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The Mars imperative: Species survival and inspiring a globalized culture

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ABSTRACT

Humanity has crossed a unique technological threshold enabling self-guided survival, a first in the history of life on Earth. From a human perspective the Earth may be considered as a single interconnected ecosystem, and given our tenuous understanding and control over the environment as well as our own behaviors, ever-looming specters of social collapse or even extinction dictate enacting immediate off-world diversification and self-preservation efforts. Herein, Mars is touted as the most tenable and sustainable location in which to initiate such permanent diversification. Scientific curiosity alone cannot initiate nor drive such off-world settlement and concerted impetus and public support for such an endeavor is shown to be constrained by human attention span. Lastly, the initial act of settlement uniquely serves as humanities greatest globally inspiring self-initiated endeavor, a tangible benefit capable of inspiring generations, connecting cultures and motivating college enrollments and career path choices in science, technology, engineering and math (STEM) in a manner similar to the dawn of human space exploration.

1. Introduction

We begin simply with a fundamental assumption before considering several wider associations, that humans are intrinsically important and somehow worth preserving. This work further presumes that the universe is governed by the laws of probability, which in turn reflect the timing of events and outcomes, both natural and human initiated. Therefore, actions taken for the sake of preservation must be considered in relation to all physical and philosophical constraints. As individuals we perceive reality through a series of unique filters, experiences and emotions, and all too often are moved to action only when directly forced, threatened or provoked. Our long term survival is repeatedly hindered by the difficulties associated with proactively initiating complex endeavors intended to protect from natural or social threats. Whether such actions, designed to insure our survival, are also capable of making the world a better place or not remains to be determined.

Throughout human history, few if any societies or cultures have had such advanced awareness of the multitude of dangers that threaten their existence while at the same time have developed the knowledge and technology sufficient to take the necessary measures to ensure survival. Most of human existence has been mired in mysticism, misunderstanding and hubris regarding the genuine fragility of our biosphere, societies and cultures, no matter what the scale. Our ultimate survival depends on a growing understanding and acceptance of this fragile and tenuous fabric. Over time, how much knowledge has been lost due to human negligence, ego, apathy, strife, social decay or lack of funding (e.g., the loss of the Library of Alexandria and Hattusa or the 221 B.C. purging of scholars and books by Emperor Qin)? How many times in human history must the proverbial wheel be reinvented as a result of our passively expecting others to take steps to ensure our survival? Our species short history is

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exemplified by an inability to learn from its recklessness, lack of forethought, inaction and hubris, wherefore current and future generations repeat history ad nauseam – "those who cannot remember the past are condemned to repeat it" [1].

In addition to human threats to survival (e.g., war, social and economic failure and global climate change), nature itself can impart disasters and catastrophes that affect the survival of our species to an equal or even greater extent – ranging from massive death tolls due to earthquakes, tidal waves and volcanic eruptions, to complete extinction by large impacts. The Earth and life itself may continue to survive, as it has done for billions of years, but it is unclear whether we will remain a part of its tapestry. Probability is not on our side. One of the best ways to protect against such threats is to create a refuge – at a location far removed from the birthplace of humanity. As the author Robert Heinlein once said, "The Earth is just too small and fragile a basket for the human race to keep all its eggs in."

Our species has reached a unique evolutionary and technological confluence which potentially could insure the survival of our species. The settlement of Mars is probably the most viable endeavor that would create a backup for life on Earth, in effect a global-meitosis. Such an endeavor can further provide positive inspiration to individuals on a global scale for decades or more. There are numerous reasons for going to and settling Mars and advocates extend back to before the dawn of human space flight [2–4]; yet, our fascination with this little red-planet runs much deeper, shaped by figures such as Schiaparelli, Lowell, Burroughs, Bradbury and Sagan. Currently, and for the foreseeable future, Mars is the only destination whose environment and accessible natural resources efficiently enable permanent and sustainable human habitation off Earth.

Our current understanding of Mars provides evidence of its preeminence as a second home, and it is only the availability of sufficient quantities of water that makes this possible. Mars evolved out of the primordial solar nebula much as Earth did and therefore has similar composition and features. As a result of its smaller size (~53% of Earth's diameter), lower gravity field (~38% the gravity on Earth) and early rapid loss of internal heat energy, the planet's surface became the cold and dry world we see today. Yet, early in its history and for a short period, Mars is believed to have had a much denser atmosphere, rivers and potentially ancient oceans [5–9]. Over the eons, all surface water was redistributed to various cold traps (e.g., subsurface ice and polar caps) or been lost to space [10]. The Mars Odyssey spacecraft's Gamma Ray Spectrometer used to measure neutrons emitted from below the surface [11,12] and observations from the Phoenix landing site [13] today suggest that near surface ice deposits are ubiquitous across the planets northern lowlands. The ultimate key to success is sustainability and the settling of any other world requires the extraction and use of indigenous resources. It is this remaining ice, among other resources and environmental characteristics that makes Mars the second most habitable and sustainable location in our solar system. Today, prospecting is still required to identify optimal landing sites with sufficiently producible quantities of ice and therefore water. Additionally, ready access to ice allows architects to simplify designs by using the most efficient non-closed-loop technologies available today (i.e., oxygen from ice supplements simpler leaky or non-regenerative life-support systems). Otherwise, exploration and settlement must await the development of complex and expensive closed-loop technologies. Another important aspect, in both getting to and staying on Mars, is having a comprehensive understanding of the dangers and challenges associated with such an endeavor. Many challenges face any Mars endeavor, but the most likely hurdles to implementing permanent Mars habitation include radiation dosage and physiological responses to reduced gravity (occurring primarily during interplanetary transit), surface dust contamination, and large vehicle entry, descent and landing (EDL) operations [14–21]. Years of mission designs and architectures exist in the literature, and many work under assumptions of excessive optimization and risk avoidance [22,23], while others advocate more straightforward approaches [4] in light of limited government support and funding. Ultimately, all hindrances to initiate the settling of Mars are believed manageable and may be overcome in a timely manner given creative, judicious, synergistic designs and architectures [24].

Presupposing Mars as our obvious destination, the only further obstacle to acquiring this unique survival insurance, is ourselves. Critics of space exploration base their argument on the perceived need to solve humanities problems here on Earth first. The probability of a positive global paradigm shift in human behavior or nature is fleetingly small and furthermore, our species has been attempting to solve its ongoing social problems ever since we became a uniquely differentiated and highly social species, more than a 100 thousand years ago [25]. Surely, no one can argue this history. And yet what has become of it; are we, the entire species, truly any better off today than any other point in history? Delaying the migration of our species off Earth only serves to heighten the probability of catastrophe and extinction.

Indecision, obstinacy, ego and shortsightedness generate unending obstacles, which are further hampered by a current unwillingness to accept the risk or to implement and finance programs to completion. Unfortunately, history is replete with examples of exorbitant government spending and waste on projects that were terminated prior to completion.

Contentious and ongoing debate across various levels of government, industry and within the human space flight community further obscures the path that should be taken to get to Mars. For example, is the Moon or another intermediate destination a necessary stepping-stone? Arguments stress that significantly more scientific, technological, and operational advancements and preparation are needed before attempting a Mars mission. Practice landing on and launching from a large celestial body is one such argument; yet, is that not exactly what we do from Earth itself? It has been said that this "logical" path for developing and demonstrating such capabilities is needed in advance of the more distant and risky venture of going to Mars. This author and others resists these assertions, believing rather, that our bureaucratically over-burdened space flight leadership is entrenched in overly conservative beliefs and fearful of risk. Yet, all missions to any other destination pose similar risks in their own right. The stepping-stone community has many unaddressed solutions to getting to Mars. They do not account for the fact that the combination of ongoing risk aversion and rapid political turnaround continually obstructs any potential for sustained support or action. Additionally, should any unfortunate accident occur during such stepping-stone missions, all advancement towards Mars would be forfeit, and again delay it another 30 years. Two more problems with stepping-stone missions include architectures that are not designed or even proposed as sustainable (i.e., flag planting), and locations that do not provide sufficiently comparable habitation, hardware, operational or resource acquisition analogs needed to prepare for Mars. When all physical and environmental characteristics are considered together, the dry valleys of Antarctica are probably a better and less expensive analog for preparing for surface activities on Mars. Therefore, every program from now on that is not overtly successful, given our ever growing risk aversive environment, or that is not designed to fully sustain human presence at the chosen location, only serves to delay the actualization of Mars settlement. Astutely and wisely, Columbus' voyage of 1492 did not delay in hopes of the development of the steamship, a voyage similarly fraught with ample risk and danger. If we are to ever begin our move off this planet in earnest, to enhance our species odds of survival, we must accept the risks involved and support such a transition with resolute and unalterable funding.

Making Mars humanities second home shall simultaneously influence and benefit the future of Earth itself. As our global culture becomes more intertwined, a growing need arises for a shared positive compass, an event or endeavor that can capture imaginations worldwide and enable the vicarious sharing of positive human adventure and achievement. That is how to win hearts and minds and the Apollo lunar program serves as our preeminent example. Though its origins were mired in geopolitical rivalry and national pride at the time, the first lunar landing on July 20, 1969 may be the only such example in human history that holds the key to understanding our world's need for a positive and shared goal. The first steps on the Moon during Apollo 11 were broadcast worldwide with an estimated 500–600 million *simultaneous* viewers (roughly 15% of the world's entire population), the largest television audience for a live broadcast at that time [26]. This globalized social event is made even more amazing given the diminutive state of global communications at that time. Though the live broadcast was banned in the Soviet Union and China, children and adults from every part of this world, ally and adversary alike, conjointly experienced an unparalleled human feat and generations were inspired to pursue lifestyles, education and career paths that positively impact people on Earth to this day.

The social impact of going to Mars is akin to William James' 1910 exposé on the need for universal conscription into a society whose only enemy is *nature*. Prior to the breakout of World War I, this work had the foresight to highlight the need for our growing and interconnected cultures to pursue a non-militaristic or threat reaction activity that can be shared by all and that can sustain political unity and civic virtue [27]. Over the past 100 years our world has only become ever more intertwined and James' proposed requirement for a binding agent was never more relevant than today. Lasting constructive social, emotional and behavioral guidance requires empathy and inspiration derived from a positive, egalitarian, nonpartisan, non-pop culture, human initiated event that engenders motivation and goodwill across borders and across whole populations at a single point in time.

