TOURISTS in SPACE

A Practical Guide

Second Edition

Erik Seedhouse

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Tourists in Space

A Practical Guide

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Published in association with
Praxis Publishing
Chichester, UK

PRAXIS

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Norway

SPRINGER-PRAXIS BOOKS IN SPACE EXPLORATION

ISBN 978-3-319-05037-9 ISBN 978-3-319-05038-6 (eBook)
DOI 10.1007/978-3-319-05038-6
Springer Cham Heidelberg New York Dordrecht London

Library of Congress Control Number: 2014937810

Cover image: Artist's rendering of Dassault's spacecraft Courtesy (© Mourad Cherfi/Dassault Aviation, 2013).
Cover design: Jim Wilkie
Project copy editor: Christine Cressy

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

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Acknowledgments

In writing this book, the author has been fortunate to have had five reviewers who made such positive comments concerning the content of this publication. He is also grateful to Maury Solomon at Springer and to Clive Horwood and his team at Praxis for guiding this book through the publication process. The author also gratefully acknowledges all those who gave permission to use many of the images in this book, especially Mourad Cherfi/ Dassault Aviation, for supplying the striking cover image. Many thanks Mourad!

The author also expresses his deep appreciation to Christine Cressy, to Production Editor Hemalatha Gunasekaran, and to Project Manager Rekha, whose attention to detail and patience greatly facilitated the publication of this book, and to Jim Wilkie for creating yet another unique cover.

Tante Gun, Onkel Lasse, Gry, Lars-Christian, og Maria

About the author

Erik Seedhouse is a Norwegian-Canadian suborbital astronaut whose life-long ambition is to work in space. After completing his first degree in Sports Science at Northumbria University, the author joined the legendary 2nd Battalion the Parachute Regiment. During his time in the "Para's", Erik spent six months in Belize, where he trained in the art of jungle warfare. Later, he spent several months learning the intricacies of desert warfare in Cyprus. He made more than 30 jumps from a C130, performed more than 200 helicopter abseils, and fired more anti-tank weapons than he cares to remember!

Upon returning to the comparatively mundane world of academia, the author embarked upon a Master's degree at Sheffield University. He supported his studies by winning prize money in 100-kilometer running races. After placing third in the World 100 km Championships in 1992 and setting the North American 100-kilometer record, the author turned to ultra-distance triathlon, winning the World Endurance Triathlon Championships in 1995 and 1996. For good measure, he also won the inaugural World Double Ironman Championships in 1995 and the Decatriathlon, a diabolical event requiring competitors to swim 38 kilometers, cycle 1,800 kilometers, and run 422 kilometers. Non-stop!

Returning to academia in 1996, Erik pursued his Ph.D. at the German Space Agency's Institute for Space Medicine. While conducting his studies, he found time to win Ultraman Hawai'i and the European Ultraman Championships as well as completing Race Across America. Due to his success as the world's leading ultra-distance triathlete, Erik was featured in dozens of magazines and television interviews. In 1997, *GQ* magazine nominated him as the "Fittest Man in the World".

In 1999, Erik retired from being a professional triathlete and started post-doctoral studies at Simon Fraser University. In 2005, he worked as an astronaut training consultant for Bigelow Aerospace and wrote the first edition of *Tourists in Space*. He is a Fellow of the British Interplanetary Society and a member of the Space Medical Association. In 2009, he was one of the final 30 candidates in the Canadian Space Agency's Astronaut Recruitment Campaign. Erik works as a corporate astronaut (*www.suborbitaltraining.com*), spaceflight consultant, triathlon coach, and author. He is the Training Director for Astronauts for Hire (*www.astronauts4hire.org*) and completed his suborbital astronaut training in May 2011. Between 2008 and 2013, he was director of Canada's manned centrifuge operations.

