JOSEPH N. PELTON

THE NEW GOLD RUSH

THE RICHES OF SPACE BECKON!

Springer

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This book is dedicated to all of the young people who aspire to be involved in the gold rush in the skies, who are now studying outer space around the world. These include students at the International Space University of Strasbourg, France, the McGill University Centre for Research in Air and Space Law in Montreal, Canada, the Leuven Centre for Global Space Governance in Belgium, the Space Policy Institute at George Washington University, the University of Capetown in South Africa, and the many other universities and institutes offering courses in space policy and law, space transportation, and space science and applications.

Preface

This book grew out of something called the Montreal Declaration. This short declaration was unanimously adopted by an international group of about a hundred space scientists, engineers, and lawyers concerned with the future development and governance of outer space in a time of some entrepreneurial innovation, global change, and some would even say turmoil. It called for an interdisciplinary investigation of all of the elements of change in the world of satellite applications and space exploration in order to assess what was new and revolutionary on the space horizon and what new forms of governance might be needed.

This was not an attempt to reject or turn back the forces of change. Rather it was a call for the study of the innovations that would give rise to a new era of space activities and to see what innovations in the international regulatory and space governance regime might help unlock the potential of the future without giving rise to conflicts in space. Heaven knows there are plenty of conflicts right here on planet Earth. Some elements of change are clear. There are more and more corporate activities in space, and space law is essentially aimed at nations and not industrial enterprises.

There are today a number of new and developing space enterprises and activities that include space mining, the installation of solar power satellites, on-orbit servicing and retrofitting of satellites, and attempts to cope with the problem of orbital debris—including active removal, or the recycling of space junk in the skies. There are new military and defense-related capabilities in the skies, and some of these relate to the idea of planetary defense, which means the deployment of technologies in the skies to detect and monitor cosmic hazards such as asteroids, comets, and solar storms as well as systems to actually defend Earth against these perils from outer space.

The result of this 2-year-long effort is a book entitled *Global Governance of Outer Space*. Space scientists and lawyers will undoubtedly find a book on such a topic to be fascinating, but the general public—perhaps not so much.

However, the general public really has a vested interest in knowing about the practical opportunities represented by what is called "New Space." In this New Space world there are new jobs, new wealth, new opportunity, and new potential conflicts among nations.

It is this practical knowledge about the future of space that this book is all about. We have sought to explain in simple language without technical formulas or arcane rules of space law what John Q. Public—or Jill X. Public—needs to know that is relevant to future job opportunities, totally new types of space industries, as well as truly serious space hazards that could have a devastating impact on our lives if we don't take the right protective steps. The bottom line is that outer space is relevant to the lives of modern men, women, and children in ways that were never true in the past.

In short, there are changing opportunities, new corporate activities in space, new sources of wealth, and even new sources of disputes that could lead to conflict over the future of space.

The New Space industry leaders may not be who you think they are. The new operatives in the commercial space game are organizations such as Google, Facebook, and the Tesla-SpaceX complex (within the empire of Elon Musk). Indeed this New Space push is fueled by who we call the space billionaires. At the head of the space billionaire pack are Jeff Bezos, founder of Amazon.com; Paul Allen, co-founder of Microsoft; Elon Musk (founder of Space X, Paypal, and Tesla); Robert Bigelow, owner of Budget Suites; Sir Richard Branson, head of Virgin Galactic; Mark Zuckerberg, founder of Facebook; and electronic game inventor John Carmack, who created "Doom" and "Quake." It is these people that are upending the world of technology and global enterprise at planetary levels who will be prominent in the space business during the twenty-first century.

This book is intended to reveal to a broader audience the cornucopia of new enterprises that could be opening up in the next few years. That future may well include clean energy beamed from space 24 h a day. Or it could mean new economies in space services from new types of communication satellites, remote-sensing companies, or other new types of space enterprises. It could well mean robotic mining of asteroids rich in platinum and rare Earth metals. It could mean solar space shields to protect vital Earth infrastructure as the Van Allen belts lose their protective power due to the shift of the magnetic poles. Most profoundly it might mean the establishment of permanent colonies inhabited by smart robots and humans on both the Moon

and Mars. It could mean the start of a whole new era for humans living on different worlds.

