A Space Age on Earth

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Throughout millennia humanity has wondered about its relation to the cosmos and about its ultimate role and purpose in the matrix of life. Based on the available knowledge of the moment, different models of thought were created to try to satisfy its quest to find the answers to these fundamental existential questions. As knowledge increased though a process of making finer and finer discriminations about the nature of reality, the prevailing models of understanding were consequently modified or replaced by newer ones in order to have a more precise and believable explanation of where we came from, who we are and what is our ultimate purpose.

Within this process, the perception of its home planet Earth has always influenced the way humanity has formulated its beliefs and conducted its affairs. When Earth was perceived of as the entire universe it gave rise to myths and religions that continue to permeate and influence society into the present time. With the advent of space exploration humanity's perception became that of the *Whole Earth* - a blue sphere floating in the vast expanses of the cosmos.

Figure 1. Photograph made by the Apollo 17 astronauts.

Today, most people are comfortable with the image of Earth as defined by the edges of its atmosphere which has become a powerful symbol of our times representing the environmental movements, the globalization of our diverse cultures and economies, and an understanding about the interdependence and interconnectedness of our climate and ecology. (Figure 1.) It is a 20th century view of Earth and the majority of its inhabitants conduct their affairs accordingly. Not very different than our early ancestors, most our world leaders and probably most people alive today instinctively assume that whatever humanity's fate in the years ahead, that fate will be ultimately decided and enacted here on planet Earth and not anywhere else. Earth problems must surely have Earth solutions.

However, this perception of our home planet is outdated, unnecessary and constraining. This essay introduces the need to formulate a new perception of planet Earth based on its true dimensions - a perception called *Greater Earth* [1] and how this perception can catalyze an optimistic path to a sustainable and prosperous future.

Our Cosmic Choice

Of all the life forms sharing our home planet, the human species appears unique in that it alone can contemplate its existence, examine its past and look ahead to its future. Our species has also developed the means to look beyond Earth into the Universe. Until now it has yet to find any hard evidence of life, as we know it, in other places beyond the Earth. Until such a discovery occurs, humanity must acknowledge that terrestrial life is not only rare but indeed may be unique. Thus, its role as the dominant species carries with it the responsibility to both nurture and further the conditions necessary for the survival and perpetuation of - not only its own species - but for all forms of life sharing the planet.

If one believes that other technological civilizations have appeared throughout the cosmos, then one can speculate they, too, must have faced a similar choice that confronts humanity at this particular moment. Did these distant civilizations decide to use their technology and knowledge to expand their civilization beyond their home planet in order to perpetuate their species, or did they misuse it and let their civilization and their future be destroyed? This situation represents the *Cosmic Choice* - a decision making process which any technological species must pass through at some critical point in its evolution.

Humanity has now reached a point where it has the technological means to leave its home planet and to begin operating in the environment beyond its atmosphere. Optimistically, this development would enable humanity to utilize this capability to harness the infinite resources located there in order to improve the well-being of the population on the surface of the planet as well as improving the chances that its current civilization can thrive and prosper in the decades and centuries ahead - both on Earth and eventually in other places. On the other hand, this same technological capability could also be used in a negative manner in order to exert control over a majority of the population thereby limiting prosperity to a select few or, in a worst case, be used to destroy human society and its chances of expansion into the cosmos. Not only would this have serious consequences for humanity but it may also prevent the ultimate survival of life in this part of the cosmos. Without technology, life may never migrate beyond Earth and when the moment comes that Earth no longer exists, then life on Earth will become extinct unless it had been planted elsewhere. [2]

In 1969, Gerard K. O'Neill, posed the following question:

> "Is a planetary surface the right place for an expanding technological civilization?" [3]

This question concisely encapsulates humanity's *Cosmic Choice*. An evolving technological species existing on a planet with finite resources is faced with the ultimate challenge of maintaining its development and the viability of its civilization before it reaches the threshold of unsustainability. In order to meet this challenge, it will need additional resources beyond those available to it on its planet's surface as well as an expanded environment that will stimulate the further development of its technological capabilities.