In addition to being a suborbital astronaut, triathlete, centrifuge operator, pilot, and author, Erik is an avid mountaineer and is pursuing his goal of climbing the Seven Summits. The second edition of *Tourists in Space* is his 14th book. When not writing, he spends as much time as possible in Kona on the Big Island of Hawai'i and at his real home in Sandefjord, Norway. Erik and his wife, Doina, are owned by three rambunctious cats—Jasper, Mini-Mach, and Lava.

Acronyms

ACLS	Advanced Cardiac Life Support
ADS	Air Data System
AFT	Autogenic Feedback Training
AGSM	Anti-G Straining Maneuver
ALOC	Almost Loss of Consciousness
ARPC	Atmospheric Revitalization Pressure Control
ARS	Acute Radiation Sickness
ATCS	Active Thermal Control System
AUV	Autonomous Underwater Vehicle
BLS	Basic Life Support
BTLS	Basic Trauma Life Support
CLL	Central Light Loss
CME	Coronal Mass Ejection
CNS	Central Nervous System
CSP	Caribbean Spaceport
CVP	Central Venous Pressure
DAS	Digital Airspeed
DCS	Decompression Sickness
DEPTHX	Deep Phreatic Thermal Explorer
ECLSS	Environmental Closed Life-Support System
EEG	Electroencephalogram
EPT	Effective Performance Time
EVA	Extravehicular Activity
FAA	Federal Aviation Administration
FADEC	Full Authority Digital Electronic Control
FAI	Fédération Aéronautique Internationale
FOD	Foreign Object Damage
FoV	Field of View
GCR	Galactic Cosmic Radiation
GDSCC	Goldstone Deep Space Communications Complex
G-LOC	Gravity-Induced Loss of Consciousness

GN&C	Guidance Navigation & Control
GOR	Gradual Onset Run
GPS	Global Positioning System
HAI	High-Altitude Indoctrination
HATV	Hybrid Atmospheric Test Vehicle
HMD	Head Mounted Display
HPS	Human Performance Simulator
HTO	Horizontal Take-Off
HTP	High Test Peroxide
HUD	Heads-Up Display
HZE	High Energy Particle
IMU	Inertial Measurement Unit
INS	Inertial Navigation System
ISS	International Space Station
IVA	Intravehicular Activity
LBNP	Lower Body Negative Pressure
LEO	Low Earth Orbit
LET	Linear Energy Transfer
LOV	Loss of Vision
MET	Mission Elapsed Time
NACA	National Advisory Committee for Aeronautics
NASTAR	National Aerospace Training and Research
NCRP	National Council for Radiation Protection
NMSA	New Mexico Spaceport Authority
NSS	National Space Society
OTEC	Ocean Thermal Energy Conversion
PAF	Pre-Flight Adaption Facility
PLL	Peripheral Light Loss
PTND	Plastic Nuclear Track Detector
RBE	Relative Biological Effectiveness
RCS	Reaction Control System
ROR	Rapid Onset Run
RRV	Reusable Return Vehicle
SAR	Search and Rescue
SCR	Solar Cosmic Radiation
SFP	Spaceflight Participant
SIVAS	Simulated Intravehicular System
SMS	Space Motion Sickness
SNC	Sierra Nevada Corporation
SPE	Solar Particle Event
SS1	SpaceShipOne
SS2	SpaceShipTwo
SSB	Single Strand Break
TACAN	Tactical Air Navigation
TEPC	Tissue Equivalent Proportional Counter

TLD	Thermoluminescence Detector
TPS	Thermal Protection System
TUC	Time of Useful Consciousness
VEG	Virtual Environment Generator
VOC	Volatile Organic Compound
VRI	Visual Reorientation Illusion
VTHL	Vertical Take-Off Horizontal Landing
VTO	Vertical Take-Off
VTOL	Vertical Take-Off and Landing
WK1	WhiteKnight1
WK2	WhiteKnight2

Preface

ONE GIANT LEAP FOR TOURISM

Forget Hawai'i or the Mediterranean. Soon—very soon—you'll be able to add a much more exotic stamp to add to your passport: space. How will you get there, what will the trip be like, and how much training will you need? All you need to know is right here in this manual. Here's a sneak peek.

