

VIRGIN GALACTIC

The First Ten Years

Erik
Seedhouse



Virgin Galactic

The First Ten Years

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Erik Seedhouse

Virgin Galactic

The First Ten Years



Published in association with
Praxis Publishing
Chichester, UK



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SPRINGER-PRAXIS BOOKS IN SPACE EXPLORATION

ISBN 978-3-319-09261-4 ISBN 978-3-319-09262-1 (eBook)
DOI 10.1007/978-3-319-09262-1
Springer Cham Heidelberg New York Dordrecht London

Library of Congress Control Number: 2014957708

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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.

The author also expresses his deep appreciation to Christine Cressy, whose attention to detail and patience greatly facilitated the publication of this book. The author also expresses his appreciation to Bill Deaver for permission to use his great shot of SpaceShipTwo, to Jim Wilkie for creating yet another striking cover, and to D. Raja and Rekha Udaiyar for their meticulous attention in bringing this book to publication.

*To
All those preparing the way for
the suborbital
flight industry*

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 2nd Battalion the Parachute Regiment, the world's most elite airborne regiment. During his time in the "Para's", Erik spent six months in Belize, where he was 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 in Medical Science, supporting his studies by winning prize money in 100-kilometer running races. After placing third in the World 100km Championships in 1992, 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 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, Erik pursued his PhD at the German Space Agency's Institute for Space Medicine. While studying, he won Ultraman Hawai'i and the European Ultraman Championships, and completed Race Across America. 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 *Tourists in Space*, a manual for spaceflight participants. 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 spaceflight instructor for the American Astronautics Institute, professional speaker, triathlon coach, author, and Editor-in-Chief for the *Handbook of Life Support Systems for Spacecraft and Extraterrestrial Habitats*. He is the Training Director for Astronauts for Hire and, between 2008 and 2013, he served as director of Canada's manned centrifuge operations.

xiv **About the Author**

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. *Virgin Galactic* is his fifteenth 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.



The author stands in front of the Fram in Oslo, October 2014

Acronyms

A-LOC	Almost Loss of Consciousness
AGSM	Anti-G Straining Maneuver
ADS	Aid Data System
ATV	Atmospheric Test Vehicle
BEAM	Bigelow Expandable Activity Module
CG	Center of Gravity
CSLAA	Commercial Space Launch Amendments Act
DCS	Decompression Sickness
EDS	Emergency Detection System
EPT	Effective Performance Time
ESA	European Space Agency
ETC	Environmental Tectonics Corporation
FAA	Federal Aviation Administration
FAI	Fédération Aéronautique Internationale
FAST	Flights for the Advancement of Science and Technology
FDD	Flight Data Display
FTE	Flight-Test Engineer
G-LOC	Gradual Loss of Consciousness
GOR	Gradual Onset Rate
GPS	Global Positioning System
HTPB	Hydroxyl-terminated polybutadiene
INS	Inertial Navigation System
ISS	International Space Station
ITAR	International Trade on Arms Regulations
KEAS	Knots Equivalent Airspeed
LAPCAT	Long-Term Advanced Propulsion Concepts and Technologies
LEO	Low Earth Orbit
MIT	Massachusetts Institute of Technology
NASTAR	National Aerospace Training and Research

xvi **Acronyms**

NCRP	National Council for Radiation Protection
NMSA	New Mexico Spaceport Authority
OSC	Orbital Sciences Corporation
PI	Principal Investigator
PLL	Peripheral Light Loss
PUG	Payload User Guide
RAF	Royal Air Force
RCS	Reaction Control System
REM	Research Education Missions
ROR	Rapid Onset Rate
SABRE	Synergistic Air-Breathing Rocket Engine
SARG	Suborbital Applications Research Group
SAS	Space Adaptation Syndrome
SFP	Spaceflight Participant
SMS	Space Motion Sickness
SNU	System Navigation Unit
SwRI	Southwest Research Institute
TONU	Tier One Navigation Unit
TPS	Thermal Protection System
TUC	Time of Useful Consciousness
USAF	United States Air Force
USMC	United States Marine Corps
USML	United States Munitions List
VMC	Visual Meteorological Conditions

Preface

“Today’s flight was another resounding success. We focused on gathering more transonic and supersonic data, and our chief pilot, Dave, handled the vehicle beautifully. With each flight test, we are progressively closer to our target of starting commercial service in 2014.”

