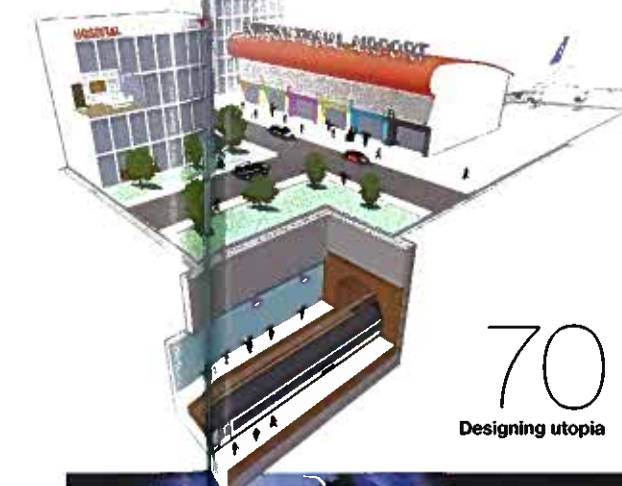
Richard Branson



Branson and Focus ed Jheni talk space



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And the winner is... We applaud the best inventions of 2009



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www.bbcfocusmagazine.com
Exclusive interview with spacecraft designer Burt Rutan, plus listen to the weirdest techno musical instruments



ON THE
PODCAST

Destination **SPACE**

Spain, the Caribbean, or space? In this special report, we go behind the scenes of the emerging space tourism industry to find out how you will be taking a break from planet Earth...



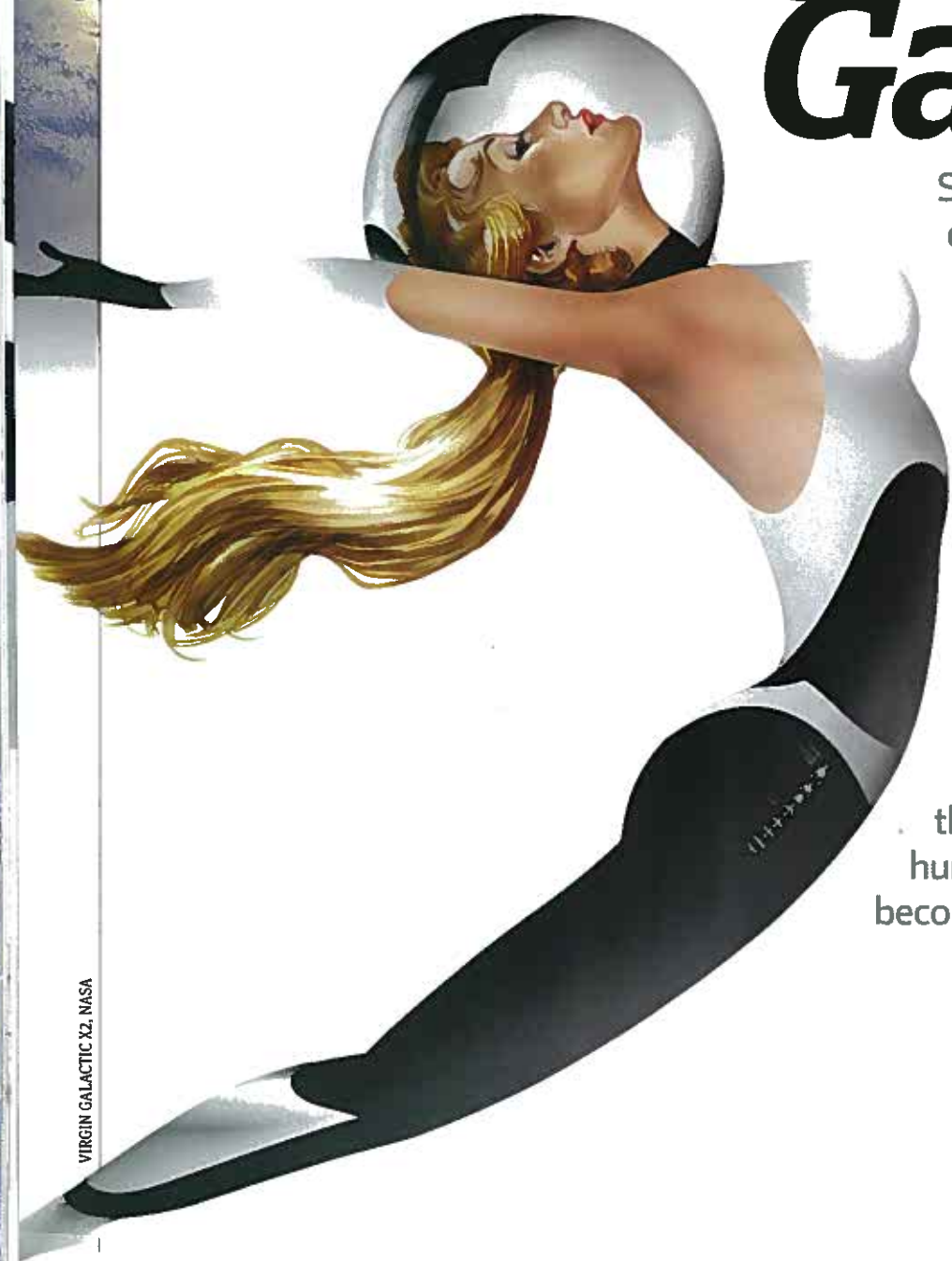
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The birth of

Virgin Galactic

By Richard Branson

Space has always been a dream for me, born of a love of aviation and flying that goes back to my early childhood. Not only was my mother one of the first international female flight crew at the end of WWII, but my parents were friends with the legendary legless flying ace Sir Douglas Bader who regaled me with visions of reaching for the sky. This diary charts the dream of the world's first commercial human space launch system becoming a reality...



