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HUMANITY IN SPACE

An Interactive Qualifying Project Report

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by

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Abstract

This project investigated humanity's abilities and desires to colonize space. In particular, the reasons for wanting to colonize space were discussed. After exploring various options for the establishment of a colony in space, it was determined that Mars was the best location. By examining the necessary technological and human requirements for the mission, we found that such a plan will be feasible within 50 years. The research needed to attain such a goal has been investigated in detail.

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Executive Summary

Throughout human history the ominous area known as outer space has always possessed almost supernatural characteristics to most civilizations and cultures of the past. This obsession with space has spawned much interest by both scientists and writers of the past and present. Since the early 1950s the idea of space exploration and colonization has been a popular topic of science fiction novels and movies. It is from this interest that modern civilization has strived to explore space and ultimately learn as much as possible from this new frontier. More recently, questions have been aroused regarding the possibilities of humanity permanently colonizing space. It is the goal of this project to investigate whether or not there is a place for humanity in space.

First, this project will investigate what motivations humanity has for exploring and colonizing space. In other words, what is there to gain or lose from such an endeavor? Then, once it has been established that there does exist a distinct advantage or necessity to colonizing space, we will then look into possible locations for colonization. Locations such as Space Stations, the Moon, and Mars will be focused on; each will be investigated thoroughly while highlighting the pros and cons of each location. Next, we will take a closer look at what Mars, the most qualified location, has to offer to Earth and humanity. After we have determined that Mars is most suitable for a space colony and that it does possess inherent and physical value to Earth and humanity, we will then discuss barriers that must be overcome before we can accomplish such a feat. Finally, we will propose a detailed plan on how humanity would have to go about accomplishing this

task. In this section we detail the first human expedition to Mars, and how the first space colony on Mars may look and function.

This report is not just a summary of our current technology and options. This report extensively investigates and analyzes the current data that is available and from this data extrapolates information on whether or not humanity has the technology and ability of accomplishing such a feat. Each possible location of colonization will be analyzed using graphs and tables that detail each one's ability to support human life. In the final sections of this report a detailed proposal is made. This proposal includes calculations on the amount of fuel and supplies needed for a Martian mission, along with methods of providing necessities of life like water, oxygen, and food to the colonists on Mars. It is important to realize that these numbers were not just artificially generated; they were found using data collected from NASA, and many other scientific sources. This report encompasses a thorough investigation of humanity's technological abilities and limitations involving space colonization.

I. Motivations for Leaving Earth and Exploring Space

A. Preface / Introduction

Mankind made the realization many years ago that there may come a time when the earth is no longer fit to continue supporting living organisms. There may come a time when in order to survive, mankind must flee the earth to establish life elsewhere. This is why it has been speculated and pondered for years whether or not it is possible to colonize space. This idea has been around for some time now, mainly dating back to the 1950s and 60s, when television series and books all dealt with various possibilities of living in space. Most, if not all, of these fantastical stories are much too far-fetched and will never become a reality. However, in the present day, the colonization of space is rapidly becoming a potential reality due to a number of factors, mainly involving one notion: the human race is growing too big for earth. It has now become necessary to look at exactly why this could happen, and how we could go about making it happen.

At present, space exploration has become relatively uninteresting and has faded from the limelight of the media. We must therefore determine exactly why we need to colonize space. As the population in the world grows at an increased speed, in fact doubling over shorter spans of time, resources are used up at a quicker pace, causing several problems for human kind. Overpopulation is rapidly becoming a major concern in many areas of the world, and will eventually have damaging effects everywhere. In thickly settled places that are already realizing the effects of overpopulation, it is only a matter of time before people will starve to death once the rest of the world is in the same situation and is unable to come to their rescue. This is also ignoring the fact that disease possesses an ability to greatly threaten the existence of mankind. Another major problem pertains to the world's natural resources. The question to be asked is, what happens when the coal, which the world is so dependent on, is depleted. Are people going to revert back to the 18th and 19th centuries, using only the things that are natural in the world? The impracticality abounds itself since even the underdeveloped, third world countries rely on "luxuries" that even the rich upper class did not enjoy or rely on in the 19th century. Aside from humanistic causes, there are external reasons for colonizing space. Civilization as we know it is much more vulnerable than most people realize. We are just one big asteroid strike away from total devastation of all of humanity. However, while the odds of an asteroid hitting earth are very good, the likelihood of one of considerable size hitting earth is far less. For these reasons, among many others, colonizing space must at least become a potential reality, as man awaits the hopeless destruction of its humanity.

Thus, it is worth expending time and effort into researching and developing possible means of colonizing space. It would be prudent for humanity at least to have a reasonable, well researched, and thorough plan prepared should the possible threats become an imminent reality. The first place that mankind could and probably should investigate inhabiting is the moon. It is the closest and most feasible choice that we have, given that space travel can be considered to be relatively in its infancy. With our existing technology we cannot travel very far in comparison to the sheer size of the universe. Currently, travel outside of our solar system is just beyond our reach. It would take many generations of pilots to accomplish a trip of that distance. Thus, it would be easiest to find the closest possible place to colonize, so that we could save as many people as possible.

What will this new civilization in space look like? Will it resemble portrayals in recent movies and television programs or will it require more scientific planning and engineering? There are a number of factors that must be considered. First of all, we need to decide where we would "relocate" scores of people. We cannot just build houses on any planet, as the gravitational fields are so different from earth that it would be nearly impossible to live on. How would we overcome this seemingly unavoidable obstacle? We certainly do not know, and it is quite possible that we will never live to see the solution to this problem. Can we hope that the future will bring fascinating new technologies that will allow us to alter gravity on different planets? This is certainly a daunting task and its realization seems almost unfeasible in the near future. What are our other options? We could find another location, where objects are lighter due to the force of gravity, and then adapt to those differences. This idea may sound silly, as most people are familiar with astronauts walking on the moon and the ensuing awkwardness of motion, and it should! We would need to acquaint ourselves with the way things move in space, as well as adapt to the difference in pressure. In addition, once civilization comes to fruition on, for example, the moon, anyone born there may never be able to visit earth, due to the difference in gravity. They would feel as though the ground were sucking them in and would have a great deal of trouble with movement. An alternative to this is to locate to a place, whether a planet or a moon, where gravity is most similar to that of earth. The problem with this is that most likely nothing nearby in our solar system will be able to meet this requirement, forcing us to look deeper in our galaxy. The only limitation imposed on this possibility is the limitation of space exploration itself.

At the beginning of the 21st century, and even some years prior, there was much talk about sending civilians into space. Several countries have gathered together to construct the International Space Station, a permanently manned orbiting station and more technologically advanced than anything else put into space. With this idea, people began having desires to explore space, discovering the feeling of the weightlessness of zero gravity, and contemplating the feasibility of living in space. Should this plan reach completion, should we put an enormous price tag on this endeavor, or should we allow anyone to pack up a suitcase, pay a small fee and board a space shuttle? It would seem that, at first, this would only be open to the extraordinarily wealthy, due to the overwhelming financial burdens this project would carry. Even today, there are companies on the Internet willing to sell intergalactic voyages. These include anything from a plane ride at a high G-force with 10 seconds of weightlessness for five thousand dollars, to going to the ISS in 2004 for twenty million dollars.

As time goes on and we find more economic forms of space travel, the option for a new life on a distant planet may become available to the less wealthy. And of course, we are only concerning ourselves with transportation to the new intergalactic civilization. What would this colony even look like and what will the financial ramifications be? This is really an open-ended question, since we would be building this colony from scratch, something that has not been done in ages. Certainly, as time passes, technology will improve drastically, and new ideas will spring forth. Nevertheless, the possibilities are literally limitless and only the future knows the outcome of man's first attempt to colonize space.

Before the solemn day arrives that mankind realizes space colonization is the only hope to combat the extinction of mankind, we must prepare ourselves by investigating all possible aspects of this colonization. We must leave no stone unturned in this investigation because the future of mankind may rest on its decision. It is important that the entire world is aware of the situation, and is willing to cooperate if need arrives. A true worldwide investigation using all possible resources is what is really needed, but it must start somewhere.

B. Mythology of Space

In order to understand fully mankind's fascination with space, we must first investigate the history of space influence on human life. We are first going to explore the ideology of the Greek philosophers and how they related their studies about space with the actual evidence they had. We are then going to continue and discuss Roman writings, which will explain the current names of the planets, and how they viewed the celestial bodies as a part of their lives. We are also going to look at some Jewish authors such as Maimonidies who taught that the universe is Geocentric, meaning that everything revolves around Earth.

The early thinkers in Greek space ideology were called cosmologists. These cosmologists started discussing these issues at around 600 BCE. The first thing that they looked at was the demythologization of nature, meaning they tried to actually figure out why things happen on Earth instead of just saying it is all the will of the "gods." This led to a knowledge revolution, people trying to figure out if there was any order to the universe. One of the cosmologists was named Anaximenes of Miletus who lived from 588 BCE to 524 BCE, he postulated that the Earth was a flat disk and rested at the center of a hemisphere of air. The sun, moon and the planets are all carried over the top of the hemisphere by rafts and at the end of each day the sun is carried around the perimeter of the hemisphere on a river which circumscribes the universe so it can be ready to rise the next day.

At around the same time as Anaximenes lived, Pythagoras was also trying to understand the Earth. He tried explaining the universe by using number, appearance of things, and the notion of proof. He was therefore famous for the discovery of the number cosmology, which used lines, spheres, and points to explain the Earth and its surroundings. The Pythagorean theorem states that the opposite side squared plus the adjacent side squared equals the hypotenuse squared as you can see below.

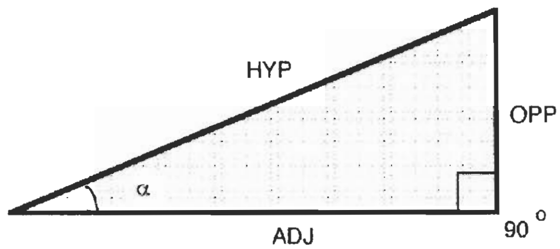

Figure 1: A Right Triangle

This theorem allowed them to measure the location of the stars and the horizon of the sun. Pythagoras's teachings brought cosmology from mythology to actual measurements in real numbers. The next step in Greek ideology was Aristotle who lived around 350 BCE, based on the teachings of his predecessors hypothesized that the moon is round; he tried proving this by constructing a model that resembled the Earth-Sun-Moon structure using a candle for the sun and a ball for the moon. Using this he proved that the actual appearance of the moon could only be replicated using a sphere and not a plate or a disk. Approximately a hundred years later a person named Aristarchus continued working on the Sun-Earth-Moon model and discovered that by looking at lunar eclipses and the shadow of them, he said that the Earth was about the twice the size of the Moon. This can be seen in the Diagram below.

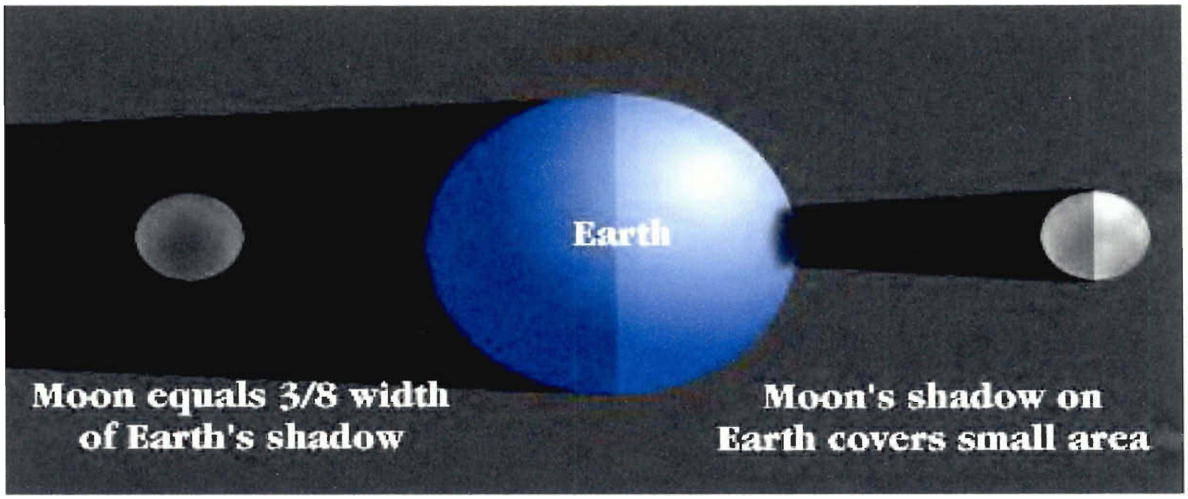

Figure 2: Lunar Eclipses[1]

This produced a realization that since during a solar eclipse the shadow is so much smaller, the sun must be much larger than the Moon and since it is so much larger it must also be much further away. By measuring the sun using a measurement based on the fraction of each lunar month he hypothesized that the sun is about 20 times further than the moon. He decided to look at it further and also say that since it is 20 times further and so large it has to be the center of the universe since nothing that large could revolve around Earth. This thinking did not continue since he could not prove that the Earth was actually moving.

Some time later in about 200 BCE, Eratosthenes made another discovery that the Earth was 25,000 Miles in circumference and round. He made his assumptions by measuring the degrees of the shadow that the sun made between two cities. Besides the scientists, the Greek civilization also produced important philosophers and one of the most famous ones was Plato. He stressed that the Earth and Universe were indestructible

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[1] http://dosxx.colorado.edu/~kachun/sess06.html

and that time and space were connected. He also said that space is finite and has no voids, and also that it is a sphere.

Finally most of the Greek philosophers and scientists believed that the Earth was the center of the universe and that everything revolved around it. Ptolemy who wrote thirteen volumes on this subject was accepted by the Roman Catholic Church and because of its supremacy, everyone had to follow it.

We are now going to briefly discuss the Roman culture and how it contributed to the study of space. The names that we currently use for the planets actually came from the names for Roman "gods." Mercury was the Roman god of travel and the planet was named after him since it moves so quickly. Venus who was the Roman goddess of love, and the planet was named after her, since it was considered the most beautiful of all in the heavens. Mars was the god of war and since the planet was red it was named after him. Even the moons of each planet got their names from the Romans such as Phobos who was one of the chariots, and Deimos, who was one of Mars's companions. These names have been adapted not only in ancient times, but also in modern times, when the planet Pluto was discovered and was named for the Roman god of the underworld.

There were several ideas about space that came from the Jewish religion as well. One of the more familiar stories, found in the book of Genesis, concerns the tower of Babel. This is a perfect example about human perception of space. After there was a big flood during the times of Noah, and many people perished, the people wanted to be able to build a tower that would "protect them" from anything like that happening again. They thought they could do that by building a tower which would literally reach into space thereby mistaking that G-d would not be able to hurt them if they were that high up. The

Jewish teacher, doctor, philosopher, and scholar named Maimonidies, who lived from 1135 to 1204 made another big impact on the study of space. He taught that the universe is not just an independent entity but that it is ruled by G-D and that is was created by Him too. Maimonidies actually rejected the idea mentioned above that the universe is eternal and stated that it was created at a certain point in time, and that before that time nothing but G-D existed. He also went on discussing Aristotle's ideas of why are we on this earth and why we need this universe. He explained that since the universe was created by G-D and all the celestial bodies were put into space for some reason, we have to serve him without question and that was the whole reason of the created universe. He also delved deeply into the idea of Geocentricity and said that the Earth was the center of the universe and that everything else revolved around it. This kind of ideology is a common theme between the Greek philosophers and cosmotologists as well.

C. The Scientific Advantages of Space

When we look through the annals of ancient history, it can easily be seen that space has always had advantages for mankind. Through careful observations of cycles, civilizations were able to determine the seasons, months, and years, and in turn create a calendar. Evidence can be traced to Egypt, where 365 day calendars were found dating as far back as 4236 B.C.; Babylonia, where alternating 29 and 30 days months were devised, based on the cycles of the moon; and many other ancient civilizations that used cycles of celestial bodies in order to create methods for determining time. Another advantage that space has is navigational assistance. Since certain stars in the solar system shine brighter than others, they can be mapped and associated with certain directions. Therefore, someone could find their way merely by following the stars. The tale of the Three Wise Men following the North Star from the Bible seems almost silly to think about, yet this practice was very common in ancient times and quite practical, due to the lack of navigational technology.

Merely understanding exactly what occurs in space is fundamental to scientists, who seek to understand everything in the world around them. It has taken many years for them to comprehend the solar system, but it is safe to say that they have figured out how the world moves and changes. The earliest models of space came into existence about the same time man peered into the night sky with wondering eyes. The earliest rational view of the world, however, was the geocentric universe, where earth was the center of the universe and everything else revolved around it. Although the Greek philosopher Aristarchus was the first to propose the concept of a heliocentric universe, it was not until the Sixteenth Century when the geocentric view of space was widely dismissed. Nicolaus Copernicus developed a model where the sun was at the center of the solar system and the planets revolved around it. This was known as the heliocentric universe. Other scientists such as Johannes Kepler, Galileo Galilee, and Isaac Newton made their own contributions to this system to further prove its existence, and thereafter describe its properties. The end result is a universe in which planets revolve around the sun in elliptic orbits, with each planet spinning around its own axis. Now that scientists understand the make-up of our solar system, they can therefore begin examining the effects of certain aspects of space on earth.

The possibility of the existence of life in the solar system seems so plausible due to the vast extent to which the universe reaches. There are various theories stating that the universe is still expanding, a fact which seems to only increase the likelihood of extraterrestrial life. Science fiction movies would lead us to believe that strange-looking aliens will invade our planet, bringing mayhem and destruction. However, it seems unlikely that this will happen, so we must search for these "aliens" ourselves. Perhaps the most notable of these endeavors is the SETI (Search for Extraterrestrial Intelligence) program, situated in a few different locations in California. This began in the early 1960s with the hope that distant civilizations would transmit signals that we could therefore detect with antennas and receivers. Up until 1993, when Congress ceased funding, SETI used highly technological antennas in order to sweep large areas of sky at a time, searching for any type of signal. The result was disappointing, as nothing was found, hence the lack of government funding. This did not faze the determined scientists, as they soon founded Project Phoenix, a project very much like SETI. However, Phoenix only examined certain star-clustered areas of space, the areas that seem most likely to support life. For this project, a computer searches through hundreds of possible frequencies for narrow-band signals, which would usually signify intelligence. Unfortunately, this privately funded project has yet to return any valuable information, but with so much sky left to examine, the possibility still seems reasonable and hopeful.