Virgin Galactic CEO, George Whitesides

As the main engine ignites, the crew feels a deep rumble behind them and a sudden sensation of motion as the rocket ignites, trailing a 100-meter-long fountain of exhaust in an inferno of smoke, searing light, and earth-shaking noise. Amid the thunder of launch, the numbing noise, and the incredible acceleration, the crew is pushed forcefully back into their seats. The gut-wrenching journey to suborbital space – an event planned for many weeks and anticipated by the crew for several months – takes less than five minutes. Once in microgravity, the thrill of the ascent is replaced by the immediacy of the moment, as the spaceflight participants – now fully fledged Virgin Galactic astronauts – pull out cameras and float to the nearest window to take snapshots from the vantage point in space.

About

We are Virgin Galactic, the world’s first commercial space-line. We are working hard to make access to space orders of magnitude more affordable, frequent, and safe than ever before. We are also having a lot of fun while doing so.

Mission

Make access to space orders of magnitude more affordable, frequent, and safe than ever before.

Description

Virgin Galactic, owned by Sir Richard Branson’s Virgin Group and Aabar Investments PJS, is on track to be the world’s first commercial spaceline. Our reusable, suborbital spaceship (SpaceshipTwo) and carrier craft (WhiteKnight-Two) have both been

developed by the legendary aerospace pioneers Scaled Composites. Founded by Burt Rutan, Scaled developed SpaceShipOne, which in 2004 claimed the \$10m Ansari X-PRIZE as the world's first privately developed manned spacecraft.

Our new vehicles share much of the same basic design, but are being built to carry six customers and two pilots on sub-orbital space flights. Each mission will give our future astronauts an out-of-the-seat, zero-gravity experience offering astounding views of the planet from the black sky of space.

The test flight programs for SpaceShipTwo and WhiteKnightTwo are well under way, leading to Virgin Galactic commercial operations, which will be based at Spaceport America in New Mexico.

In July 2012, we announced a new program called LauncherOne. LauncherOne will be launch small satellites into orbit for a wide variety of commercial and government customers.

www.virgingalactic.com

Welcome to Virgin Galactic's world of suborbital spaceflight

The above snapshot is taken from the Virgin Galactic website. Until recently, spaceflight had been the providence of a select corps of professional astronauts whose missions, in common with all remarkable exploits, were experienced vicariously by the rest of the world via television reports and internet feeds. These spacefarers risked their lives in the name of science, exploration, and adventure, thanks to government-funded manned spaceflight programs. All that is about to change thanks to Virgin Galactic, despite the tragic event on 31 October 2014, when VSS *Enterprise*, a Virgin Galactic test vehicle, suffered a catastrophic breakup and crashed in the Mojave Desert.

As George stated above, each SpaceShipTwo test flight is one step closer to Virgin Galactic's plans to launch daily flights into space. And when those first passenger flights begin, it will be the beginning of a new era in space travel. Passenger space travel has been a staple of sci-fi for almost as long as there have been commercial airlines. As far back as 1968, when Stanley Kubrick's *2001: A Space Odyssey* was released, Pan Am opened a waiting list for trips to the Moon. Part publicity stunt, the airline (it went bankrupt in 1991) estimated the service would begin no later than 2000. They even issued numbered membership cards for the first lunar flights! Inspired by the Moon landing the following year, 98,000 people signed up.

