

Tourists in Space

A Practical Guide

Erik Seedhouse

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Preface

The Ansari Prize–winning flights of Scaled Composites’ SpaceShipOne (SS1) in October 2004 (Figure 1) generated significant media and industry interest in sub-orbital and orbital space tourism. Since the flights of SS1, there have been several major developments in the space tourism industry, principally in suborbital flights, evidenced by the significant increase in activity by companies such as Rocketplane Ltd., EADS Astrium, SpaceX, SpaceDev, XCOR, and Virgin Galactic, each of which is hoping to sell tickets to the public for flights scheduled to begin within five years.

However, despite this increase in interest, little information exists for future commercial space travelers regarding the medical and training requirements for suborbital and orbital flight. Although the Federal Aviation Administration (FAA) has provided training and medical recommendations [1] to commercial space tourist companies, the guidelines provided are general and to date there exist no



Figure 1. SpaceShipOne and WhiteKnightOne. Image courtesy: © 2004 Mojave Aerospace Ventures LLC, photograph by Scaled Composites. SpaceShipOne is a Paul G. Allen Project. Source: www.scaled.com/projects/tierone/gallery/X-Prize_1/XPrize_X1_0166 - SS1

published manuals that describe the preparation commercial space travelers must undergo prior to flying into space.

The purpose of this book is to fill this void and to present astronaut training procedures with sufficient rationale and supporting information to provide the reader with a comprehensive understanding of the training required to fly into space. To that end, this guide has been developed as a single source of information on the training and procedures required for suborbital and orbital flight. As well as being intended for those planning on purchasing a suborbital or orbital ticket, this guide is also aimed at the broader audience of space enthusiasts and the public at large, many of whom will be interested in the practical and technical aspects of astronaut training. In addition to providing a valuable source of information to future space travelers, it is also hoped this book will inspire those considering traveling into space with enthusiasm and I hope you enjoy following the fascinating journey of spaceflight participants toward realizing their ultimate dream.

REFERENCE

- [1] FAA. Human Space Flight Requirements for Crew and Space Flight Participants; Final file. December 15, 2006.

Acknowledgments

The idea for this book was inspired by my dual enthusiasms for exploration and space. I realize that many people interested in these topics may not have the desire to fly to space but are nevertheless intrigued by the training required of spaceflight participants intending on making either a suborbital or orbital flight. I envisioned this book as an opportunity therefore to transmit to others the complexity of the training required by future spaceflight participants and, in doing so, endeavored to provide as much detail as possible without losing clarity or inhibiting overall understanding. In achieving this aim I am indebted to several people.

I would particularly like to thank Parvez Kumar for his insightful comments and suggestions and for his invaluable time in proofreading and careful scrutiny of this book. I would also like to thank EADS Astrium for kindly supplying the cover photo. Special thanks also to Clive Horwood and Springer-Praxis for recognizing the value of this text and for making it a commercial reality, and to copy editor extraordinaire, Neil Shuttlewood, for his meticulous supervision of the text. Finally, this project would not have been possible without the loving encouragement and patience of my wife, Doina, through the many nights and weekends dedicated to completing this book.

To Doina, Jasper, and MiniMach

About the author

Dr. Erik Seedhouse is a research scientist specializing in space life sciences and environmental physiology. He has wanted to fly in space as long as he can remember and, shortly after completing his Masters degree in 1992, he applied to be an astronaut with the Canadian Space Agency but didn't make the final cut. He then became a professional ultra-distance triathlete, winning two world championships and setting a world record for the longest triathlon in the world, performances that resulted in *GQ* magazine nominating him as "Fittest Man in the World" in 1997. He gained his Ph.D. in Physiology while working for the European Space Agency between 1996 and 1998, before working as a Co-Director of the Extreme Physiology Program at Canada's Simon Fraser University. After four years at Simon Fraser University, the author served five years as a naval officer with the Canadian Navy and recently worked as an astronaut training consultant for Bigelow Aerospace, for whom he developed and authored the company's spaceflight participant's training manual. He has authored more than a dozen articles in *Spaceflight* magazine and has written a chapter in the book *Space Exploration 2008*. He is a member of the Aerospace Medical Association, the Mars Society, and a Fellow of the British Interplanetary Society.