This change is driven by new technology, new instruments of military defense and weaponry, new entrepreneurial space enterprises, and a new awareness that there is a need for the sustainability of space just as there is a concern here on Earth with climate change and the sustainability of our terrestrial world. In short the space revolution is part of the overall change that is the twenty-first century. It is closely tied to a future inhabited by smart robots, which will require a redefining of jobs, employment, and wealth. Indeed, it is all tied into the practical meaning of sustainability and the very future of the human race, whether we will survive as a species.

Ignore this book at your own peril. The future is filled with both considerable risk and enormous opportunity.

Washington, DC
August 2016

Joseph N. Pelton
Former Dean, International Space University
Author of *MegaCrunch: Ten Survival Strategies for the 21st Century*

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About the Author

Joseph N. Pelton, Ph.D., is the former Dean and Chairman of the Board of Trustees of the International Space University. He also is the Founder of the Arthur C. Clarke Foundation and the founding President of the Society of Satellite Professionals International. Dr. Pelton currently serves on the Executive Board of the International Association for the Advancement of Space Safety. He is the Director Emeritus of the Space and Advanced Communications Research Institute (SACRI) at George Washington University where he also served as Director of the Accelerated Master's Program in Telecommunications and Computers from 1998 to 2004. Previously he headed the Interdisciplinary Telecommunications Program at the University of Colorado-Boulder. Dr. Pelton has also served as President of the International Space Safety Foundation and President of the Global Legal Information Network (GLIN).

Dr. Pelton has been speaker on national media in the USA (PBS New Hour, Public Radio's All Things Considered, ABC, and CBS) and internationally on BBC, CBC, and FR-3. He has spoken before Congress, the United Nations, and delivered talks in over 40 countries around the world. His honors include the Sir Arthur Clarke International Achievement Award of the British Interplanetary Society, the Arthur C. Clarke Foundation Award, the ICA Educator's award, the ISCe Excellence in Education Award, and being elected to the International Academy of Astronautics.

Dr. Pelton is a member of the SSPI Hall of Fame, Fellow of the IAASS, and Associate Fellow of the AIAA. Pelton is a widely published author with some 40 books written, co-authored, or co-edited. His *Global Talk* won the Eugene

Emme Literature Award and was nominated for a Pulitzer Prize. Currently he is co-Editor of *The Global Governance of Outer Space* which is the global study in which over 80 scientific and legal scholars are participating in response to the Montreal Declaration of 2014.

During his career he also held various positions at Intelsat and Comsat including serving as Director of Project SHARE and Director of Strategic Policy for Intelsat. Intelsat's Project SHARE gave birth to the Chinese National TV University that now is the world's largest tele-education program. He received his degrees from the University of Tulsa, New York University, and his doctorate from Georgetown University.

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Why This Gold Rush Is Different

"Ships and sails proper for the heavenly air should be fashioned. Then there will also be people, who do not shrink from the dreary vastness of space."

—Johannes Kepler, Letter to Galileo Galilei, 1609

"In spite of the opinions of certain narrow-minded people, who would shut up the human race upon this globe, as within some magic circle which it must never outstep, we shall 1 day travel to the moon, the planets, and the stars, with the same facility, rapidity, and certainty as we now make the voyage from Liverpool to New York!"

—Jules Verne, From the Earth to the Moon, 1865

"The choice, as Wells once said, is the Universe—or nothing… The challenge of the great spaces between the worlds is a stupendous one; but if we fail to meet it, the story of our race will be drawing to its close. Humanity will have turned its back upon the still untrodden heights and will be descending again the long slope that stretches, across a thousand million years of time, down to the shores of the primeval sea."

—Arthur C. Clarke, last words of his first book, Interplanetary Flight, 1950

Are We Humans Doomed to Extinction?

What will we do when Earth's resources are used up by humanity?