Nearly 50 years later, the bar is set a little lower. When testing is complete, SpaceShipTwo will fly to suborbital altitudes where passengers will enjoy four minutes of weightlessness. Slung beneath the WhiteKnightTwo mothership, SpaceShipTwo's ascent to the 15-kilometer launch altitude takes more than an hour. For passengers, who have paid US\$250,000 for the ride, there is nothing to do but wait for the moment of release. No drinks service on this ride. Once released, the diminutive spaceship drops away, the pilot ignites the rocket motor, and with a roar the spacecraft shudders to full thrust within a tenth of a second, its nose pointed straight up to the edge of space. Even if you've ridden the "fuge", as every passenger has, the acceleration is almost impossible to imagine, as 3 Gs pins them to the back of their seats. Twelve seconds later, the vehicle rockets through Mach 1. Mach 2 follows shortly after. Within 60 seconds, the vehicle is traveling at 4,800 kilometers per hour. Amid the diabolical noise (ear plugs are mandatory), the

vibration, and acceleration, the soon-to-be astronauts try to keep their composure as they watch the sky turn from blue to navy, indigo, and then – suddenly – black.

At around 80 seconds, the pilot cuts the engine and, shortly after, the spaceship enters zero gravity. The passengers are now Virgin Galactic astronauts. Releasing their seat belts, they float around the cabin, and gaze at the view: 1,600 kilometers from horizon to horizon, the curvature of Earth subtle but clear, the fine blue line of the atmosphere easily visible against the blackness of space. On-board cameras capture every second of the experience. At the top of its parabolic arc, the rocket plane spends just four minutes in space before it begins its fall back down to Earth. The pilot positions the “feather” for re-entry, and the passenger seats recline to enable the newly minted astronauts to cope with up to 6 Gs of acceleration during their ride back to the desert runway.

If everything goes to plan, Branson hopes not only to give birth to a new industry, but to democratize the government-dominated spaceflight business by opening the space frontier to commercial astronauts, payload specialists, scientists, and, of course, tourists. But, as the tragic event of 31 October 2014 reminded us, the aerospace business is rarely one in which things go to plan. After the accident in which pilot Michael Alsbury was killed, Sir Richard Branson vowed that his Virgin Galactic space programme, saying millions of people “would one day love the chance to go to space”. This book tells the story to date.

1

Suborbital Flight: A Primer



1.1 Courtesy: NASA

Those who have followed the media fanfare about the commercial suborbital flight industry over the past several years have cause to be a little disillusioned because it's been quite a waiting game. After the euphoria of the X-Prize in 2004, space fans and media alike discussed the possibility of flying into space the following year or if not the following year then *definitely* the year after that. Virgin Galactic, along with other operators that

2 Suborbital Flight: A Primer



1.2 SpaceShipOne. Mike Melvill waves from the cockpit on 21 June 2004. Courtesy: Wikimedia/The SpaceShip Company

comprised the nascent commercial spaceflight industry, fueled speculation that suborbital passenger flights were just around the corner by making promises they would soon be ready to fly you and your friends into space. Tickets were sold. Hundreds of them. Deadlines came and went. But nothing happened, except for the occasional test flight. One year stretched to two. Two became five. Five became 10. But, in 2014, more than 10 years following SpaceShipOne's iconic flight (Figure 1.2), Virgin Galactic was finally tantalizingly within reach of realizing the promise of the historic 2004 flight. Until the tragic event of 31 October 2014 that is.

EARLY SUBORBITAL FLIGHTS

Those lucky enough to fly on SpaceShipTwo, Mark II, SpaceShipOne's and the original SpaceShipTwo's successor, will experience a spaceflight that few have flown because manned suborbital spaceflights are something of a rarity: two Mercury–Redstone flights, two X-15 flights, one inadvertent Soyuz launch abort, and three SpaceShipOne flights. That's it. Eight flights. But, if you include animals, that list stretches a little, so when you buy your SpaceShipTwo ticket, spare a thought for the animals that made your flight possible. Many years ago, before astronauts risked their lives, it was thought humans might not survive the