03C019I

Project: JMW-LUNA -46

The Possible Future of the Chinese Manned Space Program

An Interactive Qualifying Project Report
submitted to the Faculty of
WORCESTER POLYTECHNIC INSTITUTE
in partial fulfillment of the requirements for the
Degree of Bachelor of Science
by

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Date Submitted: February 26, 2003

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Table of Contents

Figures and Tables

Prelude

In order to better understand how China might develop a space program that involves plans beyond that of manned space flight, I have also studied the social aspects of Chinese life. This involved studying the country, the people, and ultimately trying to understand how they think about technology and progress as it relates to the space program. To help me think the way a Chinese scientist may think, I have created the role and assumed the persona of a senior member of the Chinese Space Program. For the sake of this paper, I will call him Wei Chen. The thoughts and discussions that occur from this point up to and including the Conclusion are Wei's thoughts and ideas.

Wei was one of the senior engineers and planners loosely associated with the Chinese Academy of Science and Technology (CAST) that is responsible for manned space exploration. He earned his BSEE from Beijing University and his MS and Ph. D from Worcester Polytechnic Institute (WPI) in Aerospace Engineering. Upon returning to China in the late 1980's, he worked with a team of developers on the next generation Long March rockets and was a key contributor in the design of the guidance, navigation, and communications systems on the Shenzhou capsule. Since 1998, he has worked as a professor of Aerospace Studies at Beijing's Tsinghua University but is still retained as a consultant to CAST. At the University, Wei has a group of dedicated graduate students that work with him on issues involving the Chinese Space Program.

This paper is being written as an unsolicited proposal to the Chinese government and Party to put a Chinese pilot in orbit and begin a manned exploration of space. After studying the information available, I believe that the Chinese will want to seek a bigger prize than simply manned space flight, and for them, the Moon may be in their sights.

The reflections back on the US Space Program are from Wei Chen's viewpoint and show how China may view the outcome of those missions. In some sections, it appears that Wei is also searching for answers, and this may be the case based on the secretive nature of the project and the tendency of the Chinese to operate on a 'need to know' basis. In fact, their space program has been referred to as an enigma in a maze.

Introduction

In recent years, it has become apparent that the list of national players in the conquest of space has expanded beyond the Space Agencies of the United States and Russia. The European and Japan Space Agencies have made headlines with regard to satellite launches and participation in the International Space Station project. Through combined efforts from over a dozen nations, the world has a new outpost in space. But one country is determined to make it's own independent mark in the chapters of books on space history. That country is China.

Since the mid-1960's, China has been involved in developing launch capabilities that rival those of space-powers such as the United States, Russia, Europe (ESA) and Japan. The history of China's work with rockets dates back many centuries, to the first solid-fuel rockets used for pyrotechnic displays. This nation has come a long way from those early days, and based on the way the Chinese look at history, China will continue to push forward and excel in what could very well be the next space race.

Throughout the 1970's and 1980's, China designed and launched newer rocket technology than earlier projects. We realized the business potential involved in launching satellites into orbit, and utilizing their technical strengths, developed a series of rockets capable of launching payloads in excess of 5 tons. The family of Long March rockets now rivals the Ariane, Delta, and Proton rockets of the other three major space-pioneering nations. Only one thing separates China from it's larger rivals, and that is placing a human in space.

Whitepapers and public announcements that were made in the late 1990's indicate that this achievement is clearly in our sights, and whether we do it alone or with the help of another nation, it appears that we are on track to become only the third nation in the history of the world to put a man in space with their own technology. The United States and Russia were the major players in manned space exploration throughout the 1960's and 1970's, with each nation leap-frogging the other's achievements. This race seemed to sway one way in 1969, when two astronauts from the United States set foot on the Moon. No other project at that time was so monumental and involved the work of so many individuals. But it didn't end there as the Soviets had shifted their attention to Space Station technology. Throughout of the 1970's and 1980's, the United States and Russia continued to explore near space with manned missions, with each nation placing an orbiting facility, or space station, in near Earth orbit. Deep space missions were unmanned. In the last decade, Russia showed that it still maintained a strong hand in the manned exploration of space by keeping a badly damaged MIR space station aloft for more than a decade. More recently, through the efforts of many nations including Russia, the International Space Station is now an orbiting research platform a couple hundred miles above the Earth.

During the 1990's, China quietly developed a program that would also make it a major player in the world above our planet, and in November of 1999, it launched Shenzhou I, China's first unmanned capsule capable of carrying a man into space (Shenzhou means 'Magic Vessel' in Chinese). Since 1999, three more unmanned test flights have occurred, and it appears very likely that China will put a Taikonaut, our own version of an astronaut or cosmonaut, into Earth orbit soon.

One question that comes to mind is, "Why would China want to launch a person into space own?" I believe the answer to this question lies deep in the mind of the

Chinese people, who over many centuries have overcome much adversity and many challenges, often rising to the top. This most populous nation on Earth, at just over 1 billion people, appears to want a piece in the exploration of space. But where does it stop? China has long ventured into new areas of technology, and without a doubt, becoming one of only three nations to launch a human into space would be a major achievement.

However, both the Chinese and outsiders have written much on what may come after reaching this goal. One of those ideas is that China may wish to do something that no other country has been able to do: reach the Moon and create a permanent base or research facility there. Part of the reason that many people are left guessing at China's next move is that we hold our cards very close to our chest, not revealing much information until after a goal has been completed. Very little information was leaked out to the public in 1999 when the first Shenzhou mission was launched. Even in December of 2002, the world did not see the launch of Shenzhou IV until after it had slipped the bonds of the Earth.

As early as 1988, China hinted that it had plans to put a human in space, when photographs of men dressed in spacesuits were published in the Chinese propaganda publication China Pictorial. China has also released information about a program titled "Project 921", which includes three steps. The first, 921-1, is focused on the creation, launch, and recovery of a manned space capsule. The capsule for this design will be a three-person design that will allow us the most effective methods of working together in space. This design will also be required for a Moon mission, as three taikonauts would be the minimum crew size to support such an undertaking. Project 921-2 is listed as the development and assembly of an orbiting space station, and Project 921-3 is the design and use of a reusable spaceplane, similar to the United States Space Shuttle. All this publicity and attention leads many people to believe that the Moon, or even Mars, is in the sights of the Chinese Space Agency. However, we have kept our rivals in the United States and Japan guessing our next move so that they can not justify an attempt to pre-empt us. The last time we announced our intentions, the Japanese launched their own satellite into orbit, beating us by only a matter of weeks.

While the Chinese are following in the footsteps of both the United States and Russia, I believe we will choose to study the developments of the US Space Program through the 1960's and 1970's, so I will take the lead in this effort, without orders. Then, if the Moon is really on our list of goals, as I believe it is, I will be ready to take on a leadership role in the program. Since the United States is the only nation to place a person on the Moon, I will carefully study Projects Mercury, Gemini, and especially Apollo, keeping what my students and I feel is of value, and letting the rest remain as history. China clearly has the capability of launching a human into space, and with the well-documented history of the US achievements, I believe we will look at the American example as a way to help us create a template for planning a trip to the Moon.

The primary sources of information on the plans of the Chinese Space Program are in the form of whitepapers and public statements made by China. Some books and magazine articles also talk about what has been done, and what is publicly stated as goals of the program. While not publicly flaunted in China, we do not keep our successes hidden, and the Chinese press appears to cover the efforts of the program in detail. As for details on the United States space program, much has been written and released with great technical detail. It is also for this reason that I believe the Chinese will look toward the past of the US Space Program to help shape our future.

In this paper, I will focus on three major areas: what the Chinese space program has accomplished to date, what it may utilize and borrow from the US space program, and where it may be headed. I will explore the possibility of the Chinese setting out to create and maintain a permanent outpost on the Moon, and the reasons why this may be a reasonable goal. And finally, I will outline what I believe are the steps needed for China to achieve this goal.

While Project Apollo gained the most knowledge from reaching the Moon, the main reason I am including Projects Mercury and Gemini in this analysis is that China will be starting from the same point that the United States did in 1961, without any experience in manned space flight. While it took NASA almost a full decade to reach the Moon, even with advancements in today's technology, I believe it will take almost as long, if not longer, to gather the information and develop the technology needed to sustain life on the harsh climate of the Moon. But from what is known about the perseverance of the Chinese people, I don't think we are in a rush to get there. To most Americans, history is measured in years and decades. To the Chinese, history includes many centuries of time.

Finally, the Chinese have an old fable titled 'The Moon Goddess, The Hare and The Lord Archer'. In this story, a Chinese woman named Ch'Ang O fled the Earth and went to the Moon to seek out the protection of a giant Hare. She left the Earth because she had taken pills of immortality that her husband, Ho Yi, had hidden from her. Her husband followed her to the Moon, and the Hare living on the Moon protected her, making the husband promise to forgive his wife. He did so, and built her a great palace on the Moon. To this day, on the 15th of each lunar month, Chinese people celebrate Ho Yi leaving his palace on the Moon to join his wife at her palace on the Moon. We call this the 'Moon Cake Festival', and many Chinese believe that the Moon is a sacred place that deserves their worship. Some believe that this story may be enough to motivate the Chinese Space Agency to travel to the Moon and symbolically lay claim to the lunar beauty, but again, this is only folklore.

The establishment of a base of the Moon is an achievable goal, one that makes me wonder why the Americans have not returned there in over thirty years? The Chinese Space Agency, if we put our mind to it, will not only match the achievements of the United States and Russia, but will surpass them and be looked upon as one of the three major players in the exploration of space.

The Chinese Program to Date

Most people do not view China as a space exploring nation but our past history and successes paints a different story. China built and launched its first primitive rockets about 800 years ago, well before the days of Robert Goddard, Werner Von Braun, Hermann Oberth, and Konstantin Tsiolkovsky. But these rockets were solid fueled and used more for celebratory purposes. So began the world's foray into fireworks, which greatly impressed the Mongols when they acquired 'black' powder from us, which they determined could be used to set fires within a walled city under siege.

Early Rocket Development

In the years following World War II, China began efforts to design and build missile technology for the defense of the nation. Although we were developing this technology on our own, China and the Soviet Union were both Communist allies, so one may theorize that they shared information. As Lewis and Litai put it in their book, *China Builds the Bomb*, they state that while times in China were harsh, the Chinese missile program was "a magnitude equal to America's Manhattan Project and postwar missile program combined". This single statement seems to indicate that China wants to be in this business for the long haul.

China continued this development throughout the 1950's, and in 1956, formed a separate organization, The Fifth Academy, that would work to focus on missile and rocket technology. While working with the Soviet Union, we accepted an R-1 missile in September of 1956, which was no more than a copy of the German V-2 missile from the war. The next year, we received two R-2 missiles, more sophisticated than the R-1, and in the second half of 1958, launched these missiles to understand their operation (Johnson-Freese, 1998).