The remainder of this document addresses the survival imperative for humanity to begin to take steps towards the sustainable settlement of Mars. Impetus for action is shown to be based on a combination of natural, social and psychological constraints and historical observations. Lastly, the most immediately tangible benefit to humanity is in regards social and educational inspiration. By elucidating a growing culture of impatience and ever-diminished attention spans combined with a growing reliance on technology, for the foreseeable future, Mars settlement may be our species greatest opportunity for inspiring and motivating future generations towards the building of a positive future shared by all peoples of this world. We argue that the act of initial exploration itself potentially embodies our species' greatest globally inspiring self-initiated endeavor, one capable of sparking lifetime ambitions and motivating generations to pursue higher education and adopt career paths, specifically in STEM related fields.

2. The great backup

The only reason life has survived the eons on Earth is that it diversified, both genetically and by moving out and inhabiting every niche possible – the definition of biodiversity [28]. Our species is now a global culture, where its collective knowledge, works and history have reached a unique pinnacle in the evolution of all life on this planet. Collectively, we stand on the edge of an unstable and potentially unrecoverable precipice, and for the first time we have the opportunity and ability to proactively increase the probability of our own survival through conscious and proactive diversification. As such, we do not have the luxury of dividing our attention and resources at this *apex* of social and technical evolution and should focus on a single sustainable and attainable goal that could ensure our survival. Fatefully, any society or culture so advanced, having reached this cusp of self-enabled survival, must take action as soon as possible or faces degeneration or even extinction due to its own hubris, lack of vision or lackadaisical actions and behaviors. In addition to ourselves, we should also ask what knowledge and positive aspects relating to our tenure on this world would we want to survive any untoward events or catastrophes. Had that great Library of Alexandria been wholly duplicated in a distant and safe location, one wonders how different or advanced our world might be today. The last 5000 years of our history is replete with examples of societies, cultures and seats of knowledge that have all but disappeared as a result of natural or man made catastrophes, either impeding potential technical or economic growth or inducing some form of social regression. Either way, the loss to humanity of such knowledge, art and culture is incalculable.

Today a multitude of catastrophic threats span all social scales from global to national to regional. The majority being naturally occurring, but similar threats exist given our hubris in combination with our advanced technological state. Additionally, our cultures and societies could potentially decline or disappear through the occurrence of multiple, closely spaced environmental disasters or social conflicts. Recent U.S. history provides a direct example of the convergence of several large natural disasters (e.g., hurricane Katrina, Sandy and Ike) in concert with ongoing wars and a massive economic collapse. The close timing of these events has hampered this nation's ability to develop appropriate social infrastructure and respond efficiently to additional events or focus resources on any programs that might be aimed at ensuring our long-term survival such as initiating the settlement of Mars.

Table 1 highlights the greatest threats to our societies, cultures and species. All threats share a similar set of potential outcomes depending on magnitude and duration of event. This ranges from the destruction of a single city or country to economic and social disruption or collapse, to a global catastrophe and complete extinction. In February 2013 nature fired a warning shot across our bow where a house sized meteor disintegrated over Russia releasing energies tens of times the power of the first atomic weapons. One month later in March 2013, another lesser-known event occurred on the Moon; the largest lunar explosion ever observed, equivalent to an estimated 5 t of TNT. Though the boulder-sized object was too small to pass through Earth's atmosphere, this event is another stark reminder as to the resident dangers in space. In the past eight years of active monitoring alone, some 300 lunar strikes have been recorded. And yet another flyby, nearly missed by astronomers, occurred in September 2014. Given such events we must ask ourselves why we, as the preeminent sentient species on this world, continue to not learn from historical examples or at least proactively prepare

Table 1
Today's greatest threats to society, culture and terrestrial life.

Threat occurrence		Examples	Remediation potential
Asteroid or comet impact	a) Football field size ~2 per year, b) up to a kilometer ~one in one thousand to 10 million years, c) 10 km sized objects ~one in one hundred million years.	Smaller range: Tunguska event: 1908; ~100 m (300 ft) wide object flattened >2000 km^2 (770 sq miles) of forest; 10–15 Mton of energy [29]. Larger Range: Chicxulub bolide impact: ~65–66 million years ago; ~10 km (6.2 mi) wide object; cause or contributor to the Cretaceous–Paleogene extinction event (~75% of all species vanished) [30,31].	Depends on the size: nothing for the smaller range, but for the larger range, if given timely identification some form of intervention may be possible (e.g., deflection).
Volcanic eruptions	Supervolcanos and flood basalt eruptions. > Rates are variable and generally unpredictable throughout Earth's history.	Toba ~75 thousand years ago; ~2×10^7 km^2 of deposits; Yellowstone is estimated to erupt roughly every 600 thousand year; Siberian (~250 million years ago) and Decan Traps (60–68 million years ago) [32]; → Temperature and environment impacts; population bottlenecks; cause or contribute to mass extinctions [25,33,34].	Low due to variable and unpredictable forecasting; yet, quick response and preparation might diminish direct and indirect impacts of smaller events.
Global climate, ecological and environmental change	a) Global climate change. b) Magnetic field reduction or change or catastrophic geomagnetic storm. c) Species loss or extinction. > Rates are variable and generally unpredictable throughout Earth's history.	Large, short term natural swings in temperature and climate: Younger Dryas Event and Little Ice Age. Long Term climate changes – Glacial and Interglacial periods: Desertification; sea level rise; ocean oxygen reduction, acidification and chemistry change; resource reduction; human conflict escalation. Magnetic field intensity decrease (10% over recorded history), magnetic reversal (last occurred 700 million years ago) or migration [35–37]; 1859 Carrington solar event [38]: UV impingement; local or global power system failure. Loss of Honeybee populations [39]: Agriculture/ecosystem failure; resource reduction/loss.	Most likely none in case of climate change, but impact extent can possibly be mitigated or exacerbated by human behavior. None in case of magnetic field changes. Unknown in case of species loss or extinction.
Ourselves	Warfare, pandemic, overpopulation, pollution, social stratification, economic turmoil (counterfeiting), cyber and infrastructure attack, etc.	Pandemics: 1918 Spanish flu outbreak – 3% to 5% of the world's population died [40]. Ecosystem destruction/pollution: Plastic islands [41].	Medium to high depending on human behavior and social robustness (e.g., cost) and extent of preparedness.

for the worst case scenario. Is it because we are in denial, naive, unaware or have we just become a little too big for our britches? Nature's clock ticks along and unfortunately the odds are that we will be caught by surprise, never even seeing the object or predicting the event that hits us until it's too late.

Our continued actions seem to indicate that we take for granted the idea that life-goes-on, even past the point that we as individuals pass on; yet, this is incredibly naïve and inhibits our actions. It is as if global societies were independent, immortal and as invincible as newly wrought teenagers. If one could only question a trilobite on this topic, yet you cannot, as they all went extinct along with well over 80% of all species inhabiting this little world roughly 252 million years ago (i.e., the Permian-Triassic boundary event). The direct cause or causes of this event are still debated with the leading contenders being mega volcanism (Siberian Traps) or an impact [32,33] from space. Though, historically, the Permian event is probably our worst-case example, it represents just one of 10 or so well studied mass extinctions (i.e., events where between 10% and 95% of all species vanished) that have occurred on our world in over the past 540 million years. In all, research has shown that well over 95% of all species that have ever existed on Earth have gone extinct [42]. Each of these mass extinctions killed many more individuals than there are humans on Earth today.

Over the entire 4.6 billion year history of our world, volcanic activity and impacts from space have arguably had the largest effect on our world's evolution. Volcanoes themselves have had a direct and extensive influences on human history, and among the many prominent examples, three are provided here for context, including: Toba, Thera and Mount Vesuvius. Toba, the largest volcanic event of the past 75,000 years affected global and local climate and may have contributed, either directly or indirectly [34,43], to a human genetic bottleneck (e.g., a point where a species population size is severely truncated), both threatening our very existence and changing the course of our species. The ancient volcanic island Thera, now called Santorini, once stood several hundred meters above the surrounding Aegean ocean, and held a thriving Bronze Age culture. The volcano exploded sometime between 1627 and 1600 B.C. [44] and is assumed to have affected climate worldwide and instigated the collapse of the Minoan civilization located on the nearby island of Crete [45]. Lastly, in the year 79 A.D., near the Bay of Naples in Italy, Mount Vesuvius erupted, this time entombing the Roman cities of Pompeii and Herculaneum along with several thousand Roman citizens. In the short time since the birth of the United States eruptions and events continue to occur (e.g., Lakigigar in 1783, Tambora in 1815 and Pinatubo in 1991) and as world populations increase and become interdependent, the toll on humanity only becomes more devastating and overwhelming.

Collisions between the Earth and a Near Earth Object (NEO) or Earth-crossing body have and will happen again. Objects with a size larger than about 1 km (0.62 mile) could cause a global catastrophe, whereas smaller objects could decimate individual nations or the workings of our global society. Given calculated rates and the time since the last devastating impact, the likelihood of Earth being struck while we are the preeminent species only grows larger. To date, limited government funding has been directed towards programs designed to locate and catalog such objects over the past 40 years. Estimates to date indicate that we have only identified roughly one percent of NEO populations. Ongoing observations and some new international and private initiatives (e.g., the B612 Foundation) hope to fill this gap. Larger objects are expectedly easier to identify and intrinsically more dangerous due to the greater proportion of energy possessed, but it is the smaller (<0.5 km diameter) objects that are most abundant and therefore more likely to affect the modern world [46]. Significantly more work and funding is required in order to identify these objects in a timely manner.

Though volcanoes and extraterrestrial objects are among some of the largest, most influential and dramatic events ever affecting life or our world's environment, there are additional threats that must also be considered as already shown in Table 1. Below we delve deeper into just two of them, climate change and pandemics as possibly the most relevant examples of immediate and growing threats to our species, societies and world.

Climate change, today's ever-controversial topic, also has the ability to drastically and rapidly endanger society, as we know it today. Whether one sides with natural or human induced climate variations or some combination of both, it must be accepted that climate and its changes have and continue to directly affect human cultures, societies and life [47,48]. Research points to an extraordinary warming of Earth's climate in recent history. For reference, Fig. 1 shows a temperature profile over the past 10,000 years as derived from Greenland ice core data. Though climate variations are cyclic, recent research has shown that current global temperatures are warmer than roughly 75% of Holocene temperature history (i.e., the last 11,700 years of the Earth's history) [49] and model predictions show continued warming and tangible mean climate changes for the near future [50]. Whether the rapid temperature rise over the last hundred years is representative or even threatening remains to be seen and scientists across the spectrum can only surmise how future trends might affect our world and its environment. It is certain, though, that ever-more rapid and distressing environmental changes are being noticed across the world including glacial ice retreat in Greenland, Antarctica and other locations, permafrost and arctic ice loss, and changes in recorded wildlife patterns [51].