Two basic scenarios dominate today's discussions about humanity's future. The *zero-growth* approach as demanded by the Neo-Luddites [4] and the *business-as-usual* approach invoked by the Cornucopians [5]. Both of these future scenarios are at best inadequate attempts at mere survival which - however they might be packaged - not only will be ineffectual, but will eventually usher in dead-end, despotic and totalitarian regimes.

Fortunately, there is another more optimistic option – *a Space Option* – which is to utilize resources located beyond the atmosphere for meeting the growing needs of humanity on

Earth. This approach offers a third version of the future, unspecialized, with many avenues, varied possibilities, with room for different kinds of development and the necessary material assets to at least attempt to realize them. As such, it grants humanity new horizons and a hopeful future. This option represents our *Cosmic Choice.*

The World is Getting Smaller

Earth has always been the provider of raw materials and the mother of life. When humans were few Earth itself was the frontier to be discovered and explored. As exploration gave way to exploitation, the human species successfully established its dominance over the rest of nature and has since occupied the planet as no other species before it. It has devised means to extract and utilize terrestrial resources to feed its populous and to power its development. Our species has occupied the lands, farmed the vast oceans and traversed the skies in its quest for perpetual progress and development.

The phrase *"the world is getting smaller"* if often used when speaking about faster, safer, more efficient modes of transportation and communication technologies that can instantaneously connect anyone with another from almost any point on the globe. For all the positive and exciting benefits that these unprecedented aspects of contemporary society are providing us, there is an unsettling side to these developments. First and foremost is the uncomfortable realization that the world is also becoming more crowded.

Just 10,000 years ago there were only about 5 million people living, at that time, mostly in caves. For these people planet Earth was surely the entire cosmos. 8,000 years later, there were 130 million people around the time when Christianity was born. By 1650 the human population grew to about 500 million. 200 years later, at the beginning of the industrial age, it doubled to 1 billion. Our planet still seemed large enough and resilient enough to support any human purpose. 100 years later, the number of humans increased to 2.5 billion. At this time, a new development appeared - all of humanity as well as all of Earth's inhabitants began living with the threat of nuclear destruction hanging over their future.

And now, there are more than 7 billion busy humans living, working and playing on a very crowded and ecologically endangered planet. Barring a major catastrophe, by the year 2050 there will be at least 9 billion people sharing the planet with the rest of life that hasn't yet been pushed to extinction by human expansion. The positive side of having so many people on Earth is that humanity has never experienced so much creativity and progress in such a short time. Humanity itself must be considered as its most valuable resource and, in order to steer the future, its overriding challenge is to find suitable ways to feed, clothe and otherwise nourish this resource in a comfortable and prosperous manner without upsetting the social and ecological balance.

“The Limits to Growth” was the controversial book produced by the Club of Rome that appeared in 1972 and which did much to stimulate the discussion about the relationship between resource depletion, the environmental consequences of industrialization and population growth. [6] Over forty years later, its conclusions and prophecies are still being debated and indeed echoed in the current Climate Change debate. Yet, in this period human civilization has demonstrated its resiliency to adapt and innovate. Technologies in all areas of society have extended humanity’s capabilities to clothe, house and feed the growing population. However, it has become quite clear that this cannot go on indefinitely on a planet with finite resources that is bring irresponsibly managed leading to an eventual disruption of the ecological balance necessary for the survival of all life sharing our planet.

Greater Earth

In the 20th century humans began to investigate ways to penetrate the atmosphere. Today a communications apparatus installed beyond the atmosphere permits us to remain in constant touch with each other from any place on the planet. Orbital outposts are providing the information to enable human beings to adapt to this new environment. Scientific instruments placed in this area are exploring the depths of the cosmos and investigating the state of the environment on the planet below. National security systems have placed monitoring devices that track developments and movements of opponents making surprise attacks less likely. Indeed, the functioning of contemporary society is totally dependent on these technological resources orbiting the Earth and without them modern civilization would no longer function.