One year earlier, the Soviets made history by launching the first satellite, Sputnik, into Earth orbit. This success seemed to both impress and interest the Chinese leadership, so in May 1958, Communist Party of China leader Mao Zedong added a new feature to the Fifth Academy's purpose. He stated that he wanted to "make artificial satellites". While this lofty goal was set early on, progress would be slowed in the years ahead. Famine and troubled times fell on China between 1960 and 1962, and the military was affected as much as the people were.

Similar to the way the United States began its own space program, China received its main push from the development of long-range missiles. In 1960, the Chinese took the knowledge they gained from the R-1 and R-2 rockets and developed the Dong Feng 1, or DF-1, rocket. Dong Feng, meaning East Wind, was initially intended to be the stepping stone missile for reaching the United States. During these years of the Cold War, developing Inter-Continental Ballistic Missiles (ICBMs) seemed to be on the mind of more that just two major players. The next step for China was the DF-2 missile, which was capable of reaching Japan. Plans were now being drafted for the DF-3, which would put the United States within range. However, due to economic and technical problems, the DF-3 program was cancelled (Johnson-Freese, 1998).

The plan for going from short-range to global missile capabilities was not something one could turn off like a switch. China had mapped out a plan to develop this technology through a series of incremental steps and only the rate of progress was at issue. In 1964, discussions on a missile that could reach the United States were initiated again. The plan broke the program into four manageable steps. While the DF-2 was designed to reach Japan, the DF-3 would now set a distance goal of the Philippines. Following that track, the DF-4 would be capable of reaching Guam, and finally, the DF-5 would put the west coast of the United States within range.

As the Soviet Union and China began to part ways, China's missile program also took on a new face. The previous Dong Feng missiles were replaced by the CSS (Chinese surface-to-surface) series of missiles. The first of this family was the CSS-1, which according to Johnson-Freese in her text *The Chinese Space Program*, was of little value as a weapon. Believed to use liquid oxygen in its system, the missile could not be stored for long periods of time. But the Chinese moved forward, and the CSS-2 missile was developed. This missile was capable of delivering a 2-ton payload. Noticing that the range of this missile was limited, the Chinese began work on the CSS-3 missile. This program would pave the way for the Long March series of commercial rockets.

The Long March Rockets

The Long March (LM) rocket is also referred to in many texts as the CZ rocket. CZ stands for Change Zheng, which is Chinese for Long March, but because the Chinese publicize the Long March name, that convention shall be followed here.

The first in the series of the Long March rockets was the LM-1. Clearly designed as a space launch vehicle rather than a medium-ranged missile, the Long March rockets were built off of technology acquired in the DF and CSS programs. In 1970, when China launched its first commercial satellite, the DF-1 was the launch platform that was used (Johnson-Freese, 1998). Since that time, development has progressed, leading to rockets that can launch heavier payloads. The Long March family of rockets has proven itself to be a fairly reliable and effective launch platforms. This is one reason that China is now looked upon as a satellite launch provider for nations around the world. No longer would the United States, Russia, and the European Space Agency be the only nations with launch capabilities. In the late 1990's, even the United States was launching commercial satellites from China on the Long March booster, marketed by the Great Wall Corporation. (Note: All rocket data and technical specifications in the next sections were gathered and collected from Johnson-Freese, 1998 and Space in China)

LM-1D

The LM-1D is the latest version of the first Long March rocket, developed in the late 1960's. The original LM-1 was used to launch China's first satellite, the Dong Fang Hong-1. One year later, another success followed with the launch of a scientific satellite, the Shi Jian-1. The newer version has never been used, but launches in 2001 were predicted. This light-duty rocket is designed to hoist payloads of up to 400-kg into an orbit altitude of 800-km. It may also be used to lift slightly heavier payloads into low-Earth orbit. While some reports also show the development of an LM-1C rocket, no proof has been presented to the public.

LM-2C

Next in China's rocket arsenal is the LM-2C rocket, which while still capable of launching satellites into low-Earth orbit, can launch heavier payloads to higher altitudes. While development started shortly after the launch of the first LM-1, the first test flight was not conducted until 1975. Capable of lifting payloads of up to 2500-kg, this rocket compliments China's launch vehicle lineup. According to the China Great Wall Industry Company, one of the primary space contractors in China, this rocket has seen a 100%

success rate, and data shows that it has been used in 22 launches up to June of 1999, including the launches of up to 7 communications satellites for Motorola. Designed to launch larger payloads into low-Earth orbit, the LM-2C is made up of two liquid-fueled stages, and a payload delivery module. While a modified version of this rocket makes payload delivery easier (using a new smart dispenser, the LM-2C/SD), little has changed in its design in over 25 years. A variation of this design, the LM-2D has been used in only two documented Chinese launches, and the only difference is a modified diameter of the payload section.

LM-2E

Clearly at the center of China's rocket technology is the LM-2E, one of the largest and most powerful rockets used in China today. Capable of launching payloads of up to 9,000-kg, this launch platform is considered by many to be the rocket of choice for launching the first Chinese Taikonauts into space. Developed using the proven technology of the LM-2C, this big brother passed its first test flight in July 1990. It is made up of a two-stage liquid-propelled rocket, similar to the LM-2C, but also includes 4 boosters connected to the first stage. While it has seen a few failures, this rocket has also been used to launch large payloads for other launch customers. A similar version, the LM-2F, was used as the launch platform for the first unmanned test flight in November 1999.

LM-3

The design of the LM-3 was conceived in the 1980's, and was designed to lift payloads of up to 1500-kg into a geostationary orbit. It is a three-stage liquid-propelled rocket, with the first two stages using a standard rocket fuel (UDMH), and the third stage using cryogenic fuels (liquid hydrogen and liquid oxygen). While never used to launch a payload, the LM-3 cleared the way for future rocket projects. Out of this development came the LM-3A rocket.

LM-3A

The LM-3A is a modified version of the LM-3 rocket and is capable of launching payloads of up to 2500-kg. With records current up to the summer of 2000, this rocket also has a 100% success rate, launching 5 payloads without a loss. It is the primary launch vehicle for placing satellites into geostationary transfer orbit.

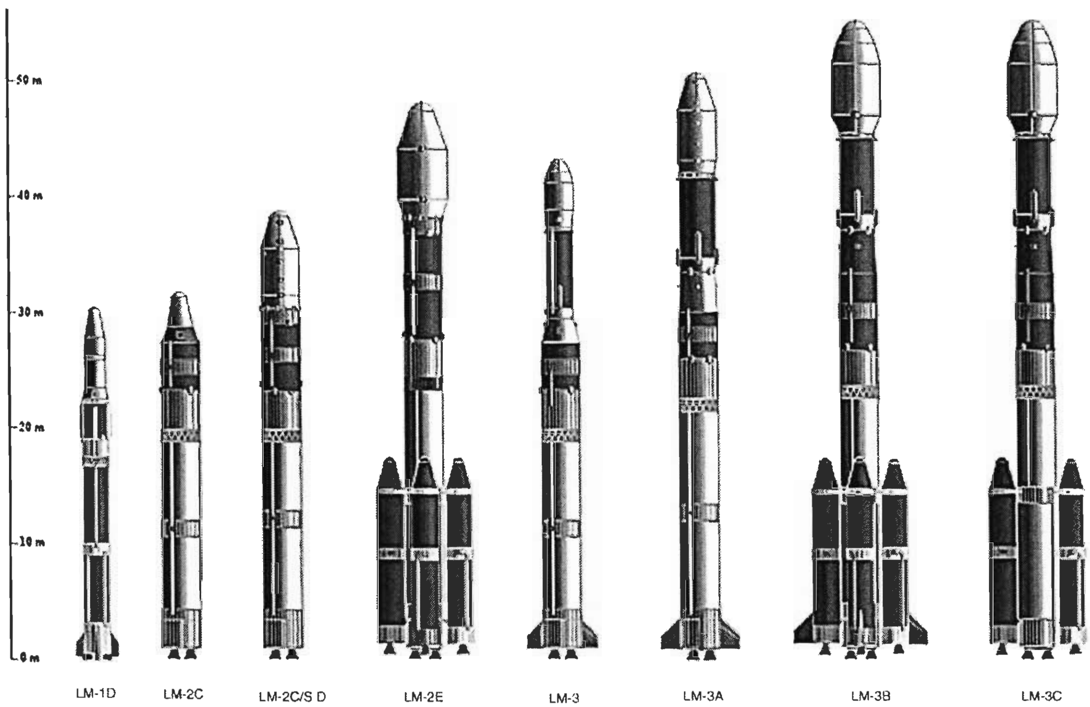
LM-3B

The LM-3B is a cross between the LM-3A platform and the LM-2E rocket in that it has the same three stages of the LM-3A and four boosters connected to the first stage. Design of this rocket began in 1986, and the first customer that signed up for payload launch was Intelsat, with its new (at the time) Intelsat 708 communications satellite. Unfortunately, the rocket and payload were destroyed on its maiden voyage. While this apparent setback raised concerns, the LM-3B has been successful in four flights between 1997 and 1998.

LM-4A

The LM-4A rocket is a 3-stage design that is capable of launching payloads of up to 2500-kg into a low sun-synchronous orbit. This orbit allows the satellites to conduct meteorological flights, further extending China's technical reach. This design is essentially a stretched version of the LM-2C, making the bulk of the design a proven machine. According to published records, this rocket has been used successfully in all 5 flights, with no losses. It is also similar to the LM-2D in that there are two payload section options available for better configuration.

Figure 1 – Long March Family of Rockets



(Photo courtesy of the FAS website, http://www.fas.org)

Satellite Technology

China's first venture into satellite design came in 1970 with the launch of the Dong Fang Hong-1 (meaning "the East is Red") communications satellite. According to records, this satellite simply broadcast the song "Dong Fang Hong" to the people of China. Looked upon as the United States does to the Star Spangled Banner, this song helped bring the people of China closer together.

The next step in satellite technology was clearly a giant one, with the development of the Fanhui Shi Weixing (FSW) satellite. This new design was not only feature-rich, but also offered a method of recovery, something not present in other Chinese satellite designs. Using the LM-2C rockets as the primary launch vehicle, these satellites have been used for everything from photo-reconnaissance and communications to remote sensing and microgravity experiments. Out of 16 launches since 1975, there has been only one failure in a return to Earth. There are three classes of these satellites, FSW-0, FSW-1, and FSW-2. While the FSW-0 satellites are no longer used, its primary role was that of surface monitoring (photo gathering) missions. The FSW-1 system is capable of carrying two 10-kg payloads and has been in service since 1988. And the FSW-2 satellite can carry a payload of up to 150-kg and has been available since 1990 (Johnson-Freese, 1998).

