
MARS via the MOON
The Next Giant Leap
Erik Seedhouse
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To those who eventually take the next giant leap

About the Author

Erik Seedhouse is a Norwegian-Canadian suborbital astronaut. After completing his first degree, the author joined the second Battalion, the Parachute Regiment. During his time in the "Para's" Erik spent six months in Belize, training in the art of jungle warfare. He also spent many months learning the intricacies of desert warfare, made dozens of jumps from C130s, performed more than 200 helicopter abseils, and fired more light anti-tank weapons than he cares to remember.

Upon returning to academia, the author embarked upon a master's degree, supporting his studies by winning prize money in 100-km running races. After placing third in the World 100-km Championships and setting the North American 100-km record, Erik turned to ultra-distance triathlon, winning the World Endurance Triathlon Championships in 1995 and 1996. For good measure, he won the inaugural World Double Ironman Championships in 1995 and the infamous Decatriathlon – an event requiring athletes to swim 38 km, ride 1,800 km, and run 422 km. Non-stop!

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

In 1999, Erik took a research job at Simon Fraser University. In 2005, the author worked as an astronaut training consultant for Bigelow Aerospace and wrote *Tourists in Space*, a training manual for spaceflight participants. In 2009, he was one of the final 30 candidates in the Canadian Space Agency's Astronaut Recruitment Campaign. Between 2008 and 2013, Erik served as director of Canada's manned centrifuge and hypobaric operations.

In addition to being a suborbital astronaut, triathlete, centrifuge operator and director, pilot, and author, Erik is an avid mountaineer and is currently pursuing his goal of climbing the Seven Summits. *Mars via the Moon* is his twentieth book. He currently works as an Assistant Professor in Commercial Space Operations at Embry-Riddle Aeronautical University where he spends time managing the suborbital spaceflight simulator and operationalizing pressure suits for use in space. He divides his time between the Space Coast, Sandefjord, Norway, and Kona, Hawai'i.

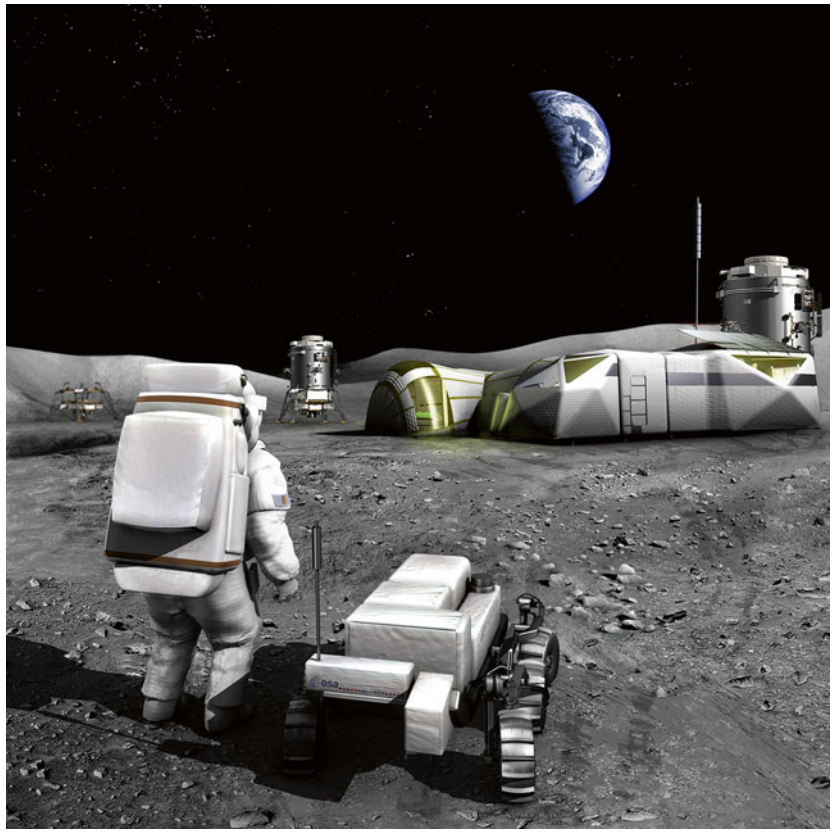
Acronyms

A-ETC	Architecture Et Cetera (A-ETC)
ALARA	As Low As Reasonably Possible
ALHAT	Autonomous Landing and Hazard-Avoidance Technology
ARED	Advanced Resistive Exercise Device
ARM	Asteroid Redirect Mission
ARS	Acute Radiation Sickness
ATHLETE	All-Terrain Hex-Limbed Extra-Terrestrial Explorer
BEAM	Bigelow Expandable Activity Module
BLSS	Bioregenerative Life-Support System
CAD	Computer-Aided Design
CAT	Computed Assisted Tomography
CATALYST	Lunar Cargo Transportation and Landing by Soft Touchdown
CLSE	Centre for Lunar Science and Exploration
CMO	Crew Medical Officer
COPUOS	Committee on the Peaceful Uses of Outer Space
CSF	Cerebrospinal Fluid
CSLA	Commercial Space Launch Act
CT	Computed Tomography
DGB	Disk Gap Band
EDL	Entry, Descent, and Landing
ESAS	Explorations Systems Architecture Study
FAA	Federal Aviation Administration
FPGA	Field Programmable Gate Array
GCR	Galactic Cosmic Radiation
GTO	Geosynchronous Transfer Orbit
HEOMD	Human and Exploration Operations Mission Directorate
HTP	Hypersonic Transition Problem
ICF	Inertial Confinement Fusion
ILD	International Lunar Decade