SOME TIME IN 2014/2015

It is 7 o'clock and it is time to begin the final preparations for the flight of your life. You have already been awake for two hours in anticipation of this day and, since you slept in your spacesuit, you don't have to worry about getting changed! You check yourself out in the mirror for the fiftieth time, paying particular attention to the mission patch on the left arm of your suit that reminds you this time it is for real. You rummage through your personal flight case and check again you have everything. Camera? Check. Mission pins? Check. The ALF mascot your daughter wanted you to take up? Check. You've waited a long time, spent a lot (A LOT!) of money, and invested in a lot of training for this day to become reality, but today is the day that will change your life and your perception of Earth. You make your way with family and friends to the spaceport restaurant where, after a routine security briefing, you eat a breakfast together with the other space tourists. After a photo shoot and a final check of your spacesuit, you say your goodbyes to family and friends. You give a final wave and then board the spacecraft where, with the assistance of the technicians, you settle into the seats as you listen to the pilot brief you on the flight. The technicians give you a final check, ensuring you have fastened your five-point harness, and then, with a thumbs-up, they leave the vehicle.

It is now just you, five space tourists, and the pilot and co-pilot. After receiving taxi clearance from the spaceport traffic control, the spacecraft taxis onto the runway and, with a kick of the jet engines, lifts its wheels off the runway, taking off just like a business jet that it closely resembles. After a leisurely 45-minute cruise, you reach an altitude of

12 kilometers and the pilot briefs you to prepare for rocket ignition. Moments later, with a flick of the pilot's switch, the rocket engine is ignited and you feel like you've been punched in the back. As the G-forces build inexorably, you are pushed farther and farther back into your seat. Within seconds, the vehicle is climbing almost vertically as it accelerates through Mach 1. You look out of the window and you notice the blue sky becoming noticeably darker with each passing second. Less than a minute after rocket ignition, the pilot announces Mach 3 and there are less than 10 seconds before completion of engine burn. At 60,000 meters, you hear the pilot announce he is switching off the engines and, a moment later, the cabin falls silent. Your view through the window is nothing short of spectacular—a view that fewer than 1,000 before you have experienced. Ever. You slowly become aware of the sensations of microgravity, just like your ride in G-Force-One. The vehicle is now more than 100,000 meters above Earth and you have officially earned your spaceflight participant wings and, in doing so, placed yourself in the select group of those humans who can say they have flown in space.

Inevitably, the four minutes of weightlessness pass too quickly as you hear the pilot request that you take your seat for the descent. You begin to appreciate your G-tolerance training as the G-forces build, once again pushing you into your seat during your roller coaster ride back to Earth. The friction in the atmosphere gradually slows the vehicle to subsonic speeds as it begins a gradual glide to the runway. You hear the familiar hum of the jet engines as the vehicle flies back to a perfect landing at the spaceport from which you took off less than two hours ago. As the vehicle taxis onto the apron, you can see family and friends waiting to hear about your experience. After greeting them with a big smile, you follow your crewmembers to the reception for the presentation of your civilian astronaut wings.

SOME TIME IN 2024?

After enjoying your suborbital space experience, you decided to save up for an orbital flight. Ten years later, you find yourself floating around an inflatable habitat more than 300 kilometers above Earth. After a week in orbit, you're spending some time engaging in your favorite pastime: Earth-gazing. It's one of the few luxuries on board. No spas or gourmet meals on this habitat. A Norwegian scientist astronaut gently brushes your arm as she traverses the length of the habitat, en route to her work station. Lucky woman. Her US$5.2 million ticket was paid for by her employer. It's 2024, and rockets are cheaper but far from reusable, so an orbital trip is still very (VERY!) expensive. So, while suborbital travel has, as predicted, increased significantly since your first flight 10 years ago, with more than 500 mostly tourist flights per year, the orbital market is dominated by research-minded corporate clients willing to pay millions for a week or two in space.