As an additional note, China has worked closely with other nations such as India and Brazil to develop lower-cost, higher-functional satellite technology. Primarily targeted at the Earth observation application, these joint projects may be just the right thing to allow China to continue to operate a for-profit launch provider. And even if China does not pursue joint development efforts with other nations, it is clear that we have a place in the satellite launching business.

Launch Facilities

China has four primary launch and support facilities throughout the country. While each of these is located in a separate geographic part of China, each has its own mission and specialized use. One common theme that can found throughout each launch center is the availability of rail service to the complexes. This is the primary method by which China moves rockets and equipment from one site to another. For many years, China has been a nation that has developed extensive rail service, connecting many of the major cities to lesser-populated areas of the country.

The oldest of the four is the Jiuquan Satellite Launch Facility, located in northern central China on the edge of the Gobi Desert. Built as early as 1958, this location was used for many years as a surface-to-surface and surface-to-air missile launch area. In more recent times, it has been used as the primary launch location of the LM-1D and LM-2 family of rockets that placed satellites in low-Earth orbit. This complex is really made up of two separate support bases, a larger one with around 200 buildings and a smaller one with storage and housing (Johnson-Freese, 1998).

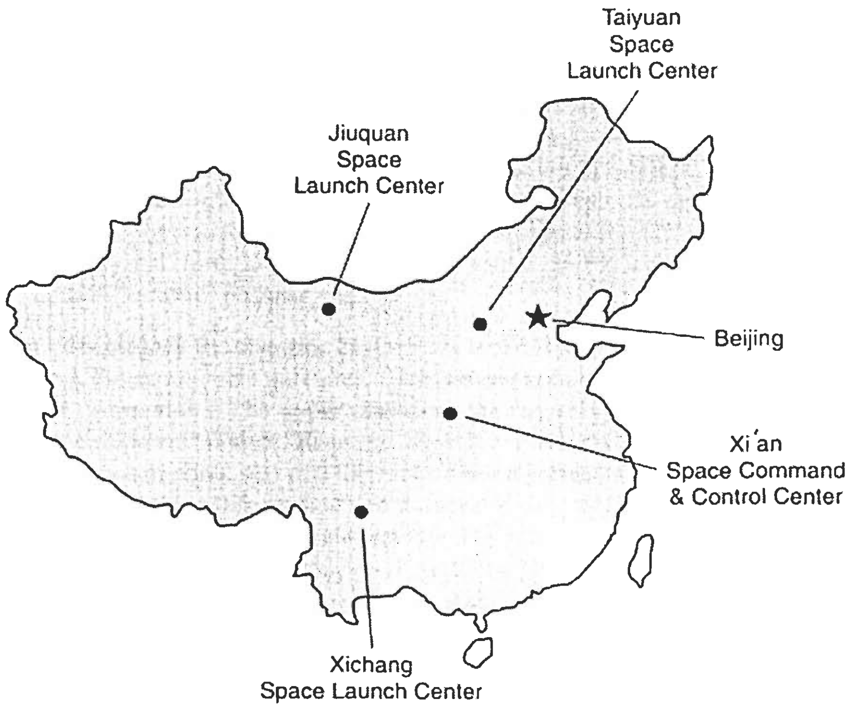
Next is the Xichang Satellite Launch Center, located in south-central China. This center supports the launch of most broadcast, communications, and meteorological satellites. From this southern location, all Chinese geostationary launches originate from here. The location of this base is believed to follow the lead of NASA, which located its primary launch site on the coast of Florida. Although this permits the United States to safely launch over water, China would rather insure that its launches occur and stay over Chinese soil to protect its national interests. The supporting offices and command and control centers are located away from the complex. There are two launch pads at this complex, each capable of launch LM-2 and LM-3 class rockets (FAS website).

The last launch center that has been used, particularly in recent years, is the Taiyuan Space Launch Center, located southwest of Beijing. This facility was built in 1988 and is has been previously used as a test site for the DF-5 and DF-31 Intercontinental Ballistic Missiles (ICBMs) (Johnson-Freese, 1998). Some US Space

Command reports also list the name of this site as the Wuzhai Missile and Space Test Center, even though the town of Wuzhai is located a good distance away. This launch complex is the primary center for launching all LM-4 class rockets and satellites designated for sun-synchronous orbits (FAS website).

Outside of the launch facilities, there are various locations dedicated to flight tracking. The only permanent and well-known one is the Telemetry Tracking and Control Facility in Xian (also known as Xi'An). These central locations support five other fixed tracking locations (at secret locations), three mobile, and two sea-based tracking ship stations. The complex at Xian is located southwest of the Taiyuan Space Launch Center and is primarily responsible for, in addition to mission tracking, the recovery of retrievable satellites (FAS website).

Figure 2 – Chinese Space Center Locations



(Photo courtesy of 'The Chinese Space Program', Johnson-Freese)

Project 921 – Unmanned Test Flights

As of the writing of this paper, China has successfully launched four unmanned test flights aboard the Long March series of rockets. While China has been launching rockets for over three decades, it has only recently begun working on the steps needed to put a human in space. Similar steps were taken by the United States in the late 1950s and early 1960s, as the rocket scientists were continuing to refine the techniques needed for a reliable launch vehicle. With its experience in developing rockets and launching satellites, China has already proven that we have the technology to reach orbital altitudes.

Starting in 1992, Project 921 was announced as China's manned space program. Similar to the United States and the Soviet Union, China acknowledged that we needed to first create the technology and infrastructure needed to safely put humans into space. While we had been launching satellites for many years, there were a number of tests that still needed to be developed. They include, but are not limited to:

- Guidance and re-entry procedures
- Life support
- Rendezvous and docking
- Construction of structures in space

While much of this technology has been developed and tested by other nations, I believe that we Chinese will try to create as much of this technology on our own as possible. In the fall of 1999, the first steps were taken.

China's first unmanned test flight occurred on November 20, 1999, when the space vehicle Shenzhou 1 lifted off from the Jiuquan Satellite Launch Center atop an LM-2F rocket (Shenzhou means 'Magic Vessel' in English). Viewed by millions across

China as a technological marvel, its impact reached much farther around the world. People throughout the United States and Russia were quick to realize that while this flight was unmanned, it would only be a matter of time before the Chinese joined them as the only nations to put humans into space. Ten minutes after launch, the capsule separated from the rocket and began to orbit the Earth. Over the course of the next day, scientists on the ground traced, monitored, and controlled the craft before returning it to Earth. It successfully touched down in the Inner Mongolia Autonomous Region in north China on November 21. (Note: Information and dates on these launches were gathered from the English version of The People's Daily newspaper.)

Fourteen months later, China proved that it was serious in its pursuit of space exploration by launching Shenzhou 2 on January 10, 2001. On this second flight, scientists performed experiments involving life sciences, materials processing, astronomy, and physics. China's President Jiang Zemin sent a congratulatory message to the scientists, engineers, and military officials on the successful launch of this nations second unmanned test flight. Entirely designed and built by the Chinese, the Shenzhou capsules were a source of tremendous pride. Unfortunately, there are rumors that the landing of the Shenzhou 2 capsule failed. Certainly, little or no press coverage was released to the public, which was a departure from the prior and following missions. The rumor is that the retro-rockets that fire shortly before landing to slow the craft failed, and the capsule was heavily damaged on impact.

Shenzhou 3 followed in similar style, roughly fourteen months after Shenzhou 2, blasting off from the Jiuquan launch complex on March 25, 2002. For the first time, China included mannequins (test dummies) that were wired to simulate human physiology in the capsule to test how a human may survive the launch and landing stages of space flight. Scientists also tested an emergency escape system on the capsule, something that would need to be proved before risking the life of a human. Just like the previous two missions, the Shenzhou 3 capsule was launched atop an LM-2F rocket. But unlike the missions of the past, officials decided to release information to the public prior to the launch. Whether it was normal on the previous flights in not known, but this time there were a number of delays that pushed out the launch date. It has been reported that these delays were due primarily to changes in the experiments packages aboard the spacecraft. China seemed to be moving forward with achieving the goal of putting a human into space.

Most recently, Shenzhou 4 rocketed into orbit on December 30, 2002. Reducing the time between launches to just over nine months, the Chinese Space Agency appeared to be ratcheting up its manned space program schedule. Similar tests as those performed aboard its predecessor were conducted on this mission, with emphasis on sustaining life in space. Although modified from the previous three capsules to provide more comfort for the two or three human passengers that would soon travel aboard, the majority of the systems remained the same. This flight also exceeded all previous time durations on orbit, allowing the scientists to gather more data from the experiments on how humans can live and work in space. Most significantly, the dummy passengers 'survived' the landing in Mongolia.

The Chinese Perspective on the US Space Program

For Chinese citizens, one of our primary dreams is to put a human into space, joining only two other nations that have succeeded in achieving that goal. While there are similarities to the Russian space program, if reaching the Moon is the central plan for the Chinese, it is my opinion that we will soon look back upon the efforts of the United States and learn from their missions.

While China has already proven to the world that we can successfully and repeatedly launch rockets and satellites into orbit, placing a human into space for any length of time remains new territory for us. In the late 1950's, the United States and the Soviet Union were developing their rocket programs from the ashes of the German V-2 missile development program. Both sides suffered technical setbacks, but eventually succeeded in not only launching satellites into space, but also sending humans into orbit.

In the United States, the National Aeronautics and Space Administration (NASA) worked for years perfecting its rocket technology. These efforts paid off, and in the spring of 1961, the first manned space flight in the history of the United States was completed, raising the stakes in what was clearly going to be a space race with the Soviets. Shortly after this launch, President John F. Kennedy made the bold step in proclaiming that the United States would put a man on the Moon by the end of the decade. This goal was achieved, but not without the hard work and dedication of tens of thousands of individuals that helped it become a reality.

Since the history of the US Space Program has been well documented, it is not the goal of this paper to repeat these efforts. Rather, I will briefly touch upon some of the technical achievements that China may refer to during the development of our own manned space program. Projects Mercury, Gemini, and Apollo each had major objectives that needed to be achieved in order to put a man on the Moon. In the following sections, I will outline the technical goals of each program and consider how China may benefit from that information, if it so chooses. The references section of this paper can provide the reader with a more detailed and thorough look at the US Space Program throughout the 1960's.

Project Mercury

There were two primary objectives for Project Mercury: successfully launch and recover a human from space, and study the capabilities of humans in the environment of space (Swenson Jr., Grimwood, and Alexander, 1966). But in order to achieve even these seemingly simple tasks, much was needed in order to make this first step a success. In October 1958, a commission established by NASA, and under the guidance of President Eisenhower, drafted plans for putting a man into space. It was almost one year since the United States had succeeded in launching its first satellite, Explorer, into orbit, and the Americans seemed interested in discovering if space could also be explored by man (Swenson Jr., 1966).

