

DEREK WEBBER



# LUNAR COMMERCE

A PRIMER



Springer

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*To the Dreamers, Doers, and Risk-Takers of the Lunar Commerce Imperative*

—Ad Astra Per Negotium!

# Acknowledgments

Let me tell you about retirement. It's a cruel mirage. The work continues, or even increases, and now you don't get paid. For a decade, I have been a member of this world of committees and volunteerism, but of course I have omitted the big plus, which is that you can focus on only the things that matter to you—and at any time simply walk away if it is not working. And that applies also to everyone else working on the endeavor, so it is indeed a mixed blessing. It requires therefore much more flexibility than previous salaried work environments. So, the work gets done solely because of the personal commitments of those involved, and trust becomes a very important, and maybe the most precious, resource. I have indeed been fortunate in that in my case a series of opportunities, and a succession of trusted colleagues, have entered my life, after I formally retired from my consulting business, to help get the (self-selected) ongoing work (all related to commercial development of the Moon) done.

As a child of Apollo, I have always been motivated to follow up on the challenge created by the risks taken half a century ago when the Apollo guys, many of whom I was later able to meet, went to the Moon the first time around. And now we are preparing to return to the Moon, under very different circumstances. So, this book rounds off for me a decade starting around 2012, and dedicated to the work of building private and commercial access to our celestial neighbor.

Since all of the work described in this book has been conducted in my “retirement” years while operating within volunteer organizations, it is particularly important that due recognition is given to all my volunteer colleagues. It is the only “payment” they will ever get! Work within three different volunteer efforts span the decade in question, and I have tried to adequately

and fairly capture those efforts at the appropriate points in this narrative. All these folk have, in their precious spare time, done their part in preparing us for a future lunar economy. They clearly believe the Robert Browning dictum: “Ah, but a man’s reach should exceed his grasp, or what’s a heaven for?”

So, I offer my acknowledgment and thanks for friendship and committed hard volunteer work from the following:

## **At Google Lunar XPRIZE Judging**

Thanks to my fellow international volunteer GLXP Judges: Alan Wells, Jeff Hoffman, Elisabeth Morse, Berengere Houdou, John Zarnecki, Derek Lang, Chuck Reynerson, Jay Kurtz, Dave Swanson, and Craig Peterson. Thanks also to the XPRIZE Foundation professional management and staff: Peter Diamandis, Anousheh Ansari, Andrew Barton, Nathan Wong, David Locke, Chanda Gonzales, and Amanda Stiles. Your combined work gave hope to a whole new generation of potential space engineers and dreamers around the world. And in a very real sense helped open the way to an era of massive cost reductions for lunar activities.

## **At the ForAllMoonkind NGO**

Thanks to the leadership and extraordinary can-do approach to protecting and preserving the lunar heritage artifacts exhibited by Michelle and Tim Hanlon, Marlene Losier, and Judith Beck, my colleagues at our June 2019 presentation to the UNCOPUOS delegates in Vienna. After having succeeded in getting appropriate legislation included in the canon of US law, the work goes on in the difficult international forums where the wordsmithing of treaty language takes place. The lunar tourists are coming, so we need to get these protections in place. We only get one chance to preserve the record and legacy of Earth’s first visitors to another world. And thanks to the guys who put the artifacts and boot-prints there in the first place, giving rise to the need to protect and preserve. I thank you collectively for your original risk-taking, and on a personal level to many for your subsequent support to my various lunar commerce related initiatives. It has been an amazing era to be alive, as mankind moved outward for the first time.

## At the Moon Village Association NGO

Most of the quantitative, and indeed qualitative, work in this book was conducted by a band of international volunteer analysts, during the period of the global covid pandemic, and so I was never able to meet them in person. We performed our work via Zoom, and I gave my thanks in that same way, but their names need to be recorded and acknowledged here as the creators of the Lunar Commerce Portfolio (LCP). Some were there for the whole 2-year duration of the effort; others contributed as they were able. My apologies if I have missed out any of the contributors. Thanks, therefore, to: Jenna Tiwana, Gidon Gautel, Christophe Bosquillon, Dallas Bienhoff, Sara Sabry, Sylvester Kaczmarek, Vedang Acharya, Erik Kulu, Yann Perot, Enrico Trolese, Andrey Lopantsev, McLee Kerrole, Alistair Schofield, Aditya Schrikhande, Aitor Hernandez, Alexis Caratozzolo, Alvaro Pubill, Antonio Fois, Ehsan Razavizadeh, Norbert Naskov, Ryuichi Dunphy, Sunny Narayanan, Richal Abhang, Varsha Shankar, Vitalii Stoliarchuk, Bryan Lachica, Habeebullah Akorede, Keerthana Gunaretnam, Nidhi Vasaika, Pinar Tan, Samantha Falcucci, Sonalli Madhanraj, Stella Tkatchova, Vishal Tripathi, Pranay Shah, Richard Howard, Jose Ocasio-Christian, Aarohi Khanna, Guillaume Videloup, Laurie Wiggins, Luca Buzelli, Luca Kiewiet, Niesha Baker, Tejas Bendre, Devanshu Jha, Kaori Becerril, Matthias Frenzl, Natasha Heidenrich, Pablo Arellano, Deep Patel, Elaine Tan, Lucien Bildstein, Oscar Fernandez, Veronica Moronese, Ilankuzhali Elavarasan, Keerthana Gunasretnam, Kristine Atienza, Suchwesna Patil, Venkataswamy Eswarachari. In addition to the volunteers, I also want to recognize the administrative and management support of the MVA's leadership board, in particular Giuseppe Reibaldi, Jeff Mankins, Oleg Ventskovsky, and Glafki Antoniou. The work goes on, and new co-chairs have taken over from where I left things, and so I wish them as much luck as was afforded me in having the helpful, creative, hardworking, and trustworthy colleagues, who "got the work done" as reported in this book. Thanks also, for their ongoing LCP support, to the Bocconi team in Milan of Simonetta di Pippo (former Director of the UN's Office of Outer Space Affairs), Andrea Conconi, Mattia Pianorsi, Clelia Iacomina, and Aristeo Saputo. And to Mehmet Sefer of Space Construction Technologies, who has taken on the responsibilities of Membership Secretary of the new Lunar Commerce User Group (LCUG).