Your time in space is running out. In three hours, you'll be heading home in the Dream Chaser shuttle that's scheduled to arrive in a few minutes. You've heard that the trip home is smoother than many suborbital flights, because the vehicle angles gradually into a 1.6-G re-entry rather than diving in a steep decline. You gaze through the window as the Dream Chaser glides into view, its Atlas booster long gone. It maneuvers elegantly towards the docking port as you notice the vast bulk of the Himalayas slide into view 300 kilometers below. It's been a memorable flight.

SOME TIME IN 2034?

Twenty years after your first flight, you're making what will probably be your final trip to space. But what a trip! You're orbiting 300 kilometers above Earth, waiting to be launched to the Moon! The pilot fusses with the controls as he stands by for clearance from ground control. These lunar trips have been going on for years now, but it was only recently that the price dropped to a reasonable US$4 million, thanks to the Chinese offering seats on board their souped-up Soyuz shuttle used for ferrying workers to the helium-3 mines. Through your window, you can see three of the 17 habitats hurtling around the planet. Clearance is received and the rockets attached to the booster behind you light up. You're on your way to the Moon.

A couple of days later, the pilot points out major features as you fly 100 kilometers above the lunar surface. You're silent, watching craters flow by, as the pilot configures the vehicle for descent. Almost directly below, you can see the huge scars on the lunar surface, evidence of three years of aggressive lunar mining. A soft landing, a pressure check, and you clamber inside your habitat, your lunar home from home for the next 10 days.

Wishful thinking? Perhaps. Despite being accessible for more than 20 years, the commercial space tourism industry is still in its infancy, and it would never have reached this stage without some over-the-horizon speculation. As we close in on the end of 2014, the commercial space industry is on the threshold of delivering on the first of these predictions. Here's a snapshot of the material in this manual via 20 Q & As.

SPACE TOURISM Q & A

Q1. When will space tourism be available?

It's available now, but you have to buy your trip through Space Adventures and a ticket will cost you US$35 million or more. That buys you 10 days on the International Space Station. You can also reserve a ticket for a suborbital ride from XCOR Aerospace (US$95,000) or from Virgin Galactic (US$250,000).

Q2. What kinds of space trips are available?

Suborbital space tourism is available through XCOR Aerospace and Virgin Galactic. Orbital space tourism is available through Space Adventures: tickets are rare and expensive (see Q1).

Q3. What is meant by suborbital and orbital?

The threshold of space is 100 kilometers. If you buy a suborbital ticket, you will spend four or five minutes floating around above this altitude. If you're lucky—and rich—enough to buy an orbital ticket, you will spend your time at an altitude of 320 kilometers, where you will orbit Earth every 90 minutes. Pretty cool!

Q4. How long can I stay up there?

A suborbital flight will allow you to spend four or five minutes in space. An orbital flight will normally last about 10 days.

Q5. Is the trip dangerous?

Let's not pull any punches here. This is a risky business. Several astronauts and cosmonauts have lost their lives over the years, but lessons have been learned and these trips wouldn't be available if it was deemed too risky. Expect to pay a hefty insurance premium though.

Q6. How much training is needed?

Not much if you're a ticket-holder for a suborbital trip. Three days perhaps. Four at most. Orbital is a different kettle of fish. A ticket bought through Space Adventures will require six months of training. Plus, you have to learn Russian. But fret not, because plans are afoot to reduce this amount of training when new operators start offering tickets.

Q7. Do I have to be really fit to go into space?

The fitness standards for space tourists, especially for suborbital trips, are not as rigorous as for orbital flights. Put it this way: you won't have to train like an Ironman triathlete. You will need to be medically screened though, but for suborbital flight this will be fairly routine.

Q8. Where are the spaceports?

The Russian orbital flights take off from Baikonur in Kazakhstan, and suborbital flights will take off from Spaceport America in New Mexico. There are also plans for spaceports in Curacao, Sweden, Denver, Houston, and Florida.

Q9. What do I do when I get up there?