VIRGIN GALACTIC X2, NASA

21 July 1969

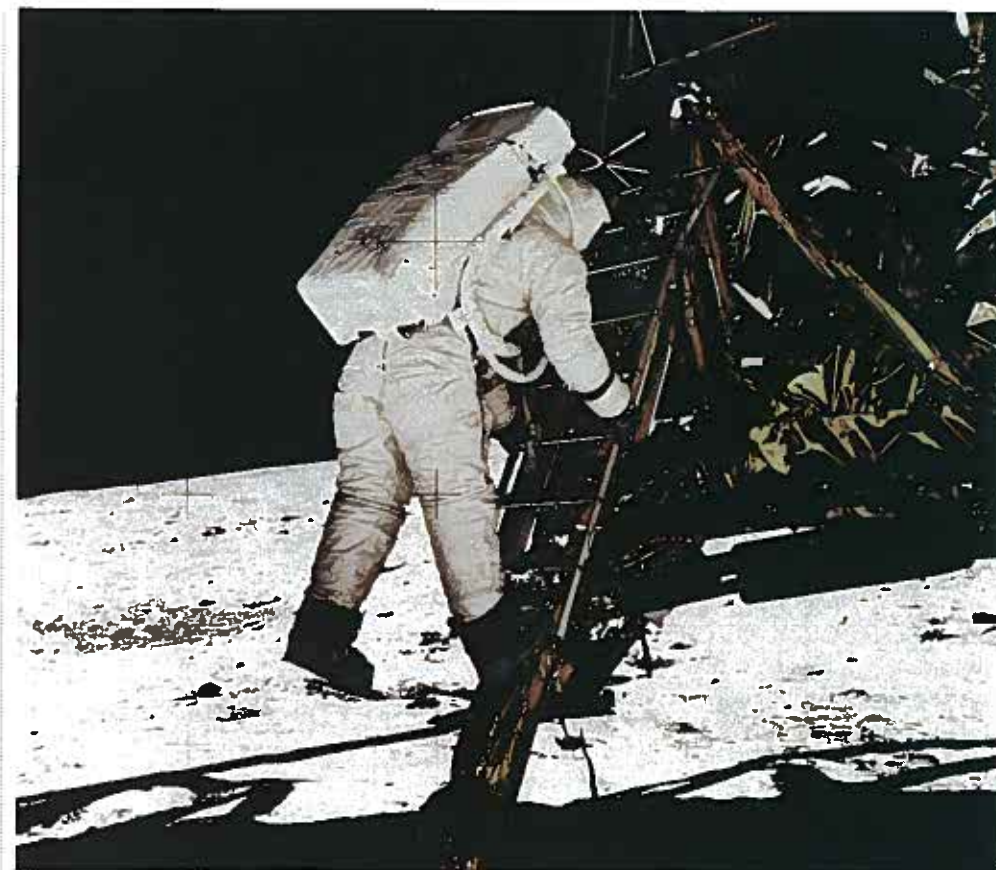
Three days after my 19th birthday, I watch the Moon landing at home with my parents. Given the pace of change over the previous few years, they both think it's possible that I will fly into space in my lifetime. Then a young entrepreneur in the throes of starting a mail order record business, they're words I've never forgotten.

1988-1989

Have in-depth discussions with the Soviet leader Mikhail Gorbachev and various cosmonauts about hitching a ride on the Soyuz rocket to the Mir Space Station for "only" \$5-10 million. The invasion of Kuwait and the collapse of the Soviet Union put an end to these plans. But the question of why getting into space is so expensive and difficult begins to interest me.

December 1995

I'm sitting in a bar in Marrakesh, waiting for the weather to pick up for the launch of my record-breaking round the world high-altitude balloon attempt. Buzz Aldrin has joined me in Morocco to check out the capsule, which will be home to myself and two others for up to 10 days, circumnavigating the globe in the jetstream winds above 35,000 feet. I ask Buzz why space is so expensive, why rockets are launched from the ground and why balloons have never been used to carry rockets into the stratosphere before launch to avoid the huge amount of energy needed at sea level. His reply is the kernel of the Virgin Galactic system. Buzz explains that the US experimented in the 1950s with balloon-launched rockets and more importantly the X-15 air



Above: Buzz Aldrin steps onto the Moon, 1969. Below: Buzz and I having a chat

launch space plane. But these projects were all abandoned due to the need to concentrate on Apollo and the race to the Moon. I park in the back of my mind that commercialising space could be interesting and ask Will Whitehorn, who later becomes President of Virgin Galactic, to keep an eye on the field.

April 1998

Peter Diamandis, Founder of the Ansari XPrize for the first commercial human space flight, visits Will and I at Virgin's Holland Park office to ask if we'll sponsor the prize. I tell him we won't, but we might well invest in the winner. None of the so-called experts believe the prize can ever be won!

March 1999

Will registers the name Virgin Galactic and we both go to look at a project in Mojave called the Rotary Rocket Company – an X-Prize contender desperately short of money and in need

of investment. The project looks pretty hopeless but we get the chance to visit the factory of aerospace engineer Burt Rutan. He makes a convincing argument that the best way to lower the cost and improve the safety of space flight would be an air launch system.

November 2003

While Burt is building the world's first all carbon composite jet for Virgin Atlantic (later piloted by Steve Fossett around the world on a single tank of fuel), he shows Virgin Atlantic Captain Alex Tai and Will the spaceship he's building for ex-Microsoft boss Paul Allen. I get a pretty excited phone call from Will, and the process of buying the rights to Burt's XPrize contender SpaceShipOne begins.

27 September 2004

At a press conference at the Royal Aeronautical Society in London, Burt and I announce the formation of Virgin Galactic. But few people at the Virgin



► Group believe in the idea or that a private space project on this scale can ever be funded.

4 October 2004

The first successful X-Prize winning flight by SpaceShipOne takes place in the Mojave Desert. As the pilot Brian Binnie steps out of the cockpit, he's simply awe-struck by what he's just done – consistent with every astronaut I have ever met, he talks of having had an almost spiritual experience. Pilot Mike Melville completes a second successful flight. In just a hand-built carbon composite spaceship, with a budget less than NASA's weekly wage bill, these men went up as pilots and came back as astronauts! My memory of chatting to them after their flights will always stay with me.

November 2004-April 2005

So much is happening so fast. The US Congress passes legislation to allow commercial human space flight – both Will and Burt have to give evidence. Meanwhile, we start selling tickets. It quickly becomes clear that we can't

simply rebuild SpaceShipOne, as research shows space tourists will only pay \$200K if they can experience weightlessness by moving around in a large enough cabin. This is a pivotal moment for Virgin Galactic as that research sets the parameters for the future business. The Galactic team argue successfully that the launch system should be capable of many other things, such as human in-the-loop space science and an unmanned orbiting satellite launch.

May 2005-May 2006

The design commences of WhiteKnightTwo [the mothership that will launch SpaceShipTwo] and the spaceship itself. It's clear they're going to be big compared to the X-Prize vehicles and at some stage we'll need deeper pockets to fund them than originally thought. This is when the twin-hulled design for WhiteKnightTwo emerges, which will allow the carrier plane to be more flexible – both as a training vehicle for astronauts and a launch platform for rockets other than SpaceShipTwo. ►

Right to left:
Me with Brian
Binnie, Burt
Rutan and
Paul Allen



VIRGIN GALACTIC, REUTERS



“They went up as pilots and came back as astronauts”

An artist's
impression of
SpaceShipTwo
on the back of
WhiteKnightTwo

July 2005

Burt and I go to Oshkosh, Wisconsin, to show off the XPrize-winning spaceship and our own Virgin Atlantic Global Flyer, which has just circumnavigated the globe. Both systems look wonderful in the summer sun and attract record crowds of literally hundreds of thousands. I meet some of the first customers, whose enthusiasm is infectious. I'm particularly struck by designer Philippe Starck's incredible passion for space.

27 September 2006

The first interior designs of the spaceship are unveiled at the NextFest show in New York. Customers and the world's media 'wow' in awe at a really cool animation of a future space flight. For the first time, I

realise that if we can build it, customers will come in their thousands. It's after this event that ticket sales really start to take off.

November 2006

Construction of WhiteKnightTwo starts at Scaled Composites in Mojave, California. Project Director, Jonathan Firth, who's overseen big projects like the Pendolino tilting train, makes it clear that we have no easy task on our hands.