The world is now hugely over populated, with billions and billions crammed into our overcrowded cities. By 2050, we may be 9 billion strong, and by 2100 well over 11 billion people on Planet Earth. Some at the United Nations say we might even be an amazing 12 billion crawling around this small globe. And over 80 % of us will be living in congested cities. These cities will be ever more vulnerable to terrorist attack, natural disaster, and other plights that come with overcrowding and a dearth of jobs that will be fueled by rapid

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automation and the rise of artificial intelligence across the global economy. We are already rapidly running out of water and minerals. Climate change is threatening our very existence. Political leaders and even the Pope have cautioned us against inaction. Perhaps the naysayers are right. All humanity is at tremendous risk. Is there no hope for the future?

This book is about hope. We think that there is literally heavenly hope for humanity. But we are not talking here about divine intervention. We are envisioning a new space economy that recognizes that there is more water in the skies that all our oceans. There is a new wealth of natural resources and clean energy in the reaches of outer space—more than most of us could ever dream possible.

There are those that say why waste money on outer space when we have severe problems here at home? Going into space is not a waste of money. It is our future. It is our hope for new jobs and resources. The great challenge of our times is to reverse public thinking to see space not as a resource drain but as the doorway to opportunity. The new space frontier can literally open up a "gold rush in the skies."

In brief, we think there is new hope for humanity. We see a new a pathway to the future via new ventures in space.

For too long, space programs have been seen as a money pit. In the process, we have overlooked the great abundance available to us in the skies above. It is important to recognize there is already the beginning of a new gold rush in space—a pathway to astral abundance. "New Space" is a term increasingly used to describe radical new commercial space initiatives—many of which have come from Silicon Valley and often with backing from the group of entrepreneurs known popularly as the "space billionaires." New space is revolutionizing the space industry with lower cost space transportation and space systems that represent significant cost savings and new technological breakthroughs. "New Commercial Space" and the "New Space Economy" represent more than a new way of looking at outer space. These new pathways to the stars could prove vital to human survival.

If one does not believe in spending money to probe the mysteries of the universe then perhaps we can try what might be called "calibrated greed" on for size. One only needs to go to a cubesat workshop, or to Silicon Valley or one of many conferences like the "Disrupt Space" event in Bremen, Germany, held in April 2016 to recognize that entrepreneurial New Space initiatives are changing everything [1].

In fact, the very nature and dimensions of what outer space activities are today have changed forever. It is no longer your grandfather's concept of outer space that was once dominated by the big national space agencies. The entrepreneurs are taking over.

The hopeful statements in this book and the hard economic and technical data that backs them up are more than a minority opinion. It is a topic of growing interest at the World Economic Forum, where business and political heavyweights meet in Davos, Switzerland, to discuss how to stimulate new patterns of global economic growth.

It is even the growing view of a group that call themselves "space ethicists." Here is how Christopher J. Newman, at the University of Sunderland in the United Kingdom has put it:

> *Space ethicists have offered the view that space exploration is not only desirable; it is a duty that we, as a species, must undertake in order to secure the survival of humanity over the longer term. Expanding both the resource base and, eventually, the habitats available for humanity means that any expenditure on space exploration, far from being viewed as frivolous, can legitimately be rationalized as an ethical investment choice.* (Newman)

On the other hand there are space ethicists and space exobiologists who argue that humans have created ecological ruin on the planet—and now space debris is starting to pollute space. These countervailing thoughts by the "no growth" camp of space ethicists say we have no right to colonize other planets or to mine the Moon and asteroids—or at least no right to do so until we can prove we can sustain life here on Earth for the longer term.

However, for most who are planning for the new space economy the opinion of space philosophers doesn't really float their boat. Legislators, bankers, and aspiring space entrepreneurs are far more interested in the views of the super-rich capitalists called the space billionaires.