Whether the short-term or average temperatures are getting warmer or colder may not much matter. What must be understood is that climates and temperatures can change significantly across time spans that are even shorter than the average human life span and can have lasting affects across generations. One of the most widely researched climate cycles began with a rapid warming around 14,500 years ago followed by a rapid return to cold and dry conditions between 12,900 and 11,500 years ago. Combined, the warming event, called the Bølling–Allerød interstaidial warm period, and the following rapid cooling event, called the Younger Dryas stadial, which itself lasted well over 1000 years, are presumed to have highly influenced the evolution of the unique eastern Medeteranian Natufian cultures and set the stage for human agricultural practices [47,52–54]. The question as to the exact cause of these climate variations remains open.

Another not so distant, yet less extreme example occurred during a period called the “little ice age” that roughly spanned from 1350 to 1850 (see Fig. 2). It is interesting to note that an additional environmental event, the anomalously low sunspot cycle called the Maunder Minimum, may have potentially contributed to the severity or duration of this cooling period [55]. The simultaneous overlapping of this sunspot minimum highlights the potential additive impact on our environment of two or more influencing factors. The result was a period of over 300 years of some the coldest times in recent human history where population centers shrank and people migrated in response to food shortages and famines. It could be argued that ongoing shortages and hording within a stratified culture led to the French Revolution and the execution of King Louis XVI and Marie Antoinette in 1793, which in turn led to radical social change and the birth of democracy, citizenship and inalienable rights; all things that are held in high regard in many societies today.

A final catastrophe to modern societies examined here is the global pandemic. Chances of a novel or uncontrolled outbreak heighten every day, and no matter the cause, given the interconnectedness of the world's population centers and evolved transportation technologies, we are all at risk. History again provides examples including the Black Death and Spanish Flu (Influenza). The former reportedly caused the death of an estimated 30% of Europe's population at the time. But it is the latter, the Spanish Flu outbreak following the First World War that closely parallels what experts believe could happen today. The 1918–1919 influenza infected up to one third of the world's population and during its most virulent and deadly second outbreak, it killed more people within a few months than any other recorded disease or epidemic [40]. Surprisingly and still not understood, nearly half of the casualties occurred in young adults 20–40 years of age. By the end there were an estimated 50–100 million casualties world-wide, with deaths occurring even in the most remote

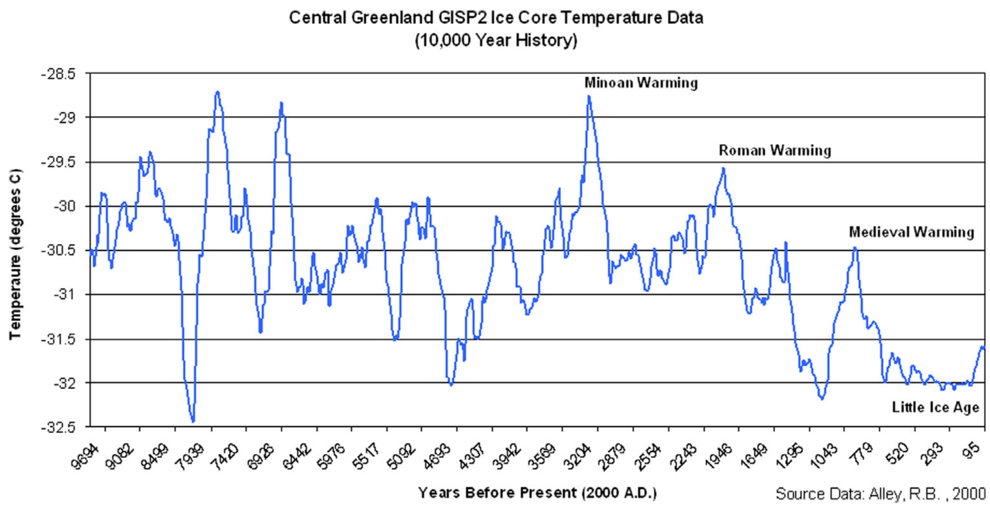

Fig. 1. Greenland GISP2 ice core temperature history for last 10,000 years [52].

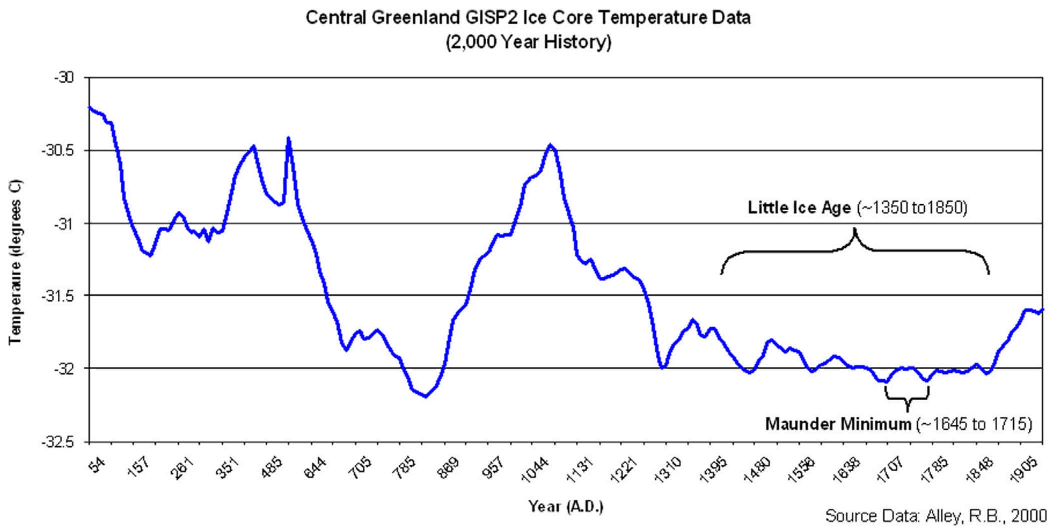

Fig. 2. Greenland GISP2 ice core temperature history for last 2000 years [52].

locations on Earth. Since then, several related, though less virulent outbreaks have occurred including the H5N1. Two of the most worrisome aspects of the 1918 pandemic are that no geographic origin has yet been identified and that it spread world wide extremely rapidly. The question remains as to whether or not we could contain or prevent another world-wide outbreak today.

Change is inevitable, and yet are we as a species willing to gamble our survival on such uncontrollable changes in our world? Again, based on history and current behavior, it seems that our societies take for granted their ability to survive all such events and catastrophes, at least in the example of how most of us live our daily lives. In the case that some of the human race does survive, it is then important to consider how long it would take for a city, a country or the whole world to recover to at least the social, cultural, ecological or technological level enjoyed prior to the untoward event. Whether it is even possible or not, of course, depends on the magnitude of the event in question. Suffice it to say that the duration of any event of scale probably surpasses what any individual or government is provisioned to survive. Having an isolated and self-sustainable safe harbor for Earth's animal and plant life could be used to help mitigate any ecological collapse following a global environmental or social catastrophe, and the reseeding of Earth from those far removed repositories may be our only chance of survival.

Given an understanding of how tenuous our hold is on this little blue ball, we must continuously ask ourselves if we are doing enough to ensure our survival. Today, governments and individual organizations are working to ensure a diversified, terrestrial ex-situ approach to collecting, conserving and preserving the biodiversity of our world. A primary example includes the establishment of both plant and animal conservatories and banks around the world. Several projects are currently underway including the Plant and Animal Genetic Resource Preservation Research Unit (PAGRPRU) of the National Center for Genetic Resources Preservation (NCGRP)[1] that houses animal genetic material and seeds in Colorado. This is part of a system of 20 such banks run by the U.S. Department of Agriculture. The Millennium Seed Bank Project (MSBP)[2] houses the largest seed bank in the world and is headquartered in West Sussex, England. The Svalbard Global Seed Vault[3] is probably the most remote bank, located 800 mile south of the North Pole on the Norwegian island of Spitsbergen. Depending on the magnitude of an eventual catastrophe, one or more of our worlds genetic sanctuaries could be compromised or lost, and the best way to ensure the survival of these resources would be to begin to copy their function by branching out the storage of these materials to a sustainable off world location. Mars provides an ideal location to establish the ultimate preservation site for genetic materials as a backup to the present sites on Earth. On Mars such a facility would serve the dual purpose of providing plant and animal resources for a growing settlement as well as serving as Earth's genetic safe haven.

The process of permanently inhabiting another planet in our solar system, replete with natural resources that enable sustainability, is the only way to remove some of the proverbial eggs from the terrestrial basket. This endeavor needs to be implemented as soon as any culture becomes capable of undertaking if it desires to survive; a lesson that should be overwhelmingly clear given the history of life on Earth. Initiating the settlement of Mars benefits humanity, not only by providing a safe haven for diversifying our species and enabling our survival, but with immeasurable and untold inspiration and benefits akin to the space exploration innovations and spin-offs over the past 60 years.

In light of the realization of Mars settlement, a fantastically inspirational happening, individual's or society's ability to maintain focus, attention and sustained support through completion is limited and constrained. As the next section proposes, except for Mars this limit, which is time and space dependent, could constrain all future human attention towards such endeavors.

3. The Limits of attention and support

Before we examine our proposed second major benefit to people on Earth, we find it important to define a novel psychological and social constraint to initiating current and future space exploration endeavors. If we assume that more people on the Earth will be attuned to the arrival of humans on Mars than any prior single event in human history (a combined result of the current level of technology and the inherent positive vicarious nature of such a human accomplishment), then it is proposed herein that this single endeavor will generate greater positive global inspiration and feelings of terrestrial commonality than any other single event in history. This is interpreted as a parallel to the first lunar landing [26], though on a more influential level.

In order to assess the capability of such an endeavor to captivate and maintain public awareness and support one must consider the interconnectedness and relationships between technology, attention, interest, empathy and dedication as imbued at the individual level. It is a common interpretation that today's societies are ever more characterized by shortening attention spans, and research has shown that the average adult human attention span is considered to be roughly 20 min [56,57]. The limit of active public interest in supporting endeavors that do not directly or immediately affect their emotions, economic status or safety directly threatens the potential lifespan of all such initiatives. Given a world of individuals filled with dissatisfaction, misunderstanding, constant distractions and waning attention, we propose a global inspiration limit to all human initiated events, herein defined as the cosmological attention boundary. This boundary defines an intrinsic psychological and sociological boundary to an average individual's active, dedicated and focused interest regarding future space exploration events as a result of round trip communication time. The basis of the boundary (see Fig. 3) is delineated by communication

[1] NCGRP: http://www.ars.usda.gov/main/site_main.htm?modecode=54-02-05-00.

[2] MSBP: http://www.kew.org/science-conservation/save-seed-prosper/millennium-seed-bank/index.htm.

[3] Svalbard Global Seed Vault: http://www.regjeringen.no/en/dep/lmd/campain/svalbard-global-seed-vault.html?id=462220.

