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A Space Cornucopia of Jobs, Resources and More

Introduction

There are those that quickly accept defeat when confronted with what appears to be an insurmountable challenge. Others, when faced with significant change in circumstance, naturally tend to fight back in order to preserve what they have achieved. Then, there are those unique individuals that transcend time. They create a new future, before the general public realizes that things have changed forever.

These innovators are the ones that create disruptive technologies, such as Uber, Lyft, Amazon, the Internet and satellite and cable-based electronic entertainment. The space entrepreneurs are like time travelers with their feet in the twenty-first century.

Space age innovators are intent on creating the New Space economy, and they are half Thomas Edison and half John D. Rockefeller. These "transcenders" of today's technology and business practice are remarkably different in personality and background as one can imagine. Despite these differences, they are alike in boldly viewing the world—not as it is but as it can be.

They pursue their various New Space enterprises—not simply to make money or to create a successful new business. No, they want to change the world and recast humans with a new image. They see Homo sapiens not as farmers and manufacturers and service providers in a closed world, but rather as masters of time and space. They truly believe that a New Space cornucopia will not only release new riches but fulfill human destiny. They are thus embarked on their various missions in order to allow the tribe of Homo sapiens to survive. They want to spread the seed of humans across the Solar System

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and eventually beyond. They earnestly see the "mission" as boldly going where no humans have gone before. The short mission statement or goal is to ensure that the best days of humanity are in the future and not in the past.

Robert Bigelow, Peter Diamandis, Jeff Bezos, Elon Musk, Paul Allen, Eric Anderson, Ray Kurzweil, and Sir Richard Branson are among those that are busy seeking to create a new future of space abundance. They are 100 % sure that new technology, human innovation and the unlimited potential of outer space will allow us to reinvent the global economy.

Despite their optimism, it is possible that even these visionaries do not fully grasp the broad scope of change that the New Space economy will bring to the world. Indeed the New Space cornucopia has enormous range and competitive advantage.

Peter Diamandis envisions low-cost space travel and mining the asteroids. Robert Bigelow envisions four-star hotels in space. Paul Allen envisions the world's largest jet that will serve as a launching station for rockets of the future. Eric Anderson envisions private space launches that can go to the Moon and back. Ray Kurzweil envisions solar power systems, including solar power satellites that make global energy clean, plentiful and pervasive. Elon Musk sees a million people living on a space colony on Mars. Sir Richard Branson named his space transportation company Virgin Galactic because he truly thinks not only outside the box but outside the "circle" that is Earth.

If you want to image the full scope of change that all this could bring, let us engage in some time travel. Try to imagine our world today without the Internet, personal computers, Instagram, Facebook, smart phones and spandex. Then recall that these services or products were essentially unknown just 30 years ago. Or let's go back a century and imagine a world where airplanes, automobiles, television, electric lighting and broadband communications were either unknown or were available to only a few. For millions of years life on Earth was relative static and changed very little. But in the age of rapid human innovation and the Internet it seems as if it changes every few minutes.

The truth is that we live in an age of super time compression, and innovation is not only speeding up but the rate of acceleration is actually increasing. This phenomenon physicists call "jerk." The bottom line is that in the age of "New Space" and electronic innovation, that change is coming faster than anyone thinks today. A few years back, the author wrote a book called *e-Sphere: The Rise of the Worldwide Mind.* This book is about e-Space, a new age of human expansion into a cosmic world and New Space economy that transcends the world as we know it today. "E-Space" will become a new reality within the next half century. It seems that only major disruptive innovations

variously described as "the singularity," (Kurzweil) "abundance," (Diamandis) etc., can alter humanity's future evolutionary course, or we are indeed headed into some major global troubles. These global problems include such challenges as climate change, overpopulation, intensive urban crowding, lack of potable water and a host of other problems related to over consumption of resources.

Indeed these current large-scale global problems present what might be called a cosmic ethical dilemma—whether we need to show that we can cope successfully with climate change and perhaps demonstrate that we can devise a successful artificial "biosphere" here on Earth before we try terraforming planets elsewhere, or whether we should just move ahead. And by devising a "successful biosphere" we mean show that we are smarter than when we failed to keep "Biosphere II" viable for "biospherians" to live inside after only a few months of experimentation. Until we can show that we truly can cope with climate change and create an artificial habitat that can sustain itself over the longer term without killing off "biospherian" life forms inside, it does seem presumptuous to say we know how to create viable colonies on Mars or the Moon or elsewhere off the planet.