A number of these billionaires and space executives have already put some very serious money into enterprises intent on creating a new pathway to the stars. No less than five billionaires with established space ventures—Elon Musk, Paul Allen, Jeff Bezos, Sir Richard Branson, and Robert Bigelow—have invested millions if not billions of dollars into commercializing space. They are developing new technologies and establishing space enterprises that can bring the wealth of outer space down to Earth. This is not a pipe dream, but will increasingly be the economic reality of the 2020s.

These wealthy space entrepreneurs see major new economic opportunities. To them space represents the last great frontier for enterprising pioneers. Thus they see an ever-expanding space frontier that offers opportunities in low-cost space transportation, satellite solar power satellites to produce clean energy 24 h a day, space mining, space manufacturing and production, and eventually space habitats and colonies as a trajectory to a better human future. Some even more visionary thinkers envision the possibility of terraforming Mars,

or creating new structures in space to protect our planet from cosmic hazards and even raising Earth's orbit to escape the rising heat levels of the Sun in millennia to come.

Some, of course, will say this is sci-fi hogwash. It can't be done. We say that this is what people would have said in 1900 about airplanes, rocket ships, cell phones and nuclear devices. The skeptics laughed at Columbus and his plan to sail across the oceans to discover new worlds. When Thomas Jefferson bought the Louisiana Purchase from France or Seward bought Alaska, there were plenty of naysayers that said such investment in the unknown was an extravagant waste of money. A healthy skepticism is useful and can play a role in economic and business success.

Before one dismisses the idea of an impending major new space economy and a new gold rush, it might useful to see what has already transpired in space development in just the past five decades. The world's first geosynchronous communications satellite had a throughput capability of about 500 kb/s. In contrast, today's state of the art Viasat 2—a half century later—has an impressive throughput of some 140 Gb/s. This means that the relative throughput is nearly 300,000 greater, while its lifetime is some ten times longer (Figs. 1.1 and 1.2).

Each new generation of communications satellite has had more power, better antenna systems, improved pointing and stabilization, and an extended lifetime.

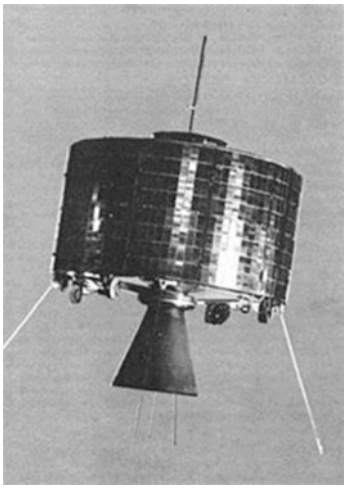

Fig. 1.1 Syncom 2 launched in 1963 with an equivalent throughput of about 500 kb/s (Image courtesy of the Comsat Legacy project.)

Fig. 1.2 The Viasat 2 with a remarkable throughput 300,000 greater than Syncom (Image courtesy of Via Satellite.)

And the capabilities represented by remote sensing satellites, meteorological satellites, and navigation and timing satellites have also expanded their capabilities and performance in an impressive manner. When satellite applications first started, the market was measured in millions of dollars. Today commercial satellite services exceed a quarter of a billion dollars. Vital services such as the Internet, aircraft traffic control and management, international banking, search and rescue and much, much more depend on application satellites. Those that would doubt the importance of satellites to the global economy might wish to view on You Tube the video "If There Were a Day Without Satellites?" [2].

Let's check in on what some of those very rich and smart guys think about the new space economy and its potential. (We are sorry to say that so far there are no female space billionaires, but surely this, too, will come someday soon.)

Of course this twenty-first century breakthrough that we call the New Space economy will not come just from new space commerce. It will also come from the amazing new technologies here on Earth. Vital new terrestrial

The Visionaries Leading the Charge into New Space Enterprises

On creating "a Million Person Colony" on Mars: "I want to make rockets 100 times, if not 1000 times better. The ultimate objective is to make humanity a multi-planet species. Thirty years from now, there'll be a base on the Moon and on Mars, and you would need a million people to be going back and forth on SpaceX rockets…to recreate the entire industrial base on Mars…people to mine and refine all of these different materials, in a much more difficult environment than Earth. There would be no trees growing. There would be no oxygen or nitrogen that are just—there. No oil."(**Elon Musk,** president of SpaceX and Tesla.)