27 November 2006

The first group of Virgin Galactic customers visit me at my home on Necker Island in the Caribbean. I remember I have to call them astronauts! In one of the most memorable moments of the project so far, we sit around listening



Getting my in-flight instructions in VMS Eve

to Stephen Hawking explaining to John Humphrys on the *Today* programme on Radio 4, why mankind must both explore and colonise space and not leave it to robots if we are to survive as a civilisation. This alone would be enough for any space enthusiast, but he then drops the bombshell that he'd like to fly on Virgin Galactic, so I get on the phone to him straight away.

July 2007

We finalise an agreement with the Government of the State of New Mexico for a spaceport to be built beside the old White Sands missile base where the first V2 Rockets were flown in the fledgling US space programme in the 1940s.

27 July 2007

Tragedy strikes. While doing a cold pressure test of nitrous oxide, which will be the future fuel oxidiser for the spaceship, three of Burt Rutan's team are killed in a terrible, million to one accident, which Burt himself later describes as his "Apollo fire moment" in a reference to the equally tragic 1967 accident. A long investigation gets to the roots of the issue. Virgin remains staunchly committed to the project, but this sad event reminds everyone that safety must be paramount in this new race into space.

3 January 2008

The final designs for the whole space launch system are unveiled in New York. But I'm very worried as Burt Rutan is clearly not well. He has degenerative heart disease but can't get to the bottom of what's wrong. Fortunately, within weeks he's being operated on at the Mayo Clinic where they discover a membrane over his heart. Days after the op he's a new man. I distinctly remember him telling me that, apart from his family, all that kept him alive during that time was the Galactic project.

27 July 2008

The finished WhiteKnightTwo mothership is unveiled at Scaled Composites in Mojave. It feels like the whole world is there – literally planeloads



Burt and I in the cockpit of VMS Eve

of customers, journalists, government officials and scientists fly in to see this amazing vehicle. But we keep the actual spaceship under wraps in the corner. As storm clouds gather, the moneymen tell me about the looming credit crisis and the importance of finding "second-round funding", as it is known, for the final phases of the Galactic project if we're going to guarantee its success in the coming recession.

21 December 2008

WhiteKnightTwo flies for the first time. At a time when the world's economy is collapsing, it's a truly beautiful and inspirational sight. Virgin businesses are holding up well, but we need to find a partner for Galactic. The logical place to look is the Middle East, so we begin conversations with several potential investors. One group stand out, as they're interested not only in space tourism and a spaceport, but in developing satellite launch technologies.

28 July 2009

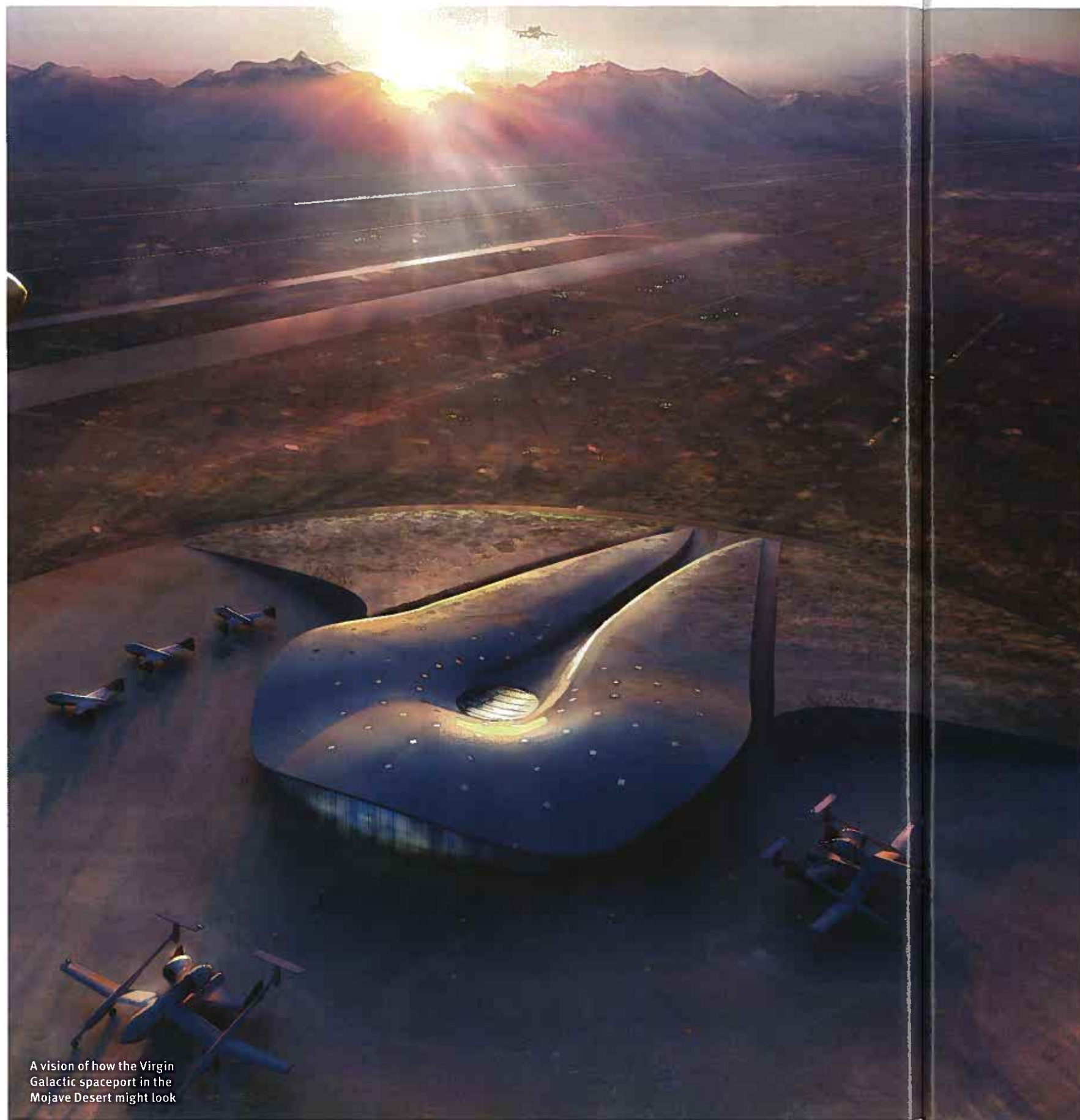
Back in Oshkosh, I fly in WhiteKnightTwo for the first time in front of the world's media and half a million people. It's an exciting day, made even more amazing by the fact that we sign a deal with

Aabar Investments of Abu Dhabi to invest \$280 million in Virgin Galactic to see it through to its commercial launch and another \$100 million to develop a satellite launch system to allow satellites of up to 200 kg to be launched from WhiteKnightTwo. *Business Week* magazine describes the event as the "Netscape moment" for commercial space in reference to the famous investment in that company, which heralded the internet investment revolution. After six months of successful flight tests of the mothership, rocket motor firings, and final completion work on SpaceShipTwo, I can see the end of the beginning of the most exciting project I've ever been involved in. I'm looking forward to the spaceship being unveiled and flown for the first time next year. ■



Thumbs up at SpaceShipTwo's press launch

VIRGIN GALACTIC HITS SPACE



A vision of how the Virgin Galactic spaceport in the Mojave Desert might look

Meet the... Pilot *Brian Binnie*

All about Brian

Binnie has logged 4600 hours of flight time having spent a 21-year career flying in the US Navy as both a strike and test pilot. He's flown 59 different types of aircraft and is also a licenced Airline Transport Pilot.