Of course, this is not only the challenge of the twenty-first century. There are also the challenges of finding ways to create sustainable global economies and global employment. This becomes a huge problem when smart machines are increasingly supplanting more and more jobs—especially in the new service economies. Some would argue that technology is now solving old problems but creating new ones at a record rate.

However, one can be optimistic that we will eventually become technologically and environmentally savvier. The grand challenge is to achieve long-term sustainability and discover what might be called environmental prosperity. If this can be achieved it will be the ideal time to look off planet in a truly permanent fashion. If we can develop the intellectual maturity to create a sustainable world then we might be ready to create off world civilizations as well. In short, the key step toward off-world colonies is to develop a new kind of technology that not only produces gizmos, gadgets and economic throughput, but true long-term societal solutions.

New Space and Creating Jobs

One of the keys to this new world rich in sustainable technologies is to find how to create productive employment for humans in an automation-rich world.

One of the big political debates in the United States today involves the issue of minimum wages. Democrats, with their low to middle income constituencies, are arguing that a raise in the minimum wage not only provides a "livable" standard of living but that such a policy would also stimulate the consumer economy. This seems fairly reasonable in that people who live on a minimum wage must spend virtually all of their disposable income. Republican advocates on the other side of the discussion, with more of an eye to their business-oriented constituencies, say that a large rise in the cost of living would be inflationary. They would argue that such a policy will only give rise to increased automation. They quite reasonably argue that, since "basic human labor" is becoming too expensive in comparison to machines, raising the minimum wages will lead to a death spiral of basic labor jobs.

The indisputable truth is that automation, artificial intelligence and expert systems are now able to replace more and more jobs. These automatons, smart robots and expert systems are not only replacing routine manufacturing, farming and mining jobs but an increasing array of more skilled service jobs as well. Just in the last few years, robots and AI computer programs have surged in numbers and sophistication. These increasingly capable machines and heuristic programs that more and more simulate the skills of "thinking humans" are moving into the service workplace. Such "smart systems" are replacing tax accountants, real estate appraisers, auto workers, pharmacists, and those that carry out inventory control in factories and warehouses.

The unanswered question of our time is, what do people do when machines take over the majority of all jobs on the planet? The minimum wage debate misses the key point that all sorts of jobs are disappearing and that we need to reimagine employment in a super automated world [1].

This is a profound issue with over a third of the world's adult population either unemployed or underemployed, and the trend line headed in the wrong direction. More and more people and fewer and fewer jobs is not a formula for success. The road to sustainability must lead in a different direction. That much is a no brainer.

Does the creation of new space colonies, space enterprises and new off-world economies and settlements become a part of the answer? Only time will tell. But this much seems clear. Time and human technological progress is a one-way gate. The arrow of time points in only one direction. We are trapped in the future we invent.

Certainly, the creation of a New Space economy and prospect of off-world activities represent the only major truly new human enterprise of our time. This is just one of the reasons that new entrepreneurial enterprise related to outer space services and manufacturing is currently quite popular in the U. S.

Congress. "New Space," being a totally new source of jobs plus its powerful stimulus to new technology and totally new types of endeavors, led to the Space Act of 2015, with its positive incentives and stimuli such as governmental liability coverage, rights to individuals to own resources mined in space and so on.

The trend to support new space endeavors is apparent around the world. Over two dozen countries have implemented or are planning spaceports. There are over a dozen spaceports now approved by the FAA in the United States. And there are a number more in the pipeline.

Spaceplane development is active in a growing number of countries around the world. Part of the interest and support for space activities is the appeal of high technology research and development and being on the cusp of new discovery and invention. The most important reason for support, however, is the prospect of new jobs.

In so-called developed economies, less that 3 % of jobs are now in the farming and mining sectors. Jobs in manufacturing continue to drop. About 12 % of jobs in developed countries are in manufacturing, and of these "manufacturing" jobs an increasing number are in areas such as sales, promotion, management, engineering and design rather than actual manufacturing. This means that 85 % of the jobs in developed economies are in services. Yet as just noted these service jobs are increasingly being automated or turned over to devices or robots that are artificially intelligent.