ILDWG	International Lunar Decade Working Group
ILOA	International Lunar Observatory Association
ILSWG	International Lunar Survey Working Group
ISECG	International Space Exploration Coordination Group
ISRU	In-Situ Resource Utilization
ISS	International Space Station
JFCC–Space	Joint Functional Component Command for Space
LEAG	Lunar Exploration Analysis Group
LEDA	Lunar European Demonstration Approach
LEO	Low Earth Orbit
LK	Lunniy Kabina
LLCS	Lunar Laser Communications System
LPS	Lunar Positioning System
LRO	Lunar Reconnaissance Orbiter
LTV	Lunar Transport Vehicle
MCF	Magnetic Confinement Fusion
MMAMA	Moon Mars Analog Mission Activities
MORO	Moon Orbiting Observatory
MS-FACS	Microwave Sinterator Freeform Additive Construction System
NAS	National Academy of Science
NCRP	National Council on Radiation Protection
NEO	Near Earth Object
NGL	Next Giant Leap
NORAD	North American Aerospace Defense Command
PGM	Platinum Group Metal
PISCES	Pacific International Space Center for Exploration Systems
POLO	Polar Orbiting Lunar Observatory
RAD	Radiation Assessment Detector
RESOLVE	Regolith and Environment Science and Oxygen and Lunar Volatiles Extraction
ROR	Rules of the Road
SDI	Strategic Defense Initiative
SEC	Shackleton Energy Company
SEPP	Solar Electric Primary Propulsion
SLS	Space Launch System
SPE	Solar Particle Event
SSPS	Space Solar Power System
STP	Supersonic Transition Problem
TDS	Terminal Descent System
TEI	Trans Earth Injection
TRN	Terrain Relative Navigation
VASIMR	Variable Specific Impulse Magnetoplasma Rocket
VIIP	Visual Impairment Intracranial Pressure
VSE	Vision of Space Exploration
WHO	World Health Organization

Kick-Starting the Next Giant Leap

"You need to tell your story better. You need a better story to tell."
James Cameron speaking to engineers working on the Constellation program, 2006



Momentum is building for a return to the Moon. NASA's international partners on the International Space Station are in favor of returning to the lunar surface, as are India and China. The National Research Council is too, stating: "Of the several pathways examined, the one that does not include a meaningful return to the Moon – that is, extended operations on the lunar surface – has higher development risk than other pathways." The horizon goal may be Mars, but the political, funding, and technological and medical infeasibility of such an objective means the next logical step is a return to the Moon. While much has been learned about the Moon over the years, we don't understand its resource wealth potential and the technologies to exploit those resources have yet to be developed, but there are a number of companies that are developing these capabilities. And, with the discovery of water in the lunar polar regions, plans are in the works to exploit these resources for fuel for transportation operations in *cis*-lunar space and in low Earth orbit (LEO).

> "If God wanted man to become a space-faring species, he would have given man a moon."
> *Krafft Arnold Ehricke, rocket-propulsion engineer and advocate for space colonization*

Ehricke was right! The time has come for commercial enterprise to lead the way back to the lunar surface. Embarking on such a venture requires little in the way of new technologies. We don't need to develop super-fast propulsion systems like those required to get us to Mars safely, nor do we need hundreds of billions of dollars that the experts reckon it will cost to transport humans to the Red Planet. No, what we do need is a place to test the technologies and deep-space experience that will enable us to build a pathway that will lead us to Mars. That place is the Moon and this book explains why.

This book begins with an assessment of the very real and very lethal "dragons" that mean a manned mission to Mars using chemical propulsion is a death sentence. Chapter 1 describes these mission killers in detail. Of all the physiological mission killers, radiation is the most dangerous dragon of all, since it not only increases the risk of cancer but also accelerates bone loss through a process of osteoradionecrosis. If that wasn't bad enough, deep-space radiation can also cause brain damage and cataracts. Compounding the effects of radiation are the risks of visual impairment, dramatic bone loss, and the wasting-away of muscles. Imagine a half-blind, brain-damaged, and severely weakened astronaut facing the challenge of the entry, descent, and landing (EDL) sequence. And, talking of EDL, this is the most lethal dragon, and one that may be the most difficult to tame. On reading Chapter 1, you may think that I'm not in favor of a manned mission to Mars. Nothing could be farther from the truth. I'm Norwegian and my country has a rich heritage of bold exploration. There is nothing I want more than for humans to set foot on Mars but it is absurd to think that reality will occur anytime in the next 20–30 years short of a series of technological breakthroughs. So Chapter 1 is a dose of realism.

In Chapter 2, we take a look at how humans may return to the Moon via a government-sponsored mission or series of missions. Russia has been making noises about landing on the Moon and establishing a base sometime in the late 2020s time frame while China has