SpaceShipOne's first powered test flight took place on 17 December 2003, to coincide with the 100th anniversary of the Wright brothers' maiden flight. Binnie was at the controls and took it to a speed of Mach 1.2 and a height of 68,000ft.

What was it like to fly SpaceShipOne?

The ride up to the release point when the spaceship detaches from the mothership is pretty much like any other flight. But when the big release from the mothership happens at 50,000ft, it's like something you've never experienced before. The rocket motor fires, there's a big jolt, a five-second countdown before you hit the 'Arm' switch, the light goes red and then the 4G hits. It feels a bit like a tsunami sweeping through the cabin.

Does it compare to flying a fighter jet?

A catapult launch from an aircraft carrier out at sea is very similar, but it only lasts for two seconds. In the rocket motor world, it doesn't end there. In two seconds you go from 150 to 300 knots [173-345mph]. At six seconds you're doing 600 knots [690mph], which causes a lot of noise and a lot of vibration. But then, after 8 seconds, things start to settle down and the vehicle goes supersonic.

So, what's it like in suborbital space?

Incredibly impressive. The real joy of the experience is when you shut the motor

down and three wonderful things happen simultaneously – the holy trinity of spaceflight. The vibrations go away, the noise ceases and it becomes very quiet, and then the best bit – you step across a line into a whole different dimension and the wonderful karma of weightlessness. It's something you're never normally exposed to, so you can never imagine what it feels like. Your limbs have no tension, your legs don't feel heavy.

What's the view like?

As you climb vertically, below you can see weather patterns, coastlines and mountain ranges. The sky gradually turns a darker shade of blue, then purple, and then you see the black ahead. Separating Earth from the black of space is this very thin blue electric ribbon of light that is the atmosphere. You've seen it on magazine covers, but there's nothing like seeing it for yourself. The eye is so much more dynamic than any

camera lens. You are reduced to saying simple things like "Wow".

Have you prepared a commentary?

We've thought about it, but we haven't yet put anything on paper. It's going to be the crew's job to talk with the passengers and calm their nerves during the hour-long flight up. But a large part of their training will prepare them for this. During the countdown to the release from the mothership, the passengers will be able to listen in to the audio coming from the crew's radios.

Are you nervous about taking passengers up?

Not at all. By the time we get to the end of the test program we'll feel very comfortable with the spaceship and its capabilities. I'll look forward to sharing the experience with others. This is an experience that will not disappoint, it's very personal.



In the cockpit of WhiteKnightTwo

Meet the... Engineer

Burt Rutan

All about Burt

Born on 17 June 1943 in Oregon, he piloted his first aircraft, an Aeronca Champ, at the age of 16. In 1965 he graduated from the California Polytechnic State University with a degree in aeronautical engineering, and went to work at Edwards Air Force Base as a flight test project engineer. In 1982 he founded Scaled Composites, one of the world's pre-eminent aircraft design and prototyping facilities.

Elbert Leander 'Burt' Rutan's spaceflight dreams date back to his childhood, and were nurtured while flight-testing military equipment at Edwards Air Force Base in California. There he witnessed the Redstone Mercury and X-15 planes race to be the first into space.

"Then I was just doodling around 1992/93 and realised that with an air launch I could create something that flies outside the atmosphere with a relative amount of safety," he tells *Focus*. "And it wouldn't be anywhere near as dangerous as launching a booster from the ground. As soon as I mentioned that to [Microsoft co-founder] Paul Allen I had funding."

This was a partnership that led to the creation of SpaceShipOne, the first privately built, flown and funded aircraft to reach space. The craft actually reached space twice in a fortnight in 2004, winning the team the \$10 million (£6.26 million) Ansari XPrize. "Keep in mind that we didn't have the budget of Boeing or NASA," Rutan says, "and I think we're the only entity that developed a supersonic aeroplane without doing transonic or supersonic wind tunnel tests. We did it all with CFD, computational fluid dynamics. We tested in a computer rather than blowing wind over a model. A lot of people thought we were crazy."

Rutan's company Scaled Composites was also bold in its attitude to 'envelope expansion'. This is the concept of taking baby steps in testing aircraft, each flight going a little higher, a little faster. In aeroplane development programmes this is typically a very lengthy procedure, but SpaceShipOne flew through the process at supersonic speeds. It reached space on only

its 15th flight, and retired after its 17th. That craft now sits in the Smithsonian Institution's National Air and Space Museum in Washington, and development of SpaceShipTwo, in partnership with Richard Branson, is almost complete.

This craft will again utilise air launches, which use half the propellant of ground launches and burn fuel only after leaving 90 per cent of the atmosphere behind. But is there a way to make the space tourism industry truly green?

"I'd like to see vacations spent swinging round the Moon"

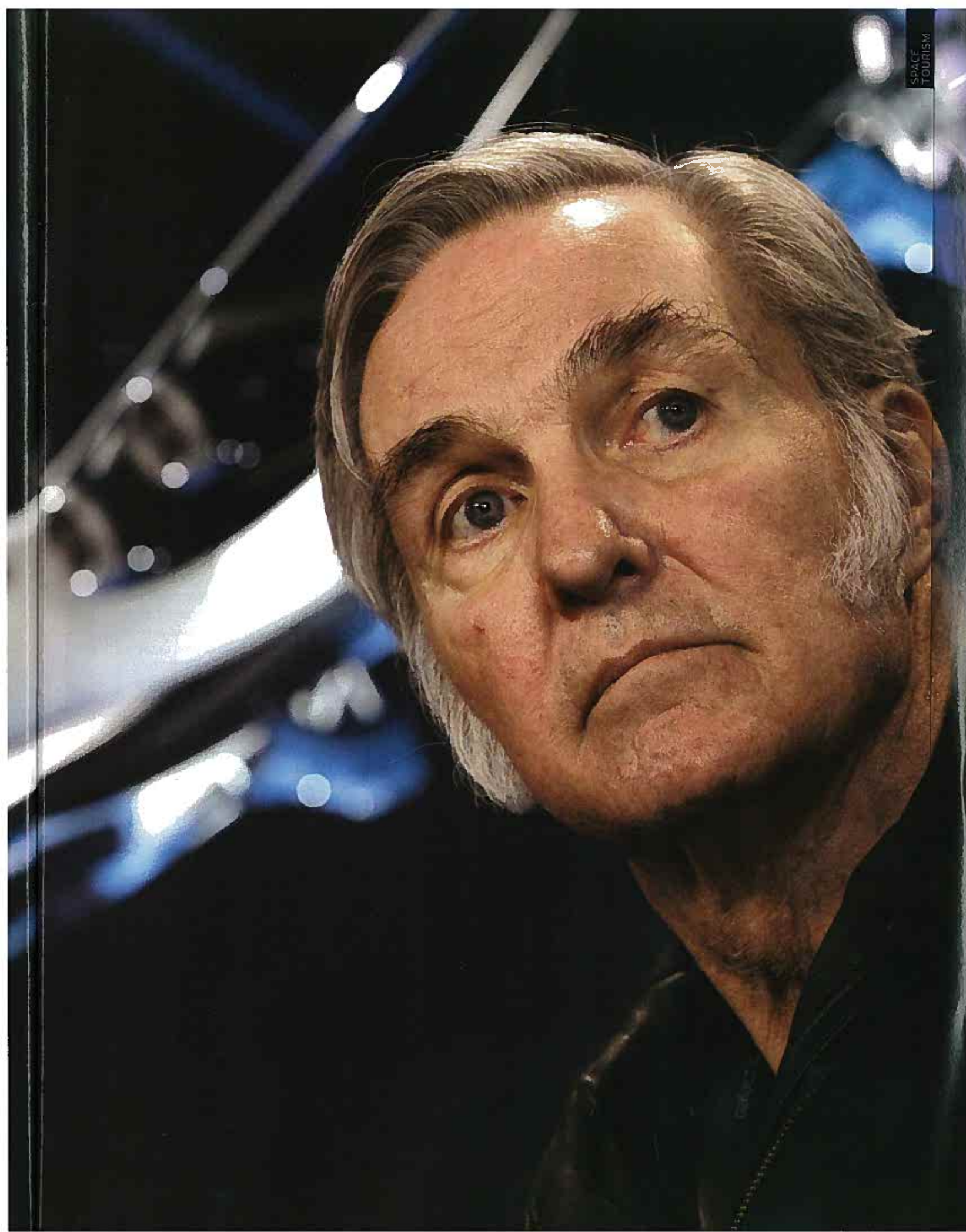
Could biofuels be used in SpaceShipTwo? "I see no reason to use biofuels [bioethanol] in ships or cars or anywhere," Rutan says. "It makes no sense. You use as much energy to develop and refine them. Oil is very good until something is cheaper. Why force people to use something more expensive, and remove corn from the crop so that food prices go up? Folk in Haiti end up starving. Biofuel is an enormous failure."