On his space business, Virgin Galactic: We'll go into orbit. We'll go to the Moon. This business has no limits. (**Richard Branson,** reported in *Wired* magazine January 2005.)

On why space is the next frontier: What should exist? To me, that's the most exciting question imaginable. What do we need that we don't have? How can we realize our potential? As a species, we've always been discoverers and adventurers, and space and the deep ocean are some of the last frontiers. **(Paul Allen,** co-founder of MicroSoft, in "brainy quotes".)

On change: "Here's to the crazy ones, the misfits, the rebels, the troublemakers, the round pegs in the square hole—they're not fond of rules… You can quote them, disagree with them, glorify or vilify them, but the only thing you can't do is ignore them because the ones who are crazy enough to think that they can change the world are the ones who do." (**Steve Jobs,** founder of Apple.)

On investing $275 million in New Space: "We seek to assist human exploration and the discovery of beneficial resources, whether in Low Earth Orbit (LEO), on the moon, in deep space or on Mars". (**Robert Bigelow, CEO of Budget Suites and Bigelow Aerospace.**)

On a space elevator providing low-cost access to space: "It's a phenomenal enabling technology that would open up our Solar System to humankind. It will be robotic, and then 10–15 years after that we'll have six to eight elevators that are safe enough to carry people." (**Peter Swan**, lead author of the International Academy of Astronautics (IAA) report on space elevators.)

On the "can do" spirit. "The "let's just go and do it" mentality will help us finally get off the planet and irreversibly open the space frontier. The capital and tools are finally being placed into the hands of those willing to risk, willing to fail, willing to follow the dreams." **(Dr. Peter H. Diamandis,** chairman of the X-Prize Foundation and CEO of the company Planetary Resources.)

technologies will accompany this cosmic journey into tomorrow. Information technology, robotics, artificial intelligence and commercial space travel systems have now set us on a course to allow us humans to harvest the amazing riches in the skies—new natural resources, new energy, and even totally new ways of looking at the purpose of human existence. If we pursue this course steadfastly, it can be the beginning of a New Space renaissance. But if we don't

seek to realize our ultimate destiny in space, *Homo sapiens* can end up in the dustbin of history—just like literally millions of already failed species. In each and every one of the five mass extinction events that have occurred over the last 1.5 billion years on Earth, some 50–80 % of all species have gone the way of the T. Rex, the woolly mammoth, and the Dodo bird along with extinct ferns, grasses and cacti.

On the other hand, the best days of the human race could be just beginning.

If we are smart about how we go about discovering and using these riches in the skies and applying the best of our new technologies, it could be the start of a new beginning for humanity. Konstantin Tsiokovsky, the Russian astronautics pioneer, who first conceived of practical designs for spaceships, famously said: "A planet is the cradle of mankind, but one cannot live in a cradle forever." Well before Tsiokovsky another genius, Leonardo da Vinci, said, quite poetically: "Once you have tasted flight, you will forever walk the earth with your eyes turned skyward, for there you have been, and there you will always long to return."

The founder of the X-Prize and of Planetary Resources, Inc., Dr. Peter Diamandis, has much more brashly said much the same thing in quite different words when he said: "The meek shall inherit the Earth. The rest of us will go to Mars."

The New Space Billionaires

Peter Diamandis is not alone in his thinking. From the list of "visionaries" quoted earlier, Elon Musk, the founder of SpaceX; Sir Richard Branson, the founder of Virgin Galactic; and Paul Allen, the co-founder of Microsoft and the man who financed SpaceShipOne, the world's first successful spaceplane have all said the future will include a vibrant new space economy. They, and others, have said that we can, we should and we soon shall go into space and realize the bounty that it can offer to us.

The New Space enterprise is today indeed being led by those so-called space billionaires, who have an exciting vision of the future. They and others in the commercial space economy believe that the exploitation of outer space may open up a new golden age of astral abundance. They see outer space as a new frontier that can be a great source of new materials, energy and various forms of new wealth that might even save us from excesses of the past.