Rather than search for signs of intelligent life through signals, a more reasonable approach would be to look for life itself. There have been many space explorations that have scanned various planets and moons looking for even the remotest possibility of life. Most of these have come up short, although some missions have seemed promising. Due to its proximity to earth, Mars is typically the best planet on which to search for life. In 1877, a "discovery" had many people convinced that civilizations existed on the planet. An Italian astronomer, Giovanni Schiaparelli, who, while attempting to map the Martian landscape, noticed a network of perfectly straight lines across the terrain. He called them *canali*, or "channels." They came to be known as the canals of Mars, and seemed to be an almost sure sign of life on the planet, as nature could surely not create something so complex. Although some astronomers doubted their existence, many agreed with Schiaparelli, merely based on his prestige. Eventually, however, he had convinced so many people of the presence of canals, that even these observers saw and recorded occurrences of them. In 1895, a Bostonian astronomer, Percival Lowell, gave a detailed account of what he observed on Mars, and offered an explanation for the canals. He described a dying civilization that constructed a vast irrigation system in order to transfer large amounts of water from the icecaps in order to survive. The reactions to this hypothesis were mixed. The public was fascinated by the idea of life outside of Earth, while many scientists decried the validity of such a claim, and passed it off as farce. However, Lowell became quite popular and sparked a newfound interest in extraterrestrial civilization. Schiaparelli himself was nearly convinced of Lowell's story, although he believed that it could be possible for the canals to be a natural part of the Martian terrain, forged during the development of the planet. It was not until 1909, when the astronomer E.M. Antoniadi used a more powerful telescope to view the Martian terrain in much greater detail, when the canals really began to lose their authenticity. Antoniadi noticed that the straight lines only appeared as glimpses under poor visibility conditions and never truly emerged as true visual identities. Soon after, acceptance of the lack of validity of the canals of Mars became widespread, and the idea was eventually abolished, meanwhile reducing the possibility of life on Mars. As time went on, however, the prospect of Martian life did not fade, and future endeavors were made in hopes of finding any signs of life.

In 1976, two spacecraft landed on Mars: Viking Lander 1 and Viking Lander 2. Both were equipped with three highly sensitive apparatuses used to measure certain gases in the soil and in the air, as well as other devices used to examine other properties of the planet itself. However, this also failed to detect any signs of life. More recently, though, a meteor from Mars was discovered to potentially have traces of an ancient microbiological organism, a discovery that could prove an existence of life on Mars on the past. But what does this mean for us, here on planet Earth? It would certainly seem fathomable that we are not alone in the solar system, but until the day comes when we have undeniable proof of the existence of extraterrestrial life, we can only wonder at the possibilities.

For scientists, space bears an enormous importance on various processes, due to the lack of gravity and its resulting consequences on Earth. One of these problems is that of buoyancy and convection. This arises when we examine the phenomenon of boiling. When water boils on earth, warmer regions from the bottom of the water rise to the top, whereas the cooler regions sink to the bottom. This is a gravitational effect known as convection. Once boiling actually begins, bubbles rise to the top of the water, in a process called buoyancy. Without gravity, neither convection nor buoyancy exists. Therefore, the problem is made simpler without these two elements. Actual experiments have been performed with the boiling of water in space. The result is quite interesting, as video footage is readily available for even those who are only casually interested. Without gravity, the hot water remains at the bottom, where a giant bubble begins to form. All of the little bubbles that would normally rise to the surface instead collect together within this bubble. The end result is one big bubble in a vat of water, just sitting there as it wobbles around. Understanding the boiling of water without gravity will allow scientists to have a more general comprehension of this phenomenon, which will allow them to design more efficient cooling systems for spacecraft, as well as water vapor based power plants.

Another area of research that benefits from space is combustion. The ability to carry out experiments under increased pressure allows scientists to examine what happens in combustion processes under pressures greater than that on earth. This eliminates any speculation surrounding what would happen, based upon results under standard pressure. After all, the only true way to really see what happens under a certain circumstance is to carry out the experiment under that circumstance. Also, scientists can actually view the process itself, much like they can on earth under normal pressure. This has countless advantages over the alternative for the examination of higher-pressure combustion processes. One of the most common is to perform the experiment in a closed structure known as a "bomb," which prevents any possible observation. Therefore, any scientific analysis is based on hypothesis on what happened inside the bomb. Another advantage space has in this experiment is the lack of buoyancy, which effects the way flames propagate. This also has a greater effect in higher pressures due to the relationship between density and pressure. Without gravity, the flames would have much less distortion and their understanding could be greatly enhanced. With this new method of analysis, scientists will be able to develop new engine systems that rely on the combustion of fuel.

The development of crystals is another area of scientific research that is affected by the effects of gravity. Here, gravity presents two major problems with scientific analysis of crystals. First, the effects of gravity cause imperfections in crystal formation. It follows that without gravity, scientists would be able to form perfect crystals and design them for specific applications. The second problem is that gravity disguises the manner in which crystals form, and prevents the study of molecular effects. The problem occurs due to convection, which affects the liquid molecules as they develop into crystalline solids. The goal of low-gravity crystal experiments is to create a mathematical model of all the fine details of structure and development, which can in turn be used to create specially made crystals with exact specifications, through the use of computer programs. Better crystals allow for fabrication of purer microprocessor chips, superior alloys, and micro-electronic applications. Crystals also have an impact on the pharmaceutical industry, as certain crystal formations could result in better design of drugs and treatment. Without gravity, the possibilities of scientific exploration seem endless, and new doors are opened every day as science progresses further into the unknown.

D. Economic Advantages

In addition to its impact on science, space offers many other opportunities that can improve the efficiency of industry and ultimately economically benefit mankind. First we are going to discuss the rationale for going into space and the processes that can be achieved in space better than earth. Secondly we are going to discuss the benefits of manufacturing in space and the money that could be made in space as well as the current costs of space manufacturing.

The space exploration became aggressive during the cold war when Russia and the United states were engaged in the "space race" to see who could reach the moon first. Their reasoning was to get power. As the cold war finished NASA and other space organizations started to find an interest in space exploration for the reason of commercialization of space. The micro-gravity of space is the best place to achieve many experiments that cannot be done on earth. Being able to make things, which are "perfect" such as the sphere, can be a very good tool. As for one example NASA invented a machine called the Monodisperse Latex Reactor, which can produce tiny plastic balls, which are all perfectly spherical, something that cannot be done on earth. These can be sold to the printer toner business and is estimated to bring a market of $1 billion a year. Many biotechnology experiments are also made in space. Things like Light Emitting Diodes or LEDs have been developed in space and they are known to emit light at a fraction of a cost of a laser and can stimulate growth of tissue, which would be very important for brain tumor patients. This is the same thing that could be done with expensive lasers that perform the same task, however this would be much cheaper. Improved cooling systems can be designed due to the research on how the water boils differently in space.

There are thoughts and ideas of being able to mine on different asteroids and such and bring back gold and other precious metals back to earth. However one of the biggest problems that are encountered is the cost of transporting these items to and from space. The cost of transporting even one pound into space is thousands of dollars, meaning that in order to make a profit, one of two options should be considered. The first is to dramatically increase the price of the object, however then no one will buy it. Or we need to find a way on how to decrease the cost of transporting things into space. Another big problem is that while there is a market for things such as gold, there is no established market yet for things like tiny plastics balls. Another way to decrease the cost of manufacturing in space is finding a way to build the mining instruments and any other instruments that are needed in space from the things, which are found in space. This would decrease at least one way of the cost.

The problem that we discussed earlier was that one of the reasons for space exploration and travel is the overpopulation of earth, and running out of natural resources, which we need for electricity, heat, and other daily routines. One of the things that we have found interesting is something called Photovoltaic cells. These are silicon cells, which are made to be very thin and to collect the sun's rays and directly transfer it to energy that can be used on earth. The Photovoltaic Special Research Center at the University of New South Wales has been a world leader in the development of solar cell technology since the early 1980s. Using a thin silicon solar cell they were able to convert

18% of all the sunlight that was falling on it to direct electric energy. This went up to 20 percent in 1985 and 24 percent in 1994. The cell is a very pure crystal, since any impurities will reduce its efficiency. Looking at this we can see how important it is to go into space. In space we are able to grow crystals, which would be nearly perfect and bring them down to earth or even keep them in space to collect more of the solar energy. 24 percent is obviously not enough to be able to support the whole world but improvements can be made in order to increase that number. The price for this energy source is also very low, about a fifth of what other energy sources cost. This could make it very affordable to third world countries that would be in most dire need if the supplies in the rest of the world would be diminished.

The Department of Energy itself is working on many projects with CSP or concentrated solar power. The feel they can save solar energy and then transport it over to where it's needed using large mirrors. This technique of saving solar energy has been used in California for 10 years. However using it has still been a very difficult task. Of course in order to use any of these techniques you there would need to be a constant source of sun on earth, which is almost impossible due to the different trends of nature. In order to overcome this problem we need to build these "sun catchers" in space this way there would be a constant source of sunlight, which could be beamed, down to earth.

Commercialization of space also takes place in other ways. Putting regular people into space and charging them money for it. As of now, it costs 20 million dollars to take a two-week trip to the International Space Station. Although this might seem very expensive this is good for two reasons. First, it could raise money for other important space experimentation, and second, it could be the very beginning of colonizing space.

E. The Threat Against Earth

It has been established that there exists many benefits to space exploration and colonization. However, colonizing space is an ominous and demanding task, and before the world attempts to tackle such a project it should be established as a matter of necessity. Therefore, we should consider, in depth, the possibility of earth ending disasters. An earth ending disaster is a disaster that could damage the earth to such an extent that it would be considered unfit for human life. By delving into all possibilities of earth's destruction we will be able to analyze all possible threats and the timetable related to these events.

We need to consider first a disaster that does not threaten to destroy earth, but rather deplete it resources. Overpopulation is a very real threat, because there is only so much space and resources on earth. According to the latest figures from the U.S. Census Bureau, world population reached 5.9 billion people in 1998. This is almost double the population in 1950. Although the rate of increase has begun to decrease since 1970, the world is still growing at an alarming rate. We see this trend by examining **Table 1**.

Table 1: Population Growth

Decade	Average Annual Rate of Population Growth[2] (%)
1950-1960	1.7
1960-1970	2
1970-1980	1.8
1980-1990	1.7
1990-2000	1.4
2000-2010	1.2
2010-2020	1

[2] http://www.overpopulation.com/FAQ/

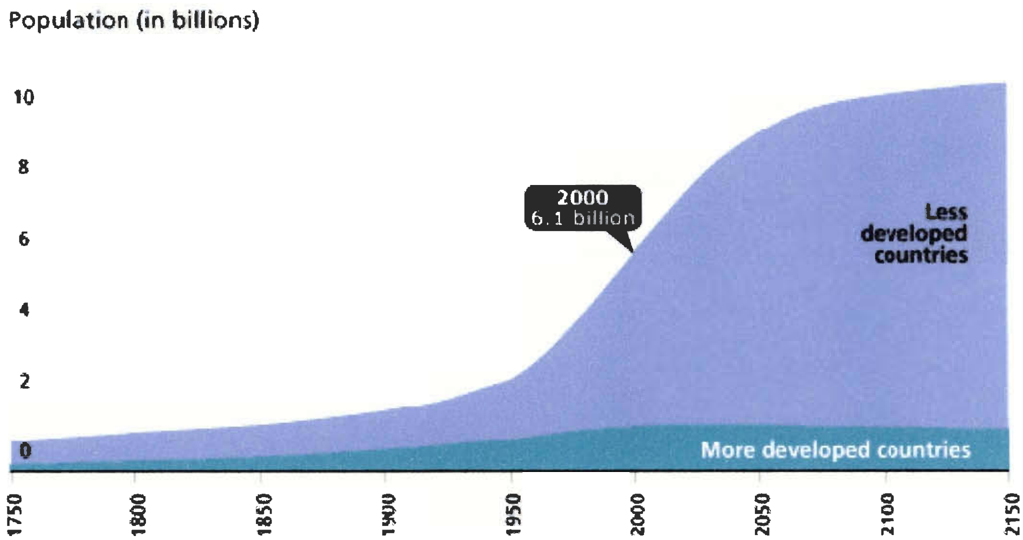

Figure 3: World Population Growth, 1975-2150[3]

It is estimated that at this rate the world's population would peak in the latter half of the 21st century, just fewer than 10 billion people, as evidenced by **Figure 3**. Then it would gradually start to decrease because of earth's limited ability to support life. The population would be forced to redistribute itself, therefore places like Africa would experience population booms while places like Europe will see population decreases. The possible outcomes to this disaster are numerous, but all would like to be avoided if possible.

Some possible consequences of overpopulation pose new threats to the stability of earth. For example, disease is a disaster whose risk increases as population goes up. For instance, a place where population density is high has a greater risk to spread a disease faster. Furthermore, as population swells so will rates of malnutrition and famine, which increase a person's ability to contract a disease. For example, AIDS was a disease that was believed could significantly reduce human population. However, through advances

[3] http://www.overpopulation.com/FAQ/

in medicine and heightened awareness the spread of AIDS was slowed down. Not before it still was able to infect approximately 30 million people world wide in 1998. A disease that is easily transmittable and untreatable could easily sweep the world, and obliterate the population of the globe.

Another disaster that has a connection to overpopulation is natural disasters and human made global changes. For example, global warming and deforestation have been considered a threat to the earth for many years, but just how real is that threat. In order to understand the threat we must look at how earth is responding to it. The polar ice caps are one way in which we can track the effects of global warming. It has been predicted by the Norwegian scientific journal *Cicerone* that the northern ice cap would be gone in fifty years. This suggests that it is melting faster than the greenhouse effect can account for according to http://www.discovery.com. In addition, in August of 2000 it was reported that the North Pole melted to such an extent that open water could be seen. This is the first time in human history that this has occurred.

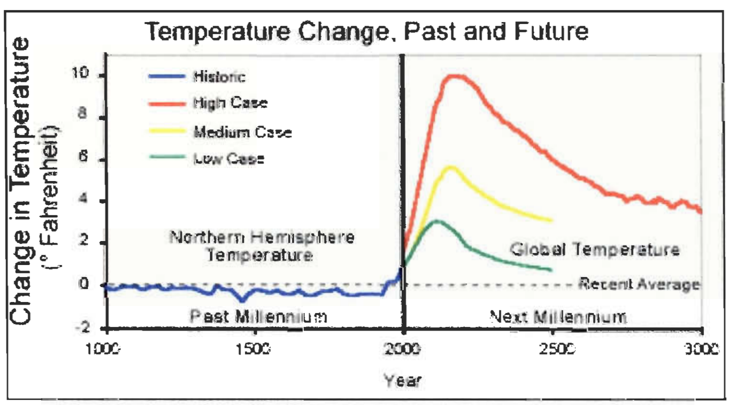

Figure 4: Temperature Change[4]

[4] www.environmentaldefense.org/programs/GRAP/y3k/

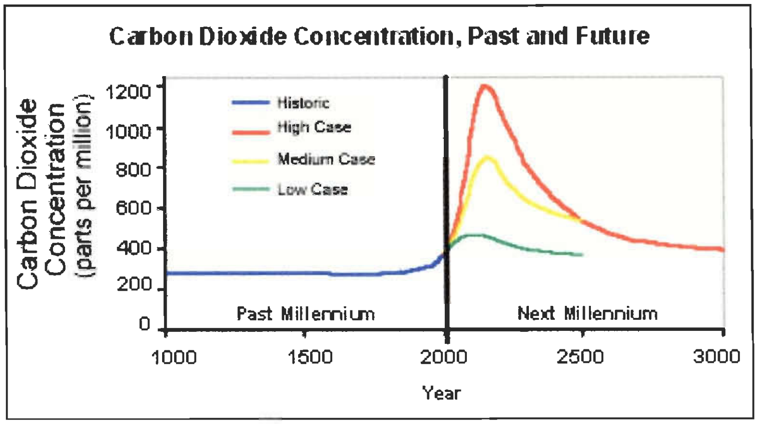

Figure 5: Carbon Dioxide Concentration[5]

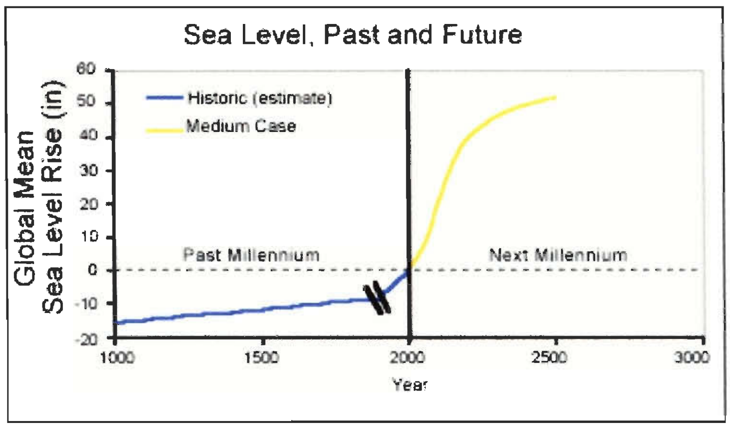

Figure 6: Sea Level[6]

So what do all these facts mean? Well for one thing all the melting that is taking place is adding a considerable amount of fresh water to our oceans. For example, the Greenland ice sheet is flooding the northern ocean with fifty billion tons of water a year. The fresh water warms the oceans, which can cause the all important ocean currents to stop flowing. These currents control the climate across the globe. Early signs show that this process may have already started. It has been reported in Europe recently that winds are reaching as high as 125 miles an hour, which are very abnormal. In addition, it has

[5] Ibid.
[6] Ibid.

been found the mesosphere has been cooling by a degree a year for the past ten years. These signs suggest that drastic climate and global changes could be in our immediate future.

In addition, to these very local threats there are more distant and less foreseeable threats that could destroy the earth. Asteroids are one of these threats that are often portrayed as very unlikely to ever happen. However, the truth behind asteroids is that we really don't know how many are out there. We track as many as we possibly can, but in order to achieve a nearly complete tracking of near-earth asteroids we would have to discover them at a rate of 10,000 per year. This rate would be near impossible to accomplish even if we had total global cooperation. Asteroids hit earth very regularly and some even get through the atmosphere. However, these asteroids are of little concern because they rarely hit anything important, and are fairly small. There does exist a possibility that an asteroid of cataclysmic size could hit. It has happened before to earth, and has happened to many planets like Mars and the moon. Asteroids are a threat that must be considered very real.

Another more remote threat that can be considered is the question of stability of our sun, or the fluctuations in its output. The sun is a very important part of life on earth. Without the sun earth would be cold and barren unable to support and kind of life form. Recent events like solar flares and other small solar events have created concern for our suns stability. However, our sun has attained equilibrium and is now passing out of it sixth billionth year. It is quite stable in comparison to young stars that are constantly changing. It is predicted that our sun will keep its efficiency and stability at least twenty-five billion years. Therefore, although solar flares do posses some radiation related risks; our sun should be considered very stable.