Ray Kurzweil, the artificial intelligence guru that invented "Siri," who so sweetly and competently responds to inquiries on smart phones, believes that the "singularity" is coming within the next few years. The term "singularity" was first used by John von Neumann in 1958. It was then amplified by Vernon Verre of Hungary and even more recently given a more focused meaning by Kurzweil, especially in his book *The Singularity Is Near*, published in 2005.

Kurzweil predicted high speed processors, memory storage and artificially intelligent algorithms that would not only duplicate human reasoning, memory and processing capabilities but would be commercially available at $1000 per unit by 2029. He anticipated that by 2040 there would be remarkable new capabilities in machine intelligence. These new AI capabilities in his world view would have an exponentially profound impact on human civilization. This he characterized as the "singularity." New Space technology and systems working in conjunction with breakthrough "singularity," such as AI and computer technology, could, in his view, transform and disrupt every aspect of the last half of the twenty-first century.

At the Comsat Corporation in Washington, D. C., in 1969 when Kurzweil was asked what is the most important and transformative technology of our

time, without hesitation he came back with the answer "artificial intelligence." The audience was expecting space or communications or perhaps satellite communications. But Arthur C. Clarke, who gave us "HAL" in the movie *2001: The Space Odyssey,* was resolute in believing that thinking machines was the technology that would change everything.

If Kurzweil's projections are in any way accurate the future of human history, economic systems, and employment are headed for profound and perhaps explosive change. In the new post-2040 world, the impact of smart robots, reasoning and highly trainable machines will likely change employment, wealth, economic structures, and patterns of life in a significant way. What this means with respect to the New Space economy is incredibly difficult to project. But certainly it can redefine the human future. The range of the dynamics can be quite wide. The concept of Elon Musk, that there will be a million-person community living on Mars, able to sustain the full range of industrial, educational, and intellectual activities comparable to that experienced on Earth, is one bold vision of the future. The one thing that seems clear is that the nature of human activity in the twenty second century will have changed forever. Part of that change will likely be some form of off-world activity.

There are many ways to project the future and note trend lines. One interesting statistic is that when NASA called for candidates to become astronauts in 2015 there were 6300 people that answered the call and four men and four women were selected. In 2016 there were 18,300 candidates that answered the call. At least young people seem to think there is an important future in outer space.

All that people need in order to subsist and procreate at a basic subsistence level is food and water, basic tools and protective devices, housing, and energy. To improve their lives they need health care, education, clothing, transportation, and perhaps art and culture. Only a small percentage of the work force is now needed to supply all these needs.

Currently automation is responsible for the bulk of the "work" needed for subsistence in so-called developed economies, and this also became true for manufacturing in the 1950s and 1960s. What might be called "super automation" that comes from machines or robotics with expert systems or artificial intelligence software seems capable of replacing most service and skill level jobs. According to Ray Kurzweil this will all happen by 2040 [2].

If we look at today's current reality this seems entirely feasible. IBM's Watson, using so-called Unstructured Information Management Architecture (UIMA), is now able to beat the world's Jeopardy champions, and currently the latest focus at IBM is to make Watson the repository

of all known medical knowledge. According to IBM researchers, medical information (and presumably knowledge) will be doubling every 73 days by 2020. In such an environment it indeed seems likely that only a machine that can cope with processing petabytes per minute could possibly contend with this plethora of information [3].

Apple's SIRI is able to answer most questions that people would have in their modern everyday life. In the world of the "singularity" in which low cost and amazingly "smart" digital processors cost under $1000, our world, employment and the nature of work will change in a way that we are totally unprepared to understand. Without the benefit of a new challenge, human civilization stands at risk of stagnation or worse. The image of the future provided by Kurt Vonnegut, Jr., in *Player Piano* is a very frightening one. In this sci-fi book the members of the vast proletariat are simply consumers, and only a handful of scientists and engineers have jobs that consist mainly of keeping the machines running. It is a frightening dystopian forecast for the future.

This view of the future that Western technology seems to be delivering to the world is presumably part of the prospect of the future that extreme Jihadists are fighting to undo. There is comfort to some in setting the clock of technological progress back a few millennia. Al Qaeda and other technological nihilist groups see comfort in a human return to a world of the brutish caveman.

What will the world of the future be like, in fact? If by 2200 there were viable human habitats in Earth orbit, true colonies on the Moon and Mars, plus mining operations on large-scale near Earth objects (NEOs), our future could be dramatically different. This future would be dramatically changed not only in terms of work but also in terms of broadband communications, clean energy systems, and our knowledge of the universe and our creation of sustainable off-world living environments. In short, the new gold rush is about more than space technology. This new future in space will alter most aspects of human life as we know it today.