Many aspects of the new craft need to be thoroughly tested before the first tourists take off. Priorities over coming months include the glide back to Earth, the rocket motor and the level of transonic control. And there's the whole question of getting permission from the authorities to fly fee-paying passengers to the edge of space.

Virgin Galactic must obtain a licence to operate commercial spaceflights from the Federal Aviation Authority, a process that has no precedent. Nobody yet knows what the regulations should be, because thankfully there have been no accidents from which to learn. But Rutan has a suggestion for testing the safety of a spacecraft. "Those that develop the ship – the engineers and the management – should fly their kids before they say this is ready for the public. Of course I could say you have to fly your wife, but not everyone likes their wife."

But what will the objective be when SpaceShipTwo is regularly carrying passengers into space? Rutan has set his sights high, in every sense. "I'd like to see as quickly as possible large portions of the public spending their vacations in Earth orbit, or swinging round the Moon. I think that's something that can happen. We need some breakthroughs but it can happen in my lifetime."

These are breakthroughs that will come once the barriers to public spaceflight are broken down. "We had personal computers for decades without knowing what they were really for. But then they went into everyone's homes and from that came the internet. But it couldn't have happened without the decade of fun. Manned spaceflight is just like that – someone will invent a reason that we did it." That person, Rutan says, will probably be someone just like you or me. "Someone will be creative and figure out a use for it. That creativity doesn't come from a NASA astronaut because they are trained to follow limits. The people that buy tickets from Richard don't have any limits."



Meet the...

Tourist

Nigel Henbest

All about Nigel

Nigel began stargazing in his spare time while at school in Northern Ireland. His studies took him to Leicester University to read physics, chemistry and astrophysics before a stint at Cambridge doing radio astronomy. He has become a renowned writer on astronomy and space, and, together with Heather Couper, has written over 30 books and the monthly *Focus Skywatching* guide. He is also an award-winning TV producer.

Is it true you sold your shares in your TV production company Pioneer to pay your deposit for Virgin Galactic?
Yes! It's been a lifetime dream to go into space. Having built up a company that had some reasonable value to it, I couldn't take it with me going up there, but I could take it with me in another way. So I cashed in my shareholding.

What's the application process for Virgin Galactic like?

You go to the website and fill in your details – name, address, email address and so on, including your phone number. Now I don't particularly like being phoned up cold, so in the 'Any comments' section I put 'Please don't phone me'.

I didn't hear from anybody for six months. And then my girlfriend told me I should re-enter all my details and not put 'don't phone'. As soon as I'd done that I got a call from the guy at Virgin, and my welcome pack arrived in the post soon after.

What did you get in your welcome pack?

Two packages arrived. The first was a smallish one. Inside was a beautiful chrome badge, which has a female figure on it, fashioned from a photograph of Richard Branson's mother Eve when she was younger. Her image is on the front of the mothership – and it's also named after her. Despite being in her 80s, she's going to be on the first passenger flight with Branson.

The other half of the welcome pack was this huge, thin cardboard package, almost as tall as me. It turned out to be an enormous book! On every page is a large photograph of what the spaceship

looks like on the ground, going up into space, what it will be like inside looking out through the window... It's in the corner of my sitting room because it won't fit on a bookshelf.

You're an astronomy guru. Have you always wanted to get closer to the stars that you've studied for so long?

I've always been a space and astronomy cadet. I became interested at about the age of 10 when my dad, who was a professor of chemistry, bought me a couple of books on astronomy. We'd go out on clear nights in Belfast where I grew up.

I remember Yuri Gagarin in 1961 as the first man to go into space, and then I followed the whole drama of the space race. But I missed the first Moon landing because we were on a family canal boat holiday in the Gas Street Basin in Birmingham – there were no televisions there.

Did you always want to be an astronaut?

Oh yes! About 20 years ago when the first British astronaut was chosen to go up with the Russians to the Mir space station, I applied along with 12,000 others. I didn't get an interview – I got turned down by letter at the first post. You had to be under 40, physically fit, have a science background, and know a foreign language so you'd have the aptitude to learn a bit of Russian. I'd done my first degree in astrophysics at Leicester University, then went to Cambridge to do radio astronomy, so I had all the science qualifications. And I could cobble together a bit of French. But I only did the odd swim, walk or cycle. Helen Sharman, who's now a

friend, got the place – she had all those things and was a keen squash player.

So, now's your chance...

Yes. I'd love to go to the space station for a week, orbiting Earth. But you're looking at \$30 million. I'm astronaut number 249 on the Virgin Galactic list. I believe Branson himself is astronaut number one. Of the six billion people on Earth, only about 500 have been into space so far. So, unless anything goes wrong, I'll be one of the first 1000 people to go into space. I'm scheduled for sometime in 2011/12. I'm looking forward to the adrenaline rush, experiencing weightlessness and, of course, knowing you're actually in space, over 100km up and seeing the curvature of the Earth underneath. I've been in Concorde, where they claimed you could see the curve, but I wasn't convinced. The great rocket pioneer Konstantin Tsiolkovsky said: "Earth is the cradle of mankind, but we can't live in the cradle forever." This is going to sound naff, but our destiny is space.



How you can be a space tourist

Cosmochemist and Virgin Galactic Operations Lead Dr Julia Tizard gives the lowdown on the spaceflight experience...

1. APPLICATION

Once you've bought your ticket, you'll be checked for any health problems you might experience. The aim is to make the trip as inclusive as possible – the oldest applicant so far, James Lovelock, is 88 years old – and the idea is not to pass or fail you, but rather to establish what is required to get you into space.