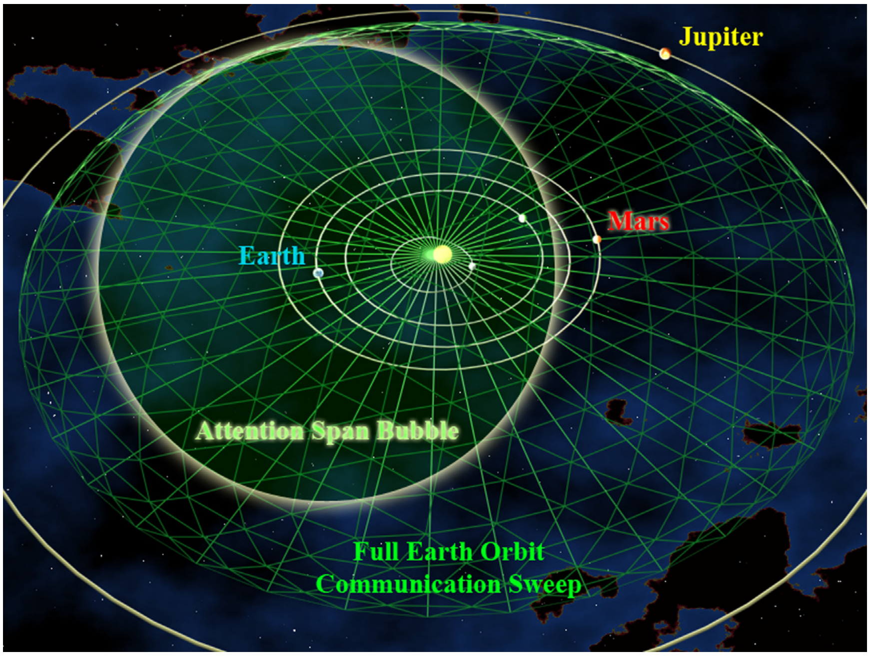

Fig. 3. Cosmological Attention Boundary: the cumulative one-way communication coverage around Earth over one orbit of the Sun bound within the sphere of human attention.

and data signals moving at the speed of light within the estimated 20-minute modern human attention span limit, or approximately 359.7 million km (223.5 million miles). Yet, as the Earth and Mars cyclically orbit the Sun they approach and recess from each other thus circumscribing, at this distance, a spheroidal shell-our cosmological attention boundary. Mars nearly remains within this boundary through its entire orbit. At its maximum distance from Earth round trip communication time is roughly 20 min and at its closest about 3 min, with the average being 14 min.

As incredibly fascinating as other locations might be, Titan or similarly interesting objects, they all fall outside our cosmological attention boundary. Therefore, most people interested in and following such a mission would have to wait hours if not days for news, and the average person in our global techno-topia, having a multitude of distractions, agendas and immediately fillable needs would lose any potential vicarious interaction resulting from such an adventure – meaning a loss of attention, interest, inspiration and motivation. Mars is the only suitable world within this region upon which we are technologically capable of reaching while simultaneously maintaining and engaging public attention and support.

On a philosophical note, there are other types of events that are not necessarily positive or human initiated which would similarly capture the immediate attention of global populations. The most striking of which might include contact with alien life (as it would most likely not be initiated by us), any number of human or natural disasters such as the imminent collision of an asteroid or comet or in the sphere of human belief systems the appearance of one of our species' many deities. Yet, when considering all such alternatives, even the construction of a utopian-like city at the bottom of one of the planet's oceans, there seems to be no clear choice that would embrace the interest nor instill inspiration on the world's populace as would the first humans landing on Mars. In this respect it is believed that as a global culture, we must turn from being reactive to proactive in order to enhance our chances of long-term survival.

As suggested above, not every act of human space exploration has the potential to draw the same level of attention and inspiration as that of Mars. One example is the return of humans to our own Moon. It is considered by the author that public imagination and attention have been diminished by the fact that we have already been there. Another part of this diminished social impact results from the mass media portrayal of various fictional "realities" which uphold misunderstood accomplishments or abilities, which has become imprinted within the public psyche, and the zeitgeist of the past 50 plus years of science fiction. In other words, the reality of returning to the Moon is less impactful on individuals and the broader society than the fictional abilities and worlds already presented through science fiction. This is an interesting irony given that many scientists and engineers today source science fiction as a major source of their youthful inspiration and career choices.

In order to further strengthen the supposition of the cosmological attention boundary we must explore the effects of the dual edged nature of ever-evolving technological capabilities on our societies and ourselves. In parallel with our attention span deficit, our modern society is driven, and not necessarily for the positive, by a need for immediate results and instant gratification [58–59]. Arguably the broadest advances in accessible, hands-on technologies have occurred over the past 40 years. The preeminent example being the cell phone, whose usage has reached 91% of American adults [60], and polls have shown that some 84% of them are completely dependent on them every day [61]. Information is accessed and moved around so rapidly, resulting in limited focused attention and limited or reduced retention of information by the user [62]. In other words, that which can be readily looked up has a lesser chance of being retained or memorized – Google-memory. This postulate is somewhat ironic in light of the response made by Einstein in the 1921 to the ever-controversial Edison Test – "[I do not] carry such information in my mind since it is readily available in books" [63]. One possible negative implication is that future generations may have less access to instantly usable information (e.g., mental maps or emergency response actions) from long-term memory since such items were never studied or learned in the first place (i.e., transactive memory vs. encoding or rehearsal) [64]. How can such a population, so dependent on these technologies, deal with any eventual catastrophe that denies them such communication and memory aids? Technology therefore both helps and hinders our ability to understand and interact with our environments. As mentioned previously, on the positive side, our technological capabilities through the 1960s allowed hundreds of millions of observers to simultaneously share in the events of the first lunar landing; an event that occurred only a couple seconds away due to the proximity of the Moon, and one that has and continues to inspire youth and adult alike.

Human intellectual capabilities enable swift adaptation and the use of ever rapidly evolving technologies; yet, humans are still bound by genetic traits that evolved hundreds of thousands of years ago. The interplay between technology and individual genetic traits, is complex, and directly influenced by learning. Unchecked, technology provides easy access to nearly anything desired, from food and shelter to entertainment. Ongoing access to these everyday technologies serves to facilitate innate dispositions to minimize energy use and output in the pursuit of satiating needs and desires, itself an evolutionary response, and reinforces individual instant gratification reactions and responses. The result being a culture which lacks sufficient self-control devices and measures that might constrain adverse behaviors. The United States, specifically, has evolved an instant gratification culture, epitomized by an ongoing overweight epidemic and all the associated negative impacts on health and wealth. Similarly, such a cyclical, technology-gratification loop may potentially emplace limits on individual attention spans.

Our construction of a correlation between technology, modern human attention span and the landing of humans on Mars based on a round trip communications time defines a limit on modern society's ability to remain engaged and therefore truly inspired during the enactment of such an endeavor. Within this cosmological attention boundary we find the act of settling Mars capable of sparking our imagination and of motivating individuals to choose a life path, both in education and work.

4. The Benefits and potential of inspiration

Knowing what kind of psychological drivers are needed to maintain long-term motivation in the pursuit of any given goal (i.e., a future career) goes beyond simply understanding of an individual's attention span and gratification needs. One must consider how people learn and determine what "spark" of inspiration is needed in order to guide someone down a life long journey, especially if that journey is rather complicated, challenging or has uncertain rewards (e.g., committing to any of the complex technical fields of study or work). Therefore, this section postulates that the heightening of higher education enrollment rates seen beginning as early as 1953, but more precisely between 1959 and 1975, may be attributed to two combined nontraditional, little postulated sources: the first being the rapid growth of the technological age and its associated development of personal consumer items and the second, the intrinsic mass appeal regarding the novel and burgeoning space exploration initiatives of the day. Ultimately the correlations may explain how initiating a settlement on Mars might similarly inspire individuals seeking, specifically, higher education over any ensuing 30 or more years from its initiation.

Government programs and leaders continually tout the need to support education in the STEM fields for a variety of reasons (e.g., innovation, economy, national security, prestige, etc.); yet, history shows that a fundamental understanding of psychological drivers and plans as to how to advance such goals remains lacking. The ability of governments to effectively engender the needed motivational state in students is limited. What is needed is an understanding and long-term goals which can cultivate an intelligent and learned culture. The ongoing implementation of ineffective programs, band-aid cures, which do not address fundamental student motivations, is exacerbated by ever-wavering government commitments and an almost haphazard throwing of resources and money into programs, educational institutions and educators. As a matter of course, these do not directly motivate students, alter their performance or inspire paths of study. Rather, one must look more broadly at society and events of the time to understand what really motivates people. Over the past decade the flow of U.S. students into STEM fields has generally been encouraging, and usually seen as a response to perceived positive changes in employment opportunities, levels and wages. Yet, we question whether this can be sustained, especially for the more technically challenging fields and skill sets. Again the question of motivation must remain central so as to address long term sustainability. Today, questions are being raised as to the actual benefits of a full college education with regards to work force talent supply and demand needs and cost vs. benefits given that educational loans now out weigh most other debts on the national stage. Some point to upper education alternatives for individuals such as self-directed learning strategies. Yet, in the STEM fields, it is unlikely that any means of instruction other than structured and organized education can sufficiently insure adequate learning and comprehension.