A New Source of Natural Resources

Nearly a decade ago the space agencies of the world agreed to work together to combine all of their collective data represented by satellite Earth imaging. In this manner they created a very high resolution integrated image of the world. This amazingly comprehensive image of all of the world's forests, swamps, waterways, deserts, mountains, oceans, glaciers and icecaps represented many terabytes of data.

What was even more important was that we were able to create comparative global images over time that mapped exactly how the surface terrain of the entire world has changed over 360° of latitude and longitude.

These high-definition images showed a world that is becoming increasingly urbanized with expanding human settlement. They showed how the deserts of the world are increasing and areas of vegetation and forests are shrinking. The collective results of these satellite-based images were to show a world at increasing risk. In short there is more to worry about than human-driven climate change, but rather to understand that human development and relentless growth gives rise to a number of problems that are interlinked together.

Today there is more and more remote sensing data. The images are now increasingly precise and insightful, with the addition of hyper spectral imaging. Today there is not only data from space and governmental agencies that collect meteorological and oceanic data but also from Google Earth and private data collectors such as GeoEye. For those who wish to stare reality in the eye there is a great wealth of imaging data mounting into the petabytes (i.e., thousands of trillions of data points).

The unpleasant truth of how the world is changing is revealed by satellite and UAV imaging. We are no longer seeing changes from the broad vistas of continents, but relentless change acre by acre, meter by meter in amazing detail. And of all these elements of change, one transformation is by far the most profound and disturbing. This change is the amount of water available to humans and to animal and plant life. Here we are speaking of precious water that is not saturated with salt, the non-seawater. This untainted water that sustains life across our planet is shrinking. And along with this diminishing water supply comes less vegetation and fewer forests and increasing deserts.

The latest assessment of the scope of change over the last three decades suggests that thousands of square kilometers of once verdant areas have changed to deserts and barren fields. Our deserts are growing and our farmlands are shrinking. Our remote sensing satellites such as those operated by the commercial operator GeoEye lets us obtain images that are on the order 35 cm^2 per pixel, or one dot per sq. foot of visualization. This is sufficient to discriminate between cars and SUVs and to determine what types of crops are growing in fields. Figure 2.1 below shows us the Saharan Desert in detail as it encroaches on land that was once farmable.

There is more to these broad global changes than just desertification and shrinking water supplies. There is also the loss of the rain forests, swamps and everglade areas, and the melting of icecap areas. The melting ice in the tundra of Siberia serves to dissolve peat fields there that ultimately will release billions

