The Vision of Human Spaceflight

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Why do some countries launch human beings into space on expensive missions? The short answer is *politics*. Nikita Khruschev quickly realized the propaganda potential of space achievements after the global consternation triggered by Sputnik and pushed his Chief Designer, Sergei Korolev, to a series of ever more spectacular missions. The launch of Yuri Gagarin into low Earth orbit was one of the factors shaping John F. Kennedy's decision to declare a race to land a man on the Moon. From 1961 until the present, human spaceflight has been a major element of the U.S. and Russian space programs.

The continuation of human spaceflight has drawn remarkably little formal political debate prior to the Congressional hearings in 2003 on the Columbia breakup. During the preparation of the NASA response to the 1989 speech by President George H. W. Bush, the report task group struggled to identify compelling "justifications" or "rationale" for ambitious human space exploration. One of the outgrowths of those discussions was the acceptance of "inspiration" of young people as a legitimate product of space agency programs.

Indeed, something about space travel excites the human imagination in ways that transcend mundane political objectives and, oddly, feeds back into the political rationalizations. I want to share some thoughts on the historical origin of that fascination with a future in space.

I work in the Space Business, an employee of NASA, the world's largest space agency. Every day, words such as *future, progress, technology, improvement, advances, long-range planning* roll off my tongue. Yet, the concept of *progress* or of a future different from the present was not always part of the human thought process.

For tens of thousands of years humans lived as their parents did. Knowledge from grandparents was passed on to grandchildren. *Change* was an alien concept.

Change did occur over time scales spanning many generations. The adoption of agriculture, the mastery of fire, the conception of the wheel, or the domestication of animals each forced alteration of culture. Climate shift or exhaustion of food sources caused civilizations to adapt or disappear. War disrupted life as usual and spurred technological innovation. Invasions could alter the culture of both the aggressor and the victim.

Nevertheless, none of these events created a fabric of steady change that would fit our understanding of *progress* on generational time scales. In fact, the concept of progress appears to be associated with, and possibly limited to, science and technology. Francis Bacon, writing around 1620 seems to be the person who first conceptualized our current Western concepts of a steadily growing corpus of scientific knowledge and the exploitation of that knowledge through development of technology. He argued that knowledge important to humankind was rooted in the natural world and was accessible by empirical techniques. Mastery over the world by what we would now call technology would stream from a clear system of scientific inquiry. He originated the expression, “Knowledge is power.” Bacon was a contemporary of Rene Descartes and Galileo Galilei. Their collective influence was pivotal in the evolution of modern scientific thought from medieval scholasticism.

Although philosophers in classical Greece championed reason and observation as a method for understanding the natural world, the accumulation of “knowledge” was idiosyncratic and limited to certain individuals, such as Aristotle, and their schools of followers. No systematic review or critique of these texts took place. Particularly lacking was any motivation to collect or advance knowledge for the common good. Aristotle’s ideas appear unchanged in the writings of the early Christian fathers, who sometimes adopted them and sometimes condemned them as heresy.

The amazingly accurate astronomical databases of Mesopotamia, the sophisticated calendrical system of Mesoamerica, and the megalithic constructs of European archaeoastronomy all point to a systematic generational accumulation of data and knowledge. However, this information was closely held by priesthoods because the ability to predict celestial phenomena and the changes of the seasons was a path to power.

In the Middle Ages, astronomy was closely allied with mathematics, and together they constituted a body of knowledge that did accumulate results. The curriculum of astronomy was a review of mathematical techniques used to predict the positions of the Sun and Moon and planets. In the early 16th Century Nicolaus Copernicus (his Latinized name) studied astronomy both to learn how to calculate the dates of Church holy days and to draw up horoscopes, which were part of medical diagnosis. Although Copernicus was a canon of the Church in Poland, he pursued studies and independent work in astronomy in order to simplify the calculation of Easter.

The mathematics of astronomy still was based on the complex “wheels within wheels” developed by the Greek philosopher Ptolemy in his work *The Almagest*. In 1514, Copernicus published a small pamphlet suggesting that the Sun is a center of the universe and that the Earth revolves around the Sun. This idea was developed much farther in a book published at his death. However, Copernicus assumed the paths of the Earth and the planets must be circles; and his model was not very successful. The book narrowly avoided being declared heretical by the Church.