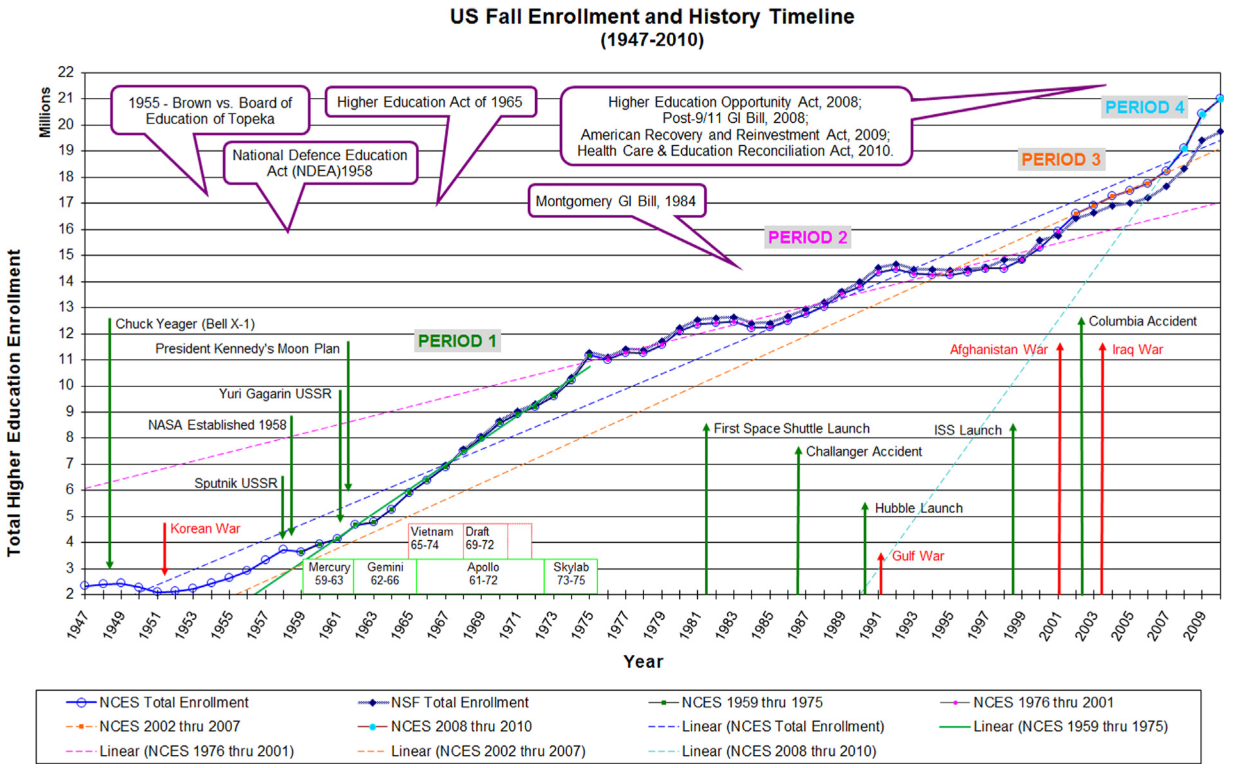

Fig. 4. U.S. Enrollment data during Period 1 is significantly unique across the entire timeline indicating a unique driving mechanism spanning the golden age of space exploration.

University and college enrollment data indicate a clear distinction between the rapid socio-technical advancements and achievements through the 1970s and any other co-occurring events, advancements or programs over the last 60 plus years. Fig. 4 shows the history of higher education enrollments within the United States. Census and college enrollment data from 1947 to 2010 were examined [65–67], including two major enrollment data sources, the National Center for Education Statistics (NCES)[4] and National Science Foundation (NSF)[5], and plotted together to demonstrate data source consistency. The NCES and NSF data differ between 0.7% and 2.2% over the entire span except for the last three years where they vary between roughly 4% and 6%. The continuous lower accounting by the NSF in comparison to the NCES beginning as early as 2001 can be explained in that the NSF only reports a subset of major institutions as provided in various college enrollment reports. The latter difference may be attributed to recent dramatic increases at the community college level [68,69], which the NSF does necessarily not track. This comparison is provided to indicate that our choice of the NCES data for further analysis is warranted. Additionally, specific time related events and data are also captured in Fig. 4 as bench marks for historical comparisons, including U.S. wars, space program events and government education acts.

The entire timeframe in Fig. 4 has been subdivided into four periods in order to begin a dialog and examine proposed drivers that may potentially clarify the data. The four periods examined and which are further clarified and defined below, include: 1959–1975, 1976–2001, 2002–2007 and 2008–2010. The timeframe from 1947 through 1958 is addressed but no analysis is provided as census data prior to roughly 1958 usually represented only a subset of the actual enrollment population (e.g., degree-credit enrollment only; NCES). Enrollment data is divided on the year following a year-to-year decline in enrollment slopes for the first two periods. The final two periods were placed at the next enrollment sample following the September 11th attacks and the bottoming of 2007–2008 financial crises. These events are considered by this author to be significant, in light of other potential social drivers, and potentially capable of influencing changes and driving near term enrollment choices and behaviors. The last upturn, Period 4, beginning at 2007, is believed to be a historical anomaly and attributed to a very complex set of social and economic interactions, both public (i.e., the enactment of multiple government education acts) and private, which have occurred as a result of the worst economic downturn since the Great Depression of the 1930s.

Several statistical comparisons were made in order to assess slope similarity (see Fig. 4): Period 1 vs. Period 2, 3 and 4, Period 2 vs. Period 3, and Total vs. Periods 1 and 3. Regression analysis was used to address the relative enrollment rate differences, i.e., the slopes, between each

[4] NCES, U.S. Department of Education: http://nces.ed.gov/.
[5] NSF, National Science Board: http://www.nsf.gov/statistics/.

period. The four regression lines spanning our periods have R^2 values between 0.94 and 0.99, which indicate that the best-fit has a strong linear relationship. We believe that this choice of break points shows that the selected periods each may be internally consistent across their timeframe with regards to the most important and influential drivers of the day. A two-tailed test of the null hypothesis shows that the slopes being compared are identical or that the lines are parallel. In general, P test values less than 0.05 are considered significantly different and indicate that the events occurring and driving enrollments over the periods are also significantly different. If the slopes really were identical, the P value would indicate that the chance that randomly selected data points would have slopes as different (or more different) than those observed.

Similarly, regression and slope data show that Period 1 differs significantly from all other periods and therefore is presumed to be driven by social or cultural events that are significantly different from all other periods. Period 1 is unique among all other timeframes. The difference in slope between Period 2 and Period 3 data is not significant, and even the combination of Periods 2 and 3, instead of analyzing separately, does not overtly change the slope as the trend remains significantly above Period 1. Period 4, as mentioned above, and owing to its short extent is unique in its upturn yet remains distinctly different from Period 1. This data supports the proposal that Period 1, from 1959 to 1975, was singular in U.S. history and that enrollments should be attributed to motivational drivers that are not only unique to this timeframe but also significantly different from all others.

That said the question remains, what factors or motivators drove the largest sustained education boom accurately recorded in U.S. history beginning around 1959, if not as early as 1953? A multitude of causes and drivers exist which only partially explain what drives people to attend and complete college. Historically, the reasoning for the various ebbs within the higher education system include parental education, state of the economy, wartime and drafts, public policy and perceived personal cost versus benefits; yet, as discussed below, alone or in some combination such drivers seem unable to persist over large spans of time and therefore inadequately address the largest uninterrupted rate change in enrollments in the last six decades. This work attributes the upward rate change beginning around 1959 (Period 1) to an exponentially increasing enlightenment (i.e., expansion of the individual cognitive universe) as a result of the development of novel transportation and communication technologies. The most influential being the growing access to personal technologies, and ultimately the vicarious participation in human space exploration – the crowning achievement of this technological boom being the landing of humans on the surface of the Moon.

The following subsections serve to highlight specific drivers and determinants that have been defined in the commerce, social science and education communities, and which are believed to have the largest potential influence on historical enrollments. The final subsection postulates that the postindustrial transition of the last century into one of rapidly evolving accessible technologies and concepts in concert with new space exploration goals and achievements were sufficient, if not overtly influential, in driving college enrollments and completions between 1953 and 1986.

4.1. Wars, drafts and the GI Bill

This section shows that no single program, event or driver other than the proposed space exploration advances, beginning in the 1950s through the 1970s (paralleling our Period 1) is sufficient to explain the persistent rise in college enrollment over our timeframe. We examine evidence to determine if enrollment rates were influenced by individuals seeking to avoid the draft or simply supplemented an already existing motivation base for attending college. Second, we address the efficacy and effectiveness of the GI Bill in motivating veterans to enroll in and complete higher education over the same period. Together the results point to the need to better understand what the costs vs. benefits are to society as a whole and to question the long range thoughtfulness and benefit of government programs and actions.

The Korean War began in June 1950 the lasted until July 1953 and during that period, college enrollments declined; yet, by the time the war ended the trend had begun to reverse. As limited census bureau data is available during this period (i.e., degree-credit enrollment data only) the downward turn in enrollments may actually be underrepresented. Beginning in August 1967, the U.S. was again at war, this time in Vietnam. Lasting until April 1975, some economists and education researchers historically proposed that the rise and sudden fall in enrollments between 1967 and 1975 were directly correlated to the Vietnam conflict (i.e., draft avoidance) [70]. The selective service draft lottery began in December 1969 and the final lottery, from which no one was actually drafted, was held in February of 1972. Card and Lemieux (2001) demonstrate that college attendance showed an increase of between only 4% and 6% late in the 1960s as a result of draft avoidance [71]. Since the upturn and monotonically increasing trend in enrollments began as early as 1958, it is difficult to attribute the entire period to just this war or draft avoidance behaviors. Further research shows that post-service degree attainment for Vietnam-era veterans was even lower than for veterans who served 10 years earlier. Around 5.5% of veterans born between 1936 and 1938 (i.e., between Korea and Vietnam), and who served in the military, attained their first college degree afterwards, where as the peak servicemen cohort in Vietnam (those born 1944–1947) only had a 4% completion rate following service [71]. Ultimately, given that no draft existed in Korea and enrollments declined and the difference in college completion rates for Vietnam Theater of service veterans vs. peacetime veterans, such trends only serve as examples that wartime does not heighten college attendance behaviors or attitudes.

The GI Bill is purported to serve as a post-service schooling incentive and a factor in motivating individuals to enroll in higher education. Some 69 years after the enactment of the first GI Bill of Rights (i.e., the Servicemen's Readjustment Act of 1944), the efficiency, efficacy and motivational ability of such a benefit to veterans has yet to be determined due a lack of graduation rate tracking of veterans attending colleges (U.S. Department of Veterans Affairs (DVA)[6]; Student Veterans of America (SVA)[7]; National Student Clearinghouse[8]). Supposedly this information will become available to the public in the near future. The data shows that the federal government has spent more than $20 billion, $4.65 billion in 2011 alone, allowing more than 817,000 veterans to enroll in college courses and training programs using the Post-9/11 GI Bill. Veteran drop out or non-completion rates have been purported to be nearly as high as 90%. In this case, the failure of such a program to engender proper motivation to keep students through completion highlights one example of the federal government's extreme inability to address the desired goal of providing veterans college degrees and more importantly provides virtually no bolstering of STEM graduates in the United States. The Post-9/11 GI Bill is a 15-year program, and by the time it ends the total cost is expected to top $90 billion or enough to initiate the first self-sufficient settlement on Mars (a program which could easily be completed in a similar timeframe given such funding). Though the GI Bill is designed to reward veterans and allows them a chance to gain a better standard and quality of life, when regarding the nation as a whole, the benefits of government sponsored support and military service is extremely limited in its ability to provide appropriate incentives or potential motivational drivers for inspiring growth in higher education. Overall, increasing enrollment trends beginning in the 1950s did not change until 1975 (See Fig. 4) and therefore should not be attributed to any intervening conflicts or subsequent veteran benefits.