He is a dynamic speaker and has presented motivational talks in Norway and the U.S. He is also a licensed pilot, experienced skydiver, and holds professional scuba diver certification. He has acted as expedition leader to some of the world's highest mountains, the most recent being a successful ascent of Aconcagua and has logged several solo ascents in the European Alps. Erik lives in Vancouver with his wife, Doina, and their cats, Jasper and MiniMach. Together, Erik and Doina have climbed Aconcagua, the highest mountain outside the Himalayas, raced in more than 20 countries, survived whiteouts on Mount McKinley, and reached the summit of Mount Rainier.

The author's overriding and unfulfilled ambition remains to one day fly into space.

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Abbreviations and acronyms

ACLS	Advanced Cardiac Life Support
ACTS	Active Thermal Control System
ADH	AntiDiuretic Hormone
AFF	Accelerated FreeFall
AFRL	Air Force Research Laboratory
AFS-2	Autogenic Feedback System-2
AFT	Autogenic Feedback Training
AFTE	Autogenic Feedback Training Exercise
AGE	Arterial Gas Embolism
AHSP	Astronaut Health & Safety Program
ALARA	As Low As Reasonably Achievable
ALPA	Airline Pilots Association International
ALS	Advanced Life Support
ALSK	Advanced Life Support Kit
AMS	Alpha Magnetic Spectrometer
ANS	Autonomic Nervous System
ANSI	American National Standards Institute
AOD	Automatic Opening Device
APAI	Airline Pilots Association International
AR	Augmented Reality
ARC	Ames Research Center
ARPCS	Atmosphere Revitalization Pressure Control System
ARS	Acute Radiation Syndrome
ARS	Air Revitalization System
ASE	Association of Space Explorers
ATAGS	Advanced Technology Anti-G Suit
ATCS	Active Thermal Control System
ATP	Astronaut Training Program

AUV	Autonomous Underwater Vehicle
AV	AtrioVentricular
BA	Bigelow Aerospace
BC	Ballistic Coefficient
BFO	Blood Forming Organs
BIBS	Built In Breathing System
BLS	Basic Life Support
BP	Blood Pressure
BPU	Bus Power Unit
BSC	Benson Space Company
BSMK	Basic Spacecraft Medical Kit
BTLS	Basic Trauma Life Support
BV	Blood Volume
BVP	Blood Volume Pulse
C/T	Cardio Thoracic
CAD	Coronary Artery Disease
CapCom	Capsule Communicator
CBT	Computer-Based Training
CCAFS	Cape Canaveral Air Force Station
CES	Crew Escape System
CEV	Crew Exploration Vehicle
CHCS	Crew Health Care System
CLL	Central Light Loss
CME	Coronal Mass Ejection
CMO	Crew Medical Officer
CMRS	Crew Medical Restraint System
CNS	Central Nervous System
CO	Cardiac Output
COMSEC	Communication Security
COTS	Commercial Orbital Transportation Services
CPDS	Charged Particle Directional Spectrometer
CPR	Cardiopulmonary Resuscitation
CRV	Crew Rescue Vehicle
CSA	Canadian Space Agency
CSLAA	Commercial Space Launch Amendments Act
CVP	Central Venous Pressure
CVS	CardioVascular System
CXV	Crew Transfer Vehicle
DARPA	Defense Advanced Research Projects Agency
DAS	Data Acquisition System
DBP	Diastolic Blood Pressure
DCS	Decompression Sickness
DEPTHX	Deep Phreatic Thermal Explorer
DIG	Digital Image Generation
DNA	Deoxyribonucleic Acid