Good question. In a suborbital flight, you will have a view extending 1,600 kilometers, so snapping pictures is an obvious activity. Aerobatics may be popular as well, as long as you don't interfere with your fellow space tourists. For those enjoying an orbital flight, you'll need to spend some time exercising (two hours a day or more), eating, sleeping, and enjoying the 16 sunrises and sunsets every day.

Q10. Will there be space hotels?

Yes, but you'll probably have to wait a decade or longer before you can visit them. Prototypes are being built and tested. In fact, one of the prototypes—an inflatable habitat—will be test-flown on the International Space Station in the near future.

Q11. How do I eat/drink/go to the bathroom in space?

That's not something you have to think about during a suborbital trip—not unless you're the really nervous type! As for orbital space tourists, the skill-sets needed to perform these activities will be covered in your training.

Q12. What government regulations cover space tourism?

Not as many as you might imagine. The government has taken a hands-off approach with the space tourism industry, choosing to provide guidelines rather than pages and pages of rules and regulations, although there is a regulatory framework for space tourism operations, including licenses and permits.

Q13. What are the views like?

Jaw-dropping. Spectacular. From the top of the trajectory of a suborbital spaceflight, you'll be able to see 1,600 kilometers across the horizon. From orbit at 320 kilometers, your horizon will extend to about 2,000 kilometers.

Q14. Will I be uncomfortable?

Well, these trips are not for claustrophobes: the cabin is cramped, especially if you're flying on board the Lynx or the Soyuz. Also, if you don't like roller coasters, then you probably won't enjoy the ride to and from space.

Q15. Can my kids go?

Well, you have to be over 18, but there is no upper age restriction. Virgin Galactic's founder, Sir Richard Branson, hopes to fly his mother, Eve, on the first revenue flight of SpaceShipTwo.

Q16. What about people with disabilities?

No problem. Weightlessness is a benign environment for people with disabilities. Take physicist Steven Hawking, for example. Hawking has the debilitating condition of motor neuron disease, but was able to enjoy a zero-G flight and he hopes to go into space when Virgin Galactic begins revenue flights.

Q17. Will I have to wear a spacesuit?

For orbital spaceflight, you'll be required to wear a pressure suit. For suborbital space travel, each operator is still evaluating its requirements.

Q18. What was the X-Prize?

In 2004, a competition was held to see who could build a spacecraft without government funding, capable of going into space twice within a two-week period carrying a pilot and the equivalent of two passengers. The US$10 million Ansari X-Prize was won by Burt Rutan's SpaceShipOne and this became the model for the suborbital space tourism industry.

Q19. Is there a market for space tourism?

There appears to be. In 2012, the consulting firm Tauri Group produced demand forecasts in conjunction with Spaceport Florida. The forecasts suggest a strong industry.

Q20. How can I sign up?

If you have US$250,000 lying around, and you want to fly with Virgin Galactic, just fill in your particulars on their website and a member of their Astronaut Relations team will get back to you within 24 hours. Alternatively, you can book through one of Virgin's Accredited Space Agents who have been specially selected and trained to handle your reservation (*www.virgingalactic.com/booking/*).

If your budget is more limited, you can spend US$95,000 for a flight on the Lynx. To begin the reservation process, just fill out the contact form on their website and one of XCOR's representatives will contact you within 24 hours to continue your ticketing process. Alternatively, you can contact Greg Claxton by phone at (941) 928-2535 (*http://xcor.com/flytospace/*).