Another comparison that needs to be repeatedly highlighted regarding social goals and benefits is the overall federal spending discrepancies and trends between the military and the National Aeronautics and Space Administration (NASA). In 1968, for example, the United States was spending upwards of $22 billion a year directly on the Vietnam War, a full 12% of the total federal budget, as compared to NASA's $4.8 billion or 2.65% in that same year. It is assumed that when overall social benefits, inspiration and positive influence are compared, that the space program provides a far better value for the tax dollars spent, ethical considerations notwithstanding. In the past few years, NASA's budget has reached 50-year lows at roughly 0.5% of the federal budget. Fig. 5 uses Office of Management and Budget (OMB)[9] data to illustrate the difference between military industrial complex (military and defense) related expenditures and national scientific and space exploration (NASA and NSF) expenditures since 1962. One can hardly be surprised, based on this simple spending difference, that America is immersed in a culture of violence and fear instead of a culture of learning and inspiration. Where a society choses to use its money, public or private, may be one the greatest barometers of a cultures ethics and morals, but in understanding and predicting social evolution. With the total costs of the last three U.S. wars approaching one trillion dollars, it seems evident that national priorities and vision lie outside the realm of building inspiration or a better future. Had our government instead put only half of that amount alone towards space exploration in the last 20 years, the results would have been unimaginable. Therefore, ultimate cost versus benefit questions need to be revisited and judiciously addressed regarding federal government actions and programs and their ability to inspire and motivate people, young and old, military and civilian, the most given available resources and an eye toward the future.

4.2. Acts, family, economics and the future

Understanding the determinants for enrollment in higher education is necessary for the vitality, safety and survival of all modern societies. The question reviewed in this section is whether any of these mechanisms are capable of sustaining long-term rising enrollment rates such as those observed in our Period 1 (i.e., 1959 to 1975)? Both enrollment and subsequent completion are functions of measured academic competence and broadly related and driven by several co-occurring demographic, social and economic factors.

We begin by noting that historical demographic research at the family or individual level has shown that higher parental education is related to higher rates of child college attendance; yet, this is tempered by reported declines in fertility for the more highly educated [72]. An individual's perceived probability of success in college, differences in region of origin and sex, have all been included as contributing factors in both enrollment and choice of major [73]. Yet, mechanisms of this kind do not seem to be consistently long-lived so as to fulfill our long-term enrollment question above.

Second we examine enrollment data in context to the ever increasing U.S. population as provided by the U.S. Census Bureau[10] (see Fig. 6). Except for the monotonic increase over the period, this data does not provide sufficient insight into potential impulses, events or reasons as to why individuals would chose to pursue higher education. As a point of comparison, our 1959–1975 period saw a U.S. population increase of roughly 16.4%, while enrollment rates soared to a historical high of nearly 67%. In the following period, 1976–2001, the population increased 23.5%, yet the enrollments over that timeframe only increased just over 30%. From 1946 to 1964, more than 76 million babies were born in the U.S., part of the generation known as the "*baby boomers*," and have been considered a contributing factor for later enrollments. Yet, this seems an unlikely source of growing enrollments until at least 1964 when the earliest cohort of baby boomers came of traditional college age. Therefore this group cannot account for the Period 1 enrollment upturn beginning in 1959, which really may have begun as early as 1953.

[6] DVA: http://gibill.va.gov/benefits/.

[7] SVA: http://www.studentveterans.org/about_us.html.

[8] National Student Clearinghouse: http://www.studentclearinghouse.org/.

[9] OMB, Executive Office of the President: http://www.whitehouse.gov/omb/budget/Historicals/.

[10] U.S. Census Bureau, U.S. Department of Commerce: http://www.census.gov.

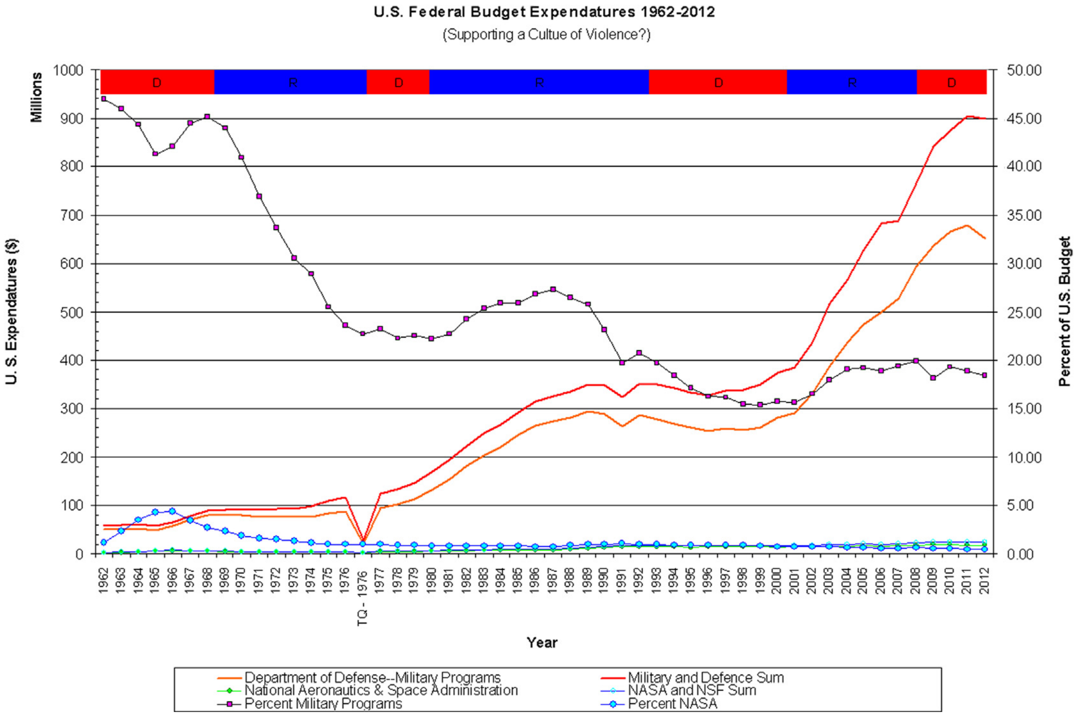

Fig. 5. Fifty years of U.S. Military and Defense versus NASA and NSF spending implying cultural intents and resolutions. The 2012 budget shows the recent disparity at around 190%.

Economic incentives and drivers (e.g., family income or employment) also contribute to changes in enrollments over time. Bureau of Labor Statistics[11] historical unemployment rates (see Fig. 7) change over time and yet generally do not indicate any correlation with overall increasing enrollment levels on similar scales. Unemployment rates historically have been shown to be lower for people holding college degrees (e.g., August 2013: 3.5% vs. 7.6% for high school only graduates) providing impetus for college attendance; yet, protracted multiyear upturns in unemployment such as during the late 1950s and early 1960s and again throughout the 1970s and early 1980s did not seem to induce immediate or lagging spikes in enrollments in following years.

Another economic variable includes the passing of laws that either open new access to previously inhibited groups or increase access to the resources needed to attend school. As for enhancing educational access, the primary example is Brown vs. Board of Education of Topeka, which occurred at the beginning of the largest upturn in recorded enrollments in the mid 1950s by leveling educational opportunity to all regardless of race, gender or ethnicity. On the government enactment side, President Eisenhower supported the inauguration of the National Defense Education Act (NDEA) of 1958, which became law on the 2nd of September that year. Partially as a reaction to a growing national sense that the U.S. was falling behind the Soviet Union in science and technology, this federal policy authorized both fellowships and loans for students and funded state educational agencies for the purpose of improving the teaching of science and mathematics. A recent government sponsored report suggests a general upward trend in rates of student preparedness and completions were obtained [74]. The report further suggests that the causal relationships and any quantitative correlations to STEM enrollments remain tenuous at best. It is believed that this act alone insufficiently contributed to the monotonic rise of our Period 1, given that this rise had begun prior to the law's enactment, nor can it explain continued growth beyond its termination in 1973 (See Fig. 4). A similar example, initiated as a result of President Lyndon Johnson's domestic agenda or commonly called the Great Society, entitled the Higher Education Act of 1965 became law on November 8, 1965. It remains inconclusive as to whether this act was responsible for the continued increase in enrollments through 1975 given that the trend had already been consistently rising since the early 1950s. This act has also been reauthorized on numerous occasions (1968, 1971, 1972, 1976, 1980, 1986, 1992, 1998, and 2008) with no comparable or sustained upturn in enrollments. The implication here is that such laws and greater access to financial assistance alone is insufficient to stimulate either overall or specific field higher education enrollments. Stated another way, potential students are not inspired solely by easier means of accessing or financing education and therefore need stronger motivating drivers for choosing fields of study as well as to complete their educational goals. Alternatively, it is more likely that these acts made it easier for students, already motivated to study STEM

[11] Bureau of Labor Statistics, U.S. Department of Labor: http://data.bls.gov/.

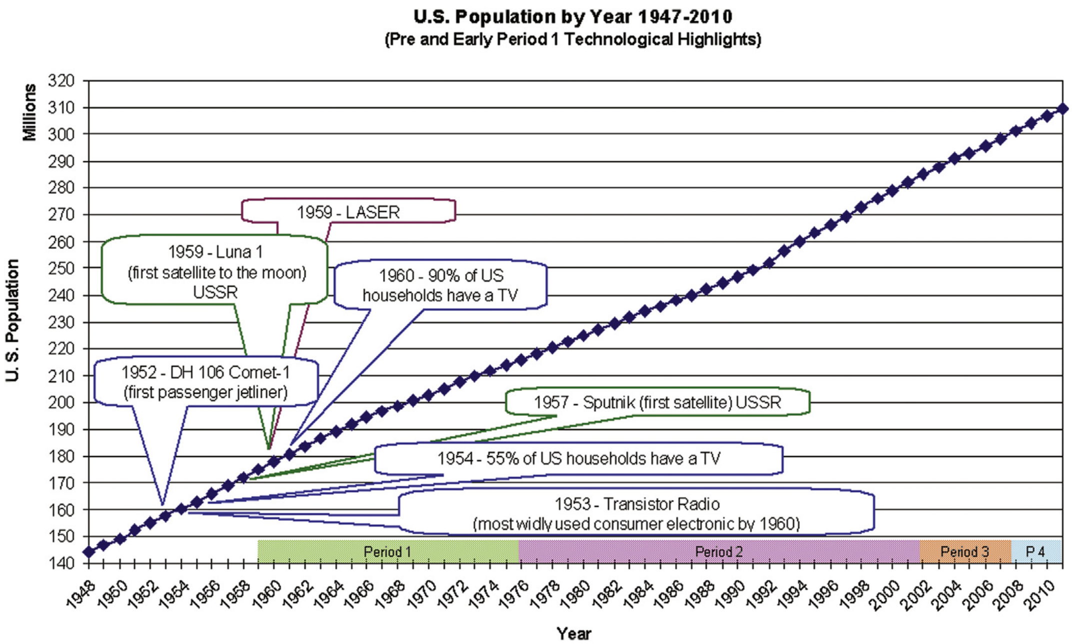

Fig. 6. U.S. Census population data between 1948 and 2011. Technology and space exploration highlights provided to give a pre-Period 1 context and evolution.