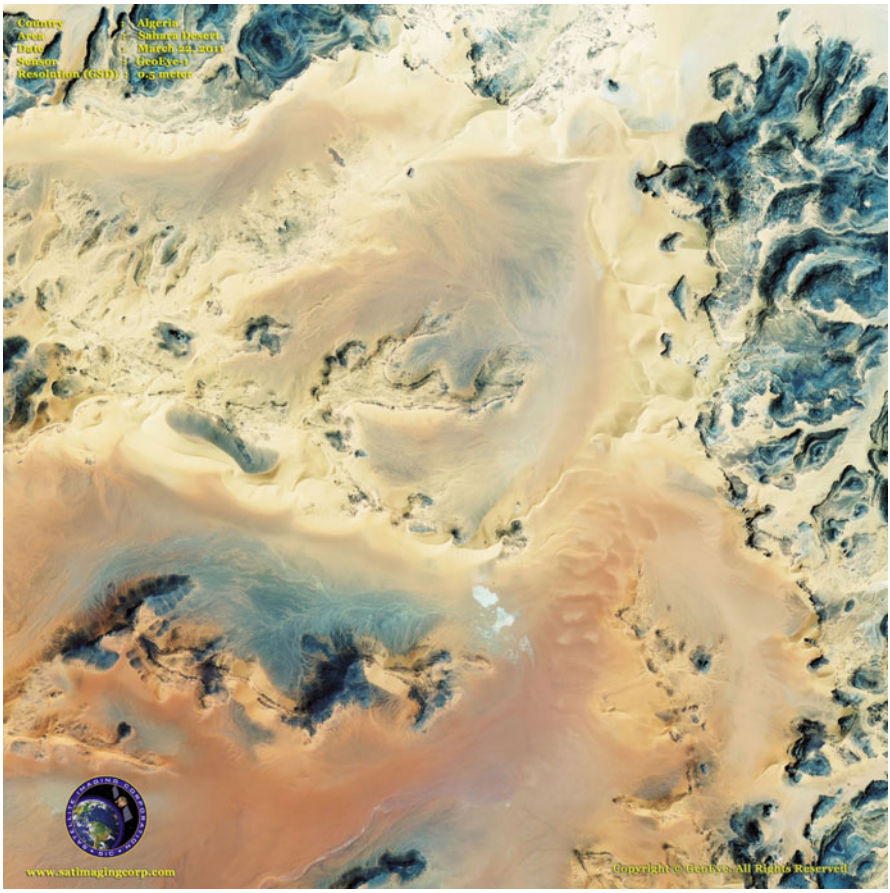

Fig. 2.1 The Saharan Desert in the Sahel area of Africa keeps expanding (Image courtesy of GeoEye. http://www.satimagingcorp.com/gallery/geo-eye-1/geoeye-1-sahara-desert/.)

of metric tons of methane into the atmosphere. The consequent release of methane from these peat fields is at least as significant as the release of carbon dioxide from coal-fired power plants. The implications from all these changes are worrisome at best and potentially disastrous at worst.

In terms of implications for human life, the shrinking water supply is currently the most concerning, even though the other changes are also highly destructive as well. No place on Earth today is turning greener. Across the planet land is turning browner. Around the world there are more people and less water. Figure 2.2 dramatically visualizes what an overpopulated world will come to look like, but the problem that will define our future will not

Fig. 2.2 Crowded beaches are just one signal of an overcrowded world (Image courtesy of Essential Environmentalists.)

be the lack of a place at the beach but insufficient water to drink as global populations grow from about 7.3 billion today to somewhere between 10 billion and 12 billion by 2100.

An even more worrisome image is that of villagers in Ethiopia crowded around a water hole that is growing dry. The image below in rural Ethiopia is being repeated across the Sahel region of Africa, where water holes and depleted aquifers below the surface that once carried a huge supply of fresh water is drying up and ending the viability of village after village. One estimate is that as many as 20 million people have felt the harsh hand of climate change and the drying up of water supplies that have forced the relocation of villages in Africa and indeed in Asia and South America as well (Fig. 2.3).

The water that is so abundant in our oceans provides us with a false impression of the supply of fresh water that is essential to life and the cultivation of crops in farms around the world. The amount of fresh water that is accessible is a tiny fraction of the water in the oceans. And as the icecaps melt and turn fresh water into saltwater, our supply is shrinking. The following graphic prepared by the Sierra Club shows the amount of water currently available in rather stark terms. The lack of water is one of the major growth boundaries that humanity faces today (see Fig. 2.4).

Space mining of the skies and significant amounts of desalinization can change all this, but to understand the logic of space mining we need to

Fig. 2.3 An Ethiopian water hole that is muddy and drying up in the Sahel region of Africa (Image courtesy of Engage Now Africa.)

understand much better the makeup of the Solar System and what resources are out there. Most people know enough about the Solar System to understand that there are the Sun, the planets, their moons and the Asteroid Belt. The general public does not necessarily realize that there is between 500,000 to 1 million so-called near Earth objects that come within striking distance of our world over time that are big enough to be city killers—or over 30 m (some 100 feet) in diameter. These potentially hazardous asteroids that come within 0.05 astronomical units, or about 7.5 million km (4.7 million miles) are now the subject of an intense hide and seek operation using ground observatories around the world and infrared space telescopes.

Fortunately most of the massive dangerous asteroids that are over a kilometer in size have been found, but there are still a huge number of the smaller "city killer space rocks" still to be located and their orbits charted. The point is that there are many, many more space rocks out there than most people realize, and that these rocks contain valuable minerals and metals (such as platinum) and what scientists call volatiles and we call water. Out in space we could use this water for rocket fuel (i.e., breaking water down into liquid hydrogen