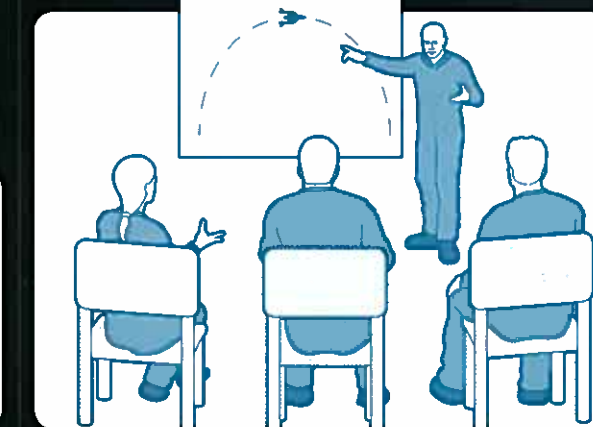
2. PACKING

You can travel light – very little is needed on your trip that's not provided for you. On arrival for your three-day preparation at the spaceport in New Mexico you'll be given a launch schedule, and your uniform. It's a one-piece suit with plenty of pockets, including a big one on the chest just in case you need something to vomit into. You'll also get a helmet and be offered special underwear in case of in-flight accidents – there are no toilets onboard. At the spaceport, the facilities will be plush, modelled on a Virgin upper-class lounge.



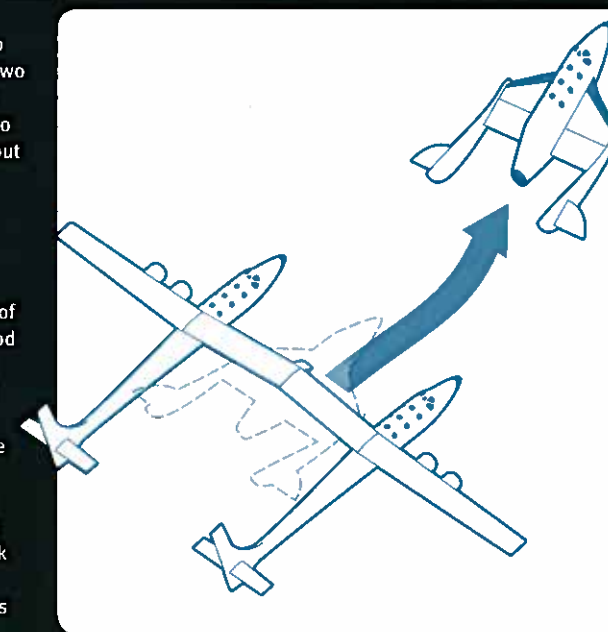
3. TRAINING

Your first day will be spent going over your trip with the pilots and engineers. You'll also do some G-training in WhiteKnightTwo, the craft that will be used to launch SpaceShipTwo. You may even take a seat on the craft as it launches the preceding tourists on their mission. Day two will include a full-scale mock up, so you'll have a flight briefing with the pilots, who'll run through the entire flight using the same protocols and comm systems as on the day itself.



4. INTO SPACE

WhiteKnightTwo takes about an hour to carry you to 50,000ft. Here SpaceShipTwo is released and goes supersonic within eight seconds. It makes the transition to vertical, and now you'll start to feel about 4G of force, on two vectors – through the chest, front to back, and from the head down. This could make you faint by stopping the blood reaching your head, so you'll perform an exercise to counteract the force. You squeeze a lot of your muscles to make sure enough blood is flowing to your head. After about 70 seconds, the rocket motor cuts out and you coast to the peak altitude. Now is your big moment – weightlessness. The seats retract into the floor, so you can float around the cabin. This part of the flight lasts five to six minutes. Then, as the ship descends, you are pushed back to the floor. Here you are strapped in, lying flat to deal with the brief 6G forces you'll experience on your way down.



5. BACK TO EARTH

SpaceShipTwo will decelerate through the atmosphere, switching to a gliding position at 80,000ft and taking 25 minutes to glide back to the spaceport. On your return, you'll disembark for the big celebration with your friends and family. You can relive the moment with footage from your flight. And, just to make sure you don't forget the whole experience, your passport will receive a 'space' stamp and you'll be handed your astronaut wings at an awards ceremony.



Contenders

Virgin Galactic isn't the only company aiming for the stars. While realistically many of them are years away, one can already get you up there, if you've got a few million quid...

XCOR AEROSPACE LYNX

Price: \$95k (£59.5k)



The experience

The ultimate high-altitude fighter jet flight. Within 15 seconds of taking off horizontally your head will be pinned to your seat as you accelerate to supersonic Mach 2 speed. At 200,000ft you get the astronaut experience – 3-4 minutes of suborbital microgravity – before gliding back down to Earth, circling as you descend. The whole thing might only last 30 minutes, but you'll feel as though you've just ridden the best rollercoaster in the world.

When: 2011 predicted

Number of passengers: 1

Take off: Mojave Air and Space Port, California

The spacecraft

The Lynx is roughly the size of a small private jet and will be capable of flying into the edge of space several times a day using a re-useable engine – keeping costs (and hopefully the price the customer pays) low. The engine is liquid fuelled, which should give a smoother ride than with a solid or hybrid engine.

Extra facts

There's no worries about trying to grab the best seat here – you're guaranteed a front-row panoramic view, sitting next to the pilot.

TALIS ENTERPRISE PROJECT ENTERPRISE

Price: 172.5k EUR (£158.9k)



The experience

Seated behind the pilot you'll soar vertically into suborbital space to float around the plane, experiencing weightlessness for roughly four minutes. Flying from East Germany you'll be able to look over Europe, picking out landmarks like the Alps. The trajectory of the flight means you'll feel less G-force – a bonus if you're not much of a fan of rollercoasters.

When: 2013 predicted

Number of passengers: 6 (a VIP module just for 2 people is being developed)

Take off: Cochstedt Airfield, Germany (TBC)

The spacecraft

The Enterprise is a suborbital space vehicle, capable of reaching an altitude of 130km. Take a look at a simulated flight at <http://bit.ly/projectenterprise>

Extra facts

You'll be able to revel in your adventure for years to come thanks to a personalised DVD featuring footage from training right through to the landing of your sub-orbital flight. For an extra cost, you will also be able to keep your space suit to show your grandchildren.

ROCKETPLANE GLOBAL ROCKETPLANE XP

Price: \$200k-250k (£125.5k-£156.9k)



The experience

After a four-day preparation you'll be ready for your flight. It starts with a conventional jet take-off before the rocket kicks in at 40,000ft for a vertical climb to 150,000ft (suborbital space) where the rocket cuts out. You'll experience weightlessness for three to four minutes before you return. You will have your feet back on planet Earth in less than an hour. If you're lucky (or perhaps pay a premium), you'll sit next to the pilot and the other five passengers will sit behind you.

When: 2011 predicted

Number of passengers: 5

Take off: Oklahoma Spaceport

The spacecraft

The Rocketplane uses two conventional jet engines for take-off and to power the craft up to where the rocket is fired. The leading edges of the wings, tails, flight-control surfaces and nosecone are covered in titanium that can withstand the 300-370°C temperatures of re-entry.