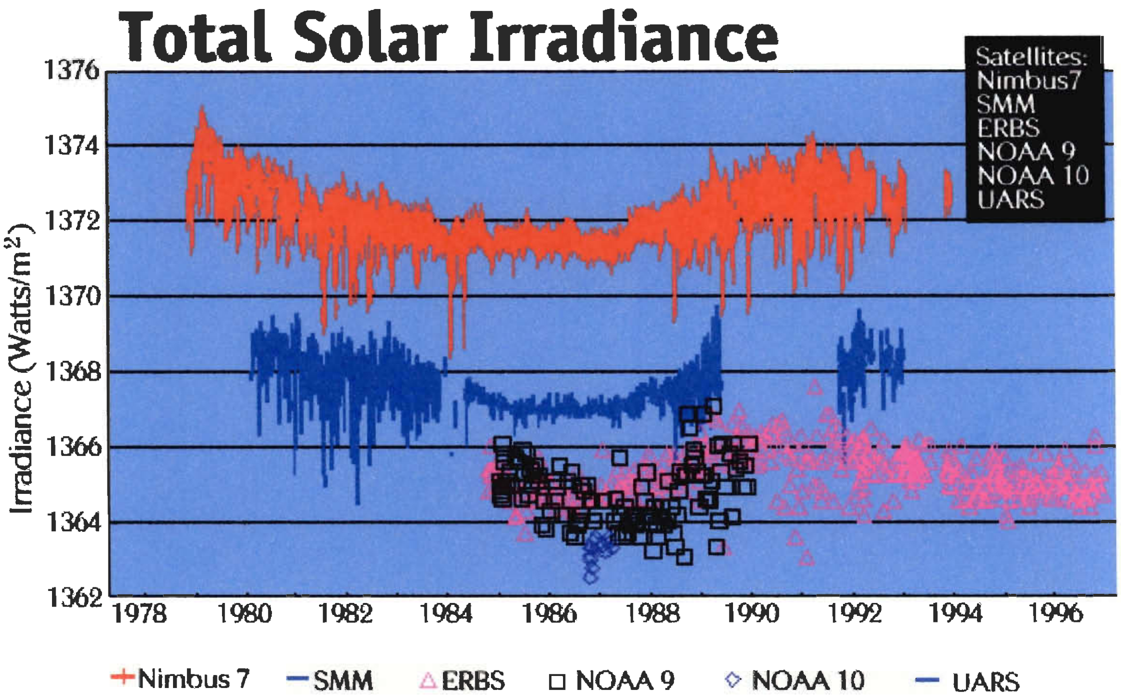

Figure 7: Total Solar Irradiance[7]

One last threat that is very unlikely, but is possible is solar dust clouds. These dust clouds are suspected to have affected earth in the past and could again in the future. There have been studies done on an ice cap in Greenland that suggests that solar dust could have been present on earth in a considerable concentration. Dust particles of the size and number found in the ice cap in Greenland could have drastically change the light transmission properties of the solar system. This could cause drastic changes in the earth's climate. There is not a lot of information on these solar dust clouds. Therefore, with limited evidence it is hard to say how immediate of a threat they are.

[7] http://daac.gsfc.nasa.gov/CAMPAIGN_DOCS/FTP_SITE/INT_DIS/readmes/sol_irrad.html

It can be said that there are many very realistic threats to life, as we know it, on Earth. Some are more immediate and likely than others, but all of the above possibilities at least posses the ability to destroy or significantly change Earth. Therefore, In order to maintain human existence in the long term, we must colonize space. It is important that we realize that in order to flourish and prosper we must have a contingency plan. Earth may not always be ideal for human life, therefore it is important to know and understand our options if there is ever a present need to evacuate the Earth.

II. Where Should We Go

A. The Space Station

One of the possibilities for colonizing space is that of the space station. Each station would accommodate a certain amount of people for an indefinite amount of time while orbiting in space. Currently, a handful of nations are uniting to construct the International Space Station, an enormous structure designed to hold 6-7 people, used primarily as a scientific laboratory. The station, or the ISS as it is commonly referred to, is a potential precursor to a colony of stations orbiting the planet. In order to look deeper into this possibility, the need arises to analyze every aspect of the current ISS, and determine whether or not there is a future for space stations.

The idea of a space station had been around for a short period of time before President Ronald Reagan approved the development of the ISS, which was initially called *Freedom*, in 1984. Other countries joined in the project, and to date there are a total of sixteen countries involved, including the United States, Russia, Brazil, Canada, the United Kingdom and 11 members of the European Space Agency. The final vision of the ISS will weigh about 470 tons and measure 356 by 290 feet, with solar panels over 100 feet long attached to 310 foot long trusses. The crew will live in 46,000 cubic feet of total pressurized volume, which is the equivalent of two Boeing 747 jumbo jets. Over 100 pieces will come together in 45 space missions, which began in November 1998, in order to assemble the ISS, with a completion date set for 2004. The construction has been organized into three phases. The first phase, which begun in 1994 and completed in 1998, was the learning period, where US astronauts boarded the Russian space station *Mir* and gained valuable insight into space operations and scientific experimentation, among other things. The first signs of actual space construction marked the beginning of the second phase in 1998, when the main control module *Zarya* was launched. During this phase, the majority of the construction will occur, finishing with a three-person crew spending four months on the station. The final phase, set for 2004, will have the remaining laboratory modules and robotic arms added on to the station.

Once the station is assembled, it will be put into orbit at 217 to 285 miles above earth, while traveling at about 17,500 miles per hour, or the equivalent of about one complete orbit every 90 minutes. In order to remain in this orbit, the station will occasionally need "reboosts," due to the drag force caused by the sparse atmospheric molecules in space, in addition to solar flux and other solar phenomenon. These reboosts will be planned on earth by the Trajectory Operations Officer at Mission Control Center in Houston and executed at the Mission Control Center in Moscow. Russia's Progress M1 cargo vehicles, single engine crafts, which are piloted from earth, will carry out the actual propulsion burns, which reboost the station. Russia has used these vehicles before in reboosting orbiting vehicles, including *Mir*. During these burns, of which there are two for each reboost, some systems and experiments will be suspended, but reduction of the main power should not be necessary. After reboost, all systems will return to their normal functions.

Energy from the sun will be used to power the ISS during its time in orbit. Eight giant solar array wings, spanning 108.6 feet in length, will be attached to a 310 ft. truss at right angles. When fully extended, the wings will cover an area of about 27,000 square feet, while reaching outward of 240 feet. Two solar cell blankets make up a single array, one on each side of a telescoping mast, which rotates on a gimbal, a device that will allow the solar panels to continuously point toward the sun. The main part of the Russian power system is the Science Power Platform, with eight solar wings extending 100 feet long and 26 feet tall. The entire structure will provide 124 volts dc to the crew and its equipment on the American portion of the ISS, while the Russian segment will get 28 volts dc. Such uncommonly high voltages will be used to meet the specialized power needs of the ISS. A pair of solar wings, is termed a "photo-voltaic module," of which there are four, and generate electricity at about 160 volts dc, which can used for batteries and transformers. The transformers convert this electricity to 124 volts dc, which is used by laboratories, living quarters, and other fundamental components of the ISS. Russia's modules of the ISS will be supplied by 30kW power at 28 volts dc. Also, since the ISS will spend about a third of each orbit in the shade of the sun, this solar arrangement must be able to provide a constant power supply of 78 kW. Batteries with stored energy will provide the necessary power for this event.

The main reason for the ISS is for scientific experimentation. Certain areas of scientific research will be examined in order to aid in mankind's understanding of many physical processes, as well as the way in which certain things occur on earth. One of these areas is earth science, which hopes to examine long-term weather patterns to allow better preparation for natural disasters, as well as analyze the ozone in the atmosphere. In examining life science, scientists must find solutions to the physical problems that arise due to the lack of gravity, such as bone loss, muscle atrophy, and immune system troubles. Recent studies have shown that microgravity can actually weaken the bones themselves, causing osteoporosis and other bone ailments. As space technology grows more advanced, with increased space travel imminent, these problems must be solved. Microgravity itself provides a vast amount of potential scientific knowledge, as many physical processes are radically different without gravity. Scientists hope also to examine new areas of engineering research and technology, in addition to the development of new space products. All of these experiments will take place in the U.S. Laboratory Module, the centerpiece of the ISS, and a technologically elite research facility. The lab module will be protected by an exterior shell of aluminum, with an insulating blanket to absorb heat from higher temperatures in space. Two shields will be placed over the module, one made out of the same material as bulletproof vests and the other aluminum, to protect the station from debris and sunlight. State-of-the-art research facilities for gravitational biology, human research, biotechnology, fluids, combustion, and space station furnaces are located within the Laboratory Module.

In order for life to exist on the ISS, thorough research has been conducted for state-of-the-art for the Environmental Control and Life Support System, which manages fundamental processes such as regulation of oxygen and pressure, and supplies water and fire fighting equipment. This system has been broken down into five subsystems. Atmosphere Control and Supply will provide the necessary oxygen and will regulate the air in the same proportions as found on earth at sea level. The Atmosphere Revitalization Subsystem will monitor the oxygen levels, as well as removing carbon dioxide and contaminate gases, while a special material will be used to absorb the carbon dioxide and emit it into space. Temperature and Humidity Control will do exactly what the name implies, by circulating air and removing humidity and moisture. In this subsystem, the Common Cabin Air Assembly uses filters to draw air from the surroundings, cool it and dehumidify, then release it into the atmosphere. The water that is collected is sent to the Water Recovery and Management Subsystem, which recycles all excess water from the station, including water from the fuel cells. Even wastewater is turned into drinking water whose pureness exceeds that of most major cities by use of the Potable Water Processor. The Process Control and Water Quality Monitor checks all these processes and the quality of the water. The fifth component is the Fire Detection and Suppression Subsystem, which provides ample solution to any and all potential fire hazards and outbreaks. The last thing NASA needs is a raging fire destroying billions of dollars worth of time and effort, so fire protection will surely be top-notch.

So what does this all mean for the future of intergalactic habitation? There are a few more additional factors that need to be examined. First off, with a budget of approximately $40 billion, the ISS seems very unpractical for wide-scale construction in the future. However, since this is mainly a scientific mission, much of this money is being spent on the state-of-the-art scientific technology, which is certainly unnecessary for residential living. However, other forms of entertainment must be provided, which are seemingly absent on the ISS. No matter how dedicated these scientists are, they are sure to grow tired of what they are doing occasionally. So what will they do in the absence of gravity? Many things that we take for granted here on earth will not be available in space, namely most recreational activities. It is important to recognize that this is a long-term mission and these scientists will be staying on the ISS for a great deal of time. Barring any unforeseeably catastrophes, they can remain in space permanently, although a rotating crew seems more likely. Nevertheless, increasing boredom could severely agitate the crewmembers, much like it can on earth. In fact, agitation could cause another problem, seeing as how these people are expected to live together in a close environment for an extended period of time. This fact, when coupled with the possibility of cabin fever, may lead to some unfortunate circumstances, which hopefully can be prevented. Another problem the space station faces is that of its financial uncertainty. Merely looking at the price tag of the ISS seems to suggest that only the extremely wealthy will be able to afford such a voyage. Hopefully, this is only a temporary problem, as large-scale production may decrease the cost. Also, if the wealthy are the only ones in space, will they really need jobs? As we look deeper into the future, it is important to realize that the creation of employment in space may become a necessity. Unfortunately, at this juncture, the possibilities are uncertain. Nevertheless, the production of future space stations should certainly take place, provided that the first one reaches completion, due to the benefit they could have for mankind.

B. The Moon

Besides Earth orbiting space stations the next closest location for a space colony would be the Moon. First we are going to discuss some of the physical features of the moon, and then discuss if it would actually be possible to live on the moon, would it be dangerous or not and how will it thrive or not thrive economically.

The moon is at a mean distance from the Earth of 239,900 Miles making it the closest celestial body to Earth besides the space stations. It has a diameter of 2160 Miles at its equator and is about 1/3 the size of the Earth. The mass on the moon is 0.012 compared to Earth's 1.0, and the gravity is only 0.165 about 1/6th that of Earth. The moon is actually drifting away from the Earth at a rate of 1.5 inches a year. To look at what is needed to go to the moon, we can look at the Lunar Prospector, which was launched in 1998 it weighed only 653 pounds including fuel and cost $63 million. After leaving the Earth orbit it took only 105 hours or a little bit over 4 days to reach the lunar orbit, at a speed of 2284 miles per hour.

After doing some extensive research we have learned that the moon was made out of the same materials as the Earth. The moon however has very little of what a human would need to survive. The two main things that are needed for a person to survive are water and oxygen, and have course food. All of these are in no way sufficient on the moon. There have been findings of the actual element of Oxygen, however this would not be sufficient for person to survive. Over many years of research it has been concluded that the moon's polar caps are made of ice, and therefore implies that the moon has over

30 billion gallons of water. If this were to be true the water itself would have to be extracted and that would again require some sort of equipment to do that. As we discussed earlier bringing materials to the moon in order to excavate or do any sort of mass work would cost a tremendous amount of money, going into thousands of dollars a pound to transport something. NASA however is coming up with newer more lightweight equipment in order to deal with this issue. Also the polar regions of the moon are in the sunlight for 80-85 percent of the time. They are also very close to the ice water and the possibilities of seeing earth a lot is much greater, making it easier to communicate with earth more often.

The moon base would have to be built underground many feet down. Without this anyone would be able to survive since the temperatures on the moon get as hot as 120 degrees centigrade during the daytime, and a negative 175 during the night. A base, which is underground, would be able to withstand these sudden temperature changes.

There are obviously many dangers of colonizing the moon. The moon is exposed directly to the sun, with no ozone shield like we are used to. There are strong solar winds on the moon, which are very dangerous to humans. As mentioned before the fact that there is no oxygen or food is a big problem for the people. When looking at economic costs or benefits, you have to realize that in order to have people live on a moon base, there would have to be food grown, and the only food that could be grown in space in those kinds of conditions would be very limited, such as soy products, wheat, and other dried goods. If that could be completed hospitals would have to be built, as well as some sort of a barter system. The things on the moon base would have to be rationed out equally to everyone and not judged by status of the person. There are of course always threats that people would not be able to get along with each other, and would cause "wars" or other such acts.

The thriving of the moon base would depend on many of the facts that we have mentioned before. Human compatibility just like on earth is very important, yet if this would be done to save the human kind time might not be available to assess those kinds of factors. However on the other hand a moon base can thrive tremendously. As we have seen there have been many precious metals and other elements discovered on the moon. A very important thing would be to find a way to get all those things out of the ground and put it into use. Perhaps even finding a way to transport it back to earth of sale. The possibilities of the positive and negative connotations to moon colorizations are vast, and should be thought about to great extent.

Another thing we can look at when we look at the dangers of colonizing the moon is muscle and other body problems a person can encounter when living under low gravity. Muscle atrophy is compared to wearing a cast, or being hospitalized for 2 weeks, those people might experience the same kind of atrophy as the people in space. Atrophy happens when muscles are not used, this happens in space since people don't need all their muscles due to the low gravity. One of the things that astronauts do in space now is a use specially designed exercise machine in order to keep their muscles active. This would be an important part in building a colony in space. Together with the hospitals, and houses. There would need to be numerous exercise machines, which would need to be installed in all of those places.

We will further discuss the reason for people wanting to spread out into outer space, as well as their need and want to survive. As compared to 400 or even 100 years ago, the danger of living now is much greater then than. In the earlier days, wars would take place, but weapons like swords and muskets would be used. In a large scale war lasting many years 100 million people could be wiped out. The Black Death killed 25 million people or a third of the population. During our days the risk has increased 100 fold. Using the nuclear capability we have now a 100 million people could be wiped out in an hour, if there were to be a full-fledged nuclear war. Biological warfare could have the same effect.

In 1997 a survey was taken and it was learned that 1.2 billion people in the world live in poverty, 1.5 billion without sufficient sanitary availability, 1 billion malnutrition, 20 percent is illiterate, the world population has increase from 1.5 billion in 1913 to 6 billion in the year 2000. The number of governments has gone up from 50 to 180, and the number of severe wars from 2 to 38. At this point in time, besides those things there are many other reasons of how the world can end. Destruction of the ozone layer, epidemic diseases, genetic engineering, failed scientific experiments, and many other reasons. As Arnold Toynbee said in Choose Life, "The threat to mankind's survival comes from mankind itself; human technology, misused to serve the diabolic purposes of human egoism and wickedness, is a more deadly danger than earthquakes, volcanic eruptions, storms, floods, droughts, viruses, microbes".

The way to prevent this is to abolish the bad governments, come up with a new set of laws, which will ban any unnecessary experimentation, as well as protect the people from any dangers that might arise. Although this might seem impossible, this is one of the only ways to protect the human race from the certain death that could arise if actions are not taken.

C. Mars

Having examined the possibilities of space colonization it has been determined that the space station and the Moon, although useful for research, do not possess the necessary requirements for permanent habitation. However, a third possibility, Mars, offers the necessary requirements for a space colony. We should start our examination of Mars by first comparing Mars to Earth in respect to size and other physical properties. Mars is much smaller than Earth when it comes to shear size. Mars's diameter at the equator is approximately 6,794 km in comparison to Earth's diameter of 12,756.2 km. Earth is almost two times the size of Mars diameter wise. Earth has a much bigger mass; it is almost ten times the mass of Mars. As a result, Mars has a very different force of gravity on the planets surface. Mars's surface gravity is 3.69 m/s^2 this is quite small compared to Earth's 9.8 m/s^2. It would take humans quite some time to adapt to the change in gravity. It could possibly even affect muscle development and strength.

However, one property of Mars that could prove very useful is the escape velocity. Since Mars has a much smaller surface gravity that means it also has a much smaller escape velocity. Mars has an escape velocity of 5.03 km/s this is quite small when compared to Earth's escape velocity of 11.19 km/s. This means that it would take far less fuel to take off from Mars than it would to take off from Earth. Any space shuttles leaving from Mars would be able to carry a heavier payload because of the reduced amount of fuel needed for take off. This makes space travel from Mars much easier when compared to our current process.

In order to better understand what life would be like on Mars we must first compare the orbit of Mars to that of Earths. The length of Mars's day is 1.026 Earth days. This means that a Mars day would be 37 minutes longer than an Earth day. The length of Mars's year is 686.96 Earth days, meaning that Mars takes almost twice as long to revolve around the sun. However, it would be quite easy for humans to adapt to Mars, time wise. The day is very similar, almost so close that it is unnoticeable. The year although very different could be easily worked around, and either broke up into two so that it is more like earth or age can just be adapted.