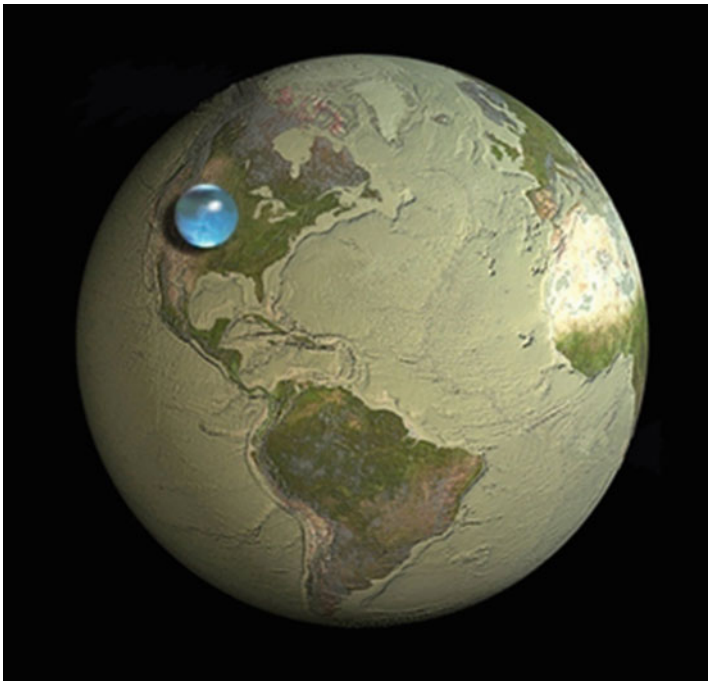

Fig. 2.4 The small amount of pure water available to humanity today (Image courtesy of the Sierra Club.)

and liquid oxygen), to sustain space colonies and for other key purposes. The current theory is that the water that constitutes our oceans came from asteroids or comets and that there is far, far more water in outer space than in the Atlantic, Pacific and Indian Oceans—tens or maybe even a hundred times more. The bottom line is that our Solar System is a big place, and there millions upon millions of space rocks out there. There is not just a handful space pebbles out there. Instead, there is a vast array to choose from. Some of the options include space rocks that contain perhaps many billions of dollars' worth of platinum, other valuable metals and rare earth components.

On one hand, these space rocks could provide us key resources we are short on when we run low. On the other hand the bigger-sized space rocks are potentially severe hazards. If they were big enough and traveling fast enough, they could take out the entire human race, just like the 5–6-km wide asteroid did in destroying the dinosaurs about 66 million years ago. Bottom line, space mining could be good not only for replacing key resources but also could lead to technology that could help to protect us from being clobbered by a giant space rock in the future.

Technology Spinoffs

If the New Space economy is to provide a truly meaningful boost to the global economy and create an increase in new jobs, then one of the primary keys will be technological spinoffs. We know from the experience of the space programs in the United States, Russia, Europe, Japan, India and China plus other countries over the past 50 years that space-related research and development leads to the development of new and improved materials, new communications, robotics and computer capabilities, new products, new agricultural techniques, and new services. It is not possible to cite a major industry that has not benefited from space technology and systems spinoffs. Benefits have been derived from mining to construction, from transportation to banking, from health care to transportation, from education and training to energy companies. Batteries, laser systems, computers, air conditioning and heating systems, antibiotics, energy transmission and generation systems, building materials, trucks, automobiles, buses, trains, ships and aircraft have all been improved. These systems are better, faster, safer, and more durable due to space R&D programs. In the chapters that follow the new space industries will be described in terms of critical new technologies that will be needed to make new space systems viable. The following chart is indicative of the new technologies or systems capabilities that the new space industries will likely give rise to in the years to come. In many, many cases the new capability will be utilized here on Earth before it is actually used in space, or the so-called "Protozone" just below outer space (Table 2.1).

Table 2.1 Challenging new space enterprises and how they could impact the global economy

New Space Industry	Key New Technology, System or Application	Implications for the Global Economy and Future Employment
Space mining	• Improved remote robotics • Improved and cleaner mining & extraction techniques • Improved remote energy systems (solar cells-P/V cells, quantum dot energy systems, batteries, etc. • More efficient electric & ion thrusters & launch systems • More effective communications and IT control systems	Enhancements to the technical and operational capabilities of manufacturing & mining companies, energy companies, robotic manufacturing companies, and air transportation companies

(*continued*)

Table 2.1 (continued)