This gold rush in the skies represents a new beginning. We are not talking about expensive new space ventures funded by NASA or other space agencies in Europe, Japan, China or India. No, these efforts which we and others call

New Space are today being forged by imaginative and resourceful commercial entrepreneurs. These twenty-first century visionaries have the fortitude and zeal to look to the abundance above. New breakthroughs in technology and New Space enterprises may be able to create an "astral life raft" for humanity.

Just as Columbus and the Vikings had the imaginative drive that led them to discover the riches of a new world, we now have a cadre of space billionaires that are now leading us into this New Space era of tomorrow. These bold leaders, such as Paul Allen and Sir Richard Branson, plus other space entrepreneurs including Jeff Bezos of Amazon and Blue Origin, and Robert Bigelow, Chairman of Budget Suites and Bigelow Aerospace, not only dream of their future in the space industry but also have billions of dollars in assets. These are the bright stars of an entirely new industry that are leading us into the age of New Space commerce.

These space billionaires, each in their own way, are proponents of a new age of astral abundance. Each of them is launching new commercial space industries. They are literally transforming our vision of tomorrow. These new types of entrepreneurial aerospace companies—the New Space enterprises—give new hope and new promise of transforming our world as we know it today.

The New Space Frontier

What happens in space in the next few decades, plus corresponding new information technologies and advanced robotics, will change our world forever. These changes will redefine wealth, change our views of work and employment and upend almost everything we think we know about economics, wealth, jobs, and politics. These changes are about truly disruptive technologies of the most fundamental kinds. If you thought the Internet, smart phones, and spandex were disruptive technologies, just hang on. You have not seen anything yet.

In short, if you want to understand a transition more fundamental than the changes brought to the twentieth century world by computers, communications and the Internet, then read this book. There are truly riches in the skies. Near-Earth asteroids largely composed of platinum and rare earth metals have an incredible value. Helium-3 isotopes accessible in outer space could provide clean and abundant energy. There is far more water in outer space than is in our oceans.

In the pages that follow we will explain the potential for a cosmic shift in our global economy, our ecology, and our commercial and legal systems. These can take place by the end of this century. And if these changes do not

take place we will be in trouble. Our conventional petro-chemical energy systems will fail us economically and eventually blanket us with a hydrocarbon haze of smog that will threaten our health and our very survival. Our rare precious metals that we need for modern electronic appliances will skyrocket in price, and the struggle between "haves" and "have nots" will grow increasingly ugly. A lack of affordable and readily available water, natural resources, food, health care and medical supplies, plus systematic threats to urban security and systemic warfare are the alternatives to astral abundance.

The choices between astral abundance and a downward spiral in global standards of living are stark. Within the next few decades these problems will be increasingly real. By then the world may almost be begging for new, out-of-the-box thinking. International peace and security will be an indispensable prerequisite for exploitation of astral abundance, as will good government for all. No one nation can be rich and secure when everyone else is poor and insecure. In short, global space security and strategic space defense, mediated by global space agreements, are part of this new pathway to the future.

Global peace will not be just peace on earth but will require ways to insure peace in the skies as well. The new space economy will need to be built not just on technology; it will also need to be founded on strategic space defense systems as well as international space agreements and a new "star map" to the natural resources on the land, the seas, and also the cosmic seas above. To achieve this new abundance, all the people of Spaceship Earth will need to create a new bond of cooperation, with legal and regulatory mechanisms, backed by strategic space systems to insure that this will ultimately be made to work.

This will likely all start by reviewing the global pacts and agreements that we have used with regard to cooperation and sharing in the global commons represented by the oceans and Antarctica and even outer space that surrounds Earth above commercial air space but below the vacuum of outer space—an area that is sometimes called subspace or protospace. If we can build on historic patterns of cooperation in these global commons, then there is potential that we can build a global governance system that can allow the era of astral abundance to become reality—sooner rather than later.