One of the first steps in this project was the recruiting and selection of a team of 'astronauts', a word with origins back to ancient Greece (Argonauts) and early ballooners (aeronauts) meaning 'space traveler' (Swenson Jr., 1966). The candidates were selected from the military, particularly from those within the ranks of test pilots and others in the field of aviation. Part of the reason for this was their physical conditioning and ability to be trained. In the spring of 1959, the first seven astronauts were introduced to the public, launching them at this point into the spotlight. Now that the men were selected, the machines needed to be created.

The manned space program of the United States launches its rockets from the east coast of Florida at a complex called Cape Canaveral (this name was changed in the late 1960's to Cape Kennedy, and later to Kennedy Space Flight Center, in honor of the late President John F. Kennedy). Selecting this location was based on two major objectives: that the launch not travel over populated areas in case of an accident and a southern location that would permit flights that could circumnavigate the Earth easily. Recovery of the launched spacecrafts would be performed in the ocean for a number of reasons, one of those being the number of ships in the US Navy. Another reason was that a recovery in the ocean meant the astronauts would return to a 'non-hostile' environment rather than landing in a foreign country with no friendly connection with the United States. In the early days of the US Space Program, these were all logistics that needed to be worked out.

Up until the success of Explorer, the United States was anything but a pioneer in rocket development. The first test flights of the unmanned Vanguard rockets were rarely successful, with failures ranging from engine shutdown after only a few inches of flight to steering off course and being destroyed remotely. Many wondered if the risk was worth it, but the work continued. Under the guidance of Werner von Braun, NASA modified the Redstone and Atlas rockets they acquired from the military, intent on making them safer for human use. This effort proved to be both a time saver and a more reliable method of putting a man in space.

The capsule selected for the Mercury program was intended for just a single occupant, and once all the computers and controls were installed, there was little room left for the movement of the pilot. Blunt at one end and coming to a dull point at the top, the capsule was designed not for comfort, but function. The astronaut would lie on his back near the bottom of the craft and have two small windows in front of him to allow exterior views. Once 'seated' in the capsule, the astronaut would be facing hundreds of switches, dials, and meters, all connected to various computer systems throughout the craft. Behind the astronaut's back was a heat shield, designed to withstand the temperatures of re-entry into the Earth's atmosphere. And while the capsule was propelled into space by a booster rocket, it was also equipped with maneuverable thrusters that allowed the craft to rotate, twist, and yaw in any direction. To return to Earth, a sequence of firings could slow the craft and position it for a landing target.

Early on the morning of May 5, 1961, Alan B. Shepard Jr. lifted off from Cape Canaveral on the coast of Florida atop a modified Redstone rocket. During his flight, Shepard took control of the capsule and rotated it through all the major axis. Although the majority of the trip was controlled by the capsule's computer, these tests were performed to make sure that in the event of a failure, an astronaut could take control of his ship and be able to maneuver it back to Earth. One major accomplishment came out of this test: Shepard reported that the feel of the fly-by-wire system was very accurate and close to that of the trainer used on Earth (Swenson Jr., 1966). This was an important milestone because the training these astronauts received before their missions would be crucial in assuring NASA that they could handle any incident that arose on a flight. Although his flight lasted a little more than 15 minutes and was only sub-orbital, it proved the function of the life support system aboard the craft. However, it bothered the Americans was that the Soviets had beat them at this first stage of the space race by orbiting a human just three weeks earlier. Yuri Gagarin would go down in the record books as the first human in space.

Within a couple months, the United States repeated its first manned flight by launching Virgil 'Gus' Grissom into space in an almost carbon-copy flight. Since only slight modifications had been made to his spacecraft, Grissom was simply gathering more data on flight control and life-support in space. On this flight however, Grissom noted that the controls did not act exactly as he had recalled from training, and what he considered to be small adjustments resulted in large changes in attitude (Swenson Jr., 1966). During the approach for landing, he also noticed that there were tears forming in the capsules parachute, but this did not create a major problem. Finally, while waiting for pickup from a Navy helicopter, Grissom reported the capsule hatch mysteriously blew off and, while he was still strapped in, began to take on water. A Navy man, he reacted and escaped by diving through the water coming in the hatch, gagging and gasping for air. The capsule sank despite the efforts of a helicopter and crew to save it, even when they realized it was too heavy to lift. The water that also filled Grissom's suit almost drowned him, as it too was filling with water. The capsule lay on the ocean floor for over thirty years before being raised in July of 1999. Whether this craft was plagued with problems from the start, or these incidents were the result of pilot error may never be known. The fact that Grissom also carried a few 'unauthorized' souvenirs aboard the capsule didn't help him either, as it was learned he planned to sell them through an agent after they had been in space.

The next step for the United States was an orbital mission, and Marine pilot John Glenn was selected for this mission. Up until this point, the longest an American had been in space was less than a quarter of hour, but now they were ready to test their systems over a prolonged period of time. During his flight in February of 1962, Glenn became the first American to orbit the Earth (3 times). He also became the first American to witness a sunrise from space while passing over the Indian Ocean. But this mission also had problems, from sensors providing troubling data to attitude control (Swenson Jr., 1966). One reading reported that the heat shield and floatation system had become disconnected from the capsule. While this proved to be a faulty reading, it caused great concern in Mission Control, and this could have easily meant a fiery death during re-entry. The life support systems also indicated dropping levels in a secondary oxygen unit (Swenson Jr., 1966), but Glenn reported no direct issues. Even with a number of system failures and glitches, the engineers on the ground were gathering the data they needed to ensure that future flights would be safe.

Over the next 15 months, three more astronauts would spend anywhere from just under 5 hours to almost a day and half in space. These flights would continue to provide the necessary data needed to make sure that space flights were safe for humans despite weightlessness and radiation hazards. Throughout the course of Project Mercury, the overall success of each mission was high, with more information about the spacecraft and life support systems being gathered after each flight.

For the Chinese, while we have proven the safety of our launch vehicles, we may look to Project Mercury for the basics of sustaining life of a pilot and crew in space. The Russian model and database is also a possible source of information, but during these early times, the Soviet men in space were passengers rather than pilots. In the earliest Soviet mission, the cosmonaut would bail out of the capsule during the descent and parachute to the earth rather than riding in the capsule to a touchdown. The American astronauts also insisted on having a window and control of their spacecraft so they could take over in the event of a computer failure. This model is closer to what we would want for ourselves. We need to consider both the physical and psychological effects of space flight, and develop the systems needed to ensure both. In addition to this, flight control systems must be developed that allows the astronaut to take control and maneuver in the event of a computer failure. While this technology may be over forty years old, the basics remain the same, and much can be gathered from the history books on Project Mercury.

It is also my belief that since manned flight was new to the Americans in the early 1960's, this was one of the reasons that they appeared cautious on each flight. Since we understand the basic effects of space flight on humans (from data gathered in all these programs), I feel that we do not need to take the small, even minimal, steps that the Americans chose as they went from mission to mission in the first few launches of Project Mercury. We should be able to move right into orbital missions on our first flight and achieve Project Mercury's goals in one or two mission, rapidly moving on to those similar to Project Gemini.

If we choose to fly a single Taikonaut aboard the Shenzhou capsule, I believe it would be so that we could minimize the impact of a failure if the pilot were killed. Once a successful flight has been flown, we will be ready for two or three pilots to fly together and perform experiments in space. For that, I believe we will need to look at the objectives and outcomes of Project Gemini as our primary model for the early missions. The closest to a failure the Americans came was when Scott Carpenter, a civilian scientist rather than a pilot, got distracted by some data gathering observations and delayed his re-entry sequence. His angle of descent was affected and he almost bounced off the Atmosphere to be lost in space rather than re-entering. He landed 200 miles downwind from his anticipated touchdown point near a Russian freighter. Seas were calm, so the United States declined an offer to pick him up, dispatching a destroyer to do so. Helicopters retrieved the pilot after divers jumped in and put a floatation collar around the capsule. The divers awaited the recovery ship, and Carpenter never flew again. So the Glenn, Grissom, and Carpenter missions were the one's with the close calls, one or two of which could have been due to pilot errors or not following orders.

Table 1 – Summary of Project Mercury Missions

Flight #	Astronaut	Launch Date	Flight Duration (hr:min:sec)	Major Objective
MR-3	Shepard	5/5/61	15:22	First Manned US Space Flight - Evaluation of man in space
MR-4	Grissom	7/21/61	15:37	Second Manned US Space Flight - Corroboration of man in space
MA-6	Glenn	2/20/62	4:55:23	First Manned US Orbital Flight - Evaluation of man in space
MA-7	Carpenter	5/24/62	4:56:05	Second Manned US Orbital Flight - Corroboration of man in space
MA-8	Schirra	10/3/62	9:13:11	Testing of man-machine interaction for 9 hours in space
MA-9	Cooper	5/15/63	34:19:49	Manned one day mission in orbit

Project Gemini

Building upon the successes of Project Mercury, Project Gemini had more ambitious goals, and with them came new challenges. In an effort to do more while in space, NASA decided that the Gemini missions would fly with two astronauts as opposed to the single occupant on Project Mercury flights. This would give the scientists back on

Earth access to more data, as medical tests and experiments could be performed on one another while on orbit. While medical tests and further research on life support were important during these missions, there were other questions that needed to be answered. In essence, Project Gemini would be the stepping-stone between Project Mercury and landing a man on the Moon in Project Apollo.

By this time, scientists were working on determining the best way for the astronauts to reach the Moon. It was quickly determined that the most efficient method of landing on the Moon would involve a two-part spacecraft, one that would descend to the lunar surface while the other remained on orbit. Upon return from the Moon, the astronauts would need to rejoin the orbiting command module. This mission requirement set forth one of the primary objectives of Project Gemini: guidance and rendezvous in space.

The Gemini capsule was similar to that used in Project Mercury, only larger and with more advanced controls. This craft was designed to dock with another orbiting target, so a docking collar needed to be designed and fitted at the end of the capsule. To allow the astronauts more freedom of movement, the interior space was also expanded, allowing them to leave their seats and move around. Godwin described the size of the Gemini capsule in his Gemini 7 Mission Report (1977) to be that of 'the front seat section of a Volkswagen Bug'. In most other areas, the capsules spanning the two programs were very similar.

The launch vehicle of choice for the Gemini missions was the Titan-II rocket, a more powerful relative to the Atlas rockets used on the earlier program. This rocket would be used to launch both the Gemini capsules and the Agena test vehicles to be used in some of the docking procedures. Werner von Braun and his crew in Huntsville, AL, worked on perfecting the performance of the rocket, and by the fall of 1964, test flights proved their work had paid off. With no flight losses, the Titan-II was ready for manned flight.