These activities have effectively expanded the territory of planet Earth from its solid dimensions of 12,756 kilometers to a diameter of approximately 84,328 kilometers. As the 21st century unfolds, humanity finds that it needs more room and more resources to sustain its numbers and to maintain its thirst for further development. The finite planetary resources that contributed to its present state are being irrevocably exhausted to unsustainable levels and their uncontrolled use within the biosphere is resulting in severe ecological consequences. As it is unequipped to occupy and transform a neighboring planet to meet its growing needs, humanity's next logical step will be to discover and inhabit the last reaches of its own planet - to expand its activities to Earth's true boundaries as defined by the laws of physics.

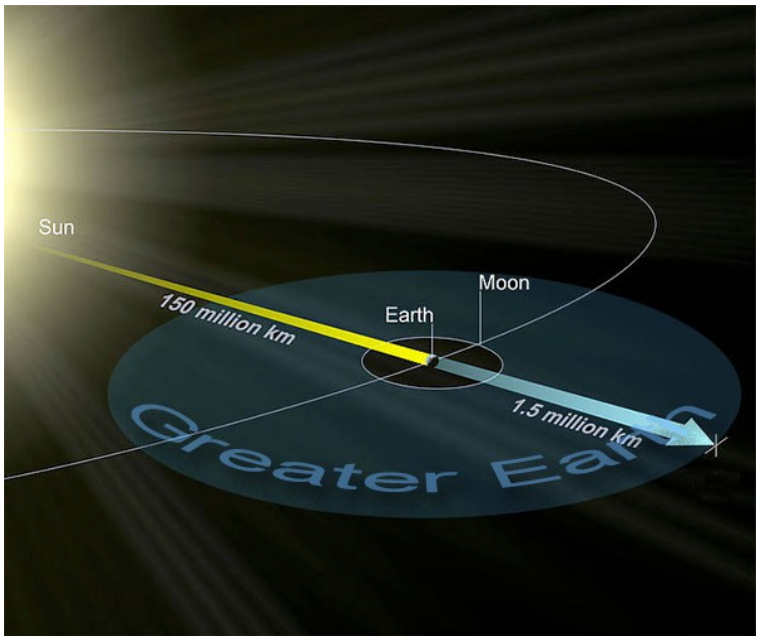

Figure 2. Greater Earth

All celestial bodies of significant concentrated mass exert a field of gravitational attraction around their cores which extends to the point of tangential intersection with other celestial bodies. Earth's gravitational influence extends 1.5 million kilometers in all directions from its center where it meets the gravitational influence of the Sun. (Figure 2.) This sphere has 13 million times the volume of the physical Earth and through it, passes some more than 50,000 times the amount of solar power which is available on the surface of the planet. In addition to energy, within this sphere of 3 million kilometers are enormous amounts of other resources, including the Moon and occasional passing asteroids. Like the territorial waters surrounding nations these resources naturally belong to our planet and should be used for the ultimate

benefit of humanity and all life which has originated here. As it has throughout its history, humanity must understand and seek nourishment from its home planet and it must now once again refine its perception of the planet in order to recognize and embrace the perception of a greater, richer and more sustainable Earth.