1

Space Tourism: A Brief History

> "Today we have made history. Today we go to the stars. You have raised a tide that will bring billions of dollars into the industry and fund other teams to compete. We will begin a new era of spaceflight."
>
> *Peter Diamandis, shortly after SpaceShipOne landed*

SUBORBITAL FLIGHT - THE FLIGHT OF N328KF

October 4th, 2004—a historic event is taking place at Mojave Airport, a sprawling civilian test center in the California high desert 150 kilometers from Los Angeles, where hundreds of rusting aircraft, their engines and undercarriages shrink-wrapped, sit parked in lonely rows. But, on this Monday morning, the motley collection of DC10s, 747s, DC9s, and 737s will bear witness to a truly extraordinary event. Here, at this desolate airport, a small, winged spacecraft built with lightweight composites and powered by a rocket motor using laughing gas and rubber will fly to the edge of space and into the history books. Registered with the Federal Aviation Administration (FAA) only by the anonymous designation N328KF,[1] but known to space enthusiasts as SpaceShipOne (SS1) and its carrier vehicle, WhiteKnight, this privately developed manned vehicle (Figure 1.1) will finally open the door for a much greater portion of humanity waiting to cross the threshold into space.

The excitement began building the night before, as cars poured into the parking lot and continued to stream in almost until take-off, by which time crowd-control personnel had almost been overwhelmed. Rows of trucks with satellite dishes and glaring spotlights greet the spectators as they stream into the airport. It is only 5:00 in the morning but a sense of expectancy already wafts through the air together with the smell of coffee and bagels. A huge X-Prize banner flutters from the control tower, as thousands of space enthusiasts from around the world wait for the Sun and the appearance of WhiteKnight.

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[1] The "N" in the designation is the prefix used by the FAA for US-registered aircraft and the 328KF stands for 328 kilo ('K') feet (the 'F' in the designation), which is the official demarcation altitude for space.

E. Seedhouse, *Tourists in Space: A Practical Guide*, Springer Praxis Books,
DOI 10.1007/978-3-319-05038-6_1, © Springer International Publishing Switzerland 2014

1.1 Astronaut Mike Melvill after his spaceflight on September 29th, 2004. Courtesy: Wikimedia/Photo taken by RenegadeAven during Civil Air Patrol duties

Legends of the space program, such as Buzz Aldrin, mill around in the VIP area together with William Shatner and Burt Rutan, Mojave's engineering genius. Only a few kilometers away at Edwards Air Force Base on August 22nd, 1963, test pilot Joe Walker reached the edge of space by flying an Air Force X-15 rocket plane to an altitude of 107,333 meters. The X-15 gave birth to the Space Shuttle, a semi-reusable vehicle embroiled in politics that became a symbol that the high frontier was the absolute dominion of governments and space agencies—a status quo perpetuated for more than three decades. Until now. More than 40 years after Walker's flight, using a flight profile similar to the X-15's, SS1 will attempt to beat Walker's record. Today, on the 47th anniversary of Sputnik, a privately developed spacecraft will attempt to demonstrate it is not necessary to spend US$20,000 to put one kilogram into orbit, or to have the technologies of space agencies to reach space.

The world's first private spacecraft is an impressive feat of engineering marked by simplicity of design that, on closer inspection, doesn't look like it should fly into space. The interior (Figure 1.2) is spare and devoid of the myriad switches, dials, and toggles crowding the Space Shuttle flight deck. There are a few low-tech levers, pedals, and buttons suggesting the vehicle is designed to fly, but the austere design doesn't exactly scream "space". Clearly, SS1 (sidebar) is a very different spacecraft from all that have gone before.

SpaceShipOne

- Crew: 1 pilot
- Capacity: 2 passengers
- Length: 5 meters
- Wingspan: 5 meters
- Wing area: 15 meters^2
- Empty weight: 1,200 kilograms
- Loaded weight: 3,600 kilograms
- Powerplant: 1 × N20/HTPB SpaceDev Hybrid rocket motor, 7,500 kgf I_{sp}
- Burn time: 87 seconds
- Aspect ratio: 1.6

Performance

- Maximum speed: Mach 3.09 (3,518 km/h)
- Range: 65 kilometers
- Service ceiling: 112,000 meters
- Rate of climb: 416.6 m/s
- Wing loading: 240 kg/meters^2
- Length: 5 meters
- Wingspan: 5 meters

1.2 SpaceShipOne interior. Courtesy: Wikimedia

"WhiteKnight is taxiing" crackles over the public address system—an announcement followed shortly after by the sound of high-pitched jet engines marking the arrival of the gleaming white carrier aircraft with SS1 slung tightly underneath. WhiteKnight and SS1 take off from Runway 30 at 06:47 local time, followed by two chase planes, an Extra 300 and a Beechcraft Starship, which will follow SS1 during its one-hour ride to separation altitude, giving spectators plenty of time to grab another bagel and a coffee.