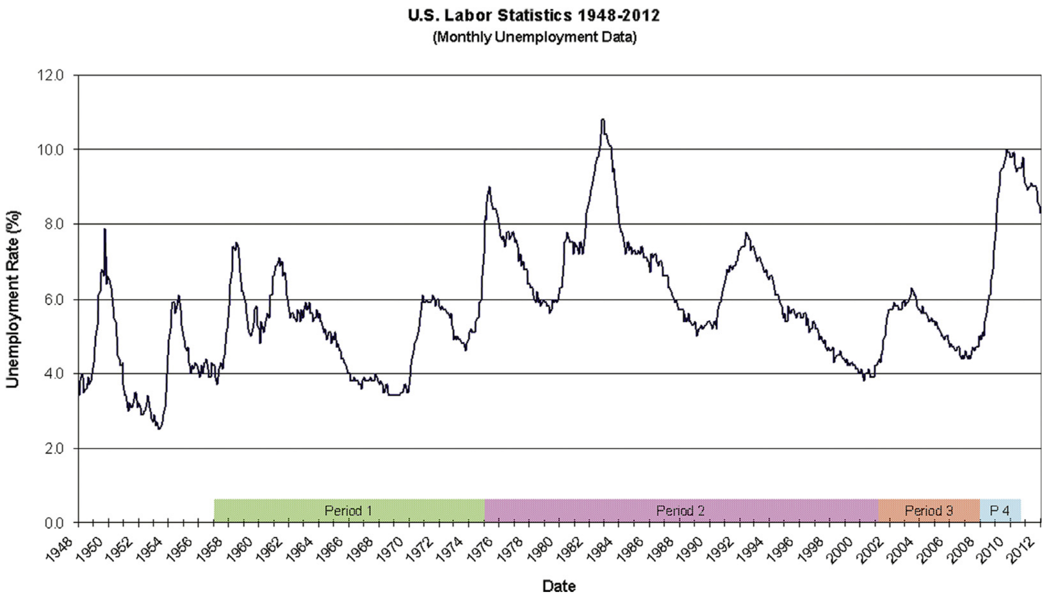

Fig. 7. U.S. unemployment rates and trends between 1948 and 2012 cycle independently (i.e., uncorrelated) of higher education enrollment or completion rate trends.

topics as a result of the dawn of human space flight, to attend collage rather than being drives themselves.

The GI Bill, as mentioned above, may correlate with a slight increase in general enrollments following major periods of large military turnover such as WWII, Korea, Vietnam and possibly Iran and Afghanistan in the past few years, but as shown earlier, the total percentage has not been assessed as significant and may even be commingled with other factors such as government education acts. Explaining any upturn in enrollments is difficult, but within the last several years, since 2008, an anomaly seems to be underway that this author attributes to the confluence of several drivers including the worst economic crisis seen since the great depression and rising minority and community college enrollment rates. The latter being either partly or wholly a result of the passing of several education related acts during President Obama's administration (e.g., Higher Education Opportunity Act (2008), the

Post-9/11 GI Bill (2008), the American Recovery and Reinvestment Act (2009), and the Health Care & Education Reconciliation Act (2010)); and long-term effects and results remain to be seen.

Finally, individuals either make an assessment or leap of faith that the long-term economic rewards outweigh the expenditures, time and energy necessary for college completion [73]. Further, the choice of college concentration is shown to depend explicitly on expected earnings potential of a particular concentration. Between 1972 and 1979, relative earnings gain between those with a college education versus a high school education, declined roughly 40%, and 55% for persons with graduate or professional training [72]. Given an individual's exposure to a society exhibiting such changes would help explain the fall off in enrollments in the mid 1970s, yet the question remains as to why such a decline occurred in the first place. In line with this author's assertion, the end of the Apollo program, the cancellation of further lunar missions and the hiatus in human space flight and the loss of an important socially motivating endeavor could serve as a potential contributing factor. The fall off at the end of Period 1 occurred as the Apollo program was beginning to be dismantled, even in light of Congressional approval for the new Space Shuttle, which was ironically voiced up to the crew of Apollo 17 while still on the surface of the Moon.

4.3. A needed spark: technology, media and space exploration

This author proposes that the primary driver for encouraging potential students to pursue higher education from the mid 1950s through the mid 1980s was a result of a cultural adaptation and a growing fascination relating to the rapid advancement of novel technologies (the birth of the consumer society) and individual exposure to advancing technological capabilities and the knowledge they provided as a whole. Within this period, no other technology was more spectacular and held such a potential to spark the imagination than those associated with the rapid advances in space exploration. In the late 1950s humanity was poised to break free from Earth for the first time. Although President Eisenhower had announced plans for America's first orbital satellite on July 29, 1955 for the International Geophysical Year celebration, space flight, both in media and fiction, truly took front stage with the successful launch of the Soviet Union's Sputnik satellite on October 4, 1957. Human space flight began with a bang, both political and inspirational, when Yuri Gagarin preformed the first orbital flight on April 12, 1961. The following year on February 20, 1962, John Glenn piloted Friendship 7 for America's first orbital flight. This early portion of our space program continued with Project Mercury, Gemini, Apollo and Skylab though 1975. Coincident with this period of time enrollments monotonically increased from roughly 4 million to over 11 million in 1975 when the first major downturn occurred. Arguably, the pinnacle of terrestrial and technical evolution was the landing of humans on the Moon.

During the 1950s, we see an unparalleled growth in technologies that directly influenced individual lives and imaginations and broadened individual and social awareness as a whole. The following list highlights some of the rapidly evolving items, which through growing availability and impression, proved socially transformative and inspiring: the transistor radio, television, nonstick teflon pan, the thermonuclear bomb, passenger jets, supersonic military aircraft, rockets, earth orbiting satellites, interplanetary satellites, the laser and the predecessors of the modern computer. At no time before were so many technologies and ideas either beginning to directly influence daily life or were instantly driving imaginations through the popular media of the day; one example being that U.S. households with televisions went from 55% in 1954 to nearly 90% in 1962.

Today, though, most advances in technology are a result of the incorporation of unseen technologies, a result of an ongoing reduction in size or the combination of previously separate devices. Influenced by various increases in usability and reductions in price, the best example today is the cell phone whose usage reached 91% within the past few years [59]; some 36 years after the first cell phone was used and 20 years after they became commercially available in 1983 (at a cost of roughly $3500). Personal technology continues to move from being relatively simple to being highly complex and the seemingly mystical nature of its operation or the perceived slowness of major advances only serves to diminish the innate potential for mass inspiration. In other words, today's black-box advances occur at unseen levels within devices that we rely on daily; a course of rapid advancement in computer chip processing capability as predicted in 1960 by Gordon Moore (i.e., Moore's Law) [75]. As technological advances in such devices are nebulous their ability to inspire individuals to enroll in higher education or pursue STEM fields seems tenuous. Though as each generation is provided tools that better fulfill gratification needs, an economic relationship might support constant enrollments rates assuming consumption remains at least constant. As the potential for a near future technological revolution paralleling the middle of the last century seems rather small today, we propose that the overall magnitude of social involvement in the placing of humans on Mars for the first time more than accommodates modern imagination and therefore will inspire youth and adults in a manner similar to the first lunar landings.

Paralleling the advent and preoccupation of new technologies, the zeitgeist and lexicon of our culture has changed over time. Language use in books has been considered a reflection of cultural change and can be linked to social behavior and cognition, and ultimately may influence social–cultural processes such as choice of career and educational path [76]. A new tool, called Google Books Ngram Viewer[12] uses a full text database spanning a corpus of 5 million book publications to search word or phrase usage and display results graphically [77]. Fig. 8 provides one such plot for a subset of words associated with space exploration and technology. A fascinating trend can be noted in the word frequency usage in book publications over our periods of interest relating to space

[12] Google Ngram Viewer: http://books.google.com/ngrams.

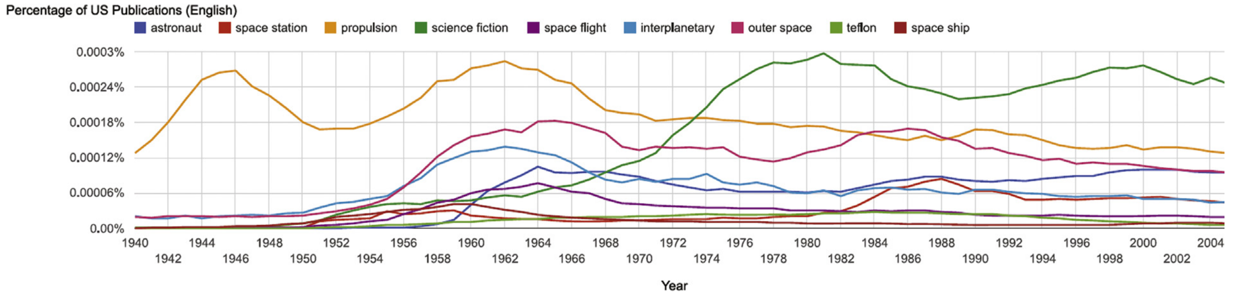

Fig. 8. Google Ngram Viewer plot examining space and technology verbiage suggests a cultural trend towards greater awareness of space exploration beginning in the late 1950s.

flight and even technology. A preliminary examination herein shows the rapid rise of certain words or phrase corresponding to the emergence of human space flight as expected. This unique rise in use of certain words (e.g., astronaut, space flight, etc.) during the early 1950s interestingly parallels our Period 1 college enrollment rise. Unexpectedly, since we still fly in space, we see a peak and fall off through the 1980s. One interesting exception is the phrase “science fiction” which simply rises to a plateau over the same timeframe. Given this initial review, we propose that the amount of face-time words and concepts have in society along with an innate capacity to induce inspiration, directly reflects the absorption and impact they have on individuals and more importantly youth seeking to evaluate future education and career paths. More research on this correlation is needed and an interesting question that could be addressed regards how a lag in time following the popularization of a word or phrase affects a cultures response to it.