DOME	Device for Orientation and Motion Environments
DSB	Double Strand Break
DTA	Drop Test Article
ECC	Expected Casualty Calculation
ECG	Electrocardiogram
ECLSS	Environmental Control and Life Support System
EDS	Emergency Detection System
EELV	Evolved Expendable Launch Vehicle
EI	Entry Interface
ELV	Expendable Launch Vehicle
EM	Electro-magnetic
EMG	Electromyography
EOA	Exclusive Operating Area
EPO	Erythropoietin
EPT	Effective Performance Time
ESA	European Space Agency
ESMD	Exploration Systems Mission Directorate
EVA	Extravehicular Activity
FAA	Federal Aviation Administration
FADEC	Full-Authority Digital Electronic Control System
FAI	Fédération Aéronautique Internationale
FCI	Freezing Cold Injury
FCS	Flight Control System
FCT	Flight Control Team
FD	Flight Director
FMEA	Failure Modes and Effects Analysis
FOS	Factor Of Safety
FOV	Field Of Vision
FOV	Field of View
FVMS	Flight Vehicle Medical System
G-LOC	Gravity-induced Loss Of Consciousness
GCR	Galactic Cosmic Radiation
GI	Gastrointestinal
GNC	Guidance, Navigation and Control
GOR	Gradual Onset Run
GPC	General Purpose Computer
GTOW	Gross Take-Off Weight
HAI	High Altitude Indoctrination
HDT	Head-down tilt
HIV	Human Immunodeficiency Virus
HMD	Head Mounted Display
HPS	Human Patient Simulator
HR	Heart Rate
HS	Handstand Position
HTO	Horizontal Take-Off

xxx **Abbreviations and acronyms**

HTP	High Test Peroxide
HZE	Nuclei with high atomic number
IASE	International Association of Space Entrepreneurs
IM	Intramuscular
IMC	Integrated Medical Checklist
IMU	Inertial Measurement Unit
INS	Inertial Navigation System
IPV	Inactivated Polio Vaccine
ISC	International Space Company
ISLAP	Institute for Space Law and Policy
ISS	International Space Station
ITAR	International Trade on Arms Regulations
IV	Intravenous
IVA	Intra Vehicular Activity
IVHMS	Integrated Vehicle Health Management System
IVS	Intelligent Virtual Station
JIMO	Jupiter Icy Moons Orbiter
JSC	Johnson Space Center
I_{sp}	Specific Impulse
LA	Left Atrium
LAP	Launch Assist Platform
LAP	Limited Access Program
LBNP	Lower Body Negative Pressure
LCG	Liquid Cooling Garment
LD_{50}	50% mortality
LEO	Low Earth Orbit
LES	Launch and Entry Suit
LES	Launch Escape System
LET	Linear Energy Transfer
LIDS	Low Impact Docking System
LOV	Loss of Vision
LOX	Liquid Oxygen
LV	Left Ventricle
MAP	Mean Arterial Pressure
MCC	Mission Control Center
MDB	Myasishchev Design Bureau
MECO	Main Engine Cut Off
MET	Mission Elapsed Time
mGy	milliGray
MMOD	MicroMeteoroid/Orbital Debris
MPL	Maximum Probable Loss
MRC	Mission Requirements Checklist
MRE	Meal, Ready to Eat
mrem	millirem
MSFC	Marshall Space Flight Center