## And Then, There Were The Others

After my having drawn attention to certain conservative elements within NASA with regard to some reticence and difficulties in implementing the task of returning to the Moon—“this time to stay”—I really ought to recognize and give thanks to those who have indeed taken the steps within the Agency to make change happen—to Lori Garver and Phil McCalister, who in their respective roles have led the charge toward the new age using the paradigm-shifting “newspace” approaches. And to that I must add thanks and recognition to the membership over the years of the LEAG and LSIC groups, who have steadily progressed, despite the constraints and vicissitudes of the budget cycle, and tested out many of the basic elements of the potential lunar surface infrastructure referenced in the LCP and in this book.

Thanks to Arlene Kelley for her clear design work and her illustration of the lunar surface tourists.

Acknowledgment is due to the architectural firm of Skidmore, Owings and Merrill (SOM) for their permission to use the image for the cover, which showed the result of a 2020 joint MIT/ESA/SOM collaborative effort at designing a Moon Village.

Thanks to the support team at Springer—Niza Jones and Jill Balzano who accepted my proposal and guided the content, and Harathi Ramu and colleagues who saw to the production process. And in that context, heartfelt thanks to the anonymous reviewers of my original proposal, who provided some excellent suggestions which improved the resulting end product.

Thanks, as ever, to SLF for review and support. I really mean it this time—now I am retired for sure. The boat is waiting, and the lakes of Maine are calling.

August 2023

Derek Webber  
Damariscotta, Maine, USA

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## About the Author



**Derek Webber** Derek Webber is founder of the consulting firm Spaceport Associates.

Originally, as a satellite and launch vehicle engineer, and later in marketing, regulatory, planning, financial, and procurement roles, he made contributions during decades in the satellite communications business sector in Europe, and also later when he came to the United States. He then re-focused his consultancy for the first decade of this century on building the regulatory and business basis of the space tourism industry and through leading a key project directing statistically valid market research among millionaires established the validity of a space tourism market.

Since his retirement, he has been working for a decade on a volunteer basis at various aspects of the commercial development of the Moon, attempting to provide a firm foundation for this important first step of the economic development of the solar system. This has involved initially being Vice Chair of the independent panel of Judges for the Google Lunar XPRIZE, an international

competition to encourage non-governmental private low-cost access to the Moon, and then in managing volunteer team members in two NGO organizations which have Permanent Observer status at the Vienna-based United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS). The first of these was *For All Moonkind*, where the aim was the preservation of lunar heritage sites, during an expected upcoming era of renewed surface activity on the Moon, including sightseeing by lunar tourists. The second NGO was *The Moon Village Association*, where during a two-year period he formed, and served as co-chair of, the Working Group on Lunar Commerce and Economics. Within this group, he directed team members performing the analysis involved in creating the *Lunar Commerce Portfolio (LCP)*—a first attempt at a fully transparent assemblage of data on lunar market segments, and deriving resulting demand-based lunar revenue forecasts. This book captures the results of this last decade of lunar commerce related activities, and includes within it an easy introduction to the purpose, procedures, and content of the LCP.

Derek Webber is the author of four previous books on commercial space development and space history, describing the satellites, launch vehicles, the Moon landings, and the space tourism sectors.