Another potential driver steering enrollments beginning in the 1960s and early 1970s, relating to both technology and space flight, was the fledgling mass media genre of science fiction. Note the rise in the use this terminology in Fig. 8, as mentioned previously. The preeminent example could be Star Trek [78], broadcast between 1966 and 1969 to a public in the midst of the color TV revolution. It was perceived as a failed serial at the time; yet, it became one of the first internationally syndicated science fiction series. Followed by several movies and evolving series, it has become one of the longest lasting science fiction families to date. This series, in particular, spurred individuals to become engineers and scientists and to join the space program since the late 1960s. In addition, the hopeful aspects of the genera, as a whole, have inspired adults and youth alike in a positive and moral direction, stimulating a desire in youth to enhance their education in hopes of creating a better future. Over the past 40 years science fiction has taken peoples’ imaginations to all corners of the universe, foretelling potential advances and futures that inspire and invoke wonder and admiration alike. Yet, this may be a double-edged blade, as we could just as easily maintain our present course and adhere to the script, “work hard, increase production, prevent accidents and be a happy;” the mantra of the film THX 1138 [79]. Media's influence on behaviors and society is evident and yet some forms are questionable as to their ability to inspire positive social progress. For many Americans, the National Football League (NFL), a billion dollar a year and growing industry (including both public and private funding), fulfils many entertainment desires and exemplifies our societies short-term, gratuitous, distraction oriented mindset. It also continues to foster our culture of violence, places hollow heroes and role figures on a grand stage, and for all its resources and influence seems to contribute little to the advancement or preservation of our society. There are other examples, and members of any society must actively decide as to what they want to fund and support in light of all potential benefits. Yet, if we as a species are to survive, our world's cultures need a common concrete form of inspiration, media derived or otherwise, which can guide people's actions and behaviors into the future.

Changes is spending and vision negatively influences student views as has been shown in the highest levels of education when NASA's decreased spending corresponding to the cancellation of the Apollo program directly resulted in a decrease of between 25% and 50% of STEM related doctorate degrees completed a few years later [80]. Additionally, as jobs were lost, markets became saturated with a surplus of highly trained and qualified scientists and engineers; again decreasing the likelihood of prospective students entering these fields. Overall, there seems to be a negative correlation between job availability and the continuing increase in STEM enrollments during the persistently unstable period from 1968 to 1984 where unemployment rates generally increased (see Fig. 7) implying job acquisition was difficult. With the above in mind, it is yet proposed that the entire dawn of the space-era, beginning in the mid 1950s, initiated a bow-wave of inspiration, hope and vision that uniquely encouraged individuals to enter and complete STEM fields of study. NSF data provided in Fig. 9 shows a monotonic increase in conferred degrees from 1966 through 1986 in STEM fields as compared to all other fields whose degree confirmations peak around 1974 and then enter a multiyear stagnation. This observation is attributed to our belief that a more meaningful and motivational spark extended enrollments in STEM fields as individuals were drawn to them by the evolving technology, media and space exploration accomplishments of the preceding 30 or so years.

An interesting observation concerning individuals born during this technology transition, i.e., the late 1950s, 1960s and 1970s, highlights the uniqueness of this timeframe. These

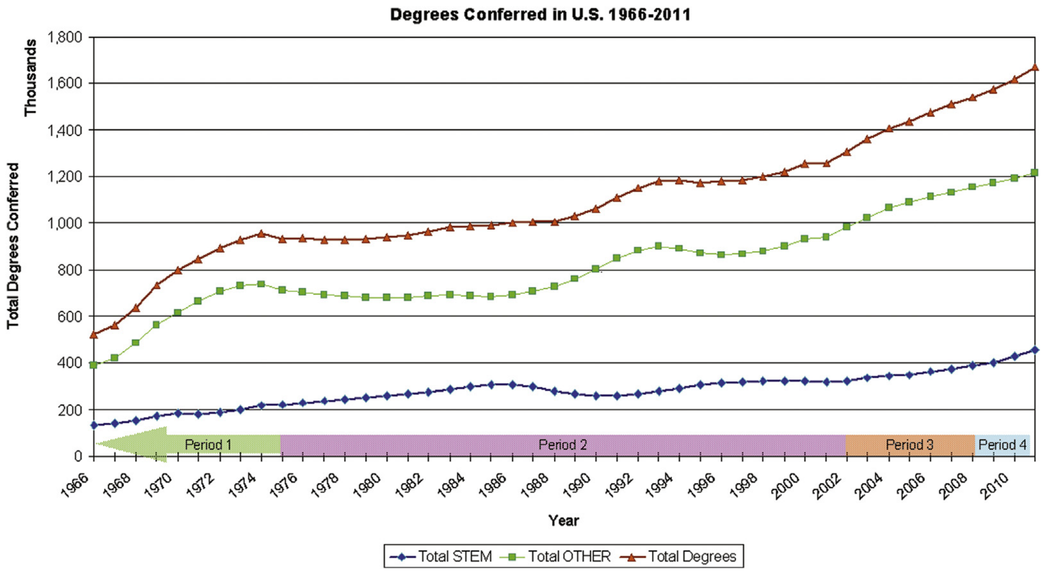

Fig. 9. A non-decreasing STEM graduation trend through 1986 indicates that technology and space program initiatives continued to drive college major choice well beyond the 1975.

individuals were in unique position to be inspired by the rapid changes occurring, and the first generation as a whole capable of rapidly adapting in parallel with the ever evolving technologies and zeitgeist. This bridging generation seems to be uniquely tied with, and empathic to the differences between their own and their parents' and grandparents' times. Today, we reminisce with generations who have never been without the computer, the Internet, the cell phone, the microwave and so on and so forth. And now human space flight itself seems lackluster as media's portrayal of human accomplishments completely outweighs our true accomplishments and capabilities. Ongoing mundane visions, goals and methodical technological advancements are incapable of competing for attention, resulting in continued indifference and diminished wide-reaching inspirational capacity for commitment and dedication to difficult long term tasks (e.g., pursuing STEM education).

Ultimately more empirical studies need to be initiated in order to explicitly correlate all enrollment rate increases in conjunction with any given external factor. It might also prove enlightening to examine available international higher education enrollment data over these timeframes to determine whether the accomplishments of the Apollo program, at a minimum, affected study and career choices abroad. We cannot reinforce the point enough that our space program has, is and will be a unique source of economic opportunities and benefits, as well as a source of positive guidance for inspiring people in their pursuit of education. Questions need to be asked as to how long our space exploration programs can languish, resting on their laurels, repeating cycles where programs begin and are canceled, maintaining a stagnant and fabricated status quo?

5. Discussion

Ultimately, the question of utmost import is whether the human race is worthy of being saved? The answer to which is completely subjective. Yet, any species that finally comes to understand its tenuous place in nature, its lack of control over itself and the environment, and which does not immediately pursue all efforts to preserve itself as opportunities are presented, deserves to go the way of the dinosaurs. With each tick of the clock the probability increases that any number of known or unknown natural or man made catastrophic events shall occur, either straining and crippling modern societies to the point of decline and collapse or the complete extinction of our species as a whole. The time to stop being a reactionary society has already passed.

Furthermore, what a society venerates can be seen through its fiscal history. In comparing historical military and science expenditures, our societies seems to prefer the perpetuation of fear, violence and gluttony instead of inspiration, empathy and education. If governments tout the need to increase interest and education in science and technology they must realize that the only way to inspire future generations is by funding great and noble endeavors. Any nation or group that has the foresight and courage to implement this venture shall reap not only historical adulation, but prestige, pride and profit, but potentially draw the best and brightest our world has to offer to their doorstep under a global spotlight.

To date only a few enterprising organizations seem willing to commit to extending humanities reach to Mars. Most that are capable are hobbled by stagnant bureaucratic approaches, unwilling to initiate or commit to partnering in such ventures when risk is high or profits undefined. Similarly, many are stifled by its lack of vision and an inability to commit to long-term, potentially costly endeavors that do not somehow directly benefit specific constituencies.

It is important to highlight that this work does not include fundamental science of any form, including fields such as comparative planetology, biology, solar system evolution or even exploration of new frontiers, as an adequate or sustainable reason for settling Mars. The pursuit of knowledge itself provides insufficient inspiration and motivation for initiating permanent off-world settlement. Beyond ever changing political timelines, agendas and goals, two reasons account for this constraint. The first concerns the splintering within the scientific community as researchers compete for funding, tools and research opportunities. Individuals or organizations are rarely able to see the bigger picture that once established all disciples will be afforded research opportunities simply as a result of the permanence of such a settlement. The second reason science alone cannot inspire, motivate or drive settlement is that the general public does not explicitly understand the scientific process, and that it takes time before results provide direct benefits to their lives.

People generally accept and understand that the pursuit of science as important, but to most, the scientific process is closer to magic then to everyday reality. Public support itself is mainly derived from the emotional and vicarious connection to events, and as our attention spans decrease and instant gratification impulses are increasingly satiated then it only becomes increasingly difficult to harness and sustain needed support. At times the public needs to be guided, hand in hand, in order for great accomplishments to be accomplished, and sustained public support depends on intrinsic interest and a belief that society is the ultimate beneficiary.

As a species, we must acknowledge that our primary adversaries are nature and ourselves, and as nature cannot be controlled, we must learn to mitigate destructive and narcissistic behaviors that condemn us to repeatedly impose pain, suffering and tragedy, on ever growing scales, and instead initiate long-term acts of inspiration, hope and preservation. The decision to act or not is ours to make.

6. Conclusion

Many aspects of society, behavior and life are explored as a set of drivers and constraining factors that influence human action, and this work highlights the most relevant regarding the long term survival and immediate benefits to humanity of initiating the settlement of Mars.

1) Species survival requires diversification. Given growing severity and probability of threats to a globalized species, from a single catastrophic event to a series of compounding events, humanity must establish permanent, sustainable and growing settlements off Earth as soon as possible.
2) Examining the confluence of physics, technology, social predispositions and attention we find a limiting constraint regarding incentive and support, a cosmological attention boundary. Mars provides the preeminent destination for human expansion and is the only proactive and positive human initiated endeavor capable of capturing global attention and support.
3) Direct benefits to people on Earth as a result of initiating Mars settlement include a collective spark of inspiration, motivation and goodwill. When compared to last century's feat of sending humans to the Moon, the ability to engender inspiration and motivation driving multi-decade increases in enrollments in higher education, specifically STEM fields, is overwhelmingly high when compared to currently conceivable human initiated endeavors. This result is supported by the longest contiguous rise in enrollments between 1958 and 1975 as well as rising STEM confirmations through the mid 1980s as compared to all other fields.

Baring some un-realistic leap or advancement in technology, or universal understanding, humanity shall not find another source of global inspiration nor another destination so appropriately suited for permanent human expansion and preservation then Mars.

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