In late March of 1965, Virgil Grissom and John Young lifted off from Cape Canaveral on the maiden flight of Project Gemini. Their craft, officially referred to as 'Gemini 3' was also named 'Molly Brown' by its crew as she was said to be 'unsinkable' in an American story, as she survived the Titanic disaster (Hacker and Grimwood, 1977). This mission had some routine flight tests planned in, the first of which included testing of the orbital attitude and maneuvering system (OAMS), which controlled the flight path and orientation of the capsule. According to Hacker and Grimwood, the original flight plan for Gemini 3 was modified to allow this due to a story in a science fiction novel titled *Marooned*, by Martin Caidin. In this story, the crew of a spacecraft was stranded in space because their retro-rockets would not fire. Although the source of concern was strange, considering all the technical resources assigned to the project, deep down it made enough sense to include it as one of the first tests of the mission.

Now that two astronauts were in space together, more medical study procedures could be performed. Two of the experiments that were done may provide data to the Chinese that would be helpful on future manned space missions. The first involved the radiation of blood samples. Human blood samples were exposed to a known quantity and quality of radiation on the ground and in the spacecraft (Hacker, 1977). On earlier flights, there were signs of radiation damage to the cells on the Mercury astronauts. While this was not a total surprise, the amount of damage incurred over a short period of time was greater than they expected. The second experiment is one that has now been repeated on many space flights up to and including missions involving the Space Shuttle. That test involved the effect of low-gravity on the development of fertilized cells (Hacker, 1977). On Gemini 3, the eggs of a sea urchin were fertilized at the start of the experiment and the results would be analyzed back on Earth. While this seems to be a somewhat generic test, the Chinese may use the data gathered in this and many similar experiments if prolonged stays in space are considered.

The success of Gemini 3 was tough to beat, but less than three months later history would be made again. James McDivitt and Ed White blasted off from the coast of Florida in early June 1965. During this mission, White would perform the first extravehicular activity (EVA), or spacewalk by an American. Using a 'zip gun' attached to his right arm, White opened the hatch to the capsule and floated outside (the 'zip gun' was a handheld rocket that resembled a handgun, earning it that name). Once clear of the craft, he tested the maneuvering system by firing short bursts of propellant. As expected, he drifted away from the capsule, although still safely tethered to it in the event of an emergency. He moved around the capsule for more than 15 minutes before being ordered back into the capsule by mission control (Hacker, 1977). Once again, though, the Soviets had beaten the Americans by just a matter of weeks. In late March, Soviet cosmonaut Alexei Leonov became the first man to walk in space. However, he was almost lost due to the expansion of his space suit. He could get out of the capsule easily but struggled to get back in due to the suit expanding larger than the hatch opening. Sweating, exhausted, and almost out of air, he finally squeezed his way back in soon enough to save himself. While the basics of walking in space have changed over the years, the Chinese may consider a system similar to that of the United States for its simplicity and ease of operation.

Project Gemini continued forward, and because of a technical difficulty, two future missions would meet head on. In late October of 1965, NASA scientists launched an Agena target vehicle from Cape Kennedy (the name of the space center had now changed) with the intention of docking Gemini 6 to it in a short time. The mission failed, and radar data showed the Agena vehicle had broken into at least 5 large pieces (Hacker, 1977). A decision was made to scrub the launch of Gemini 6. With schedules as they were, however, NASA continued to move forward with an early December launch of Gemini 7. Mission planners were now considering whether they could launch two spacecraft in a relatively short period of time. Provided there were no major failures at the pad, NASA engineers determined they could do this, so a new mission plan was set in place. Shortly after the launch of Gemini 7, Gemini 6 would follow it into space for rendezvous.

The joint missions were a total success, and the two spacecraft came within one foot of each other. This single step would be critical on future Apollo flights, as two separate spacecrafts would need to return to the same point and dock together. While the intended mission of Gemini 6 was to dock with the Agena test vehicle, a near rendezvous with Gemini 7 proved to be just as beneficial to the successes of future projects. Rendezvous and guidance in space was something that all those interested in space travel needed to improve on, and the Chinese will certainly need to repeat this mission as well as look back on the early flights of Project Gemini for the knowledge gained. In our case, we will want an actual docking and crew exchange mission is which a Taikonaut goes up into space in one capsule and returns to Earth in another. This will demonstrate rescue capabilities. One crew should go through a docking tunnel and another via a space walk, essentially exchanging crew members and demonstrating both methods.

On the flight of Gemini 8, docking with an Agena test vehicle was finally achieved, but not without incident. Once connected with the target, the Agena was to be controlled by the computers aboard the Gemini capsule. Shortly after the docking was complete, the internal navigation systems aboard the Gemini craft indicated a 30-degree roll (Hacker, 1977). Piloted by Neil Armstrong, they took control from the computer and tried to correct the problem. This was of no use, and after just over five minutes, Armstrong and co-pilot David Scott had to release the two crafts from their embrace and go their separate ways. Once clear of the Agena, the two astronauts determined that one of the maneuvering thrusters on the Agena had stuck open, causing the two crafts to tumble together. While the mission had experienced a technical failure, the lessons learned in training came in very handy, as the crew proved able to recognize a problem and solve it without losing their lives.

Four more Gemini flights would follow, each building on the lessons learned from the earlier missions. Their primary objectives continued to be physical and physiological tests, as well as perfecting rendezvous and guidance techniques to be used on the Apollo missions. During Gemini XII, the radar computer failed and could no longer be relied upon. Fortunately for NASA, Edwin 'Buzz' Aldrin put his studies from MIT to the test and manually navigated the capsule to rendezvous with the Agena. Referred to by his peers as 'Dr. Rendezvous', Aldrin had helped develop the procedures and systems that allowed the computer to control a rendezvous in space (Hacker, 1977).

As the two crafts slowly came together, Aldrin and Jim Lovell manually docked with the Agena. Over the next few hours, they would practice docking and undocking the two spacecrafts, as well as raising and lowering the altitudes of the two. Each of these tests proved to be successful.

While the main objective behind Project Gemini was rendezvous and docking in space, numerous other medical experiments were performed in order to better understand space travel. Physical tests such as cardiovascular conditioning and studies on bone density helped prove that humans could live in space for extended periods of time. On Gemini 7, experiments were done with a phonocardiogram, which was used to measure the fatigue state of the astronaut's heart muscle (Gemini 7 – The NASA Mission Reports, Godwin, 2002). Other tests measure the effect of weightlessness on balance and vision. Medical testing in space proved to be a great source of data for the scientists back on Earth, and the results of many of these early tests may help China in understanding the health effects on the human body. For us, there is no good reason to repeat most of them.

In addition to medical experiments, many technical tests were also conducted aboard the various missions. On more than one flight, experiments involving the study of the Earth's magnetic field and the levels of radiation in space were measured. This data would later be used to understand how solar storms affect the weather patterns on Earth. We too should find ways to keep the taikonauts busy while gathering practical information for scientists in various countries and fields. Star studies that will improve their navigation skills in the event of a computer failure would be very beneficial. The study of radio emissions from stars was also important in the Gemini missions as it gave the scientists on Earth a better understanding of the makeup of different planets and celestial bodies. Finally, just as critical as the other tests aboard each mission, the astronauts were tasked with taking various photographs of the Earth. On Gemini 7 for example, high-resolution photographs were taken of cloud formations to better understand weather patterns back on Earth (Godwin, 2002). The knowledge and techniques gathered on these missions would help the engineers at NASA come up with the most effective methods for photographing the surface of the Moon on the Apollo flights. Lunar surface photography would be key to choosing safe landing areas for the Apollo crews, and will also prove beneficial to the Chinese in determining the best locations for landing on the Moon. However, we can start studying the American picture surveys any time, and then duplicate the photography for the most promising sites only.

While the information gathered on the Gemini missions may now be somewhat dated, it may still be of great use to the Chinese in developing the experiments they will need to conduct on their early manned space flights. Rendezvous and guidance techniques have remained relatively the same over the years, and many of the experiments performed may still yield valuable information to this day. For the Chinese, any information that they can gather from the early days of the NASA programs will prove beneficial, and the experiments aboard the Gemini missions were no exception. Both the medical and technical experiments provided data that was used in later US Space Programs to help advance research and procedures.

Table 2 – Summary of Project Gemini Missions

Mission	Astronauts	Launch Date	Landing Date	Primary Objective
Gemini 3	Grissom and Young	3/23/65	3/23/65	Demonstrate manned orbital space flight - evaluate two-man design
Gemini 4	McDivitt and White	6/3/65	6/7/65	Evaluate effects of prolonged space flight
Gemini 5	Cooper and Conrad	8/21/65	8/29/65	Evaluate rendezvous guidance and navigation system with REP
Gemini 6	Schirra and Stafford	12/15/65	12/16/65	Rendezvous with Gemini 7
Gemini 7	Borman and Lovell	12/4/65	12/18/65	Conduct 14-day mission and evaluate effects on the crew
Gemini 8	Armstrong and Scott	3/16/66	3/17/66	Rendezvous and dock with GATV (Gemini Agena Target Vehicle)
Gemini 9	Stafford and Cernan	6/3/66	6/6/66	Rendezvous and docking
Gemini 10	Young and Collins	7/18/66	7/21/66	Rendezvous and dock with GATV
Gemini 11	Conrad and Gordon	9/12/66	9/15/66	Rendezvous and dock with GATV in 1st revolution
Gemini 12	Lovell and Aldrin	11/11/66	11/15/66	Rendezvous and docking

Project Apollo

More has been written about Project Apollo than any other space program of that era. It was also the most challenging undertaking that any nation had attempted at that time. One of the outcomes of this program was the massive amount of information on experiments performed both during orbit and on the surface of the Moon. Most of the results are available in the public domain, with NASA publishing hundreds of reports and whole journals listing the outcome of each mission. For the Chinese, the information is there for the taking, but one question remains. Will China opt to simply take the data from the experiments or will they use this information as a starting point for their own research? In either case, they will be starting their efforts further along than the United States did in the 1960's.

Once again, rather than repeating the words of history that have already been printed, I will explore some specific areas of the Apollo program that I feel China would benefit most from. In some instances, China may look at this data and take it completely, while in other instances we may decide to replicate it or disregard it entirely. Many of the experiments and tests performed on the Apollo missions, particularly while on the surface of the Moon, provide the best source of data on its harsh environment. The fact that no human has set foot on the Moon since 1972 also emphasizes that some of this data, while over thirty years old, is still the most current data that any human has collected on the lunar surface. The only other soil samples were gathered on unmanned Russian missions in the early 1970's.