Aristarchus had argued thousands of years before Copernicus that the Earth and planets traveled around the Sun. His ideas did not take root because Ptolemy’s mathematics was so successful. The theory put forth by Copernicus might have suffered the same fate except for the fact that one of contemporaries, Tycho Brahe, had accumulated a massive amount of good quality observational data on the positions of the planets over time. Brahe was not a mathematician, but he hired a penurious though arrogant astrologer by the name of Johannes Kepler to try to analyze the data. Brahe was afraid that Kepler might actually succeed and thereafter achieve fame greater than his own. Consequently, he did not share all his data. Kepler confronted Brahe about this; and Brahe gave him the data on the movement of Mars, then considered to be the most intractable of the celestial motions. Kepler asserted that once he had the data, he would solve the problem of Mars in eight days. The solution actually came more than eight years later, after Brahe's death.

Kepler showed that the path of Mars around the Sun was an ellipse, not a circle, and that it traveled faster when nearer the Sun than when farther away. Once this fact was recognized, Copernicus's idea of a solar system worked quite well. Isaac Newton put the icing on the cake with his theory of gravitation that explained why the planets followed elliptical paths. Newton's theory was challenged by another great scientist of the time, Robert Hooke. However, Edmund Halley believed in Newton and used his theory to predict the return of a great comet. When Halley's Comet did reappeared as predicted after Halley's death, Newton's equations were widely accepted.

Galileo's role in our story was what we would now call an experimentalist He demonstrated in various ways the action of gravity by dropping objects from the Tower of Pisa and rolling balls down inclined planes. He was also an opportunist. When he heard about an invention in Holland called a telescope, he built one. He wanted to sell it to merchants who could make a killing in the markets if they could confirm the successful return of trading ships before anyone. Galileo used the telescope to look at the Moon, at Venus, and at Jupiter. He observed bodies orbiting Jupiter, bodies we now call the Galilean satellites. These observations lent credence to the idea of a solar system.

People then understood that the Moon and planets were physical locations and might have life forms of their own. Kepler wrote about a dream of flying to the Moon. Thus begins science fiction and the realization of the possibility of travel between here and there.

The 18th and 19th Centuries saw the institutionalization of science along the lines envisioned by Bacon and the explosion of technological advances. Now it became possible to conceptualize *progress*. Without some sort of metric for assessing the current state of affairs with respect to some idealized goal, discussion of progress is not possible. Two of the great philosophers of science differed in their view of that metric. Karl Popper argued that progress could be measured by how scientific theories converged to some universal truth. Thomas Kuhn suggested progress would be measured by the problem-solving capacity of theories. In our discussion, Kuhn's characterization is more appropriate. Individual visions of a space future are always constrained by limitations of technology. Therefore, *progress* is determined by the application of knowledge to the development of technology.

Over the course of history, nations have established dominance through the application of technology to the military arts and then through applications to commerce. Societies were transformed from rural to urban, from agricultural to industrial. By the beginning of the 20th Century, physicists declared that all great scientific questions had been answered, the mechanism of the universe had been deciphered, and only a few details needed tidying up. This point of view arose within what we now call classical physics, and a decade later physical science was turned on its head by the introduction of quantum mechanics and relativity.

The latter part of the 19th Century was an age of exploration, built upon the exploitation of scientific knowledge by technologists. The target of exploration was often Africa, ”The Dark Continent”. The Public was thrilled by lectures on the geography, flora, fauna, and peoples of this unknown world. After the turn of the century, the emphasis shifted to the polar regions. The race between Scott and Amundsen to the South Pole galvanized readers. Explorers were lionized.

After the Great War, aviators were in the public spotlight. Lindberg’s solo flight across the Atlantic electrified the world. Innovative and sophisticated technologies were opening new frontiers of adventure and discovery.

The literature of science fiction grew and stimulated young minds. In my view, science fiction falls into three categories: speculation as to the implications for application of advanced technologies; social commentary set in future society; and fantasy. The first master of the former genre was Jules Verne. His writings inspired Konstantin Tsiolkovsky in Russia to first write science fiction and then to study the principles behind space travel. Tsiolkovsky, who published over 500 technical papers at the beginning of the 20th Century, is regarded as the father of Russian space research. One of his most famous quotes is “The Earth is cradle of mankind, but one cannot live in the cradle forever.”

Verne also inspired Hermann Oberth, the father of German rocketry. A famous photograph from the 1920’s shows Oberth with a group of students, including a young Wernher von Braun.

H. G. Wells was responsible for thoughts of travel to Mars in a very young Robert Goddard. The American Goddard is regarded as one the founding fathers of space travel, along with Oberth and Tsiolkovsky, although he did not have nearly the influence on rocketry in the U.S. as did Oberth and Tsiolkovsky in their respective societies.

Arthur C. Clarke, the first Chancellor of the International Space University, is also a prolific science fiction writer who described special orbits where the period was equal to the time of rotation of the Earth so that satellites there would appear to be stationary in the sky. We now routinely position communications satellites in geostationary orbit. He wrote the story upon which Stanley Kubrick's classic movie *2001: A Space Odyssey* was based. Many of his speculations are now part of our everyday lives; others have yet to come to fruition.