Extra facts

In 2008, a French airhostess won the chance to fly on a future Rocketplane flight after finding a lucky KitKat wrapper. Space weddings are a future plan, estimated to cost \$2 million (£1.25m) for the happy couple and three friends.

NOW BOARDING

SPACE ADVENTURES



On 28 April 2001, multi-millionaire Dennis Tito became the first space tourist, or 'private space explorer'. He blasted off from the Baikonur Cosmodrome in Kazakhstan aboard a Soyuz rocket before docking with the International Space Station. Space Adventures, the company behind the trip, has since organised trips for several super-rich individuals – most recently Guy Laliberte, the man behind Cirque du Soleil. Tickets don't come cheap. English-American video game developer Richard Garriott reportedly paid \$30million (£18.8m) for his ticket. But Space Adventures wants to bring space flight to the masses. It is planning to offer suborbital spaceflights for \$102,000 and already has over 200 reservations. If you're on a budget, you can still experience weightlessness for \$3750 by boarding a parabolic flight taking off from Florida. Although you're not in space, by descending rapidly in an aircraft you can float around in zero G.

EADS ASTRIUM SPACE PLANE

Price: Reportedly 150k-200k EUR (£138.7k-184.9k)



The experience

You will be one of four passengers able to experience weightlessness for more than three minutes. During this time, you'll be able to leave your seat and float around the cabin, grabbing on to handles on the interior so you can get a better look at the view. You'll take off with a jet engine before blasting into space with a rocket at three times the speed of sound.

When: 2012 predicted – but development has slowed

Number of passengers: 4

Take off: Unspecified – regular airports

The spacecraft:

Similar in size and appearance to a business jet, the Space Plane will be able to take-off and land like a typical plane, before the rockets kick-in. There will be more windows than in your standard jet to give passengers a better view.

Extra facts:

Astrium, which employs people across Europe, says it has temporarily slowed its 'technical activities' focusing on the 'risk mitigating aspects' of the spacecraft's development – although it still says suborbital spaceflight is a viable concept.

EUROPEAN SPACE AGENCY FAST 20XX

Price: \$200k (estimated) (£125.6k)

The experience

Starting with a gentle climb up to 50,000ft – probably on board an Airbus A380, rockets will suddenly propel you upwards until you reach the edge of space.

When: TBC

Number of passengers: 6-8

Where: Sweden

The spacecraft

Using a similar system to Virgin Galactic, the spacecraft will piggyback on a carrier before hybrid rockets blast it into space.



Extra facts

ESA's aim for the Future High-Altitude High-Speed Transport system is to develop hybrid propulsion engines and look at a safe system for separating the super-fast craft from a carrier. ESA is also involved with LAPCAT II, creating a Mach 5 vehicle that could travel from Europe to Sydney in 2-4 hours.

SPACE EXPLORATION TECHNOLOGIES SPACEX

Price: TBC



The experience

Very little has been explicitly said about SpaceX's tourism plans, but its Dragon capsule could carry people into low Earth orbit. This would be blasted into space on top of SpaceX's Falcon 9 rocket. You would parachute down to Earth inside the capsule for an ocean landing.

When: Dragon testing expected 2010

Number of passengers: 7 in total

Take off: TBC

The spacecraft

The Falcon 9 spacecraft looks like your standard rocket and is a re-useable two-stage liquid oxygen/kerosene powered vehicle. The first stage is powered by nine engines, the second, one. Dragon, the craft you'd travel in, could even dock with the International Space Station.

Extra facts

SpaceX is owned by Elon Musk. (Turn the page to read an interview with him.) The company is working on a variety of commercial vehicles to launch people and cargo into space, and is already contracted to deliver cargo to the ISS for NASA.

Meet the...

Tycoon *Elon Musk*

All about Elon

Born in South Africa in 1978, the engineer and entrepreneur is said to be worth \$328 million. He developed and sold his first piece of computer software aged 10. He sold his company Zip2 for over \$300 million, before founding X.com, which later became PayPal, a company he sold for \$1.5 billion. More recently, Musk co-founded Tesla Motors, which produces the electric sports car the Roadster. He has also co-founded SpaceX which manufactures space launch vehicles.

Building a spacecraft is every boy's dream. Did you always want to?
Well, basically, exploring space is really the key to extending life beyond Earth. If you extrapolate the pace of technology improvement we'd never get there. So that's why I thought of SpaceX, which is a chance to create the technology necessary to establish life on Mars and make life multi-planetary. I've been pretty clear about this from the start – for me it's not about being the first to get a commercial vehicle into space, but to create the technology necessary to extend life beyond Earth.

Where do you think space agencies like NASA should be aiming for next?
It makes sense to hand over Earth orbit human transportation to the commercial space companies. That seems to be the direction that NASA's leaning, if you look at the results from the Augustine Commission. The panel of experts the

White House put together recommended that overt operations be turned over to commercial.

Do you think commercial space industry competition is healthy?
Yes. But everyone's doing different things. For example, Virgin Galactic is going into sub-orbital space, while SpaceX is going into orbital space. Most people don't appreciate the difference in complexity between sub-orbital and orbital operations. Sub-orbit only needs one and a half per cent of the energy needed to get to orbit. Just to reach lower orbit you need a minimum of Mach 25. So technologically speaking, we're the ones breaking the frontiers.

Out of Tesla and SpaceX, which project is closer to your heart?
Well, they're both really important. It's like asking 'what's your favourite kid'. I love them equally.

Earlier this year you unveiled the Tesla Model S [an electric saloon family car]. At around \$50,000 (£30,000) it's a lot cheaper than the Roadster. But it's still not cheap! Have you got plans to produce a truly mainstream electric car?

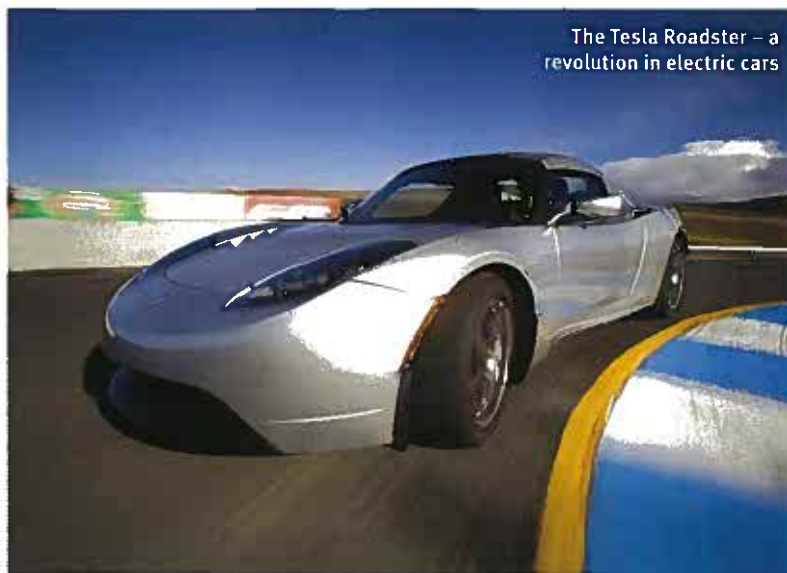
Absolutely. We're currently in partnership with Daimler to create an electric Smart car. I think I'm right in saying the first place these will be released is London, by the end of this year. But this decision is Daimler's at the end of the day. We're providing a battery pack and charger. In terms of a third generation car that we at Tesla fully make ourselves, that's probably five years away.