After the setback of the Apollo 1 fire, NASA engineers took a closer look at the safety of the machines they were building. They wanted to make sure that no other lives would be lost in the future due to design related issues. They had learned in a painful way that some of the materials used in the capsule were fireproof in normal air, but became extremely flammable in pure oxygen. Another issue was that the hatch for the capsule, while designed to open easily in the weightlessness of space, became nearly impossible to open on the pad. During the testing of Apollo 1, the pressure buildup inside the capsule compounded with this, resulting in the loss of the crew. We should learn from this lesson and spend some time designing a proper escape method.

Throughout the development process, the astronauts assisted the engineers in daily work with the prime contractors on the design of the vehicles they would be traveling in. While reviewing the designs, many suggestions for changes were made by the very men that would be traveling beyond the reach of our planet. No matter the plans that the Chinese already have, safety should be a top priority.

The two primary components of the Apollo program were the Command Module, the ship that would carry the astronauts out of our atmosphere, and the Lunar Excursion Module (LEM) that would bring two crew members to the surface of the Moon. The Command Module was a capsule design similar in shape to the earlier capsules of Project Mercury and Gemini, but was made to fit three crew members. During the liftoff and landing sequences of the mission, the astronauts would lie with their backs toward the blunt end of the capsule, which was covered in a heat shielding material. Also connected to the Command Module for most of the flight was a Service Module, which contained the life support systems and fuel for the mission. This section was jettisoned from the Command Module just prior to re-entry into the Earth's atmosphere. The LEM would be stored just aft of the capsule during liftoff, in an enclosed section of the rocket, and during the coast phase of reaching the Moon.

The Command Module would separate from this section and orient itself facing the LEM. A small amount of thrust was added to bring the two crafts together and docking of the two was completed when the latches on the Command Module made contact with the LEM and snapped into position. For the rest of the journey to the Moon, the two crafts would travel together as one ship.

The LEM was designed to bring a crew of two down to the surface of the Moon, and when their mission was complete return them to the Command Module back in lunar orbit. Since the LEM was designed for function and not comfort, the two occupants would work from a standing position while maneuvering for a landing. No seats were included to help reduce the weight of the ship. Attached at the base of the ascent stage was an area for equipment storage and the rocket that would both slow their landing on the Moon and return them to the Command Module. On later missions, the storage area was enlarged to accommodate the Lunar Rover, a small car-like vehicle that could transport the astronauts further away from their landing zone.

For the Chinese, this configuration may not make the sense for long duration stays on the surface. While the concept of a vertical landing system makes pinpoint landings easier than a runway-like landing, it also limits the size of the craft and the payload. For the United States, the LEM was adequate for their short stays on the surface, but the need for a larger vehicle may be required to bring equipment and supplies to the Moon.

The first mission to reach and explore the surface of the Moon was Apollo 11. In July of 1969, Neil Armstrong and Edwin 'Buzz' Aldrin became the first two humans to walk on the surface of the Moon. Although they both spent just over two hours outside of the LEM, they conducted a number of experiments that provided vital initial data on the Moon. The first experiments were part of the Early Apollo Scientific Experiments Package (EASEP) and contained a passive seismic experiment package (PSEP) and a laser ranging retro-reflector (LRRR) (The NASA Mission Reports – Apollo 11, Godwin, 1999).

The PSEP experiment was helpful to scientists in better understanding the interior structure of the Moon. It was primarily used to record the impact of meteorites and Moonquakes. Power was generated by a series of solar panels, and communication back to Earth was accomplished with a high-frequency data link. The LRRR experiment was used to find the exact distance from the Earth to the Moon. This somewhat simple experiment consisted of reflective cubes of fused silica that were placed on the surface of the Moon. Scientists back on Earth could project a laser ranging beam at these cubes and calculate the distance to the lunar surface based on the time delay it took to receive the signals back on Earth. While seismic activity on the Moon's surface would be an important factor in creating a research facility, I don't believe that China needs to repeat this experiment. Additionally, the LRRR project provided all the data needed on laser range finding, so no further tests would be needed, whether we have reason to think that it changes over time or in some cyclical fashion.

A part of every Apollo mission involved the collection of soil samples and rocks from the surface of the Moon. These samples would later be evaluated back on Earth to better understand the early origins of the Moon and see if life ever existed there. During this first mission to the Moon, the astronauts were bothered by the fine texture of the lunar dust, complaining that it easily covered their spacesuits and brushing it completely off was near impossible. Although there was nothing that could be done, it caused no harm to the astronauts and did not impair their work. Certainly, this will be something that anyone spending time on the lunar surface will need to take into account, so China may need to develop tough materials that will prevent the buildup of this dust, or a means of cleaning it off personally.

The spacesuits that the astronauts wore while on the surface of the Moon served multiple purposes, but the most important aspect was for protection from the void of space. Each suit was actually made up of multiple layers, the first being a liquid cooling garment that would cool the astronaut during their walks on the Moon. Over this went a multi-layer external protective suit that would shield the astronauts from the harsh temperature extremes and lack of oxygen. The gloves attached to this suit were bulky and somewhat hard to use, but safety was the first concern. On their backs they carried their life support system, complete with oxygen tanks and filter systems so the astronauts could breathe. The last piece of gear they wore was a helmet that would seal itself to the external suit. On the front of the helmet was a visor that contained a coating that protected their eyes from exposure to UV light. Within this self-contained suit, the astronauts also had a water supply and a communications system that allowed them to talk with one another, as well as back to controllers on Earth. Once on the surface of the Moon, the astronauts quickly realized that these suits were made for protection and not movement, as they reported some difficulty in walking around and bending over to pick up samples (Godwin, 1999). This is something that will need to be addressed by anyone wishing to maintain a presence on the Moon. The design of functional and safe space suits should be a primary task for the Chinese to allow more mobility in space, both while in orbit and on the Moon.

There would be six other missions to the Moon, but only five would reach the surface. The journey of Apollo 13 was cut short due to an explosion on the Service Module. Although this meant less time on the surface, it was also one of NASA's triumphs in crisis management, and the versatility of manned missions was showcased. Planners at NASA scheduled the most beneficial of the Apollo 13 experiments on each of the remaining flights. One of the most important packages flown on the remaining missions was the Apollo Lunar Surface Experiments Package (ALSEP). A next-generation version of the EASEP flown on Apollo 11, the ALSEP would provide scientists with even more data on life on the Moon.

The ALSEP packages flown on Apollo 12, 14, 15, 16, and 17 were all very similar, yet improvements were made to each subsequent version. Each package contained the same seven base experiments, which were:

- Passive Lunar Seismic Experiment
- Active Lunar Seismic Experiment
- Lunar Tri-Axis Magnetometer
- Medium Energy Solar Wind Experiment
- Low Energy Solar Wind Experiment
- Suprathermal Ion Detector
- Lunar Heat Flow Measurements

Each of these experiments provided additional information on the activities on the Moon once the astronauts had left. On some missions, one or two of the tests aboard ALSEP became damaged during the setup of the units, but because they were carried aboard multiple missions, there was little loss of data (Mellberg, 1997).

The Lunar Seismic Experiments gathered data on impacts that contacted the Moon's surface, as well has if there were any Moonquakes. Sensors were placed both on the surface and penetration down into the soil approximately one foot. The passive portion of this experiment was intended to measure single incidents that occurred during the lunar exploration and once the astronauts had left. Testing and data gathering from the active portion of the test included the astronauts using a thumping device to create simulated impacts on the lunar surface. In addition to this, a series of small mortars were set up to launch small grenades some distance from the experiment setup. This method was similar to systems used on Earth to find new oil and gas fields. Here on the Moon, however, the intent was to determine if there was a layer of solid rock beneath the surface at a depth of about 1000 feet (Mellberg, 1997). The results of these tests showed that there appears to be a concentration of solid rock below the surface, with the depths varying with the location of the test. The Chinese may need to consider this approach and review the data prior to any planned long-term lunar missions. The depth at which solid rock is found may be key to the Chinese for two reasons. The first is that if we create a permanent base on the Moon, we would need to locate solid rock close to the surface so that structural anchors may be set. The second reason that comes to mind is that if mining of the lunar surface is planned (for the extraction of Helium-3), we would want a large area of loose soil to make recovery of material easier. This tradeoff will need to be part of China's evaluation when considering a lunar mission. Much of this data is available in the post-mission reports that followed each Apollo mission.

The Magnetometer experiments were intended to determine if the Moon once had a molten core, similar to that of Earth's core (Mellberg, 1997). The results showed that while there were weak magnetic fields at the lunar surface, the level of these fields varied from one landing site to another. The readings taken at the landing sites for Apollo 12 and 14 indicate a larger magnetic field than the one measured at the landing site for Apollo 15 (The NASA Mission Reports – Apollo 15, Godwin, 2001). Scientists are still unsure if this had anything to do with the proximity of the experiment to the rest of the package or a larger concentration of iron deposits near this site. If the Chinese are planning long-term missions on the Moon, we may need to consider these results for the positioning of equipment that may be sensitive to the presence of a larger magnetic field.

Further testing would be needed to determine if there are significant fluctuations in the fields measured.

Testing that was conducted by the Solar Wind experiments were intended to measure the velocity and direction of protons, electrons, and alpha particles radiated by the sun (Mellberg, 1997). Apollo 15 deployed these experiments on the Moon when it was in the magnetospheric tail of Earth, so no solar winds were occurring there (Godwin, 2001). This experiment was scheduled to begin collecting and reporting data in August of 1971. The results of these experiments showed that only helium and neon isotopes were found. The primary benefit that China can gain from this experiment is the need for shielding of their spacecraft and any base on the Moon from these isotopes.

The Ion Detection tests were setup to measure the pressures of the lunar ionosphere (Godwin, 2001). The Suprathermal tests were only conducted on the Apollo 15 mission, and due to a technical failure, yielded no data. On Apollo 16 and 17, a Cosmic Ray Detector was deployed to measure the same data with a different approach. This system would measure the atomic masses present at the lunar surface, and while results showed that these values ranged from 1 to 1000 atomic mass units, the data did not show significant results that prompted further testing. China may opt to look at this data and simply use the results, rather than repeat any part of it.

One of the most important experiments conducted on the lunar surface (for both the United States and China) may be the Heat Flow experiment. In this test, sensor probes were pressed into the lunar surface just a small distance to measure the changes in the surface temperatures. The results from each mission showed that the thermal variations on the lunar surface changed greatly in both temperature and rate of change during the transition from day to night. On Apollo 15, for example, these variations ranged from +87 degrees C to –128 degrees C in the transition from day to night (Godwin, 2001). They also found that the most dramatic drop in temperature occurred in the first 32 inches of soil, with a drop of over 100 degrees C in this region, while the next meter of depth only showed a slight increase of a few hundredths of a degree. This data will help the Chinese develop a shelter that will be able to withstand the wide variations in temperature that will occur throughout the lunar month.