No one should be naïve enough, though, to overlook the fact that our future in space involves a three way tug-of-war between: (1) the new businesses hoping to realize the riches of outer space via space commerce; (2) the push for new international space agreements—i.e., new "rules of the outer skies" and cooperative space standards and practices—that can allow a fair and equitable set of practices for the "cosmic commons" and (3) the strategic

and even military space systems that will "police" the new space economy as it grows and matures further and further away from Planet Earth.

Astral Abundance

Unless we turn to the commercial opportunities of New Space and breakthrough new technologies here on Earth, we could indeed be in deep trouble. This will be ever clearer as populations continue to rise and resources shrink (Fig. 1.3). Dr. Thomas Malthus, the economic prophet of the eighteenth century who predicted we would eventually run out of food and vital resources, will be proven right even though he was perhaps three centuries premature. Some very capable people have gathered data from all over the world to put together the following chart on so-called "non-renewable resources."

This chart was compiled in 2000, when the global population was under seven billion and commodities were more abundant. Think what this chart will look like as time goes by, as world populations grow and as global standards of living rise and everyone in the world wants a computer and a smart phone.

Global Natural Non-Renewable Resource Scarcity			
Extremely Scarce	***Very Scarce***	***Moderately Scarce***	***Not Currently Scarce***
Bromine	*Aluminum*	*Antimony*	*Arsenic*
Gold	*Bauxite*	*Beryllium*	*Barite*
Mercury	*Cadmium*	*Bismuth*	*Boron*
Tantalum	*Chromium*	*Cobalt*	*Garnet*
Tellurium	*Copper*	*Gallium*	*Lithium*
Thallium	*Fluorspar*	*Germanium*	*Niobium*
	Magnesium Compounds	*Graphite*	
	Molybdenum	*Cypsum*	
	Nickel	*Indium*	
	Rhenium	*Iron*	
	Selenium	*Lead*	
	Strontium	*Lime*	
	Sulfur	*Manganese*	
	Tungsten	*Salt*	
		Silicon	
		Silver	
		Tin	
		Vanadium	
		Zinc	
		Zirconium	

Fig. 1.3 Global inventory of scarce global resources

However, astral abundance is about more than just resources and energy. It is about new and different types of jobs. In short, it is about new hope, new horizons, a new understanding of sustainability, new frontiers for humankind and a new understanding of the shared global bounty of the riches of outer space .

The new space and advanced technology economy will bring the opportunity for new and different types of jobs, better global education and health care, a cleaner and healthier environment, and what Pope Francis would call the "bright light of hope for a better and more peaceful world."

The New Space Entrepreneurs and Commercial Space Enterprises

The new world of astral abundance can bring us a wide range of totally new jobs for the millennials and even a redefinition of wealth. Today there are only a small number of people now working at Planetary Resources, Deep Space Industries or Shackleton Energy. These young and enterprising people are focused on ways to mine important resources available in outer space that might be available from near-Earth asteroids.

Some enterprising workers in the New Space industry are busy designing solar power satellites that can bring us clean and abundant energy from outer space. Others at SpaceX, Bigelow Aerospace, Virgin Galactic, Boeing, Sierra Nevada, Blue Origin, British Aerospace, XCOR Aerospace, Orbital Sciences ATK, Kelly Space and Technology, Swiss Spaceplane Systems, Reaction Engines Ltd, Stratolauncher, etc., are seriously working to engineer and build new spaceplanes and commercial launch systems These are just some of the new cadre of New Space enterprises working away to create the new commercial space industries.

Meanwhile enterprises such as Lockheed Martin Skunkworks have shown us how we can unlock the energy of the Sun right here on Earth. Others such as the Blue Brain project, headed by Professor Henry Markram in Switzerland, are busily seeking to create artificial intelligence with the equivalence of the human brain. The synergy of the all these enterprises will be critical to the ultimate achievement of this breakthrough economy. This breakthrough to a new type of world has been anticipated for some time. However, it would not be possible without first achieving new international agreement and standards of behavior based on true corporate responsibility.

Breakthrough: Transcendence? The Singularity or Astral Abundance?