This is *Greater Earth* and within its boundaries our species will find the room, resources and opportunities that it will need to survive and prosper in the current millennium. To do so, its next step is to exercise its fullest capabilities to occupy and enjoy this new territory. Undertaken responsibility and consequently, the severe pressures and stresses currently facing our civilization may be mitigated which may in turn lead to eventually achieving worldwide security, prosperity and ecological balance. [7]

The Resources of Greater Earth

The first and foremost requirement for the future of human civilization is an inexhaustible supply of clean, environmentally benign energy. Solar Power Satellites (SPS) were proposed by Peter Glaser in 1968. [8] Since then, a number of studies have described the feasibility of supplying Earth with solar energy from space. A recent study by the International Academy of Astronautics and a subsequent book by the study's lead author John Mankins, realistically describes how a SPS located in Earth orbit would use the latest technologies and be built by robots out of modular components – a concept that has both economic and maintenance advantages. [9] In the mid-eighties, David Criswell introduced a significant variation of the SPS concept called the Lunar Power System or LPS. Instead of building the photovoltaic system in Earth orbit using materials transported from Earth, he proposed a more efficient approach which was to use an existing platform - the Moon - for the location of the solar collectors and to use lunar materials for their construction. Thus, instead of sending tons of materials from Earth into geo-stationary orbit at great cost and constructing these enormous and complex satellites in orbit, one would send a small team of humans accompanied by the necessary robots to the Moon to carry out the job on site.[10]

The main criticism for development of SPS over the years has been the huge financial investment necessary which is tightly correlated to the high cost of transporting an enormous amount of mass into geo-stationary orbit. In the past few years, private launch companies such as SpaceX have substantially lowered launch costs compared to governmental launch systems. A commitment to SPS would create a larger demand for such launch services which would consequently optimize production costs resulting in even further cost reductions. *Skylon*, a British project to build a reusable Single Stage to Orbit spaceplane has recently received serious funding for further development and could be operational within a decade. This concept could also drastically reduce launch costs for a future SPS system.[11] Another recent study by the International Academy of Astronautics has looked at the feasibility of building a space elevator that would reduce the cost to orbit in the way that no rocket propelled system could ever achieve. [12] The necessary nanotechnology to build the required cable does not yet exist but research could be accelerated if the financial commitment was there and a synergy with SPS could be established. Alternatively, one could utilize lunar materials and space manufacturing for much of the solar power hardware – an approach that would lead to creating a viable industrial capability within the territories of *Greater Earth.*

In addition, the projected size and composition of the future energy markets foreseen in the year 2050 tempers this criticism somewhat. In 2013, three of the world's important energy organizations: the World Energy Council (WEC) [13], the U.S. Energy Information

Administration (EIA) [14] and the International Energy Administration (IEA)[15] have each made predictions about the future energy needs of society for mid-century and how these predictions will be fulfilled. Together they predict that energy consumption will increase by more than 50% from today's numbers due to an increase in the population to approximately 9 billion by the year 2050 and by increased energy use in the developing countries. The sobering insight from their predictions is that the overall per capita energy consumption will be about the same level or slightly more as today which means the developed countries will have reduce their standard of living and use substantially less energy as now in order to satisfy these predictions.

Such development and population increases will stimulate a burgeoning energy market of enormous proportions. Factoring in a projected rise in the cost of oil, the energy market will increase from US$ 7.6 trillion in 2010, to US$ 12 trillion in 2020 and to US $25.5 trillion in 2050 to meet the expected needs of humanity. In order for the entire world to aspire to an energy use and prosperity level equivalent to that of Europe today, it will require more than twice the amount of energy that is currently being produced and used. In this case, the estimated value of such an energy market would be more than US$ 38 trillion. Truly this is an economic incentive for any new energy technology and even if energy from space supplies just 10% of that future market, it would appear to be an attractive economic opportunity for its eventual development. [16]

Also sobering, the three energy organizations further believe that the primary source of energy up until the year 2050 will still be fossil fuels. Alternative terrestrial renewable energy sources such as hydropower, geothermal, photovoltaic and wind, though desirable and important additions to the world's energy mix, apparently cannot scale to meet these future energy demands. The WEC report asserts that energy production from these alternative sources will remain a modest fraction of the total energy picture as these technologies are unlikely to provide the huge amounts of new energy that will be needed in the coming decades. Likewise, use of nuclear energy, with its unsolved political and environmental issues as well as its high start-up costs, will increase at about the same pace. Notwithstanding, the most recent IPCC report states that the world needs to triple the energy it gets from renewables, nuclear reactors and power plants that use emissions-capture technology to avoid dangerous levels of CO_2 caused global warming. [17]