New Space Industry	Key New Technology, System or Application	Implications for the Global Economy and Future Employment
Solar power satellites	• Improved remote energy systems (solar cells-P/V cells, quantum dot energy systems, batteries, etc. • Improved remote robotics • More efficient electric & ion thrusters & launch systems • More efficient long distance energy transmission systems	Innovations and efficiency gains for energy and power generation and transmission companies, improvements in the design & manufacture of solar power systems
Spaceplanes, Space Adventures	• Improvements in space range control plus tracking and guidance systems safety • Improvements in supersonic & hypersonic air transport propulsion and safety • Improvements in avionics and automated guidance systems	Improvements in the development of new supersonic and hypersonic aircraft, improved safety systems for all types of aircraft, improved air traffic management and control systems
Space habitats and space colonies	• Improvements in construction industries • New construction materials • Improved heating and cooling systems • Improvement in hydroponics and agricultural techniques • Improvements in remote health care and surgery	New materials for building construction, maintenance and refurbishment, improved and more energy efficient HVAC systems, enhanced district energy systems, improved farming techniques and genetic engineering of new agricultural products, range of improvements in health and medical care in remote areas
Space defense, planetary defense and traffic and control systems	• Improved radar and guidance systems • Improved broadband communications and IT networking systems • Directed energy systems • High-powered laser beams	Improved radar, remote guidance and tracking systems for all types of aircraft, improved broadband networking capabilities

The innovations discussed in the table above are, however, only the most obvious listings of the most predictable spinoffs that should occur as new technology, processes and techniques are developed to support the various New Space commercial activities that are now anticipated. Indeed the listings in this table are restricted to just the cutting-edge new space enterprises. Established space businesses such as satellite communications, remote sensing, space navigation, meteorological satellite services and on-orbit services will also likely have positive spinoffs of new technology and applications.

When the first transistor, solid-state computer, laser, artificial satellite, or synthetic material such as plastic were initially developed the actual practical uses

of these new technologies or products were far from clear. In many instances some of the more important applications were totally unanticipated. The same is very likely to be true for the New Space industries that are burgeoning around the world and will come on line in the next 5, 10 or 20 years. This pattern of new and totally unique developments seems to especially percolate through such places as Silicon Valley. These innovation 'hot spots' seem to grow up in proximity to major research universities, governmental research laboratories and aerospace, computer and networking centers.

Where and How the New Gold Rush Will Begin

Certainly Silicon Valley seems to represent the almost ideal conjunction of interacting intellects that spawns innovation almost like spontaneous combustion. This rather uncanny place—as represented by Google, Facebook, Yahoo, Intel, a host of computer, communications, and genetic research companies, NASA Ames, various aerospace companies, Stanford University, and the Singularity University—seems almost unique, although there are a plethora of wannabes being cultivated around the world.

The students who convene at the highly selective Singularity University in Mountain View, California, on the campus of NASA Ames are perhaps indicative of those young aspirants that want to change the world. They are given the assignment of conceiving of a project that in a decade can have a positive effect on the lives of millions, if not a billion people. This never fails to get the creative juices flowing.

In such cauldrons of invention, such as Silicon Valley—and like-minded centers of learning and creativity—there is a strong likelihood that when one breakthrough innovation comes, it will trigger an avalanche of new findings and applications. Aerospace companies, telecommunications and networking labs, computer systems, artificial intelligence, and genetic engineering all churn around in proximity to one another, and new ideas flow. This "noosphere," a term coined by the philosopher Teilhard de Chardin in the 1900s, where there is a growth and sharing of information, ideas, and knowledge by creative minds on a global scale, brews a hardy stew of innovation that fuels invention and entrepreneurial startups. When ignited by the challenge of doing things in outer space, especially things that have never been done before, this powerful mix creates an intoxicating drive to change the world.

And there is enormous impatience to make it happen. New Space commerce has triggered new ideas, new companies, new technology, and an array of change with an urgency that is faster than ever before. The twenty first century is seeing the coming together of "future compression" time scales and

a mushrooming of sometimes outlandish goals to go where no one has gone before.

It is these new "commercial space frontiers"—to accomplish the impossible—that start the dreamers dreaming. Space mining, unlimited clean power from the Sun, travel into the dark sky of space, self-sustaining colonies within the reach of Earth's gravity—these are the ideas that motivate remarkable people such as Elon Musk, Peter Diamandis, Bob Richards, Jim Keravala, Rich Tumlinson, Paul Allen, Robert Bigelow, Jeff Bezos and Sir Richard Branson. About half of these powerhouses of innovation the author has gotten to know through the International Space University, the Singularity University or at space conferences. When one sees these mere mortals up close you sometimes overlook the magnitude of their daring dreams and their commitment to change the world. But change the world they aspire to do.