So far all the characteristics that we have discussed can be worked around if Mars were to be colonized. Size, mechanics, and time are not essential for human life. Therefore these are considered important, but not life threatening differences. However, one very important characteristic of Mars that is vital to colonization process is the atmosphere of Mars. Mars's atmosphere is made up of 95.32% Carbon Dioxide, 2.7% Nitrogen, 1.6% Argon, 0.13% Oxygen, and trace amounts of Carbon Monoxide, Water, Neon, Krypton, Xenon, and Ozone. This atmosphere is far from ideal when compared to earth. In actuality an atmosphere of this composition is not breathable for humans. This means an artificial atmosphere must be created, and living on the surface would be impossible. In addition to the composition of the atmosphere the temperature of Mars is quite different than Earth's. Mars's temperature ranges from –284°F to 68°F, with an average temperature of –145.4°F, this temperature is way to cold to sustain human life on the surface. Even at the equator during peak summer months, temperatures only reach as high as 68°F.

We have now established that Mars's surface is uninhabitable because of its atmosphere and temperature. Therefore if Mars were going to be colonized we would need to build some kind of shelter with an artificial atmosphere. In order to build something like this we would need a good location with possible building materials. Fortunately for us Mars is made up of mostly rock and metal, materials that could be mined and used to build protective structures to live in. In addition, there are many canyons and chasms on Mars that can be used to shelter any colonization from Mars's sand storms. There are also volcanoes on Mars, which suggest that Mars's inner crust may be very similar to Earth's.

If we were able to construct a shelter that could contain some sort of artificial atmosphere, we would still need to generate air from the elements that are present on Mars. This is also a possibility because of Mars's polar ice caps. Mars has a South Pole, which consists of frozen Carbon Dioxide, and a North Pole that consists of frozen water. This North Pole could be used to convert the frozen water into oxygen that we could breath. This water could also be used for drinking. It is believed by scientists that the North Pole is not the only location on Mars where water is present. It is believed that Mars was once very wet, and that as the temperature slowly dropped on the planets surface the water on Mars began to freeze. Therefore, it is believed that there may be many underground frozen water deposits that could be used throughout the entire surface of Mars.

Figure 8: North Polar Ice Cap[8]

Even if all the above problems and dangers could be overcome there still remains one last problem that humans would face if they wished to colonize Mars. They would have to transport all the people and supplies they would need to colonize the planet. This could prove very complicated and time consuming. A rocket traveling at a speed of 25,000 mph would take 2.5 months to reach Mars assuming no delays or problems. This is a fairly long voyage for people to make multiple times. Therefore it would only make sense that it would have to be a one-way trip. In addition, the amount of weight on each shuttle would be limited because of the amount of fuel needed to escape Earth's atmosphere and to make the journey. It would take a convoy of many space shuttles to transport a force large enough to begin any colonization process on Mars.

Mars is not a complete mystery as there have been multiple attempts by NASA to collect more information about the red planet. For example, so far NASA has performed two missions to Mars: Viking and Pathfinder. Viking was composed of two spacecrafts, an orbiter and a lander, which were to obtain high-resolution images of the Martian surface. The ultimate goal of Viking was to try to look for signs of life on Mars. Pathfinder was a faster and cheaper alternative to Viking. Pathfinder's mission was to land a scientific payload on Mars, and demonstrate its mobility on the planet's surface. In

[8] http://pds.jpl.nasa.gov/planets/welcome/mars.htm

more recent years NASA has sent multiple Mars Orbiters that orbit the planet and send images of the surface back to Earth.

NASA has many future plans for Mars mission and exploration. They hope to launch a new Mars mission every 26 months and each one will build on the previous mission, so that better more efficient methods are found. They have plans to gradually begin to use larger rovers and even attempt to return the rovers back to earth with samples from the planet's surface. Hopefully, in the next ten to fifteen years there will be missions carrying humans to Mars, but these will be much more complicated and expensive. There are also many other ideas that NASA has, but does not have planned for any future missions yet. These ideas range from aircrafts surveying the surface to even drilling core samples from the Martian surface. NASA sees Mars as a very important and promising celestial body. Currently, the sky is the limit on ideas involving Mars mission, anything and everything is possible.

Mars possesses many traits that make colonization possible. However, Mars also possesses traits that would make colonization more difficult than it currently is on Earth. It would be very unlikely for us to find a location that would perfectly match the properties of Earth. Therefore we must find the next best location that can be adapted and colonized. There are still many things that must be investigated before we understand the true value of colonizing Mars. This essay was meant to examine the traits of Mars in respect to the prospect of colonizing it. In order to properly investigate the possibility, we must also look into the technology involved in colonizing Mars. We must find out whether or not it is within our technical knowledge and financial and physical resources to accomplish such a feat.

III. Advantages of Going to Mars

A. Value of Mars to Earth and Humanity

In investigating the possibilities of colonizing Mars it is evident that an endeavor of this magnitude would require substantial financial backing, and years of planning and research. This is money and time that the human race cannot afford to waste. Without clear beneficial reasoning any effort to colonize Mars would meet intense financial limitations, and would ultimately be considered a complete waste of time and resources. Therefore, it is extremely important to investigate what there is to gain from an endeavor of such magnitude. In other words, what value does Mars posses that either Earth does not have, or humanity cannot provide?

It is evident from previous research that there exists a substantial threat to Earth and humanity's existence. Therefore, one of the single most important values that Mars can posses is to be considered a viable place of refuge. When the time comes that Earth can no longer support human life, humanity will strive and search for an alternative to death. Mars is probably one of humanity's most feasible locations for planetary colonization. It possesses many characteristics and properties that make it very inviting to space explorers of the future. Without going into the details, which have already been discussed, it is important to realize that Mars will always have value when the fate of humanity is at stake.

Another, more psychological, value that Mars possesses is the prospect that it will be the new frontier. Throughout history mankind has demonstrated the need and desire to continually expand and explore their surroundings. During every period of time there was always a new frontier where settlers and explorers were willing to take a chance and try to settle. Often times they went with limited supplies and technology, with the hopes that they would find a new way to survive. Space will be no different, as long as there is mystery surrounding it. There will always exist an interest to explore and settle this unknown region known as space. Since Mars is the closest and most promising, it sparks the most interest from the curious and adventurous, and it holds great value as the new frontier.

Mars's possible value as a new frontier and a home for the continuation of humanity are great examples of the possible uses of Mars. However, it would also be helpful to know what Mars has to offer in terms of physical benefits to Earth and humanity. For example, finding new energy sources on Mars would certainly give Martian real estate some value. Some scientists believe that solar-electric power satellites are our best bet for future energy production. These satellites could not only be placed around Earth, but similar solar collectors could be placed on the Martian surface. Since Mars does not have an atmosphere, solar activity on the planet's surface is much greater when compared to Earth. This still leaves the problem of transporting this energy back to Earth, and maintaining such devices. Although producing energy on Mars sounds promising, there still lacks direct influence on Earth and humanity. In a practical sense any energy made on Mars could only be used efficiently on Mars. Transporting the energy to Earth would cost more than producing it on Earth. Therefore, seeing energy production on Mars as a benefit to Earth is not yet a promising idea.

If we take a closer look at solar-electric satellites it is evident that more research must be done. During the 1970's energy crisis a great deal of research was put into solar-electric satellites that could orbit earth and beam microwave power back to Earth. However, these satellites would be required to collect the solar power, and then convert it from DC to microwave power. Then they would have to form controlled microwave beams that hit a precise location on Earth. Finally, back on Earth this microwave energy would need to be collected and converted back into a useable form. In order to accomplish this it was found that each SPSS would have to be 21 square miles, and would have to contain 400 million solar cells. A prototype for this satellite was estimated at $74 billion dollars. This is not including the receiving antenna on Earth. Therefore it can be said that before Mars can produce energy this way, it should be perfected on Earth first. Recently a different approach has been proposed: using smaller satellites and smaller receiving antenna maybe this system could be made more manageable. The bottom line is that currently Mars does not posses any great sources of energy, and until energy collection methods like the SPSS can be perfected Mars will not hold value in energy production.

Another possible value that Mars could offer Earth and humanity is the possibility of building industrial settlements on Mars. As discussed before there are many different industrial processes that would operate more efficiently in a zero gravity environment like Mars. Lasers and crystals can be manufactured in such a way that they will lack any imperfections that would be caused by manufacturing on Earth. This would not only save the industries money but it would also allow them to produce a pristine product. Of course, the problem of transportation would still be an issue. However, the resources on Mars along with the higher efficiency should be enough to overcome the industry expenses of transportation. In addition, the need and desire for more efficient methods of space travel, may be just the inspiration NASA needs to further develop their rocket program.

In addition to manufacturing these, industrial complexes could also be used as a jumping station for rockets and shuttles that wish to explore deeper into our solar system. This can be considered an invaluable resource that Mars possesses that no other planet or body can offer. Mars's gravity and lack of atmosphere makes taking off from the Martian surface simplistic when compared to an Earth take off. For example, Earth's gravity is almost twice as strong as Mars's, meaning that any payload leaving Mars would need twice as much lifting power to get off the surface of Earth. In addition, the lack of an atmosphere on Mars makes landing almost trivial. It would require no heat shield, no re-entry window, and little to no concern of anything going wrong. With this in mind it is quite evident that Mars could save Earth and humanity billions of dollars if it could act as a jumping station to the rest of the solar system.

This value may be one of Mars's most overlooked resources that it has to offer. NASA is currently working on a project that involves launching unmanned rockets off of the Martian surface with the intent of carrying Martian soil back to Earth for research. The Mars Ascent Vehicle, MAV, is approximately six feet tall and 13 inches in diameter and will weigh about 300 pounds. The MAV will use a two-stage fueled motor that will produce 2,000 pounds of thrust; enough to put it into orbit 310 miles above Mars. These facts alone emphasize the simplicity of launching from Mars. If an extremely small rocket can lift off of Mars with such ease, the possibilities of future Mars launches are endless. The MAV gives inspiration for interest in Mars because of its size and power. Launches from Mars will not only save money, but also time and manpower.

In addition to jumping from planet to planet, Mars could also be used as a central base for asteroid mining. Asteroids that pass by Mars and the Moon are much easier to track and land on. Therefore, Mars could be used to coordinate expeditions because all the resources could be brought back to Mars faster and more efficiently than to Earth. For that reason alone, Mars would be the perfect headquarters for a space-mining colony. Once again transporting the raw materials back to Earth would once again pose a financial and technological barrier, but these barriers could easily be overcome if there was enough money at stake.

On a similar note Mars can also be used as an observatory for the rest of the universe. What we can see from Earth is limited to the strength of our telescopes. However, if we could get these high-powered telescopes to Mars we would be able to look further into the universe than ever before. Mars could be used as an observatory for not only looking deeper into the universe, but also monitoring Earth as well. With the help of telescopes on Mars and the Moon tracking of near earth objects could be more efficiently managed. With more eyes and different angles being used we are sure to benefit from this heightened awareness.

It is apparent that Mars possesses not only sentimental value, but also physical value to Earth and humanity. It would be very disappointing if this value remained untouched. On the other hand, there are some scientists that believe human existence on Mars would only take away from the environment and destroy one of the last remaining pristine frontiers. However, other scientists believe it is the duty of humanity to explore and utilize all of the universes resources. Mars could be the hurdle that separates humanity from another technological boom. It is important that humanity thoroughly investigates Mars and does not overlook the possibilities that lie there.

IV. Overcoming Barriers

A. The Health Effects of Living in Space

Although the idea of permanent space habitation seems fantastic, there are some drawbacks. The main problem stems from the fact that human beings have always lived on earth and their bodies have adapted to the various conditions that are imposed upon it. The physical conditions in space, whether on the moon or mars, or on a space station, can have drastic effects on the body, with varying degrees of severity. If any attempt is to be made at colonizing space, these problems must be addressed and possible solutions must be set forth, or else humans will not be able to survive in space.

The most crucial element of space habitation is that of gravity. An enormous problem arises when looking at the fact that the human body is not conditioned for zero- or low-gravity environments. Man has always existed where the acceleration due to gravity is roughly 9.8 m/s^2. On Mars, the acceleration is about one third of this, on the moon about one sixth, and aboard a space station it is virtually negligible. The effects of these differences in gravity are not readily apparent to those freely floating in space or bouncing around on a low-gravity surface. However, unbeknownst to them, at least until recently, their bodies are undergoing detrimental physical changes, which do not really become apparent until they return to the surface of the earth, where gravity is much stronger than in space. Since their bodies have grown accustomed to the weightlessness of zero- or low-gravity, they often cannot properly function due to the sudden increased attractive force from the earth. In the past, astronauts have needed to be carried away on stretchers and spend weeks, even months, recovering. The two areas of the body that are affected the most are the parts that do the most physical work in the body: the muscles and the bones. In space, these parts are virtually unused in respect to the amount of work they perform on earth. This results in atrophy of the muscles and bones, which is a loss of mass. Astronauts on average lose 1-2 percent of their bone mass each month they spend in space, a statistic that becomes staggering in looking at the prospect for permanent intergalactic habitation, such as the ISS. On Mars or the Moon, since there is some gravitational force, this statistic would be lower, but atrophy would still exist, since the bones and muscles would not be used as rigorously as they are on earth. Therefore, a complete understanding of this physical phenomenon is necessary, especially if intergalactic habitation is to ever become a reality. Research done pertaining to these effects in space has enormous potential benefits for research on earth as well, since similar problems arise, only under different circumstances. For instance, research on bone loss in space could directly benefit those with osteoporosis, a condition marked by loss in bone tissue. Therefore, this research could benefit all of mankind, no mater where they live, be it in space or on earth.

To understand the effects of zero- or low-gravity conditions, it is necessary to look at the effects of gravity on the human body. In a gravitational field, objects experience a downward force, which is what prevents things from floating away. As a result of this force on someone on earth, their body applies a force on the ground. According to the laws of motion established by Isaac Newton, the ground will push back on the body with a force equal to that applied. This is the force that causes leg muscles to contract. Through everyday use, these muscles will maintain their tone and structure, but when this force decreases, so does the muscle, since less physical exertion is being required of the muscles. This result is common in bed-ridden patients, who are unable to walk, and therefore experience muscle atrophy. A similar explanation can be given for loss in boss mass, since bones are actually living tissue that constantly augment their structure in accordance to the stresses they experience. Therefore, if they experience no stress, or greatly reduced stress, they will begin to deteriorate. The reason for this lies in what are known as osteoblasts, bone-creating cells, and osteoclasts, bone destroying cells. Typically, these two types of cells are produced at the same rate and are balanced out. However, when there is little to no stress on the bones, the production of osteoblasts decreases, causing a relative increase in osteoclasts, the result of which causes bone loss. Over time, these losses add up and have potentially damaging effects, such as brittle bones. Since this effect is seen on earth, with osteoporosis, the benefits for zero-gravity research are already present.

B. Limitations on Space Travel

Another barrier that must be addressed is the current technological limitations of space travel. Without reliable and efficient methods of transporting equipment and manpower to Mars any efforts to accomplish such a goal will be very costly and time consuming.

In order to understand the limitations on space travel we must first look at our current technological abilities. The space shuttles that are used today by NASA are primarily for orbiting Earth. These vessels specialize in escaping the Earth's atmosphere and establishing an orbit around Earth. These shuttles as they stand right now could not be used efficiently to transport people or supplies to Mars. However, currently NASA is developing other space vessels that they hope will replace the somewhat outdated space shuttle. Regardless, the question still remains how would we get something to Mars. Currently the only missions that have been deployed to Mars have been unmanned mission, meaning a vessel like a space shuttle was not needed to transport the payload. Instead of a vessel, rockets alone were all that was needed to get the Satellite or Lander from Earth to Mars.

If we look at a particular mission and determine what was required to accomplish the trip with, we can get a better idea of the limitations of our current methods. Let us examine the Mars Surveyor Mission information, which was taken directly from NASA's own web page about the mission. The Surveyor used a Delta-7925 Rocket that, including Surveyor and propellant, weighed approximately 510,000 lbs. The maximum payload that this rocket can deliver to geosynchronous transfer orbit is 4,550 lbs. This weight includes The Surveyor vehicle and the propellant needed to get to Mars. This mission was the first Mars Mission that used the Delta-7925 Rocket instead of the Titan launch vehicle, this saved the mission approximately 300 million dollars. It took surveyor 309 days to reach Mars, which was slightly lower than the ideal transit time for the mission of 259 days. However, the journey can take anywhere from seven to ten months depending on the trajectory and planet location. Since we know that the distance to Mars varies from 78 million to 377 million kilometers, we can calculate the speed that the rocket traveled. Since we know average speed is equal to total distance divided by total time, we can take the minimum distance 78,000,000 km and divide it by time 26,697,600 s. This yields an average speed of 2,921.6 m/s, or 6,535.4 mph. Surely, this is a rough calculation, since the distance will not remain constant, as the two planets are both orbiting around the sun.

Now that we have some information on real Mars Mission we can make some estimates of what it would take, using current technology, to get a modest size payload to Mars. First we must assume the Ideal Rocket Equation, which states $\Delta V = (ISP)(g) \times \ln$ (total mass/total mass-propellant mass). Assuming that the journey to Mars will require three distinct maneuvers we can calculate the propellant that our modest payload will need to accomplish a trip like this. We will start with a modest payload like a full shuttle cargo (22,000kg). We only will be looking at the second maneuver because the first maneuver will be covered by a suitable launch vehicle, and the third requires substantially less fuel than the second. We will use the ΔV that we found above from the Surveyor Mission, the g for Earth, and the ISP will be 500, which is the ISP for the rockets on the space shuttle. The calculation for the second leg yields 9,880.7 kg of fuel.

If we add this to the payload we want to deliver we get a total payload of 31,881 kg (70,285lbs). This is a very large payload for a launch vehicle to deliver, for instance the Titan IV Rocket, one of NASA's more powerful rockets, has a maximum deliverable payload of about 12,000 lbs. This means that our modest deliverable payload will require a very large and complex launch vehicle. It is important to note that we did not include fuel tank weight or the weight of propellant needed to land on Mars; these factors will add even more weight to the payload.

The calculations above demonstrate that, although possible, it would be very difficult and expensive to send even a modest space shuttle like payload to Mars. This is also assuming that the individuals involved in the project do not mind waiting 8 months to get to the planets surface. Current space travel technology does make it possible to get people to Mars, but the process is far from efficient and quick. If we want to make any realistic attempts at sending people to Mars, we must first develop a better method of space travel. However, before we can start developing better methods of traveling through space we must understand the technological barriers we must overcome.

The two key barriers to Space Propulsion breakthroughs are the need to exceed light speed, and the need to manipulate mass and space-time coupling. If these two barriers could be overcome not only would space propulsion be quick, but it would also be much more efficient. First, let's take a look at the speed of light barrier. Obviously, the universe is extremely large, and the faster we are able to travel the further we can explore and settle. If we look at it just from a Mars perspective, it would take 4 minutes to get to Mars if we were able to travel at the speed of light. This is drastically different than our 8-month plan outlined above. However, traveling faster is not as simple as building faster more powerful rockets. Unlike Earth vehicles a rocket does not have anything to push against like a road or air. It has to carry all the mass that it needs to push against. Therefore, the further you want to travel the more mass and propellant you need to bring with you, and the more mass you bring with you the more difficult it is to get that mass into space.