In the Climate Change debate, it would seem that SPS would be the obvious solution for providing plentiful energy without increasing CO_2 and it is quite amazing that it is not even under consideration or even mentioned as a possible solution. Earth's climate is cyclical and if the climate goes into a cooling phase resulting in a new Ice Age as some scientists predict *- a scenario that would be much worse for civilization than global warming* – space solar power technologies could also provide warming capabilities in the form of Snow Melting Satellites (SMS) - a concept proposed by space researchers P. Collins and M.C. Bernasconi. [18]

In addition to having enough electricity to power our industrial development, we would also have the necessary energy to break water down into its hydrogen and oxygen components and to use the hydrogen as fuel for our cars, trucks and tractors insuring personal mobility and farming as well as having sufficient energy to power desalination plants for providing drinkable water where needed.

With a plentiful source of energy located outside of the atmosphere humanity could then consider placing some of its most polluting industries outside of the biosphere making our

terrestrial home a more pleasant place to live. For this to happen we would need also a plentiful source of raw materials. The Moon is the obvious choice here. The recent discovery of water on the Moon adds to these projections significantly as this could potentially supply a lunar colony with sufficient water at a considerable savings over transporting this water from Earth. [19]

One would expect new industries to flourish as the economies of *Greater Earth* catch on. Space tourism, soon to become a reality in a sub-orbital context, will be a source of economic development which will contribute to other developments. The idea of harvesting Helium-3 (He-3) - which is plentiful in lunar soil but rare on Earth - to be used in future nuclear fusion reactors back on Earth when this energy technology matures. For this to happen we will have to have safe, reliable and reusable launchers and spacecraft which will permit travel throughout the new territories of *Greater Earth*.

Humanity is becoming more sensitive to the vulnerability of its home planet to the ecology of the cosmos. The impact of the comet Shoemaker-Levy 9 into Jupiter in 1994 showed us that major events in our immediate cosmic vicinity can and do happen in our lifetimes. More recently, the Chelyabinsk meteor which impacted Russia in 2013 with an estimated initial mass of about 10,000 tons, exploded in the atmosphere with 20–30 times more energy than was released from the atomic bomb detonated at Hiroshima. The fact that this object was undetected before it entered the atmosphere is yet another warning about our vulnerability to cosmic events beyond our control and our present ability to respond or adapt and the necessity to develop an infrastructure beyond the atmosphere for planetary defense.

In 1997, astronomer Jim Scotti announced the discovery of asteroid 1997 XF11 that is headed for the vicinity of Earth in the year 2028. It is estimated to be between 1.3 km and 2.8 km wide and will pass the Earth at a distance of 930,000 km which is about 2.4 times the distance of the Moon from Earth. [20] If an asteroid of this size passing through the territory of *Greater Earth* could be captured and placed in a stable orbit at Lagrange point 5 (L5) it could then be mined for its potentially valuable resources and subsequently converted into a human habitat with a natural protection shielding the inhabitants from cosmic radiation. NASA is developing a program for making an asteroid capture while NewSpace companies Planetary Resources and Deep Space Industries are developing business plans and the initial technologies for doing so.

This has been just a brief introduction to the resources of *Greater Earth* and the probable impact of their development. The main advantages include:

1. Access to vital and plentiful new resources necessary to meet the growing needs of humanity, especially a source of unlimited clean solar energy
2. A pollution sink for moving industries outside of the biosphere
3. A restoration of the environment with sufficient energy
4. A new territory for human endeavors leading to new knowledge, skills and technology
5. Industrial development which would create many thousands of new skilled jobs on Earth which would stimulate the world economy
6. The real possibility of creating an optimistic and prosperous future for the next generations
7. A lessening of political tensions as competition for finite resources diminishes
8. Creating an infrastructure beyond the atmosphere may help provide a defense from possible impacts by asteroids and comets
9. Developing the territory of *Greater Earth* will open the door to further Solar System exploration and development.