"Three minutes to separation". Spectators scan the sky searching for the thin white line that is SS1. At 14,000 meters, SS1 is dropped like a bomb above Mojave Airport. Falling wings level, pilot and soon-to-be commercial astronaut, ex-Navy test pilot, Brian Binnie, 51, trims SS1's control surfaces for a positive nose-up pitch and fires the rocket motor, boosting the spacecraft almost vertically. "It looks great," says Binnie as he rockets upwards at Mach 3. Within seconds, SS1 is gone, trailing a white line of dissipating white smoke. SS1 accelerates for 84 seconds, subjecting Binnie to three times the force of gravity as it rockets upwards. The engines shut down and SS1 continues on its ballistic trajectory to an altitude of 114,421 meters. A loud cheer goes up from the spectators who are following the proceedings on a giant screen, each of them euphoric with the realization

1.3 Brian Binnie. Courtesy: Wordpress

that high above them is a privately developed spacecraft that may one day carry them into space. High in the sky, his spacecraft's rear wings feathered to increase drag upon re-entry, Binnie prepares to bring SS1 back to Earth. The spectators wait, spellbound, straining to hear the double sonic boom announcing SS1's return to the atmosphere. Seconds later, the unmistakable sound announces SS1 is on her way back from her historic mission, her signature shape descending in circles. Binnie guides SS1 gently back to Earth, gliding the spacecraft back to a perfect touchdown on the runway like any other aircraft. He has just become the 434th person to fly into space (Figure 1.3). Welcoming him enthusiastically are 27,500 spectators, including Microsoft's co-founder, Paul Allen, who helped finance the project; Burt Rutan, SS1's designer; and Peter Diamandis, chairman of the X-Prize Foundation. Private spaceflight has just become a reality. But this is just the beginning.

> "It's a fantastic view, it's a fantastic feeling. There is a freedom there and a sense of wonder that—I tell you what—you all need to experience."
>
> *Test pilot, Brian Binnie, describing his record-breaking trip*

WHAT HAPPENED NEXT

SS1 was unveiled at the Smithsonian Institution's National Air and Space Museum on October 5th, 2005, in the Milestones of Flight Gallery and is now on display to the public in the main atrium between the Spirit of St. Louis and the Bell X-1. The project cost less than US$25 million, or about the same amount as NASA spends every day … before lunch! The price tag is one of the most important aspects of SS1's flight because it finally demonstrated that passenger spaceflight travel, contrary to what was widely believed, really can be achieved at low cost.

Shortly after the celebrations, Richard Branson, chairman of Virgin Atlantic Airways, announced he will invest US$25 million in a new space venture to be called Virgin Galactic, a project that will license Rutan's Scaled Composite's SS1 technology for commercial suborbital flights starting at US$200,000. For Branson, this venture will be different from any other his Virgin group has been involved with. His travel business, cell phone company, and funky record business are all enterprises that have kept the champagne flowing and kept Branson in the headlines but, until the flights of SS1, no Virgin business has ever had the potential to change the world. Virgin Galactic will be the world's first off-planet private airline no less, fielding a fleet of five spaceships by the end of the decade. The price tag for the whole venture is US$121.5 million, or about half the price of a single Airbus A340-600, of which Virgin recently ordered 26.

> "It may take decades. It may take 50 to 100 years. But it's going to lead to a new industry."
>
> *Dennis Tito, Californian millionaire and the world's first paying space passenger*

Promises of space travel for the masses reached a euphoric pitch in 2004 when SS1 air-launched over the Mojave Desert and became the first privately financed, manned