The next question is "How do we get around these barriers"? Currently the JPL (Jet Propulsion Lab) has determined that "faster-than-light travel is beyond our current horizons. Not only is the physics inadequately developed, but this physics is not oriented toward space propulsion or toward laboratory scale experiments" (Millis, 2). However, this does not mean that theories about "warp drive" (faster-than-light travel) do not exist. Marc G. Millis of the NASA Lewis Research Center believes that contracting space-time in front of the ship and expanding space-time behind your the will accomplish "warp drive." The catch is that in order to expand space-time one must generate negative mass, which according to physics cannot exist. In addition to his "warp drive" theory Millis proposes many other methods of space travel that do not involve propellant. Unfortunately these theories have no experimental backing and tend to break the laws of physics. So if we lack the ability to overcome these physical barriers, is there any hope for more efficient space travel?

NASA is currently developing a new type of rocket technology called The Variable Specific Impulse Magnetoplasma Rocket. This rocket is not powered by conventional chemical reactions like rockets of today, but rather by electrical energy that heats the propellant. The propellant is plasma and can reach temperatures as high as 50,000 degrees. This new rocket technology could dramatically shorten human travel time between planets. For examples, instead of an 8 month journey to Mars this rocket will only take 3 months to reach Mars. In addition to providing a faster trip, the rocket also can carry very large payloads. NASA hopes the plasma drive will be able to propel robotic cargo missions with payloads as large as 100 tons. However, it is important to realize that this is a project that has been in development since 1979. It could take years to successfully develop a first flight experimental plasma drive, and could take even longer to use them in actual missions.

It is evident that the human race currently has very limited abilities when it comes to space travel. The focus of this project is getting to Mars, but Mars is extremely close when you consider the immense area that makes up the universe. If the human race wishes to explore outside of our solar system than some of the theories involving faster-than-light travel must be explored, and the physical properties of space travel, as we know it, must be changed. However, if Mars is our current goal we should focus on developing more efficient and faster rockets like the plasma drive rocket. With a transport vehicle like this, exploration and settlement missions will have a realistic chance of accomplishing their tasks.

C. Arguments Against the Colonization of Mars

It is vitally important to determine if America is able to support this mission financially and morally. If the public is not behind the mission, then it is sure to never see the light of day. Therefore, all reasons for dissension must be analyzed and taken care of. However, there are still some major areas of concern that must be addressed before looking further into the colonization process.

One of the biggest reasons for wanting to colonize Mars is to allow the continuation of the growth of mankind, since earth is slowly becoming too small to hold everyone. That is, natural resources are running out while the planet becomes overpopulated. These are very real threats, although they may not require drastic action for several centuries. This brings up the question of whether or not we need to venture into space now. Would it be wiser to wait until we have better technology in order to achieve our goals with a better chance of success? Or should we press on, allowing ourselves to be the pioneers for this noble feat, and not a future generation. The technology required for this voyage is quite awe-inspiring and very expensive, and the question still remains of whether or not we are capable of producing it at this time. For instance, in the latter stages of this plan, the entire planet would need to be terraformed, a process where the entire atmosphere and landscape structure are altered to suit human needs. Nothing like this has ever been attempted before, although a lot of research has been done, which has shown that terraforming is a possible reality. This procedure calls for enormous orbiting mirrors which harness the sun's energy and direct it toward the polar ice caps in order to raise the temperature by approximately 4° Celsius, thereby triggering a reaction which would allow the temperature of the entire planet to rise. Other parts of the procedure involve various constructions to produce certain gasses, such as carbon dioxide or halocarbons (commonly referred to as CFCs, or chloro- fluorocarbons), in the atmosphere that can trap radiation of the sun in order to warm the planet. Again, this idea is unprecedented, and its outcome, however calculated it may be, could still lead to potential problems. More research and experimentation is needed to prevent any possible disasters with the atmosphere, although this phase of the colonization is still several years away. We can only hope that we possess the necessary technology when it comes time to commence construction for the terraforming phase of the colonization process.

A major source of dissent towards the colonization of Mars is that of money. Streamlined rough estimates of the initial stages of the project are roughly between 20 and 30 billion dollars, according to Robert Zubrin, one of the leading advocates for the colonization of Mars, and the author of The Case for Mars, a detailed account of how we can accomplish this project. Some might argue that this is an excessively large amount, and there are much better uses for the money on earth. For instance, we could put this money toward the search for a cure for cancer, or for other troubles plaguing the world. With this in mind, it would seem that there are certain problems that must be fixed here on earth before we should think about colonizing another planet. How can we promote the advancement of human existence on another planet, when there are so many problems afflicting human beings right here on earth? Wouldn't money be better spent on research for disease treatment, building new homes and schools, or any other areas that would directly benefit mankind? This is a good thought, but the problem with it lies in the fact that there have always been troubles that will exist with or without aid from the space program, which seems like an unrealistic idea anyway. True, there are many problems on earth and many areas that could desperately use the money. However, there are plenty of other resources from where these areas can obtain financial assistance. Also, even if the plan to colonize Mars falls short, the money will still remain in the budget of the space program. It will merely be used for other purposes such as the continued exploration of outer space and the search for extraterrestrial life. Space research has a certain amount of money allocated for it from various resources, mainly the government. There would be a lot of unhappy people if they knew where their money was being directed if not the space program. The point of the matter is that there is and always has been great deal of interest in space and it would be a shame to see that die out. Problems will exist on earth, and they will also occur on Mars if the project is carried out. Nothing can prevent them: they stem from human nature. Where disease is concerned, it does not seem like much of a threat on Mars, since we know how to deal with it and how to treat it, although new diseases are always a problem and they could potentially exist on Mars. However, future scientific missions should be able to find any information on extraterrestrial sicknesses. Nonetheless, we should not let a seemingly large budget prevent us from carrying out the greatest feat in human history. It seems as though 30 billion dollars would be a bargain for opening up an entire new frontier for human civilization.

One reason for not attempting to colonize Mars at this moment is the turbulent nature of the current affairs of the world. With the current situation involving Afghanistan and the "war on terrorism," some might argue that the colonization of Mars is not a pressing issue, and that there are much more important affairs to be dealt with.

Why should we colonize another planet when we cannot even secure peace on this one? If people cannot get along with each other on earth, how will they cope on Mars? However real this problem is, it must be noted that only a select few countries will be going to Mars, which will instantly ease the international relations in outer space. The affairs on this planet will not be brought to Mars, so this project can be completed without regard to the social problems facing the world. In fact, the benefits of reaching Mars compound themselves in realizing that America could be united in an act of patriotism. This is merely hopeful enthusiasm, but a great possibility. It could provide a much-needed spark in the area of global affairs for the American public.

Perhaps the final problem with colonizing Mars is that of uncertainty. There is so much mystery enshrouding this entire endeavor that it very well may seem as though we are not ready for it. No matter how many robots we send to roam the surface of Mars, nothing can prepare anyone for actually being on the planet. Although very few problems are anticipated with this aspect of the mission, nobody can quite be sure what exactly will happen with the first human explorers of the planet. Since human life is at stake, it is vitally important that every danger to the astronauts be inspected and prevented. However, we cannot really be certain that we know of all possible dangers due to the uncertainty of the mission itself. There are certain medical issues that must be resolved before we can set up a colony on Mars, such as bone-loss and atrophy of the muscles and bones. The human body has been conditioned to earth's gravity, and since gravity on Mars is about one-third of that compared to earth, the body will react differently. For instance, the lowered impact will create less force on the bones and muscles, causing them to lose strength and summarily shrink, a process known as atrophy. Long-term space flights have shown that this process does not end at a certain point, so this area requires a lot more research. Luckily, on the International Space Station, scheduled for completion in a few years, scientists will spend a great deal of time on these problems and will hopefully be able to find remedies. Otherwise, it may be necessary for humans on Mars to experience these physical breakdowns and perform exercise routines to offset them. As much of a hassle as this seems, there are sure to be plenty of people who are willing to endure this minor setback in order to experience first hand the colonization of Mars.

Colonizing Mars carries many potential risks that could create a lot of uncertainty with the general public as to whether or not we follow through with the plan. However, it is evident that we have the resources to begin the initial phases of the exploration. All we need is the support from the public and the determination of the scientists who have the power to make this happen. Once we begin, the motivation for solving any potential problems will arrive when the need for solutions arise. As for now, there is nothing holding us back from commencing work on this marvelous enterprise.

V. Surviving on Mars

A. Making Mars Habitable

It was determined from the analysis of Mars's environmental and physical properties that colonizing the planet would be feasible, but extremely difficult. There are many hurdles that would need to be overcome in order to properly sustain human life on the planets surface. By examining the possibility of making Mars more habitable for humans, we will determine what needs to be changed in order for humans to survive, and the ability of accomplishing such goals.

First let us look at the possible threats to human existence on the surface of the planet. For instance, one major concern that many scientists have is the unknown long-term effects of zero gravity on the human body. Although this would not be a problem on the Martian surface because of Mars's surface gravity of 3.69 m/s^2, it will be a problem for the astronauts when they first arrive on the planet. In zero gravity muscle mass can decrease by about 20%, and bone density can decrease by about 40 to 60% depending on the time exposed. Astronauts experiencing zero gravity for the long trip to Mars would need to keep well exercised in order to be effective on the planet's surface on arrival.

Another more severe threat to the astronauts attempting to colonize Mars would be the Carbon Dioxide rich atmosphere. Unfortunately, the atmosphere of Mars only contains 0.13% oxygen, which is far from a breathable atmosphere. Therefore, the astronauts that will be attempting to colonize the planet would need to have plenty of oxygen to breath. In addition, they would need methods of producing more oxygen on the planet's surface for future use. This may actually be much easier than it sounds.

Currently NASA is developing a prototype that does exactly this. The Mars In-situ Propellant Production Precursor (MIP) is currently schedule to be tested on the Mars Surveyor 2001 Lander. It has already been tested successfully in an atmosphere that simulates Mars, but an actual test on the surface would be more convincing. This device can also be used to produce rocket fuel for any journeys off the planet. A device with the MIP's capabilities would be a huge step in making Mars more habitable.

Even if this MIP could be proven useful for colonizing Mars there is still one more major problem with the surface. The surface of Mars experiences very large fluctuations of temperature and violent weather patterns. Any group of people hoping to colonize Mars would need to be able to combat both the temperatures and violent windstorms. Since temperatures at the equator get as warm as 68°F in the summer, this would be the ideal place to colonize. Although the equator does experience negative temperatures in the winter, a sheltered human colonization could withstand these cold temperatures. In addition, these shelters could easily protect humans from the violent sand storms on the planets surface. Luckily, there are plenty of building materials on the planet's surface. However, tools to mine and use these resources would need to be transported to the planet with the colonists.

So now that it has been established that colonists can survive on the Martian surface, we must now look at how life is going to be sustained. In order to sustain life for any extended period of time, there must be a constant supply of water. Without water humans will die and any attempt to farm the Martian surface would be hopeless. Therefore, finding a way to get water to Mars colony would be the first major project of any long-term colonization. Transporting water to Mars would be near impossible, but recent images of the North Pole have shown existence of frozen water deposits. If these water deposits could be melted and harvested the Martian soil could be irrigated and humans would have water to drink. In addition, the irrigated soil could then be used to supply the colonists with food, which is another staple of survival.

Another possible location for water on Mars is deep beneath the surface. Scientists believe that beneath the surface there are large streams of flowing water. It is believed that these underground streams could be mined much like oil is on Earth. This would not be an easy procedure and would encompass drilling, harvesting, and filtering the water. So in either case getting water to the colonists would be a very difficult task. However, it is not beyond the reach of current technology.

One of the biggest problems facing any expedition to Mars is the current technology barrier of space travel. Using current rockets it would take 2.5 months to get to Mars. It takes a large quantity of fuel to accomplish this journey, and the spaceships will be weighed down with supplies for the colonists. The colonists will have to be able to survive the long journey to Mars; along with the period of time it takes them to establish a working colony. Therefore it would take a large number of space shuttles to carry the massive amount of supplies needed. These supplies would have to consist of all the equipment mentioned to accomplish the above colonization tasks along with food and water. The average space shuttle can carry a payload of approximately 55,000 pounds, but this would be far less because of the amount of fuel needed to get to Mars. Therefore, we would estimate that at least twenty to thirty spacecrafts would be needed to transport the colonists and their supplies. However, this is only an estimate not a scientific approximation.

Mars is a very promising location for a possible space colony. It seems to have all of the building blocks needed to construct a fully functional colony suitable for human life. We examined the different problems with inhabiting the planet and possible ways around these problems. In order to get a better idea of the scope of the task we would need exact numbers and projections. However, we have only outlined what must be overcome in order for human life to stand a chance in an attempt to colonize Mars. We will further pursue these concepts and propose a possible scenario for colonizing Mars using all the knowledge we have gained so far.

B. Life on Mars

We will now discuss some facts about life on mars. We will look into the possibilities of tree planting, as well as other plants, for the production of oxygen. We are also going to look at the adaptation process that the people would have to go through if they go to Mars, including muscle and bone deterioration and other aspects of human life. Also the possible effects of radiation that could touch the plants and people that would inhabit Mars.

96 percent of Martian atmosphere is made up of carbon dioxide, and the other 4 percent are made up of different trace gases. Martian soil contains only 1 percent of water, however some vegetation could still grow. As we know the reason mars appears red is because there is a high concentration of iron in the soil, there is also nitrogen and phosphorus, therefore with the transportation of potassium from Earth making it capable of plant growth. Hydroponics as it is used on earth is also a possibility for some plants. When we look at human stability on mars, we know that humans need air, and it might be possible to make air on mars, using the oxygen taken from the carbon dioxide, nitrogen, argon, and water vapors. The plant growth on mars though could be inhibited by the high radiation on mars due to its thin atmosphere between the planet and the sun. Also the four main elements that comprise organic matter, which are hydrogen, carbon, nitrogen, and oxygen are all readily available on Mars although some search might need to be done for them. This is what gives Mars an advantage over the Earth's moon and other places thought of being inhibited. When we look further at the growth of plants we see that its

not only the absence of gases on the moon that makes Mars more desirable but also the sunlight that is on the moon is not available in the form needed for crop growth. When we look at a $1km^2$ of land on Earth we see that it takes 1000 MW of sunlight on an average sunny noon. This is also equal to the amount of power that is used to power a city in America with one million people. Mars has the sunlight capacity of 43 percent that of Earth. Most importantly plants need photosynthesis and which could easily be achieved and even accelerated on Mars using specialized domes since by filling those domes with a higher amount of CO2 which is more available as mentioned before would help this process. We also have to consider the pressure at which these domes would have to be. A lot of plants do not need to have air to live according to Martin Caidin. Living without air and developing of plants is called anaerobic development. Perhaps that mars would not be able to develop such colors of plants as there are on Earth. Depending on the plants and the kind of environment that is set up for them we can perhaps see the kind of different colors that could be developed. Plants are able to tolerate a pressure of .7 Psi however humans cant and would have to wear spacesuits when entering the dome, therefore the best idea is to make the pressure at 2.5 Psi which would eliminate the need for spacesuits, or even 5Psi which would allow the people to act regularly with no need for any sort of protection gear. The difference in these domes should be the CO2 levels with .4mbar for humans and 7mbar for plants.

Now we are going to look at the effects that Mars could have on humans, especially the factors of high radiation. The first problems could arise on the actual trip to Mars, according to some opinions of the skeptics the only way to get through the so called radiation infested seas of space is by using an ultra fast spacecraft or alternatively since that would probably be impossible, a spacecraft that would be the size of an asteroid in order to shield the crew from the radiation. However Robert Zubrin disagrees and says that those sayings are nonsense. He says, "Radiation is deadly only if taken in access quantity." He goes on further to explain and describe the radiation factor here on Earth. People in the United States receive an annual radiation of 150 millirem at sea level and those who live at higher altitudes such as Aspen Colorado or other high altitude places have an annual radiation of 300millirem. This is different however than a doze of radiation at a time. Doses such as a nuclear reactor explosion and other big event could kill but does of 200 rem causes sickness at 600 rem 80 percent die, and at a 1000 instant rem no one survives.

Now we can look at the rem amount that a person can expect to get on Mars. There would be dangers of two different kinds of rays' cosmic rays in transit and on mars as well as solar flares in transit and on mars. The average dose for all of them combined is only 58.4 rem a year! As we can see this is not a very big difference than the Earth and would not pose a great danger to the Mars explorers.

Another big risk that the astronauts will take besides the radiation is the fact that gravity on Mars is quite low. Exposure to low gravity environments for a long period of time could cause such effects as bone and muscle deterioration, due to the lack of exercise, cardiovascular deterioration, as well as some aspects of the immune system. These symptoms in fact all appeared with the people who were on the Mir space station and other long time spending astronauts and cosmonauts in space. Experiments have been performed in these cases and have been successful in stopping the muscle deterioration by having rigorous exercise and specially made elastic spacesuits which would force the astronauts to move more. However nothing has been found as of yet to stop bone demineralization which would be a big factor for a trip to mars. We need to realize though that they would not have to go to Mars with no gravity, on the contrary gravity could be provided in the spaceship by spinning it. This can be done by having small rocket thrusters on each end going in opposite direction, which could be controlled to control the amount of gravity to be made.

With all this said we also have to consider another issue, which is the "human factor" according to Zubrin, it just means that the people could go crazy and become unstable. A lot of times this could be compared to the GI's in WWII and Vietnam War. The confinement to one space, the treacherous atmosphere and the being away from home for so many years causes PTSD (post traumatic stress disorder) in many of them. However this should not be the case with the astronauts since they will be living in much better environments with good food, health, and rest.

C. Terraforming

We are now going to discuss the idea of terraforming Mars. First we need to look at what terraforming is. The actual word comes from two words; terra- The Earth, and forming- the process of giving form or shape. A science fiction author named Jack Williamson in July of 1942 invented it. As of now there are no official definitions for terraforming, but one good one that we found states that; Terraforming is a process of planetary engineering, specifically directed at enhancing the capacity of an extraterrestrial planetary environment to support life. The ultimate in terraforming would be to create an unconstrained planetary biosphere emulating all the functions of the biosphere of the Earth, one that would be fully habitable for human beings. [Martyn J. Fogg *Terraforming Engineering Planetary Environments* 1995. Pg 9]. As you can see terraforming would be employed in order to make life on celestial bodies other than Earth. There have been many meetings by scientists, engineers, and other scholars and although studies have not concluded this to be 100 percent possible, no studies concluded that this would be completely impossible.