The terms "the Singularity" and "Abundance" are used interchangeably throughout this book to refer to breakthrough technologies and the rise of super intelligence that are presumed to accelerate global innovation and the means to cope with problems of all types, from clean energy to climate change to overpopulation. It was Ray Kurzwiel, the Artificial Intelligence (AI) guru, who popularized the term Singularity. Dr. Peter Diamandis, who in cooperation with others founded the International Space University and then went on to found the Singularity University and also breathed life into the wonderful X-Prize initiative, simply calls it "abundance." And before him R. Buckminster Fuller called it "transcendence."

No matter what you call it, the idea is to go ahead and think outside the box. Indeed the trick is to think outside the limits of the 6 sextillion-ton spaceship we call Planet Earth. Fuller, Kurzweil, Diamandis and other space enthusiasts, including the authors, are trying to convince our economic and political leaders that the trick is to think outside constraints of the current world economic systems and the resources we have trapped within the orb we call Earth.

The key to such a breakthrough may rely not on the graybeards but on the youth of the world. Many of those under 30 in age are more than a little miffed at the older generations and the mess that they have created here on Earth. They look askance at pollution, greenhouse gases, exhaustion of resources, religious strife, unlivable mega cities and excessive and runaway population growth. The graduates of the 2015 Space Studies Program of the International Space University have started a series of meetings around the world called "Disrupt Space" in localities such as Shanghai, China, and Bremen, Germany. Their idea is to challenge a group of international entrepreneurs to work with corporate representatives, government officials and investors to combine efforts to solve today's problems using space. The full title of this new space global initiative is: "Disrupt Space Summit: Turning the Solar System into Our Backyard. Let's Play!"

The problem with such initiatives is not innovative thought, not youthful zeal, not lack of commitment to real change. The biggest problem could turn out to be human arrogance or a warped value system that puts expansive growth above societal survival. We need real understanding of "sustainability and long term ecological reform" before we humans venture seriously

into space with the mistaken idea that a larger playground ensures a better tomorrow. We must embrace the long-term sustainability of both Earth and space as we venture forth toward a better tomorrow.

We must embrace the potential of the Solar System, of solar energy, of nuclear fusion, of artificial intelligence, and examine what is meant by the breakthrough economics of transcendence, the Singularity or astral Abundance. If our political, economic and business leaders are able to think creatively and embrace the potential that the space billionaires and New Space entrepreneurs can unlock, then we can solve the problems of a world populated by ten billion people and over-urbanization.

Today there are just a few hundred highly entrepreneurial companies that understand the potential of astral abundance. These visionaries are hell-bent on engaging in space mining, solar power satellites, nuclear fusion, artificial intelligence and robotics, and transcendent technologies that can free us from the non-sustainable practices of past industrial practices that exploited resources and the ecology rather than the potential of human intelligence and astral abundance. If one goes to the website of Planetary Resources, Inc., you are met with the following evocative message: "We dare you to change the course of humanity with us." Peter D. certainly never thinks small. If you should be able to get into the ever more selective Singularity University (founded by Peter Diamandis, Ray Kurzweil, and Peter Worden, until recently head of NASA Ames) the challenge you are given is to come up with an idea or project or invention that will have a positive impact on a billion people within a decade's time.

Those that are starting up new companies to engage in space mining today are largely focused on rapid payoffs to fund their larger and longer term ambitions. They hope to realize a significant economic return from exploiting rare earth minerals, platinum-rich asteroids and new energy sources such as helium-3.

The enterprising Planetary Resources Ltd. was able to raise $1 million from crowd sourcing for their Arkyd space telescope that will seek out promising near-Earth asteroids that could be captured and brought back to Earth or lunar orbit. Not only is this a huge technical and engineering challenge, but there are a range of legal and regulatory questions as to whether such action is consistent with the Outer Space Treaty of 1967 to which more than 100 countries are members. While such issues are being considered in the United Nations, Planetary Resources Ltd. forges ahead to cope with the problems they feel technically competent to address (Fig. 1.4).