Who do you think will win the green car race out of hybrids and electrics?
I'm not sure it's so much a race. I think there's going to be a lot of winners potentially, but the entire industry is going to go electric. Technologically I don't see anyone beating Tesla though. I may sound overconfident, but Daimler would agree, that's why they invested in us. To a certain extent, though, everyone will be a winner as long as they move to electric – and move quickly.

What will be the next challenge for you? Are you planning to go into space yourself?

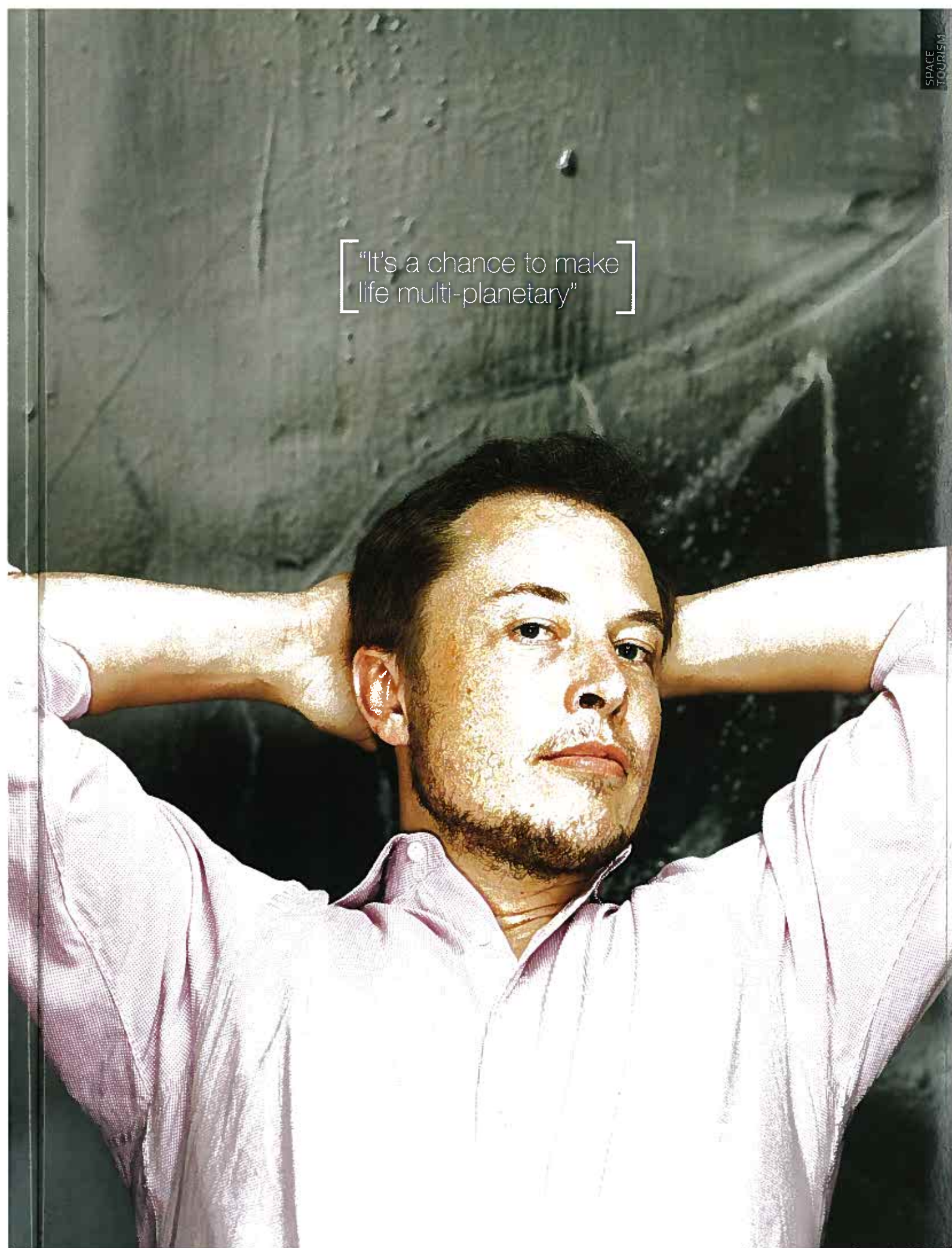
Well, I'm a little over-booked right now. My plan is to remain focused on Tesla and SpaceX. But I hope to get up into space myself sometime – maybe in about five years.

What would you like for Christmas?
Well, it would be great if NASA would commit to commercial human spaceflights. I think it's likely.



The Tesla Roadster – a revolution in electric cars

"It's a chance to make life multi-planetary"



Rooms with a view

The desire to perform microgravity research could lead to opportunities for starstruck tourists

If escaping our gravity and experiencing weightlessness is an awesome prospect, the next phase is more exciting still – blasting to orbit for a sleepover at a space hotel. If the grand schemes of a new breed of space entrepreneurs come to fruition, such a vision may not be as far in the future as you might imagine.

The American/Russian/Japanese collaboration Excalibur Almaz uses modernised equipment from the former Soviet space programme, and hopes to begin flights by 2013. One contender, Bigelow Aerospace, already has two prototype

inflatable habitats, Genesis I and II, circling Earth. Michael Gold, Director of Washington Operations at Bigelow Aerospace, is filled with enthusiasm for the potential of the project, and says that while their aims right now are scientific in nature, tourism is a natural progression.

“We’re essentially attempting to construct a national lab in orbit, that’ll provide opportunities for commercial and scientific microgravity research, as well as manufacturing, and international astronautics opportunities.” With the Genesis craft in orbit, construction

has begun on a smaller craft called Sundancer. Two of these craft will be launched, and then joined by the planned BA 330, so called because it carries 330 metres of useable cubic volume. “One BA 330 plus one Sundancer gives you useable volume in excess of the International Space Station, and we can do that in three launches. It took dozens of launches to get the ISS to the point it’s at today. There are six astronauts right now on the International Space Station, we’re looking to eventually put up between 600 and 6000. It’s a sea change.”

Bigelow Aerospace BA 330

Blown up

Modules are 13.7m long. They fold up inside a rocket’s nose cone and expand when released into orbit. They expand through the diameter, like a pencil becoming a cola can.

Hardened hide

The external shell is composed of strong Kevlar fabric, with the outer layer covered by ‘orbital degree shielding’ designed to protect against micrometeorites.

Bulletproof

Further inside, a layer of super-strong woven Kevlar surrounds airtight bladders.

Level one

A kitchen featuring a table for 12, fridge-freezer, microwave, water dispenser and some room for personal luggage items.

Level two

Six individual rooms. Mechanical room dealing with environmental control, life support, power, avionics and return airflow.

Level three

Crew health is handled here. Treadmill and exercise bike, medical equipment and room for personal luggage items.

Tough core

A solid metal core tightly holds the different modules of the craft in one structure. A corridor provides access to all levels.



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