Research that has been done by different scientists shows that there was once a warm and wet climate on mars as could be seen by the different river tracks still on the planet's surface. In order to make an atmosphere there needs to be CO_2, which would also help, warm up the planet. There is evidence of CO_2, which would be enough to make a 300-600 MB atmosphere. However this source is probably frozen at this time. As we can see from reading Robert M. Zubrin's paper on terraforming, one of the main necessities for mars exploration is nuclear power. He says that using nuclear powered objects things could be delivered to Mars with much more ease. He also quotes that 21st century technology is progressed enough to be able to do this kind of task. In order for Mars to be habitable we need to warm it first. He suggests that the greenhouse effect is the best way to warm it. He says warming it using 1000Mwe would take about 50 years to modify the temperature to our needs. In fact one of the 3 methods he mentions in doing this is by using halocarbons or CFC's, which we are ironically trying to banish from the Earth. In doing this, the people would be able to live on the surface on mars with no pressure suits, however they would need to wear breathing gear. Another way proposed of warming up mars is using a large mirror, which would be manufactured and kept in orbit in order to melt the Martian ice caps.

VI. Plan for Exploration

A. 2001 Mars Odyssey

Before man can set foot on Mars, we must determine if it is actually possible for him to live on the surface. Currently, NASA is attempting to explore Mars as deeply as possible, with Mars Odyssey, an orbiting satellite. Launched on April 7, 2001, the Odyssey has very specific tasks, which will aid scientists in determining if humans will someday be able to inhabit the planet.

One of the goals of the Odyssey mission is to map the chemical composition of the surface. As cosmic rays bombard the Martian surface, each element gives off neutrons. These high-energy particles collide with each other and other atoms and give off gamma rays in the form photons. Each element gives off a specific set of energies, which can be measured using a Gamma Ray Spectrometer (GRS). The energies appear as sharp peaks on the spectrometer, indicating a presence of that particular element. The neutrons themselves are measured using a high-energy neutron detector (HEND) and a neutron spectrometer. Although these measurements will determine the presence of upwards of twenty different elements, scientists are most interested in the abundance of hydrogen, which would most likely be found in the form of water, as much as a few feet beneath the surface.

Another component of the Odyssey mission is THEMIS (Thermal Emission Imaging System). This tool is able to measure the amount of solar heat radiated back from the surface of the planet, using the infrared portion of the electromagnetic spectrum.

With a shorter wavelength than visible light, infrared light is invisible to the human eye. However, THEMIS is able to create a thermal map of the surface with the "spectral fingerprints" of each mineral present in the surface. Scientists hope to discover "hot springs," which are subsurface reservoirs of water, and could potentially harbor life. THEMIS will also take advantage of the visible spectrum by taking high resolution images of areas where water once existed in order to characterize the geological history of the Martian surface.

The final component of the Odyssey mission is the Martian Radiation Environment Experiment (MARIE). As we have discussed, a serious problem with Martian habitation is solar radiation. If we are to live on the surface of the planet, we must know how much radiation is present and how to predict the doses we would receive. Therefore, MARIE, a spectrometer in the satellite, will measure the amounts of radiation around the satellite's orbit.

With these three tools, scientists will be able to help fulfill two requirements for survival on Mars. They will be able to determine if there is an adequate water supply with the GRS and THEMIS, and they will be able to better protect people from radiation using results from MARIE. These tools will continue to collect data until August of 2004, although the satellite is continuously transmitting the information back to Earth. Also, since the satellite will be in orbit for about 30 months, it will be able to observe an entire Martian year, therefore allowing us to examine the manner in which the planet changes with the seasons. The Odyssey will prove overwhelmingly useful, provided we do not encounter any unfortunate mishaps.

B. Preparation for Human Expedition

Now that we have explored the possibilities of human life surviving on Mars, we must now determine the steps that will be required to successfully get a human expedition to the Martian surface. The process of accomplishing this task will be long and strenuous, and will involve many telescopic and robotic surveys of the planet. The planning that will go into the first human expedition will have to be detailed and fool proof. It must be taken very seriously, and must resolve all questions and problems that could occur on the expedition. This first expedition will most likely be very expensive, and will have an enormous amount of risk related to it, and that is the exactly why the preparation must be precise and methodical.

The first step of planning an expedition of this magnitude is to determine what it is we already know about Mars, and what additional knowledge we must gain before we can start this expedition. It has already been discussed in depth our current knowledge about Mars's atmosphere, surface conditions, and surface geology. This is information that will be critical in planning both the remaining surveys and the human expedition. Some information that would prove extremely useful is actual soil deposits from the Martian surface, so that scientists will have a better idea of what they are working with. In addition, it would be helpful if NASA's MIP could be tested under actual Martian conditions by one of these robotic surveys. However, These are just minor details that are not a necessity for a human expedition.

The first priority of these surveying missions should be to gather information for the critical decisions of the human expedition. One of the most critical decisions of the expedition is the determination of the landing sight. The landing site must posses many characteristics that will not only protect the astronauts from exposure on the Martian surface, but it must also possess good scientific research material. For example, a landing sight that is very well sheltered may not be the best choice if it is too far from areas of scientific interest. Therefore, we must use all our current knowledge to scout locations that would best serve the purpose of the first expedition. Then the remaining survey mission could be used to scout these possible locations, and determine the final landing sight. Of course, this decision would be highly dependent on the ultimate goals of the first expedition, which is another aspect of preparation that must be discussed.

It will be a great technological feat when we finally send a human expedition to Mars, but what are these astronauts going to do once they arrive on the Marian surface? The answer to this question is directly related to what we would like to do with Mars. For example, if our ultimate goal were to colonize Mars, then we would want to focus the expedition on investigating the possibilities of sustaining people, supplies, and food on Mars. However, if our ultimate goal were to just explore and learn more about the planet we would want to perform a wider array of tests and experiments. In other words the ultimate goal of our first expedition to Mars is directly related to our expectations for Mars. We will assume that our ultimate goal as a human civilization is to eventually colonize Mars. Therefore, the first expedition will be focused on task such as finding possible locations of water, natural shelter, and modes of transportation, with the ultimate goal of determining methods of sustaining life for an extended period of time.

With this being said the next important decision that must be made is who is going to be sent on this first expedition. Some believe that it would best serve us if we sent scientists because they are the most capable of performing the needed experiments and determinations. However, others believe that astronauts must be sent because they are the only ones that posses the training and knowledge of operating vehicles and apparatus in space. Therefore, it would best serve the expedition if half of the crew was astronauts, and the other half was scientists. This would allow the crew to be knowledgeable in both fields, and would most likely be more productive than crews made up of all astronauts or all scientists. Although the exact number of people to be sent is not known, a good guess would be three astronauts and three scientists. The astronauts would be made up of a pilot, a copilot, and a general-purpose expedition overseer, and the scientists would be made up of a chemist, a geologist, and an agriculturist. This crew would best serve the purpose of the first expedition having all areas of expertise covered.

Now that the goals of the expedition have been established, and the crew has been determined the next step of the preparation would be developing an itinerary for each crewmember involved. This would assure the best use of the resources that are being sent to Mars. If each individual crewmember has his or her own tasks more work can be accomplished. If the tasks are aimed at the individual crewmembers area of expertise the job will get done more efficiently than if someone else was doing it. Obviously, the astronauts' task would involve flying the spacecraft and operating the space vehicles on the Martian surface, while the scientists' goals would be gathering scientific information and performing scientific experiments. In addition, the itinerary would assure that no time was wasted, each day could be mapped out and a schedule could be made. This would assure that all information that is wanted will be gather in the time that they are on the surface.

Another extremely important part of the preparation would be the development of the launching device and spacecraft that takes the crew to Mars. The planning that must go into these devices should start as immediate as possible. As discussed before, it is going to be a great technological accomplishment; therefore it is going to involve a lot of time, money, and planning. Currently, there does not exist a lunching vehicle that can accomplish the feat, but it is not technologically beyond us to develop such a vehicle. Exact calculation would have to be taken to determine the weight of the payload that is to be delivered to Mars, only then will engineers be able to determine what kind of vehicle will need to be used.

These are just some of the major steps that must be taken in order to properly prepare for an expedition of this magnitude. Ultimately every little detail of the expedition should be covered and documented. The more prepared that we are for this the less likely something major will go wrong, but as history has taught us we should always be ready for the unexpected. In the next section we will propose a scenario of how we see the first expedition unfolding. We will document all of the preparation and activities involved in accomplishing the first human expedition to Mars.

C. Human Expedition

The first human expedition to Mars will be the greatest moment in space technology history to date, and will also be considered humanity's first real effort to explore another planet. The technology and information used in this mission will encompass years and years of past research and development. It will require large amounts of financial backing, and political support from industries and countries all around the world. The eyes of the world will be focused on every little detail of the mission and its goals. Therefore, this mission will be the focus of NASA's space program for many years leading up to the final mission date. NASA will require the support of the nation and humanity to accomplish this feat. The following is a detailed look at how this first human expedition to Mars could play out.

The first step of any space mission is the planning that goes into deciding on whether or not the mission can and should be done. With our current knowledge of the planet Mars, and the limitations and abilities of our technology it is feasible that NASA will find that a human expedition to Mars is possible and should be their next major goal. Therefore, NASA's first step is to announce to the public that starting in January of 2003 NASA will begin the preparation for the first human expedition to Mars. They will set an approximate deadline for sometime in 2007 for the actual mission to take off, but the exact mission date will be determined at a later date. The purpose of this announcement is to spark interest in the space program, which may help send some extra funding to the program. In addition, it will give the United States as a whole something to look forward to, it will give a sense of accomplishment to the nation. If possible NASA could try to get President Bush to support the idea like Kennedy did in the 60's for the Moon Mission. The Presidential support will give the mission a higher priority in the eyes of the public, and will give the nation a common goal to work towards.

Once NASA has established their goal they will be able to start planning and preparing for this mission. With a four-year preparation phase NASA will be able to take their time and make sure everything is done right, but they will still have to use almost every portion of NASA's resources. The best way to start the preparation is to break up the major tasks and assign them to a particular group or organization inside NASA. The four major tasks for the first stage of preparation are developing the launching vehicle and the landing vehicle, deciding where to land, developing the living quarters, and deciding what will be brought. These are four distinct tasks that are all critical to the mission and to each other. For example, the launch vehicle group will need to be aware of the size and weight of the living quarters and the amount of cargo to be brought. That is why all four tasks must be accomplished simultaneously. The groups should be made in such a way that the people involved in each task are knowledgeable in that field. For example, it would be most beneficial to have the Jet Propulsion Lab involved with the development of the launch and landing vehicles.

First, we will look at the task of deciding where to land. This is a good starting point because it is not dependent on any of the other groups, but the other groups are dependent on the decisions made by this group. With the recent discovery of significant deposits of frozen water in the South Pole region of Mars, it is obvious that any mission to Mars would want to be fairly close to these deposits. However, the climate in that portion of the planet is not ideal for a human expedition, it can get extremely cold and windy. This can pose problems to the individuals on the planets surface and any equipment that is exposed to the elements. Therefore, the best location would be somewhere in between the South Pole and the Equator. Of course, it would have to be close enough to the South Pole that the astronauts can get there in about a half a day or so traveling on the Planet's surface. With this in mind the best location for the landing sight of the expedition would be one that is just off the ice cap, and inside some kind of natural shelter like a crater or mountain terrain.

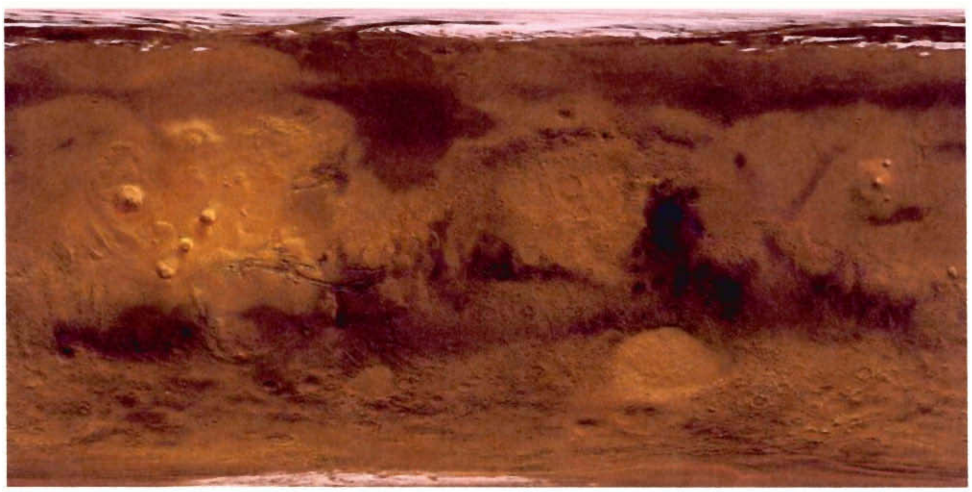

Figure 9: Map of the Martian Surface[9]

From **Figure 9** it is evident that there is rough terrain just above the western portion of the South Pole. If the astronauts were able to land there they would be in a well-sheltered area with craters and stone peaks that could shelter them from the wind, and they would only be about141 miles from the center of the South Pole and only 50 miles from the actual ice cap. They could easily reach the ice cap on a rover in a couple

[9] http://marsoweb.nas.nasa.gov/landingsites/mer2003/mer2003.html

hours or so, and they would not have to worry about direct exposure to the wind and sand. Therefore, the best possible landing sight for the first expedition to Mars would be 67.5°W, and 22.5°S. Currently, NASA has never landed any vehicles on that portion of the planets surface; all previous landing sights were close to the equator. However, this location will be most beneficial scientifically for Martian research. If possible NASA would probably send an unmanned landing rover mission to this location to scout it before sending a manned mission. Currently, there are plans to send the Mars Lander Rover to Mars in 2003, but the landing sights are more equatorially centered. This could be changed though if the ultimate goal of NASA was to send a manned mission there in 2007.

Now that a location has been specified the group that is developing the living quarters can get a better idea of what type of shelter will be required. They will be developing a moderate size compartment that will be used to hold the astronauts for the entire journey to, from and on the Planet's Surface. It must posses all functionality that will be needed and must be as light as possible. This group will have to work very closely with the flight vehicle group because the living quarters will be coupled with both the launch vehicle and the landing vehicle. In addition to living space this module must have a cargo hold, but this part will be less complicated than the living quarters. This group will have two options when designing this craft. The first option will be to convert the current space shuttle, and the second option would be to design a new craft. The current space shuttle design is very old and may be too bulky to be used efficiently. Therefore, it is probably in NASA's best interest to develop a new craft that can be used, this craft would be specialized just to accomplish this mission.

This new spacecraft should be made up of a cargo hold that can hold the equivalent of about 22,000 kg, about the size of a tractor-trailer truck. It should also have a living space that can comfortably hold six astronauts, and a cockpit that controls the landing vehicle, which will get the astronauts to the planets surface and ultimately back to Earth. The living quarters will have to allow for enough room for sleeping, exercising, and general everyday activities. Also, it should have a port that allows the astronaut to leave the craft easily once they are on the Martian surface. Although designing the craft will not be as difficult as some of the other tasks, it will be very important. The astronauts will be living in this craft for well over a year, so they have to be as comfortable as possible.

Once the design for the spacecraft has been established the next major task will be deciding what to bring. This group will need to calculate how much food, water, and oxygen the astronauts will require for the entire mission, and they will also have to determine what kind of equipment and materials they will need to perform the desired experiments and explorations. During this whole process they must keep in mind the total mass of all the items they are bringing, and how much volume they will occupy. All of the supplies and equipment add up to the final weight of the payload and this final weight must be kept as low as possible. Therefore, this process is a long and tedious one and greatly affects the launch vehicle group.

First, we will take a look at the amount of food, water, and oxygen the astronauts will require for the mission, but before we do that we must determine how long the astronauts will be in space. In order to make a good estimate of how long the astronauts will be in space we must take into account all factors. First of all the journey to Mars will take somewhere between 7 to 8 months. Then the astronauts will need time on the Martian surface. Since the journey will be long they will want to spend a moderate amount of time on Mars, a good estimate would be about 2 months. Lastly, the journey back to Earth could take anywhere between 10 to 12 months. This is because the planets will now be further apart and the ideal trajectory will be lost. This comes to a grand total of 21 months; therefore we will want to provide the crew with enough supplies to last at least 21 months. However, in order to take into account trajectory errors and or other mishaps that could delay the mission's progression we should provide enough supplies for at least 24 months.

Now that we have estimated the duration of the mission we will be able to make an estimate on the quantity of supplies needed to complete the mission. First, we will look at the amount of food needed per crewmember. NASA uses a basic formula to calculate the base energy expenditure (BEE) of each astronaut and then supplies meals according to there caloric needs. The equations calculate the daily calorie intake for each crewmember according to weight, height, and age, for women, $BEE = 655 + (9.6 \times W) + (1.7 \times H) - (4.7 \times A)$, and for men, $BEE = 66 + (13.7 \times W) + (5 \times H) - (6.8 \times A)$. However, since weight is the most important factor in designing the food to be taken into space, NASA has limited the daily food consumption to 3.8 pounds per person per day. If we assume that each person will be taking the maximum amount we can calculate the maximum food weight for a six-person crew. They will need food for 730 days at 3.8 pounds per day, giving a weight of approximately 2,774 lbs of food per person and a total food weight of 16,664 lbs. for the entire crew. This gives a mass of approximately 1,700 kg. This value is most likely on the high side, but it is better to calculate for the worse case scenario.

Next, we will take a look at the amount of water needed for each astronaut. Currently, there is a system on board the shuttles that can be used to make the amount of water needed per person extremely low. The fuel cells, which produce electricity by combining hydrogen and oxygen, provide ample amounts of water for the rehydrating of foods, drinking, showering, and other daily uses. However, a small amount of water should be kept on board in case these fuel cells fail and the mission is aborted. We should plan for a maximum amount of abort time lets say 10 months, but we should only need about half of the normal intake of water, since the normal intake is about 1 liter a day we will figure for 0.5 liters a day per astronaut. Taking into account the 300 days and the six-person crew we get a total emergency water supply of 900 liters, which is roughly 900 kg.

Lastly, we will take a look at the amount of oxygen needed for the long journey. It is reported that on average the human body needs about 0.83 kg of oxygen per day. This means that a six-person crew will require about 5 kg of breathing oxygen a day. This means that for the entire 730-day trip the astronauts will require about 3,650 kg of oxygen. However, this number may be reduced with the help of the MIP. If the MIP can be tested before hand on one of the exploratory mission then the astronauts would be able to use this device on the planets surface instead of there cabin air. In addition, a similar device could be used to refill the oxygen tanks while on the Martian surface so that the total oxygen required could be reduced by almost one half.