Other experiments performed throughout the Apollo missions also provided a wealth of knowledge to the scientific community. Much has been published in journals and books, making it a very valuable and available source of information should the Chinese decide to pursue a lunar mission. Many groups in the United States have wanted to return to the Moon, but for many reasons NASA has not taken up this challenge. During the 1960's, the United States' top rocket designer, Werner von Braun, noted that the Moon should not simply be a place to visit, but should become a permanent outpost in space. If China wishes to place the Moon in its sight, there is certainly an abundance of material from experiments performed there and other tests conducted on lunar missions by those who expected to return and stay there in a Moon base.

Table 3 – Summary of Project Apollo Missions

Mission	Astronauts	Launch Date	Landing Date	Primary Objective
Apollo 7	Schirra, Eisele, Cunningham	10/11/68	10/22/68	Demonstrate Command Service Module (CSM)/crew performance
Apollo 8	Borman, Lovell, Anders	12/21/68	12/27/68	Demonstrate CSM/crew performance (navigation and communications) and translunar injection
Apollo 9	McDivitt, Scott, Schweickart	3/3/69	3/13/69	Demonstrate Lunar Module (LM)/crew performance - docking with the CSM
Apollo 10	Stafford, Young, Cernan	5/18/69	5/26/69	Demonstrate crew - space vehicle - mission control and communications support
Apollo 11	Armstrong, Collins, Aldrin	7/16/69	7/24/69	Perform a manned lunar landing and return - lunar exploration
Apollo 12	Conrad, Gordon, Bean	11/14/69	11/24/69	Perform detailed exploration of the lunar surface and collect samples of lunar soil
Apollo 13	Lovell, Haise, Swigert	4/11/70	4/17/70	Mission objectives were not met due to an accident on board the CSM
Apollo 14	Shepard, Mitchell, Roosa	1/31/71	2/9/71	Perform extensive lunar exploration in the Fra Mauro region of the moon
Apollo 15	Scott, Worden, Irwin	7/26/71	8/7/71	Perform extensive lunar exploration in the Hadley-Apennine region of the moon
Apollo 16	Young, Mattingly, Duke	4/16/72	4/27/72	Perform extensive lunar exploration in the Descartes region of the moon
Apollo 17	Cernan, Evans, Schmitt	12/7/72	12/19/72	Perform extensive lunar exploration in the Taurus-Littrow region of the moon

The Possible Future of the Chinese Space Program

While some information about China's Space Program has been published in the past, China is most noted for keeping details quiet until success is achieved. Prior to each of the unmanned Shenzhou launches, very little publicity has been given to the project. Once a launch or recovery is completed and determined to be successful, our policy has been to come out with great praise for the work that was completed and never discuss the experiments that did not work. Due to the lack of coverage of the landing of Shenzhou 2, I believe that we might as well have announced the crash on landing, as most people are assuming it was a failure by reading between the lines.

Still, the lack of information that causes the United States and others watching the situation in China to wonder what their next move will be has its benefits. Limited information on many aspects of the space program has been written about, both in China and throughout the world. The biggest problem they will have is finding this information and then determining what is accurate and what is propaganda. We don't really want to start another space race to the Moon, so publishing our intentions for Project 921, as it has been announced to date, will leave the others believing they have 20 years to respond. Actually, we believe we can match their Apollo feat much faster than they did. It took the Americans almost nine years to go from launching their first pilot into space to landing one of their own on the Moon. We should be able to achieve this in 2-3 years.

The Future of Satellite Technology in China

Since the mid 1980's, China has proven its capabilities in the launch of satellite technology, but little has been written about the actual satellite technologies themselves. The United States' Space Transportation System (STS, The Space Shuttle) was grounded after the Challenger disaster, a Titan 34-D rocket had exploded, and a Delta Rocket failed (Patterson, 1995). At the same time, the European Space Agency (ESA) suffered an Ariane rocket failure. As these events were occurring, China was positioning itself to join the international business of launching foreign satellites.

In 1984, China launched their first satellite design, a communications satellite that would beam video images to parts of China that were not able to receive normal television programming. Since that time, China has launched four more communications satellites, giving us radio and television coverage throughout almost the entire nation and much of the rest of Asia (Patterson, 1995). Looking at this from China's viewpoint, this achievement gave us a great sense of pride in not only designing the rockets used to launch the satellites, but also designing and developing the satellites themselves. However, there was no point in starting with the equivalent of 1960's technology. To leap-frog to the current state of the art, we needed partners with access to the US and European technology. This we found in Brazil.

On other satellite endeavors, China has worked with other nations to develop both a technological partnership and improve our relations with those governments. One example of this is China's recent cooperation with India to develop a series of Earth observing satellites. China is now exchanging information with India, a nation developing their own Earth observing satellites, to help better develop our own technology. Plans for our own observing network involves a series of early-warning satellites that will be able to monitor the environment and alert scientists and the government to impending floods, fires, droughts, sandstorms, and other natural disasters. Japan seems to be interested in technology of this kind, but we prefer not to work with them. However, developing a trade proposal with a third party nation to obtain their technology is a possibility.

Paralleling this effort is a group of geostationary weather satellites, similar to the United States GOES satellites. These systems will provide visible, infrared, and radar data on the weather patterns above China (Aviation Week and Space Technology, October 29, 2001). In a similar effort, China is partnering with Italy for the development of a satellite system called Double Star. Double Star is intended to monitor the lower regions of the Earth's magnetosphere, particularly the main part of the magnetic storm belt, the substorm and the particle storm belt. This program will consist of two low-Earth orbit (LEO) satellites, one that will orbit the earth from pole to pole, the other orbiting around the equator. I am told that the Chinese Space Agency expects to launch these satellites in early 2003, so time will tell if the partnership with Italy will last (Aviation Week and Space Technology, October 29, 2001).

While China has also been working with India and Italy, our cooperation with Brazil is even greater. One of the reasons for this close partnership is that both China and Brazil have similar agendas with regard to science and space exploration (INPE website). In July 1988, China and Brazil signed an agreement for the joint development and launch of at least four Earth-monitoring satellites. The China-Brazil Earth Resources Satellites (CBERS) are to include a high-resolution wide-field camera system that allows both visible and infrared bands of lights to be monitored (Air and Space Magazine, Oct/Nov 1997). As part of this agreement, Brazil will accept roughly 30 percent of the cost to design and build these satellites, while China contributes the remaining 70 percent.

The first satellite, CBERS-1 was launched in October 1999 from the Taiyuan Launch Complex in China. After the initial tests, the satellite was deemed perfectly functional and has been in use since (INPE website). Due to the limitation of an approximately two-year lifespan, CBERS-2 needed to be launched by October 2001. This launch did not occur, and as of December 2002, the launch was now planned for late in 2003. Reasons for this were not given, but based on the Party's past history of not providing full information in advance, the world may not know until the launch actually occurs. What led to the delay, I do not know, nor do I have a 'need to know', and prefer not to ask unless I have a greater need than my own curiosity. According to the INPE website, all four CBERS satellites were built and ground tested by mid-2001.

China's Manned Missions

Many people have questioned whether or not China may be planning a manned space mission. By now they must know that we are but cannot respond with a preemptive mission in the next 12 months. So it appears China will be the third, before Europe and Japan, to fly a man in a system of their own design. The real question should be how far will China go with its manned space flight program? I can only advocate for my plan, but I think it is what the leadership wants to hear, at least for now. Based on the success of the four Shenzhou unmanned flights over the last three years, a manned effort is imminent. Once this first mission occurs, space, rather than the sky, is the limit. Then I hope we leap frog straight to the Moon on our own, and build a coalition to stay there that excludes the Americans and Japanese.

In April 1992, I was in the Ministry of Aeronautics, and at that time we decided to formally create and announce to the world the Chinese manned space initiative. Our international image at the time was that of the cut-rate but unreliable satellite launch agency, since we were undercutting the price of the Ariane launches by two-thirds to get into the commercial launch business. This program, code-named Project 921 consists of three parts. Since the military and the Communist government of China play such a major role in Chinese Space Program, many of the details were only briefly explained. Some foreign communication called it a bluff, pure propaganda, and beyond our capabilities. They called our words empty, trying to make us loose face. That made us furious, and made our dreams even stronger. Journal articles and public press releases started to emerge from the Chinese Space Program, to ground our claims and make our detractors loose face.

The first phase of China's manned space program is Project 921-1, which is simply a manned space flight. While this sounds very basic, only the United States and Russia have succeeded in this goal. China has been training a group of Taikonauts, which means 'astro-explorer' from the Chinese word 'taikong', meaning space or cosmos, but while we could show their picture, they were to remain nameless while the government officials took the credit without the physical risks. Of the Taikonauts in training, only two have so far been identified by name. Li Qinglong and Wu Zi are both Chinese pilots that trained at Star City, the Russian space flight training center just outside of Moscow back in 1996 (Air and Space, Oct/Nov 2002). They returned to China after spending about six months in training and began working with the Chinese military on developing our own Taikonaut training program.

Using the Shenzhou capsule, China plans to launch its first space explorers in the near future. Most of the equipment to be used on the mission has been designed and made by Chinese experts, but back in the mid-1990's, we took advantage of poor economic times in Russia and purchased a used cosmonaut space suit and life-support system to use as a model, which we improved, or course. We made sure the journalists knew that China's intent was simply to study the suit rather than purchase them directly for use in space from the Russians, however familiar they were to our Russian trained veteran's of Star City.

The next phase of China's manned space program is called Project 921-2, which is defined as the assembly of a space station in Earth orbit. This undertaking is enormous in scale compared to simply putting a human in space. In early 2000, China tried to join the coalition of nations that were participating in the International Space Station (ISS). At this point, however, many nations had already been working on the program for many years, and China was not granted inclusion. However, since China announced their plans in 1992, it would appear that we simply wanted to learn enough from the ISS program to develop our own station rather than skip that step. But the ISS is overly complex and the Americans and Russians did not start with such a structure. Skylab and Salyut were both modest stations, even in their time.

Looking at possible motives for developing our own space station, one could gather that we want to create a long-term research facility in space, preferably in lunar orbit. As China witnesses the benefits and outcomes of experiments performed on space shuttle and ISS missions, it is understandable why we would want to conduct similar research. But before China develops a space station, we need to prove that we can successfully launch and recover men from space. In addition to this, we would also need to design a launch vehicle capable of launching a larger payload, such as the sections that would be needed for a full size space station, on the scale of Mir.