# Acronyms

## A

A&E Architecture and Engineering  
ASA Australian Space Agency

## B

BLSS Bio-regenerative Life Support System

## C

CAB Chargeable Atomic Batteries  
CLPS Commercial Lunar Payload Services  
CNES French National Centre for Space Studies  
CNSA China National Space Agency  
COPUOS Committee On the Peaceful Uses of Outer Space  
CSA Canadian Space Agency

## D

DARPA Defense Advanced Research Projects Agency (of US Govt)  
DLR German Space Agency  
DOE Department of Energy (of US Govt)  
DSN Deep Space Network (of NASA)

## E

ELDO European Launcher Development Organisation  
ESA European Space Agency  
ESM European Service Module (of Orion spacecraft)

**xviii      Acronyms**

ESRO	European Space Research Organisation
EUMETSAT	European Meteorological Satellite Organisation
EUTELSAT	European Telecommunications Satellite Organization
EVA	Extra Vehicular Activity

**F**

FAA	Federal Aviation Administration
FCC	Federal Communications Commission

**G**

GEGSLA	Global Expert Group on Sustainable Lunar Activities (of MVA)
GLXP	Google Lunar XPRIZE
Govt	Government
GPS	Global Positioning System
GROWLER	Grading and Rotating for Water Located in Excavated Regolith

**H**

He3	Helium 3
HiDef	High Definition
Hi-Vac	High Vacuum
HLS	Human Landing System (of Artemis program)

**I**

ILRS	International Lunar Research Station
INMARSAT	International Maritime Satellite Organization
IOAG	Interagency Operations Advisory Group
ISA	Israel Space Agency
ISRO	Indian Space Research Organization
ISRU	In Situ Resource Utilization
ISS	International Space Station
ITA	International Trade Administration
ITU	International Telecommunications Union
IWP	Ionomer Membrane Water Processing

**J**

JAXA	Japan Aerospace Exploration Agency
JPL	Jet Propulsion Laboratory (of NASA)



**K**

KREEP Potassium, Rare-Earths, Phosphorous

**L**

LCE Lunar Commerce and Economics (Working Group of MVA)  
 LCP Lunar Commerce Portfolio (of MVA)  
 LCROSS Lunar Crater Observation and Sensing Satellite  
 LCUG Lunar Commerce User Group  
 LEAG Lunar Exploration Analysis Group  
 LEM Lunar Exploration Module (of Apollo program)  
 LMV Lunar Mobility Vehicle  
 Low-g Low Gravity  
 LRO Lunar Reconnaissance Orbiter  
 LRV Lunar Roving Vehicle (of Apollo program)  
 LSA Luxembourg Space Agency  
 LSIC Lunar Surface Innovation Consortium  
 LTV Lunar Terrain Vehicle

**M**

MAPP Mobile Autonomous Prospecting Platform  
 MoU Memorandum of Understanding  
 MVA Moon Village Association

**N**

NASA National Aeronautics and Space Administration  
 NGO Non-Government Organization  
 N/K Not Known  
 NZSA New Zealand Space Agency

**O**

OST Outer Space Treaty

**P**

PGM Platinum Group Metals (Ruthenium, Rhodium, Palladium, Osmium,  
 Iridium, Platinum)  
 PhilSA Philippine Space Agency  
 PPS Peaks of Perpetual Sunlight  
 PSR Permanently Shadowed Region

**xx**      **Acronyms**

**R**

RDI	Required Daily Intake
RF	Radio Frequency
RGD	Radiant Gas Dynamic
ROM	Rough Order of Magnitude
ROSKOSMOS	Russian State Space Corporation
RTG	Radioisotope Thermoelectric Generator

**S**

SEE Lab	Space Economy Evolution Laboratory (of Bocconi University)
SEI	Space Exploration Initiative
SLS	Space Launch System
SMR	Small Modular Reactor

**T**

TBD	To Be Determined
-----	------------------

**U**

UAESA	United Arab Emirates Space Agency
UNCOPUOS	United Nations Committee on the Peaceful Uses of Outer Space
USG	United States Government

**V**

VSE	Vision for Space Exploration
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**W**

WG	Working Group
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**X**

XPRIZE	Xprize Foundation
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# 1

## Introduction

Been there, done that? Why go back to the Moon—didn't we already do that 50 years ago with Apollo? We didn't find anything worthwhile up there, or we would have stayed, right? What on Earth, if you'll pardon the expression, will folks be doing there this time around to make it worth the effort, and to be such an expensive distraction from other more urgent matters? What has changed?

The general public (that means all of us) can be forgiven for raising such questions, because there has been a rather poor—and even confusing—narrative associated with the current US-led Artemis Program activities. On the one hand, there is talk about this time we are going to the Moon to stay, and that “sustainability” is therefore a key aspect of the planning. However, the funding being provided to the governmental space agencies to make this happen is only sufficient for a few trips to the Moon, even years apart (whereas during Apollo, when the intention was not even to create a permanent presence, the crews nevertheless went twice a year throughout a four-year period). Also, back in the sixties, there was complete clarity among the public (and of course the astronauts) about why we were going. It was about science and exploration, but mainly about the USA beating the Soviets in an existential battle for dominance in the new medium of space. Nowadays, the public does not in general consider (do we?) that there is a geo-political rationale for going back to the Moon. Certainly, the Chinese and other nations are continuing to send spacecraft, and human crews will eventually be included, but surely this cannot be a race, if the USA already won the race a half century ago? And *commerce*? Really? What are we even talking about?

In this book, we are going to come to terms up-front with these questions and provide the missing rationale. We'll explain what's new, and how recent data on lunar resources has opened up expanding possibilities. We are,