The emotions they engender are two-fold. Awe and inspiration is the first reaction as to the magnitude of their goals. This is followed by concern and caution as to whether the world is ready to change so rapidly. With a world filled with tension and jihadist extremism and political leadership that sometimes has difficulty recognizing global challenges such as climate change, over generation of greenhouse gases, and the threat of global pandemics, it does at times seem doubtful that human are fit to colonize the world—let alone the universe. This is why we must look to innovation that produces more than neat new products. Rather, we need inventions that can usher in a sustainable world that can: (1) survive over the long term; (2) curb population growth; (3) figure out the twenty first century human employment conundrum; and (4) create new economic systems that usher in a better and more productive future.

In the latter chapters of this book we indeed look back to these very real concerns. In doing so we look to what types of rules and regulations might deliver us into a better world and new type of space economy. In a McGill University landmark study of the "Global Governance of Outer Space" efforts have been made to see where new standards, laws or policies could help. This 2-year effort has drawn on the expertise of over one hundred space lawyers, regulators, space scientists and engineers [4]. The purpose of this global and comprehensive study of the changing world of space was to explore what changes we need to make in terms of national legislation, codes of conduct, and international regulations to get ready for the new gold rush. This effort is a prelude to the discussions that will take place at the Unispace + 50 Conference to be held in Vienna, Austria, under the auspices of the UN Committee on the Peaceful Uses of Outer Space in 2018.

Conclusions

Some may doubt that New Space commerce is the vital threshold to the future. These skeptics see important research and innovation occurring in biological, chemical, computer networking, artificial intelligence and energy research, among other scientific fields of inquiry and dismiss the need for off-world enterprise as a 'secret sauce' ingredient that serves as the top fuel to major new invention. Certainly we have other challenges to motivate and vex us. These include such challenges as climate change, addressing oceanic pollution, changes to the icecap albedo, overpopulation and underemployment, new epidemics, plus global hunger, health care and educational needs. Certainly these challenges could and should also spur us to innovate. But it turns out that space technologies are often the vital means that allows us to cope with most of these challenges from a fresh new perspective.

Remote sensing and meteorological satellites that monitor the entire planet synoptically are vital to measuring climate change and determining pollution levels on the land, the seas, and arctic regions. These eyes in the sky are key to monitoring crops, disease in trees and vegetation and reporting on patterns of human settlement. Communications satellites are key to tele-education and tele-health, and broadband networking around the world. These links in the skies also supports rescue operations, banking, and all sorts of transportation systems. Space navigation satellites are vital to transportation safety, food and drug shipments and distribution, and even the synchronization of the Internet. The original meaning for what we now identify as satellites was provided by Galileo. That word was actually the Latin word *satelles,* and it meant helper or servant. The truth of the matter is that we are today much more dependent on our space servants that most of us ever suspect. If you are just a bit curious about the extent of this space-based dependency go to "You Tube" and find the short video entitled "If there were a day without satellites."

The truth of the matter is that satellite-based communications, networking, monitoring, transportation routing, positioning, navigation, weather forecasting, rescue, and safety systems are now vital to our everyday existence. One of the great lures of outer space is to explore the unknown riches of the cosmos. In a wide variety of ways space applications, space science, space transportation and space exploration will either guide our future or provide the technology to allow humans to have a future. If our technologies fail us, human civilization as we know it may also fail.

There are those that say "Why waste money on outer space?" To those critics we point out the following: The money that is spent on space is a part of

the global economy. The equipment that is developed and the salaries paid in truth benefit real human beings. Satellites provide news and entertainment to billions of people. The Internet, aircraft takeoffs and landings, automobile navigation systems, global shipments and national defense systems—all this and more depend on space navigation systems. The warnings against violent storms and hurricanes, the knowledge about how to combat climate change, and rescue systems for stranded pilots, seaman and passengers—these, too, all depend on our servants in the skies. Much of our knowledge of the universe, and clear warnings of cosmic dangers from the Sun and asteroids, depend on satellite servants in the sky.

Had the dinosaurs had a space program their kind might have survived the asteroid hit that exterminated them. Let's hope that we humans are smart enough to invest in space to not only colonize the cosmos and learn from whence we came but also to survive as a species. As far as we know not one red cent spent on space has ever gone to pay an alien. Space is actually a very human enterprise. And indeed it is the most likely enterprise to open a totally new window on the future.

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