Having calculated the amount of food, water, and oxygen that the crew will require for the mission, we can now estimate space we will have for equipment and materials. Fortunately, although all of the supplies do take up a significant amount of weight the actual space they use is very small. Therefore, the only factor we will need to keep and eye on is the total weight of the desired equipment and materials. A good estimate for the weight of the equipment and materials would be about 15,000 kg (≈150,000 lbs). We believe this would be more than enough weight for any vehicles or test equipment that will be needed; keeping in mind that most of the equipment will be specifically made to accommodate the weight limits. Therefore we can now give an estimate of the final deliverable payload. The food, water, and oxygen all add up to about 10,000 kg, the crew will be about 450 kg, and the equipment and materials will be about 15,000 kg. This yields a grand total of 25,450 kg. (≈250,000 lbs.) to be delivered into space.

Now that we have calculated the payload we will now be able to determine the type of launch vehicle that will be required to get this payload to Mars. Fortunately the launch vehicle group will have the ability to send this payload into space in pieces. With the existence of the International Space Station (ISS), NASA will be able to send the payload into orbit in smaller, easier deliverable payloads. These payloads can then be combined with the final vehicle, while docked with the ISS. This means that the initial task of escaping Earth's gravity will not be as difficult as previously believed. Once all of the components are assembled we will need to know the approximate total weight of the payload, vehicle, and fuel so that we can calculate the fuel needed for the trip to Mars. Let us assume that the shuttle used for this mission will weight about the same as one of our current models. Therefore, the vehicle will weigh about 150,000 lbs (≈15,000 kg.), the payload weighing about 250,000 lbs. (25,000 kg.), for a grand total of 400,000 lbs. (≈40,000 kg.). Using the Ideal Rocket Equation we find that a spacecraft of this weight will require about 54,000 kg of fuel to get to Mars. However, this does not take into account the weight of the fuel needed to land and return home. Taking this into account the Ideal Rocket Equation yields 77,743 kg of fuel, not including the amount of fuel needed for landing because it will be significantly smaller in comparison. This would take up about half of an average space shuttle's fuel tanks. Meaning that if the space shuttle is refueled on the ISS this launch vehicle could easily carry the needed payload and fuel to get to Mars and back.

Having completed the preparation phase of the mission it is clear that a manned mission to Mars is realistically within our technological reach. In addition, to the preparation discussed above, NASA will need to design a communications system for the mission and many other smaller items. However, the four-year preparation should be more than enough time to accomplish all of the tasks that are required of a mission of such a large scale. The design and manufacturing of the shuttle, launch devices, and equipment will most likely be the largest expense. Hopefully, we will be able to take existing technology and adapt them so that they can be used for the Mars Mission.

Now that we have discussed the preparation and events leading up the mission let us now discuss who will be going, and what they will be doing. We determined that the ideal crew for the first mission to Mars would consist of a pilot, co-pilot, equipment engineer, chemist, geologist, and an agriculturist. Thus half of the crew would be highly skilled astronauts, while the other half would be scientists. This would assure that each individual experiment or task is being completed correctly. The crew will need to be in good physical and mental shape, and must be prepared for the long journey ahead. Most likely individuals with few attachments will be chosen, as they will be gone for 2 years.

During the 8-month journey to Mars the pilot and co-pilot will be busy making sure the shuttle is on track. In addition they will be attempting to keep in contact with Earth for as long as possible. The equipment engineer will maintain all of the equipment to be used on Mars as well as the space shuttle itself. It will be the equipment engineer's job to make sure the space shuttles fuel cells are working properly and that all devices on the space shuttle function as intended. The scientists will most likely perform some zero gravity experiments during the 8-month journey. Why waste the time sitting around when they could be performing experiments that cannot be done on Earth? Once they land on the Martian Surface the pilot and co-pilot will begin preparing for the return flight. They will have about 2 months to make any fuel that they will require for the journey home, and they will also have to calculate the trajectory for the return trip. The equipment engineer will once again be taking care of the shuttle and the Martian Land Vehicles. It will be his job to make and repairs that are necessary. The scientists will be busy doing experiments on the Martian soil and South Pole region. The chemist will perform a wide array of tests on the soil, ice, and air of Mars. He will be checking for impurities or any elements that could prove useful. The geologist will be looking at the terrain of Mars. He will also be investigating the possibilities of life forms past or present on the Martian Surface. The agriculturist will be taking many samples of soil and ice from different locations on the planets surface so that he may attempt to establish agriculture using the Martian soil and water.

For each leg of the journey the crew's responsibilities will change, but that is the exact reason for the diversity of the crew. The first manned expedition to Mars will be a difficult and historic event, and that is why it is important to accomplish as much as humanly possible. This first mission will serve as an icebreaker for Martian exploration. We hope that the findings of this first mission will excite new interest in Mars, with the hopes that more missions will be financed. Ideally, these first few mission could establish some sort of base building for housing long-term experiments and expeditions. In the next section, we will propose such a building and discuss the means of getting it to Mars, and what purpose it will serve once it is there.

D. Base Settlement

We will try to paint a picture of what a habitable place would look like. We are going to look into different options such as domes, or living on the actual planet as well as explore the possibilities of how many people could live there at a time. We will also try to determine what kind of materials are going to be needed for the building of this "base on Mars."

One possibility of survival in space is living in the actual space ship that they would land in. This brings many possibilities of how to make it habitable and how the people could survive on it. It is possible that the space ship after landing could be made into the living quarters for the crew. The inside area or at least a part of the area would have to be filled with oxygen where the crew would be able to walk freely without space suits as they did during the flight. There would have to be space for exercise equipment since as we said before the low gravity environment has a very bad effect on the human body bones as well as the other bad side effects such as atrophy and the like. Artificial gravity therefore is a very important topic to research before this trip is made. In this kind of an environment the crew would also have to have some sort of a "plant" or vegetation room where they could produce some simple vegetation products for oxygen as well as food consumption. It is important to try to establish some sort of a food-growing network on Mars since it would allow for the bringing of many more important things in the space, which would have been taken up by food. Things such as medicine, tools for exploration, and other things that cannot be either made or grown on Mars should be brought up instead. Since the ship would be built on Earth it would not be possible to predict all of the conditions that might arise on Mars and therefore build a ship that would suit the environment perfectly. Due to this it is very important to send up people that would be able to fix any problems that arise. It is also very important to have an alternative living arrangement, which we will discuss next.

An alternative to living in the space ship would be to have a dome on the planet. This dome would have to be built on Earth and when the people got to the planet it would be easily inflatable and would either be independent or connected to the space ship. This would have to be made of special plastic material, which could withhold the temperatures, which exist on the Martian surface. This dome would have to be very similar to what we described earlier about the space ship and it would have to be checked often for any leaks or holes, which could be fatal to the people in it. The environment should be made such that the people would not have to wear space suits but if it is on the surface of Mars it might prove to be difficult to do that. There would also be a dome for growing plants, which would give the necessary oxygen to the people living on the planet. This would either be a separate connected dome or the same dome depending on the possible size it could be made. The weight of the dome though might prove to be a bad idea to carry into space instead of living in the ship due to the high cost of transport into space. There is however a plus to making these domes. When there are few people in space it is not a problem to have them live in the space ship but when you have a population that grows there might come a day when there is a need to have more room and people living in the domes.

It is also very important to look at where exactly these living arrangements would be made on the actual planet. From what we know about Mars so far, we realize that there are a few a choices. First, there is the equator; the equator would be a good place to settle since the weather is the most stable of the whole planet. The sunlight each day would be plenty in order to do the things that need to be done. The communication with Earth or a ship in orbit, for example, would also be better if they were at the equator. However, we also must think about the fact they are going to need water. There have been discoveries made that there might actually be frozen water on mars in the polar caps. If it were proven that this water actually exists and is drinkable, it would be a very important part for the people who would settle there. Therefore we have to also think of the possibility of making the base on one of the polar caps in order to benefit the people by having a steady supply of hopefully what will be drinkable water. Yet there is a dilemma, since as we mentioned before the quality of life on the poles would be much inferior to the life at the equator.

One idea for this dilemma is to have the actual settlement or base somewhere in the middle of the two places. This way the communication could still be good as well as the sunlight atmosphere and if the water is needed the pole could be traveled to by a rover device that they will have on the planet with them. This will be a good idea especially considering all the pros and cons of living in each one separately. This will certainly entails a lot of work due to the travel and setting up but will be very well worth the work.

However both of the suggestions that we have offered concerning the actual physical place of living might prove to be an either difficult or a bad idea and we might to think of yet another alternative solution. This would be making some sort of a living environment for the people in the craters of Mars. This might be a good idea since if there is a dome which starts underground they could be more protected from the radiation and the weather, and they could possibly look for minerals that exist in the craters and lower on the Martian soil and use them for their daily needs. As time passes it might be possible for the people to actually start using the native Martian available things in order to construct structures and tools. We have to realize that all of these options would be dangerous to the first few missions since no one can predict what a human would be like on Mars. Much research has to be done in order to figure out the best way to send a human expedition to Mars and how to make it survive.

E. Funding

Before anyone takes off toward Mars, we must first determine the financial feasibility of such an endeavor. After all, money is the most important fuel for this mission, and without proper appropriation can sabotage the whole project. By examining the financial needs of the Apollo missions in the 1960s, which saw the first man walk on the moon, we can assess what we need financially for the mission to Mars.

In the early 1960s when President Kennedy first pushed for a man on the moon, the nation was in the middle of an international "space race" with the Russians. Since there were tensions between the two countries, the U.S. was motivated to be the first country to complete this monumental task. For this reason, the goal was accomplished within the decade. If we look at the amount of money NASA was able to acquire during this era, we can impose a possible, albeit hopeful, trend on the current mission to Mars. **Table 1** shows the amount of money NASA received from the years 1960 to 1973, which corresponds to the initial research phases of the Apollo program, through the completed lunar landing in 1969, and continuing with successive missions to the moon:

Table 2: Appropriation of Funds (Billions of Dollars)[10]			
Year	NASA Budget	Apollo Budget	Manned Space Flight Budget
1960	0.5236	0.0001	---
1961	0.9640	0.0010	---
1962	1.6718	0.1600	---
1963	3.6741	0.6172	---
1964	3.9750	2.2439	---
1965	4.2707	2.6146	---
1966	4.5116	2.9674	---
1967	4.1751	2.9162	---
1968	3.9706	2.5560	---
1969	3.1936	2.0250	0.5464
1970	3.1138	1.6861	0.4227
1971	2.5550	0.9137	0.3150
1972	2.5077	0.6012	0.3075
1973	2.5099	0.0767	---

Included here are the amounts of money spent on the Apollo program alone and manned space missions. These figures (**Figure 10**) display an almost parabolic trend, one that we hope to see repeated for the Mars missions. It is important to examine the trends for both the entire NASA budget and the amount spent on the Apollo program. They are virtually identical, meaning that the percentage set aside for the program was nearly constant the entire time, with the proportions for the years before and after 1964-1970 tapering off a bit. This is important when considering our current program for Mars. If we keep this percentage constant, especially for lengthy periods of time, then we will be able to achieve our goal, at least financially.

[10] Data from <http://www.hq.nasa.gov/office/pao/History/SP-4205/app-h.html>
and <http://www.hq.nasa.gov/office/pao/History/SP-4009/v4app7.html>

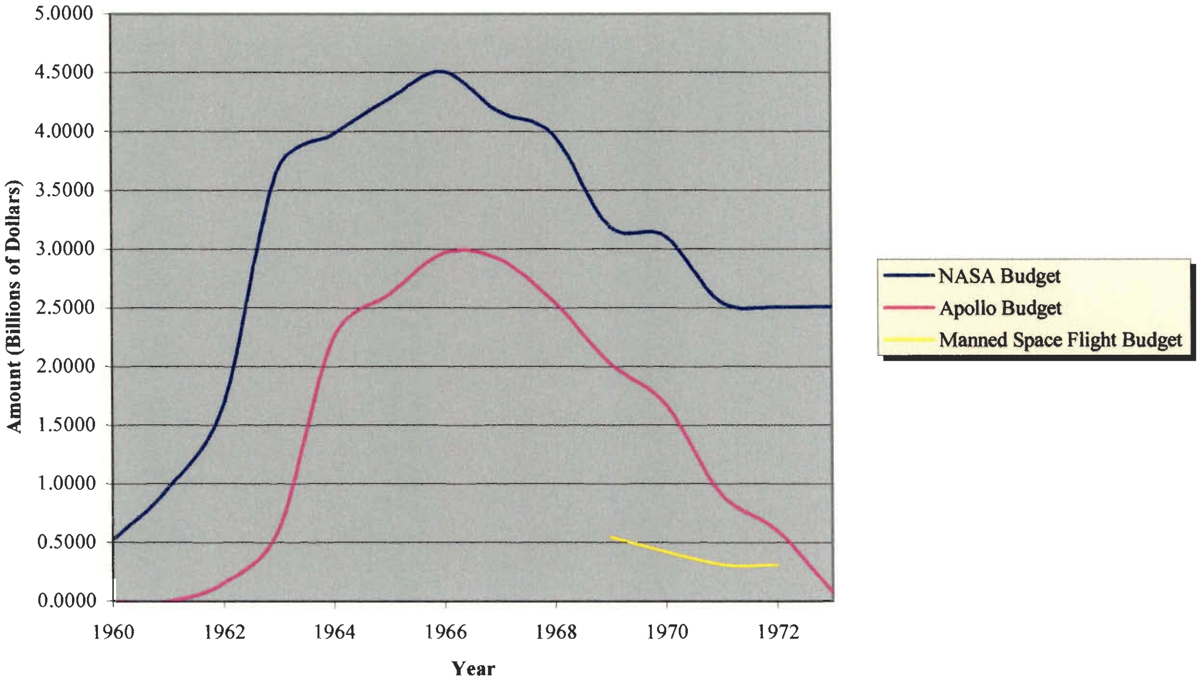

Figure 10: Appropriation of Funds

By themselves, these numbers have very little meaning. True, they can show the pattern by which money was acquired, but without the right scale, what good is that. Therefore it is essential to analyze the total amount of money the U.S. spent during this time period. Using the GDP (Gross Domestic Product), we can compare these numbers. In **Table 2**, the GDP is listed for each year, with the percentages of each budget listed next to it. We see a peak in 1965 at 0.621%, which would seem to suggest to us that this could be a maximum value.

Table 3: Appropriation of Funds (Percentage of GDP)

Year	GDP (in Billions)[11]	NASA Budget (%)	Apollo Budget (%)	Manned Space Flight Budget (%)
1960	519.8	0.101	0.000	---

[11] taken from <http://w3.access.gpo.gov/usbudget/fy2001/sheets/hist10z1.xls>

1961	530.9	0.182	0.000	---
1962	568.6	0.294	0.028	---
1963	600.2	0.612	0.103	---
1964	642.3	0.619	0.349	---
1965	688.2	0.621	0.380	---
1966	757.2	0.596	0.392	---
1967	811.7	0.514	0.359	---
1968	870.0	0.456	0.294	---
1969	949.4	0.336	0.213	0.058
1970	1013.7	0.307	0.166	0.042
1971	1081.7	0.236	0.084	0.029
1972	1178.5	0.213	0.051	0.026
1973	1313.6	0.191	0.006	---

Again, plotting these percentages allows us to see the trends that occurred (**Figure 11**). Although very similar to the previous figure, some fundamental differences can be noted. The shape is no longer very symmetric, with a skew to the earlier part of the decade. This would suggest that during this time, NASA furiously tried to complete this project, but then slowed down, perhaps realizing the imminent reality of the project. In fact, this agrees with history, since motivation was at a high soon after Kennedy made his passionate speech. After a while, though, the public began to lose interest, even when a moonwalking was nearby. Nonetheless, it is quite possible that this trend could reverse itself for the mission to Mars, meaning that the current lack of motivation could be quickly jump-started once people realize the importance of this mission.

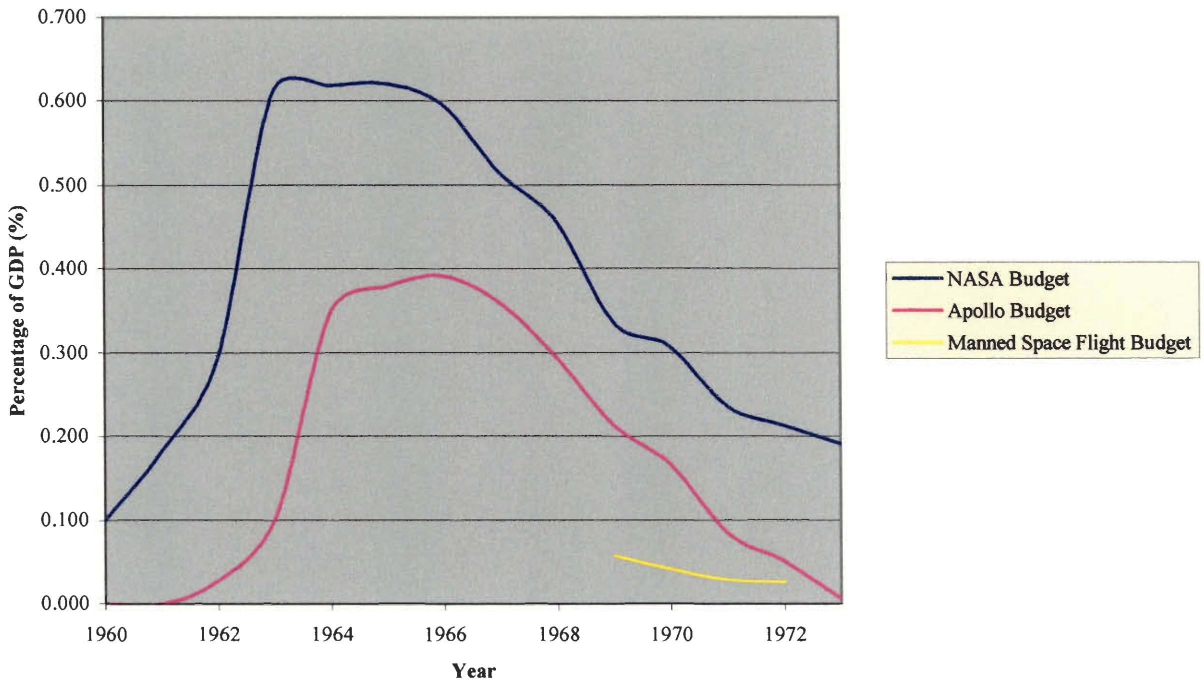

Figure 11: Appropriation of Funds (Percentage of GDP)

Another way to look at the amount of money NASA had during the Apollo program is to take into account inflation rates and convert the totals into a 2002 equivalent. This was done using a CPI inflation calculator, which uses the CPI (Consumer Price Index), a number based on the amount of money spent annually for goods and services in urban households. The results of these calculations can be seen in **Table 3**.