mSv	milliSieverts
MV	Minute Volume
NASA	National Aeronautics and Space Administration
NASTAR	National Aerospace Training and Research Center
NCRP	National Council on Radiation Protection
NEO	Near Earth Object
NIAC	NASA's Institute for Advanced Concepts
NPRM	Notices of Proposed Rulemaking
NRC	National Research Council
NSBRI	National Space Biomedical Research Institute
OCF	Operational Countermeasure Procedure
OH	Orthostatic Hypotension
OI	Orthostatic Intolerance
OMS	Orbital Maneuvering System
OPV	Oral Polio Vaccine
OSHA	Occupational Safety and Health Administration
OST	Outer Space Treaty
OTEC	Ocean Thermal Energy Conversion
OV	Orbital Vehicle
PAB	Premature Atrial Beat
PADI	Professional Association of Diving Instructors
PAF	Preflight Adaptation Facility
PBA	Portable Breathing Apparatus
PDA	Personal Data Assistant
PFD	Primary Flight Display
PFE	Portable Fire Extinguisher
PLL	Peripheral Light Loss
PLS	Personnel Launch System
PNTD	Plastic Nuclear Track Detector
PP	Pulse Pressure
PP	Partial Pressure
PPL	Private Pilot License
PSF	Personal Spaceflight Federation
PSK	Personal Sleep Kit
PV	Plasma Volume
PVB	Premature Ventricular Beat
RA	Right Atrium
RAAS	Renin Angiotensin Aldosterone System
RAD, rad	Radiation Absorbed Dose
RBC	Red Blood Cell
RBCM	Red Blood Cell Mass
RBE	Relative Biological Effectiveness
RBH	Reverse Bear Hug
RCS	Reaction Control System
RD	Rapid Decompression

RDC	Rapid Decompression
rem	radiation equivalent in man
RF	Radio Frequency
RLV	Reusable Launch Vehicle
ROR	Rapid Onset Run
RPB	Return to Preflight Baseline
RpK	Rocketplane Kistler
RPM	Revolutions Per Minute
RV	Right Ventricle
SAA	South Atlantic Anomaly
SAR	Search and Rescue
SBP	Systolic Blood Pressure
SD	Spatial Disorientation
SEU	Single Event Upset
SFP	SpaceFlight Participant
SFPMC	SpaceFlight Participant Medical Certificate
SIRCA	Silicone Impregnated Refractory Ceramic Ablator
SIVA	Simulated Intra Vehicular Activity
SIVAS	Simulated IntraVehicular Activity System
SLC	Space Launch Complex
SLD	Subject Load Device
SMOC	Space Medical Operations Center
SMP	Space Medical Program
SMP	Spaceflight Medical Program
SMS	Shuttle Mission Simulator
SMS	Spaceflight Medical Summary
SMS	Space Motion Sickness
SMSS	Space Shuttle Main Engine
SPC	Soluble Protein Crystallization
SPD	Subject Position Device
SPE	Solar Particle Event
SPEWS	Solar Particle Event Warning System
SRB	Solid Rocket Booster
SS	Side Straddle
SS1	SpaceShipOne
SS2	SpaceShipTwo
SSB	Single Strand Break
SST	Single Systems Trainer
SV	Stroke Volume
SWCNT	Single-Walled Carbon NanoTubes
t/LAD	Trapeze-Lanyard Air Drop
TACAN	TACtical Air Navigation
TEPC	Tissue Equivalent Proportional Counter
TLD	Thermoluminescent Detector
TM	Telemedicine

TMO	Trash Management Operations
TPR	Total Peripheral Resistance
TPS	Thermal Protection System
TS	Trauma Sonography
TTD	Tilt Translational Device
TTT	Tilt Table Test
TUC	Time of Useful Consciousness
TV	Tidal Ventilation
TV	Tidal Volume
TVC	Thrust Vector Control
TVIS	Treadmill Vibration Isolation and Stabilization System
UCD	Urine Collection Device
UV	Ultraviolet
VAFB	Vandenberg Air Force Base
VAPAK	Vapor pressurization design
VCG	Vectorcardiograph
VE	Virtual Environment
VEG	Virtual Environment Generator
VF	Ventricular Fibrillation
VLA	Very Large Aircraft
VR	Virtual Reality
VRI	Visual Reorientation Illusions
VSS	Virgin SpaceShip
VT	Ventricular Tachycardia
VTO	Vertical Take Off
VTOVL	Vertical Take-off Vertical Landing
WCS	Waste Collection System
WK1	WhiteKnightOne
WK2	WhiteKnightTwo
WMC	Waste Management Compartment
WMS	Waste Management System
WS	Waist Straddle