The U.S. military did not give much attention to rockets until the experience with the V-2 in the Second World War. After the war, American research depended heavily on the German team under von Braun that surrendered to American forces in Germany. Von Braun himself had a strong personal vision of travel to Mars using very large rockets of his design and wrote a book on the subject in the early 1950's. His intellect and commanding presence made him a celebrity in the United States. Walt Disney produced television programs about space using Donald Duck and other Disney characters. Wernher von Braun narrated a program illustrating his ideas for space development, including a large toroidal rotating space station.

Capitalizing on public response to polar explorations, the international scientific community persuaded various governments to fund a coordinated program of polar research. The program was very successful, and in 1954 a group of scientists proposed an International Geophysical Year to study the planet Earth and particularly external influences from the space environment. Included in the plans were the launches of two satellites, one by the United States and one by the Soviet Union. If successful, they would be the first artificial objects placed in Earth orbit.

The Soviet satellite, called Sputnik, was launched first. It caught an unsuspecting world by surprise. In the context of the Cold War, that event shattered the complacency of an American public in the innate technical superiority of its society and led to a race to land a man on the Moon. The scientists who wanted to study phenomena from automated satellites were peeved at the sums of money being spent to launch humans. On the other hand, some engineers and technologists were thinking of moonbases when NASA was formed.

The U.S. government initiated Project Apollo as an element of the Cold War. However, tens of thousands of workers and professional people toiled long hours and made sacrifices in order to realize the goal of walking on the Moon. While carrying out this effort, many of those involved became enamored of a space future that they were helping to create. In 1969 a Space Task Group from NASA proposed a human space program that would include hundreds of people in low Earth orbit, multiple bases on the Moon, and humans exploring Mars before 1990. This ambitious vision, echoing the ambitions of Wernher von Braun, was rejected outright by the U.S. President. The new space visionaries throughout the country felt betrayed at the cancellation of Apollo even before all the rockets and spacecraft were utilized.

In the 1970's NASA changed its focus to Earth orbit transportation in the form of the Space Shuttle, which flew for the first time in 1981. Meanwhile, young people with eyes still on the stars were inspired by visions of space colonies from Professor Gerard O'Neill of Princeton. Peter Glaser and others proposed massive solar collector satellites to beam inexpensive power to cities on Earth. Neither of these ambitious schemes came to pass.

In the 1980's , I was personally involved in an effort to revive planning for human lunar exploration within NASA. At the same time, a group of graduate students at the University of Colorado were initiating a series of technical conferences called *The Case for Mars*. Thus began a vigorous debate over whether humans should go to the Moon or to Mars at a time when humans were not leaving Earth orbit and had no prospect of doing so. That debate lives on today within the context of the new Vision for Space Exploration within NASA.

Where does that leave us?

First, we live in a world where change is the norm, not the exception. The scientific revolution springing from quantum mechanics yielded new understanding of solid state physics leading to stunning advances in computation, communication, and transportation. Two World Wars and one Cold War introduced massive governmental investment in research and development. The unusual pragmatic and classless entrepreneurship of U.S. society promoted commercialization and innovative marketing of new technology. As a result, the 20th Century experienced a constantly accelerating culture of change. Those societies that accepted and embraced the new capabilities dominated commercially and militarily; those that did not fell behind. I remember when there was no color television, when there were no personal computers, when there was no email, when there was no World Wide Web, when there were no cell phones. Now many of us cannot live without these things. Change has become the measure of success. Our children anticipate the future and do not expect it to look like the past.

Secondly, our elementary school students are fascinated by dinosaurs, ghosts, and space. Astronauts create excitement. None question that humans will be in space in their future. They see it every week, even every day, in stories on television. To be an astronaut is considered a legitimate ambition. They see space travel to be an adventure just as our grandparents saw exploring Africa or the polar regions to be an adventure into the unknown.

Third, we live in a time when our understanding of the space environment makes us realize that the existence of our species is one large impact away from extinction. We understand that our population explosion is changing our home planet in fundamental ways and that wars over terrestrial resources may be less than two generations away. We feel more connected to our space neighborhood than ever before. Many nations of the world are looking outward toward our Moon in an unprecedented way.   A lunar space mission will be launched from somewhere every year for the next decade, at least.

In the United States (and elsewhere) a new space vision has been articulated. It anticipates a generation of exploration of the Moon and then expeditions to Mars. What will be learned is not yet fully known. The potential for our future society is not fully understood. This space vision is embryonic and politically vulnerable and may not be the exact roadmap to the future. Only one thing is sure: Humans will continue to dream, and space is the destination.

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