The final manned space initiative from China is called Project 921-3 and involves the design and flight of a reusable space vehicle. Early conceptual drawings show that it is closer in design to the Dynasoar project (a lifting body design) that the United States has been working on for years rather than the space shuttle. There are obviously financial savings in being able to reuse a launch vehicle, but the purposes of that craft would be somewhat limited. A reusable vehicle could be used to ferry people and supplies to the space station. The design of the United States space shuttle was to serve a dual-purpose role, that being transportation of humans to space stations and a cost-effective way of delivering satellites to space. It never worked out for the second application, as the Shuttle is not as financially competitive as unmanned launch systems and could not compete with a two-manned Shuttle for those missions that required a human touch. Since China's launch costs for satellite launches is so much less than that of either the United States and even ESA, one could deduct that we would continue our satellite launches aboard the Long March rockets.

The Moon or Beyond

I propose that we advance quickly from a Gemini-style mission directly to a 'Skylab' type of program, publicize a space station as our goal, and go straight on to the Moon for a landing with 'Skylab' as an emergency outpost in case of an Apollo 13 style problem. At this time, one landing on the Moon will suffice as proof that we have the capability to achieve this goal. Then, we should resume building our 'space station', while requesting inclusion once again into the International Space Station program. If refused once more, we should immediately humiliate the United States, Russia, and Japan (but not our friends at ESA) by pointing out that their solution for a laboratory in space is too costly to build and maintain. Of course, we favor a more cost-effective platform that was proposed years ago by the Europeans. Since ESA already had plans to build a 2-man shuttle, Hermes, to serve as a transport between Earth and a space station, we should offer to work with them, splitting the cost and resources to bring this program back to life.

Similar to the way the ISS was created, we will jointly design the modules and fittings so that we can work in parallel with them on the development. Combined with the rockets of the Europeans, our Long March family would compliment the power needed to launch these pieces into orbit. Together, China and ESA have nearly the equivalent economic and technological power as the United States, Russia, and Japan combined. Once completed, maybe other nations will wish to join us in our platform for performing space research. Of course, we would want our friends in India and Brazil to have the first choice. This will leave the Americans and the Russians with their aging Space Shuttle fleet and an overpriced research platform.

Once the Russians, who are still cash-strapped and riding on the heels of the Americans, see that we can serve the same purpose, we should try to welcome them in as well. Rather than have the Americans feed them money, we should offer an agreement to help design and build future space-faring vehicles. The Russians should respond favorably to being offered the supply contract similar to that the Americans have offered them, but clearly the financial margins will be highly. A consortium of China, Europe, and Russia would clearly pave the way to space superiority.

In the future, these three groups could work together to create MIR-2, a transit point for sending personnel and supplies to and from the Moon's surface. With a Chinese designed 'International' research facility on the Moon, it would provide further opportunities for us to continue new research. Working with our partners, this should be achievable within 10 years. Once this is establish, we could 'trade' Moon access for ISS time with the Americans and Japanese, who will no longer be the technological leaders in space.

While we still wait for China to launch humans into space, others can only assume that we would want to make a lasting impression on the international community. China has already proven that we can reliably launch satellites for a fraction of the price (even half the price if we want to take a good profit, a third if we don't need profit) that all other launch-capable nations, making us an attractive business partner. Whether these low costs are simply to promote the business remains to be seen, but even US companies are turning to China for launch services when they have satellites they need launched inexpensively.

'Why the Moon?' one might ask. I don't believe that the fable in the introduction section of this paper is the motivation for going to the Moon, but since no nation has sent humans back there in over thirty years, China may set its sights there while NASA dreams of going to Mars. It is easier and has yet to be done right. In the 1980's, ESA had plans for a manned space program and also mentioned the Moon as a goal, but this program quickly faded. Both the United States and Russia have sent unmanned probes to the Moon to gather more information, but plans have gone no further.

In the late 1990's, NASA examined plans that involved sending humans to Mars, but that plan was quickly dismissed on the grounds of cost. The United States clearly does not have the rocket technology any longer to launch a spacecraft to another planet and still have energy reserves to propel it back to Earth. Russia has the Proton rocket, which can reach lunar orbit (sort of, on a fly-by mission), but there have been no mention of flights beyond the ISS by the Russians. And the Soviet's N1 Moon rocket was never perfected after Korolev died. For China, a mission to either the Moon or beyond would certainly raise awareness of our capabilities, but we need to remember that the Chinese have yet to launch a human into space. To consider a mission to Mars at this point would not only be premature, but would sound more like the wording in a science fiction novel. Still, from John Glenn's mission to Neil Armstrong first setting foot on the Moon, six years had passed. The question is, what then? It is only worth doing if you can figure out how to stay there.

Conclusion

China's increase in activity throughout the space program should be taken as a clear sign that something significant is coming soon. The increase in launch activity of the unmanned Shenzhou capsules seems to indicate that the world should watch closely in the coming months for a manned space flight. On the most recent mission, which ended in January of 2003, observers clearly noticed the test dummy strapped into the capsule, and judging by the coverage the mission was given in the media, one can assume that the next flight may very well carry a human.

Looking back on the last ten years of publicity and development efforts seems to show that China is serious about becoming only the third nation to launch a human into space. While the efforts of the United States and the Soviet Union in the 1960's clearly demonstrated the will of nations to beat one another in a space race, the Americans showed that they could go from a fifteen-minute sub-orbital flight to landing a man on the moon within nine years. Unfortunately, once this goal was achieved, the United States seemed to lose interest in our nearest orbiting body.

I believe that at this time, China is ready and poised for a manned space flight during the year 2003. Since China is also a nation that believes in its capabilities, I feel the Chinese will launch a man into space next, rather than another animal. We are already well aware of the effects of space flight on humans, as hundreds of people have slipped beyond our atmosphere and returned with minimal side effects. In the early 1960's, there was concern that any living creature that passed beyond the Van Allen radiation belts would not survive, so animals were used as experiments to test this theory. I also believe that China would want to show the world its great technical capabilities through the launch and recovery of a human. Throughout China, pride is key to motivation, and for this nation to be able to enter an elite club of space-faring countries would help propel it even further.

Once China succeeds in launching a human, I believe more manned flights will follow, and while little or no information has been made public, I also think that plans for a reusable space vehicle are already in the works. Since it has taken China more than ten years from the announcement of our space program to reach this point, I don't feel that they are on a time schedule. As was noted earlier in this paper, China considers many decades to be fairly recent history.

There is also a question as to whether China's space program will create another space race, and if so, what nation will step up to the challenge? Certainly, the United States and Russia already have a wealth of experience in space exploration, so I don't believe that they will join a race with China just yet. The same would go with ESA, as their own Project Hermes was scrapped in the early 1990's. The only nation that I feel would have the capability and determination to match China's achievements in space exploration would be Japan, but with no real plans announced, I don't believe a manned flight of their own will follow in the near future. They will continue to send their people to the ISS on the Space Shuttle for now.

Once China shows the world that they have the capability to independently explore space, it is my personal feeling that China should set an even higher goal. While a space station is already in the public plans for China, I believe that we should set our sights on the Moon. The Americans are the only people to have set foot on that distant land but they could not get back there today and stay. I feel that China has the motivation and the momentum to continue new efforts, and the creation of a research facility on the surface of the Moon should be on our public list of goals, 5 years from now.

While the Moon does not offer complete freedom from gravity (it has approximately 1/6th the gravitational field of that on Earth), experiments can be performed in a reduced gravity environment, yielding much scientific data. Data from the Apollo missions is both available and abundant, and while China should develop its own set of experiments, we can leverage the work of the past explorers to expedite our efforts. The basic information about how to sustain life on that world is already available, as are detailed maps and plots of the lunar surface itself. Planning a long-term research facility on the Moon should begin now, so that once a reusable space vehicle and space station are created, it will make missions their possible in the short run. The space station could serve as a collection point for both personnel and equipment to make the trip to the Moon. As China launches and assembles our space station, we could continue to the Moon at that time. This would also give the Nipponese and the Yankees little or no time to react and mobilize to counter our move. Further research may be needed, but there is no apparent reason that our space station could not be positioned in lunar orbit.

Some scientists have indicated that the Moon's surface provides some water, considerable oxygen and an abundance of Helium-3, an element that has been shown to harness tremendous energy. Research has been done at the University of Wisconsin in using Helium-3 as a reliable source of energy to power the Earth. While the rewards from harvesting Helium-3 from the lunar surface appear great (it is estimated that 1 ton of lunar material could be worth over $1 billion), I do not feel that China should go to the Moon for this reason.

The efforts of the Americans in the 1960's showed that anything could be possible if people believe in it and there is the backing of the government. Much great data came out of Project's Mercury, Gemini, and Apollo, but we must realize that the small steps they took were conservative at the time. Until 1961, no human had escaped the bonds of Earth, and the great unknown had many secrets. The effort was politically motivated and losing astronauts would have undercut the political gain. I think most people would agree that while space exploration is dangerous and costly, it could also provide people drive and motivate new technologies and discoveries. The Chinese people will need to see these benefits in a short time if support for the program will continue. Economic and living conditions around China are not optimal, so the government will need to show the people that funding such a great project will also provide them with a better future, as well as a more glorious image.

Setting our sights on the Moon should be a goal of the Chinese Space Program so that we are looked upon as leaders in space exploration, rather than just observers. China has both the technical ability and the determination to follow through on plans of this magnitude, so this effort should not sound unreasonable. Through the combined efforts of the military and the engineering community, we should be able to achieve this goal and allow other nations to look to China as a leader in the exploration of space, and hence the world. Ideally, as the keepers of the treasure of the Socialist Revolutionary flame, we want to be role models of wealth and power with the future in our pockets. We must overcome the failings that overcame the Soviet state and has the North Korean's envying their well fed southern cousins today.

Discussion

Throughout this paper, I have considered how China may look back on the history of the United States Space Program's Moon missions and what information, if any, they would leverage for their own use. Understanding the Chinese culture in some detail prior to writing this paper also helped me to make decisions based on how they might approach this project. In some cases, these decisions did not come easy, but I believe that with time, some of my predictions may come true.

The creation of a character, as well as providing some background information on him, also helped establish my ideas and thoughts. In many cases, I put myself in his shoes and asked 'What would I do here?'. From someone that has always viewed the American Space Program from the inside, this provided me the opportunity to look at from the outside with an unbiased opinion. I truly believe that China will look back on what we accomplished and choose to either take something at full value, disregard it entirely, or a combination of the two. To not look back on others history would be a shame, and it does not appear that the Chinese people would want to make the same mistakes we did.

Finally, while I approached this project from the aspect of the Chinese viewing the American space program, one could easily do the same using the Russians as a model. While they have not reached the moon, their efforts in space station technology and their knowledge of prolonged stays in space would clearly provide vital information to the Chinese. And as a former Communist state, Russia is likely to work more closely with the Chinese than the Americans would despite the fact that the Russians are now ‘running dog capitalists’ rather than Bolsheviks. Five years from now, someone should revisit this paper and see how accurate my predictions about China’s intentions were.

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