An extended online group discussion among space enthusiasts resulted in the *Greater Earth Manifesto* which expands upon these points. [21]

A Space Age on Earth

The arguments for expanding human civilization into the territory of *Greater Earth* appear overwhelming. In the past fifty years humanity has developed and demonstrated most of the necessary key technologies which has also catalyzed numerous other technological innovations and developments. Already, humans have been living continuously in orbital outposts for almost thirty years and have amassed both experience and knowledge about living in this harsh and unforgiving environment. The remaining technical obstacles associated with the development of *Greater Earth* are in reality mostly engineering challenges which could be met with sufficient commitment and resources.

This concept is not utterly new as it builds upon work of space visionaries and pioneers such as Krafft Ehricke and Gerard K. O'Neill who recognized the eventuality that humanity must move beyond the atmosphere to survive and thrive. They and their followers developed both the scientific rationale and the technological capability to address the impending human dilemma. Krafft Ehricke called it the *Extraterrestrial Imperative*. [22]

In 1970 he wrote:

> *"While civilization is more than a high material living standard, it is nevertheless based on material abundance. It does not thrive on abject poverty nor in an atmosphere of resignation and hopelessness. It needs vigor as well as vision. Therefore the end objectives of solar system exploration are social objectives in the sense that they relate to, or are dictated by, present and future human needs."* [23]

Over the years these ideas have been merged into a concept called *The Space Option* which is an evolutionary plan to meet the basic and anticipated needs of humanity through the utilization of near Earth resources - *not for the in-situ support of science or exploration* - but rather to apply these resources and/or their products for use on Earth at a conspicuous level. [24] In addition to this emphasis on direct socio-economic returns, what sets the Space Option concept apart from other space development initiatives is that it does not promote an urgent need to focus humanity's energies and resources on destinations that lie beyond the true cosmic boundaries of our planet. There is enough room, sufficient resources and plentiful opportunities within the 3 million km sphere of *Greater Earth* to more than satisfy the needs of our civilization in the 21st century.

Furthermore, if one believes that economic and technological development are necessary preconditions for peace, then one has to arrive at the conclusion that significant resources are necessary (a.) to fuel development, and (b.) to reduce tension. By embracing the Space Option and settling the territories of *Greater Earth,* humanity could provide the necessary new and sufficiently abundant resources for this purpose. This tension-reducing potential is perhaps the greatest contribution to eventual peace and security on Earth.

Our civilization is at its peak - we have the means today to embrace *Greater Earth* but not yet the commitment. However, if our species does not soon grasp this unique opportunity with sufficient commitment, it may miss its one and only chance to do so. Humanity could soon be overwhelmed by one or more of the many challenges it now faces. The window of opportunity is limited as the population increases and the associated stresses to our civilization multiply. To survive and to prosper in this new millennium the next step for our

species is to exercise its fullest capabilities to exploit this new territory that is a natural part of its cosmic home. By doing so wisely, humanity will make the appropriate *Cosmic Choice* and go on to other places and adventures. *Greater Earth* is the gateway to the Solar System.

Astronautics, space technology and the knowledge and experience that humanity has accumulated over the past 50 years are there to open up this vast new arena for human activities. For the environmentalists and the Neo-Luddites this represents the ultimate environmental solution. For the Cornucopians, it is the technological fix that they have been relying on. For the hard core space community, the obvious by-product would be an infrastructure upon which the eventual exploration and settlement of the solar system could be imagined. For most of humanity however, the ultimate benefit of creating a space age on Earth is having a realistic hope in a prosperous future with many new possibilities.

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