Table 4: Appropriation of Funds (in 2002 Equivalency) (Billions of Dollars)

Year	NASA Budget	Apollo Budget	Manned Space Flight Budget
1960	3.1451	0.0006	---
1961	5.7324	0.0059	---
1962	9.8426	0.9420	---

1963	21.3482	3.5862	---
1964	22.7985	12.8699	---
1965	24.1057	14.7580	---
1966	24.7581	16.2841	---
1967	22.2255	15.5240	---
1968	20.2866	13.0591	---
1969	15.4720	9.8105	2.6471
1970	14.2689	7.7265	1.9370
1971	11.2168	4.0113	1.3829
1972	10.6667	2.5573	1.3080
1973	10.0509	0.3071	---

In viewing these numbers, it is hard not to wonder whether we could attain that kind of money today. Suppose we want 20 billion dollars in 2005. According to the estimated Gross National Product of roughly 12 trillion dollars for 2005, this corresponds to less than 0.2% of the total. Clearly, this is a feasible amount. If, instead, we wanted the maximum we could attain, this would correspond to about 0.6% of the GNP, or 72 billion dollars. We easily see how these numbers get out of hand, but recognize that with increased public support, may become affordable in the near future.

So will our own mission to colonize Mars be as successful as the mission to the moon? Regrettably, there are many hurdles that we must overcome that we were not faced with in the 1960s. First, we currently lack the motivation that we had when President Kennedy first proposed such a plan. Currently we have no competition and, in fact, this time around the Russians are on our side. We would be doing this for our own personal satisfaction. Another drawback is the overall lack of interest in space flight. The reasons for this could be a number of things, but it seems as though we have not been able to out-do putting a man on the moon, and the space program has hence lost much of its appeal, despite the amazing technological breakthroughs that occur each year. The question arises; why wouldn't the colonization of Mars sound interesting to people?

Again, while people will come up with several reasons, the bottom line is that this idea will take a lot longer than a decade to reach fruition. The hope is that once this program starts becoming a reality, people will realize the importance and will lend their support. We may not have the necessary motivation right now, but if we give it time, we may just achieve what we need. After all, it could be the greatest thing mankind has ever achieved in the history of its existence. And that is no small feat.

VII. Plan for Colonization

A. Who Goes

Now that we have seen how the Mars project will be funded, and who the first astronauts, as well as the first explorers to Mars will be, we need to look at the possibility of actually making a permanent settlement on Mars and having people go there without returning but building a small colony on the planet.

Here we will try to research and explain some of the different possibilities of people who could go. We will look at the characteristics and personalities these people will have to have. We are going to speak about their health; mental as well as physical, and we will even touch upon the subject of genetically altered humans who might be able to sustain the conditions on Mars.

We first have to look at how long the trip to Mars will take. With the current technology the trip to Mars will take somewhere in the high end of half a year or more. This means that the people who would go on this mission would have to be able to sustain such a trip. Supplies would have to be plenty, such as oxygen, food, and other necessities for human existence. There would of course be a chance of finding some way of putting the people to sleep in some sort of a hibernation technique with an IV so the would not have to have as many supplies as they would otherwise. If however they were not sleeping these people would have to be able to get a long with each other. Before the trip, many psychological tests would have to be run as well as physical tests in order to see which of the people could go on this trip and survive. When they get to Mars of course many unexpected things could happen and the psychologists on Earth might not be able to tell how they will react to things, which are completely new to them.

Besides the regular physical and psychological harm to the people we also have to think about events which human nature brings on such as strife between two peoples or people killing each other. This would hopefully not be a problem on the trip to mars since the selection process would have to be designed so as not to choose two peoples who hate each other to go on the trip. It is also very important to realize that in establishing a colony on Mars we cant just chose rich or smart people to go. People would have to be chosen to do some of the more menial work as well such as cleaning up the garbage and the like. This means that there will have to be extensive training for all the people who would be brave enough to settle that planet.

As we mentioned earlier another possibility of the choosing process is altering the genes of fetuses in uterus to make them more viable to live in the conditions that mars would bring. This altering of the genes would entail making them perhaps be able to stay up for extended periods of time without sleep or easily withstand a long commute to Mars without extensive need for food. There will be many pros and cons to these experiments since we do not know how it can affect the life span of the people that it would be done to. Even now we see that people are very against cloning and might also be against genetic alteration.

As we can see, there are many choices and possibilities of whom the first colony will consist of and therefore, we must be very careful about choosing and building a "team" of people who will successfully prove that humans are able to conquer even the fiercest of conditions and put people on the Red Planet.

B. Sustaining Life

In order to examine what is required for human survival on Mars, it is first necessary to look at the requirements for human survival anywhere. The absolute necessities include water, oxygen, and food. Simply put, the human body cannot function without these essentials. However, there are other things on Earth that we seem to take for granted in our daily lives. Some of the more important ones are protection from radiation and protection from the elements. On Earth, we have the ability to ensure our safety by satisfying each of these requirements. On Mars, however, we are faced with certain challenges. Basically, we are starting from ground zero, meaning that we must find "new" methods for sustaining life. Since we wish to establish a firm base of human civilization on Mars, these methods will in all likelihood, mimic those on Earth, with some differences in relation to the basic differences between Mars and Earth. These necessities of living, as well as other commodities, need to be analyzed, so as to determine exactly how to sustain a colony on Mars.

The most vital necessity for habitability on Mars is that of oxygen. As discussed previously, the atmosphere is almost entirely carbon dioxide. Therefore breathing apparatuses will be required outside the housing components. This would require the use of oxygen tanks at first, although as time goes by (with the possibility of terraforming and the advent of new technology), it may be possible to convert the carbon dioxide into breathable oxygen. However, although this may seem like an unrealistic endeavor, the creation of such a device may never be physically possible, due to the inherent composition of the carbon dioxide. The hope is that as the planet is terraformed, the atmosphere will become richer in oxygen, and a breathing apparatus, which could filter out the carbon dioxide, could be used. No mater what happens, it is desired to minimize the weight that would be transported. As it stands, however, oxygen tanks are the only possibility. As with much of the colonization, there may be alternative solutions, which are dependent on future technologies.

One of the most important elements in sustaining life on Mars is water. The problem is, however, that as we speak, no definite source of water has been discovered. There are many speculations concerning the possibility of ice water at the polar caps, but none have yet to be firmly proved. There are currently satellite missions that intend to answer these important questions concerning the existence of water on the planet, as well as the existence of life, past or present. However, it will be some time before we have a definite answer to this question, so right now we can only hope for the existence of water. But what happens if there is not an abundant source of water? Is there any chance we can maintain a colony without local water supplies? Clearly this is an impossibility, as the only other option would be exporting water from Earth, an extravagantly costly procedure that is well out of the limits of the program's financial means. In this case, the possibility of colonizing Mars is out of the question.

But suppose we do discover a source of water, one that is abundant enough to maintain human existence. What must we do? First off, the first civilization must be formed around this water source, no matter where it is. If there are multiple sources, then we merely choose the better location, as based on certain parameters: distance from earth, condition of terrain that is suitable for living, amount of radiation, etc. Once we have a location, we need to determine how the water is to be extracted and transported for use throughout the colony. During initial settlement, manual transportation will be required with the use of rovers or other vehicles. However, as the colony develops, a pipeline system will need to be constructed, installed with water purification devices, much like on Earth. Since water is perhaps the most vital necessity, this should be constructed right away, so as to minimize manual transportation while the colony expands. As time goes by, the construction of a sewer system will be of great importance, with emphasis on recycling as much water as possible. This will allow the development of a plumbing system, a modern necessity.

How will the colony obtain its food supply? Each voyage to Mars will contain enough food to last the entire trip, but what will the crew members do when they run out of food? We must determine a method of growing crops in the Martian soil, which will in turn allow for the production of food. Although there are certain things we know about the soil, we do not know if it is conducive to plant growth. During the initial exploratory mission, the soil will be tested, and the uncertainties concerning plant development should be laid to rest. If it turns out that we will be able unable to grow plants on the soil, then we will need to find another method. One possibility would be to import soil from Earth. At first this idea seem extravagant, but we must realize that the initial missions will have small crew sizes that would require only a specific amount of soil. Another possibility is to grow plants without soil altogether. Instead, they would be grown in an apparatus that supplied the necessary nutrients and water, while allowing necessary exposure to sunlight (real or simulated). While this idea seems primitive, researchers may actually have discovered a form of artificial photosynthesis. While still in the early stages, it is possible that the byproducts from the plants in this process could be used as fuel, or even as food. The advantages of such a procedure are clearly evident, especially if they can be made widespread. However, while the research looks promising, we cannot put all our faith into this plan. Therefore, we should approach this a future possibility, and recognize that we need a definite source of food on the planet.

Aside from the absolute necessities for human survival on Earth, there are many other things that must be considered to maintain an overall sense of happiness. In short, the people who make up the colony must have sources of entertainment. What we wish to achieve is a level of comfort that parallels Earth. Whatever we enjoy doing here, we should try to bring to Mars. This tactic works fine for books and games, but what about television and sports? Would it be possible for television broadcasts to reach Mars? It would seem so, but if not, then we would need to position additional satellites in Mars orbit. If this was unable to link the signals, then we may be faced with the possibility of no television. To some, this is a great tragedy, but certainly videos and DVDs could still be used. As for sports, we would need to do some exploratory research, since the difference in gravity will have a profound impact on most outdoor activities. Since airborne objects tend to stay in the air longer on Mars, this may actually prove quite interesting. Since the people of earth tend to be fairly curious, we can only imagine the creative possibilities for sports. For instance, a game of football becomes quite different when the ball floats in the air for an extended period of time. However, this is only one form of entertainment, and certainly will not apply in a sandstorm, for example. It is therefore imperative to prevent "cabin fever" by determining a multitude of options for these people.

C. Initial Colony on Mars: A Glimpse into the Future

As the Sun rises, it shines its life-sustaining rays onto the planet's surface revealing from the darkness of the night a group of circularly clustered dome like structures. The domes vary in size starting from the center dome, which is the largest, and gradually decrease with each additional concentric circle. Each structure is masterfully constructed from metal and treated glass, which provides a strong foundation to protect against storms and the harmful effects of prolonged exposure to direct sunlight. All of the domes are interconnected to each other and ultimately lead to the center dome.

The center dome glows with activity, especially when compared to all of the other domes. Inside the central dome there are many buildings and structures. The center dome is divided into four major areas of interest. The center most buildings contain all of the government related offices. This is where town meetings take place, and where important decisions about the colony are made. A little further out lies the headquarters for the businesses and industries of the colony. These are the largest buildings, which are mostly filled with offices and act as a center of industry and finance for the colony. A little further out from that lies the entertainment district of the colony. These buildings are smaller, but more densely packed. Colonists visit this area when they want to relax and hang out with friends and loved ones. Finally, at the outskirts of the central dome lie the shops and the stores. This is where colonists go to find everyday necessities and commodities.

The middle region of domes is very similar to each other. They are all about the same size and look almost identical from the inside too. These domes are the housing domes, this is where the colonists reside and flourish. They are all architecturally identical, with identical layouts and land divisions. Although each house is allotted a standard amount of space, the colonists are given some freedom of expression. Each house is identical from the outside in shape and size, but the inside of the houses are customized to the family's tastes. This assures that the needs of all households, no matter how large or how small, are met.

The last region of domes are the smallest, but most numerous. These domes are used as centers of scientific research and development. In addition, some of the domes in the final circle are used as portals to the planet's surface. Industries and scientific groups use the portal domes to house their land vehicles and equipment, so that they have easy access to the planet's surface. In the research and development domes scientific organizations conduct experiments from materials gathered from the planet's surface. Their ultimate goal is to learn as much as possible in order to better the colony as a whole. The portal domes are also specialized according to what equipment they house. The planet's surface can be a very hostile environment so not all colonists are allowed in the portal domes.

The entire colony with all of its circles of domes is quite large. However, motorized modes of transportation are not permitted inside of the colony. This is to prevent the pressure and air quality of the domes from being compromised. Therefore, colonists use either electric or manually powered scooters. These scooters cut down on the area required to park or store vehicles because they easily fold up or can be stored.

Since all of the buildings are tightly organized and packed the scooters are ideal where car like vehicles would only congest movement. In addition, to personal modes of transportation there are also public scooters that can be rented for the day. These scooter rental places are located all over the colony in a similar sense as bus stops, and one does not need to return the scooter to the original location where they rented it from because all of them are owned by the colony.

Just outside the domed structures of the colony lies the device that regulates the pressure and oxygen level of the dome. It is a large building size machine that is made up of different parts. Its main job is to take the Martian air and convert it to oxygen in a similar manner as the MIP does. It stores the oxygen in large tanks and a separate machine regulates the amount of oxygen that is pumped into the colony from these tanks. Computers automate the whole process, but there are a few colonists that monitor the operation to keep the machines in proper working order. If the computer systems were to fail there is a backup computer system that runs in parallel with the original system. This backup system takes over if there are any problems with the original system. In addition, to providing oxygen for the colony the device also manufactures rocket fuel, and stores it in large fuel cells. This fuel is used to supply fuel to any shuttles that are heading back to Earth. Although this would be a rare event, so the Martian Land Vehicles would use the majority of this fuel.

Both scientists and industrial workers use Martian Land Vehicles. The scientists use these vehicles to transport themselves to different locations on the planets surface where they collect samples and conduct scientific experiment. On the other hand, the industrial workers use these vehicles to collect the resources that are needed by their particular industries. Many industries on Mars use the materials that are found on the planet to produce their final product. Therefore, efficient and reliable transportation devices are needed whenever an industrial worker needs to venture out of the safety of the domes.

Possible Projects for Scientists on Mars

- Collect Martian Minerals
- Investigate Unknown Elements or Compounds on Mars
- Investigate and Document Chemical Processes on Mars
- Investigate and Document Physical Processes on Mars
- Investigate Possibilities of Past Life on Mars
- Learn More about the history of the Martian Planet
- Aid Industrial Organizations in Manufacturing on Mars
- Use Mars as an Observatory for Further Investigation of the Galaxy

The most important industries that use materials found on the planet's surface are the ones that provide food, and water. Water is found and purified in a similar manner that oil is processed on Earth. All over the Martian surface there are many tall structures that house water drilling equipment. These devices drill into the surface where water is located and then pump the water up to the surface. Here the water is sent through a pipeline back to the colony. Once it arrives at the colony it is purified in purification facilities located in the outside circles, and then distributed to the colony. Food on Mars is not very different from food on Earth. Just like on Earth livestock is raised and slaughtered for food, but this all takes place inside the domes. However, farming on Mars works slightly differently then on Earth. Agriculture industries use small greenhouse like structures on the planet's surface to grow their crops. The structures are not as sturdy as the domes. Their purpose is to protect the crops from the harsh sand and bitter cold spells that are common on the planet's surface. Martian soil along with purified water is used to maintain the crops. Just like on Earth crops are harvested by vehicles and then are transported to the center of commerce for sale.

The economic structure of the Martian colony is very similar to how Earth's Economy functions. In addition, to the food, water, oxygen, and technical industries there are many different jobs that colonists can do on Mars. There is a functioning government that requires government workers and elected officials. Also, the financial district is made up of offices that require secretaries and accountants. For the lesser-educated colonists there is a large entertainment district that is made up of bars, restaurants, movie theaters, and other entertainment based establishments. The Martian colony is not just for the rich and powerful. Over time it will offer opportunities for people of every class.

As the sun sets, marking the end of another Martian day, the colony begins to glow from the inside out. The electricity that has been gathered by the solar panels on the planets surface could power the city for the days. However, this seamlessly endless supply of solar power returns day after day to replace the power that was used the previous day. The same sun that forces them to live in domed enclosures, allows them to live in convenience everyday of their lives. Just like on Earth the colony on Mars flourishes and thrives because of humanity's ability to adapt and conform to the environment that surrounds them.

Open Problems

- Space Travel – Although it is reasonably possible to complete a Martian expedition with our current rocket technology, it would be extremely helpful and more efficient if faster methods of traveling through space could be developed. There were many theoretical and experimental methods that were very promising and could be investigated further. In the coming months and years we expect rockets like the plasma drive rocket to be used by NASA, making space travel more efficient and faster.
- Martian Energy – Many different ways of generating energy for a Martian colony were discussed. We found that solar panels would most likely be the best option for the early Martian colonies. However, we believe that their still exists many alternative ways of generating energy on Mars. Although this was not the focus of this report, we feel that a further investigation into alternative energy sources would be very helpful to an initial colony on Mars. It may be found that these alternative energy sources may not be as efficient as the more obvious ones, but we feel they still deserve consideration.
- Search for Water – During the completion of this report it was discovered, by NASA's Mars Odyssey Spacecraft, that there was an extremely good chance that water exists at the South Pole of Mars. In this report we assumed that the report made by NASA was true. However, the methods used to determine this do not prove without any doubt that water exists. The device that NASA used measured hydrogen ion concentration over the South Pole and from their reading NASA

determined that there was most likely significant water beneath the Martian surface. It is imperative that we have definitive proof of water before we begin any plans for colonization.

- Muscle Loss and Bone Atrophy – We discussed in detail the effects of prolonged exposure to the zero gravity conditions of space. Many possible solutions to this have been proposed, but none of them are concrete solutions to the problem. Although these issues should not affect the first couple of expeditions, it is important to investigate the effects of living in a reduced gravity environment like Mars for an extended period of time. Currently, NASA does not have a method for maintaining muscle and bone mass in space as yet, but perhaps with the help of the ISS NASA will be able to perform experiments in order to develop precise methodology for overcoming this issue.
- Radiation Effects in Space – It was discussed that any manned expedition to Mars would have to contend with increased exposure to radiation from the sun. The Martian atmosphere is not as thick and protective from the sun as Earth is and therefore could prove dangerous to the astronauts. However, with the increased damage to Earth's ozone layer it is uncertain just how different the radiation levels are. It is the opinion of the author that over time Earth's atmospheric protection form radiation will continue to decrease. Therefore, it may be necessary not only to develop protection on Mars, but on Earth as well.

Conclusions

As it stands now, it will be years before a colony begins to develop on Mars. This is a monumental project and it will be years before it is completed. Nonetheless, we can look at each step we take toward achieving our goals. Clearly our first desire is to see a man on Mars. This possibility could very well be a reality in our lifetimes. With enough funding and enough interest, there is very little to prevent this from happening in the next thirty or forty years.

As time goes on and technology grows more and more formidable, stunning new options for space travel will present themselves, rendering today's methods virtually obsolete. Part of the excitement of this mission is knowing that this will happen. When we construct the most magnificent rocket ever imaginable, we always know that some day there will be something better. For this very reason, we know that some day there will be a faster more efficient way to travel to Mars. Some might argue that it is not really worth our effort when our descendents in the distant future could easily perform the task. But why should we let our sons and daughters, our grandsons and granddaughters take all the credit? We have the opportunity to etch our names in the history books as pioneers. If we do not accept this challenge, then what kind of men and women are we? If we have the chance to create our own futures, to shape our own destinies, then to back away from that is nothing less than a travesty. The torch is in our hands. We know what to do with it.

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