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THE FUTURE OF SPACE EXPLORATION: A SECOND MOON RACE

An Interactive Qualifying Project Report:

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by

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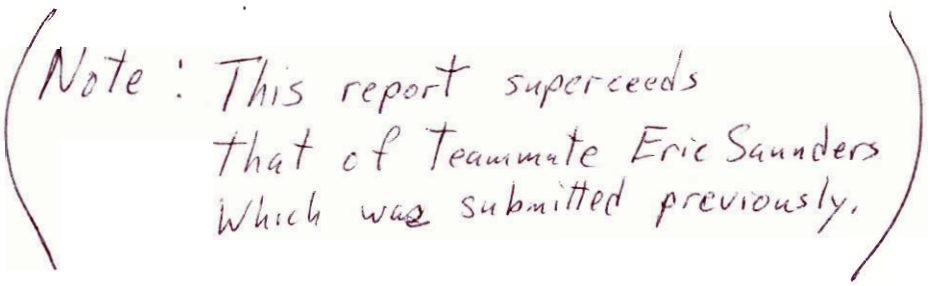
Abstract:

The current study is part of the forecasting phase of a proposed technology assessment. This report represents the literature review phase of an effort to predict what the Moon and near space would look like thirty years from now if the USA and People's Republic of China (PRC) had a space race to the Moon. Another objective of the project is to assess the likelihood that competition rather cooperation in space will prevail.



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Introduction:

This research project is the forecasting aspect of a technology assessment. Specifically, the goal of this project is to look into the possibility of a Moon race between China and the US. It is not clear how far we will get considering what the social and technological implications of a renewed space race would be. However, we will try to describe its likely implications for the Moon itself and the region of space between the Earth and the Moon.

Our approach to the problem is to make predictions on the likely outcome of any new race by comparing the current situation with what happened in the past, where the past refers to the previous space race between the Soviet Union and United States. After some research this group has decided to assume a competition between US and China, rather than cooperation or forming coalitions with other space agencies. The focus of our project is to make a grounded speculation on the space race, based on our social and technological analyses of the capabilities of each country covered by our research. Another focus of this project is to describe what the interests of each country are in a space race, and how they are likely to pursue these interests. Also, we will consider whether either country will have more trouble than the other in getting the support of its citizens for an ambitious space project, and why.

This group will be analyzing reports and doing our own investigation into the Chinese space program today, NASA, and the previous space race between the Soviet Union and the United States by means of existing books (such as Hanford's Biography on *Korolev*) journals, periodicals, multimedia, and online sources. From these sources we hope to obtain the necessary information to understand the previous capabilities of NASA

and where they stand today. Furthermore, getting information on the Russian space program and China's relationship with Brazil is important because it is necessary to know what technology the Chinese may have access to on the open world market.

This literature research will compare what happened in the previous space race with what is happening in the present to assess the current relative capabilities of China and US. Finally, based on this information, we will make a projection about what will probably happen in the next thirty years if there is a Moon race, how, when, and why. This group will make an assumption that there will be no huge technological breakthroughs in next thirty years. Since we have limited time, we will not be able to discuss the full social implications of this technology buildup on the future of planet Earth.

In achieving these goals it is important for our group to look deeply into technological capabilities as well as, economical, political, and cultural dynamics of both United States and China. After gathering this information our group will compare the differences between each society and find out which differences will be an advantage or a disadvantage to each country. Since we are making a prediction thirty years into the future knowing what happened in past, events can greatly assist us in understanding the capabilities of each country and the way they deal with certain situations. The Soviet Union's and United States' previous race is very important because it is an example of how each country approached the race; how they justified it, and where they left off. Also, the equipment the Russians used will likely be available to the Chinese. Knowing what technology they have at the outset will be important to consider predicting where this race will take us in thirty more years of rapid incremental development.

One of the things the group will try to find out and describe is the technical capabilities of the Chinese space program. When assessing China's technical capacities, this group will compare current known technology that China has to other countries (e.g. Russia) at various points in time to determine how fast they developed their own technology. This will be necessary to determine how far Chinese technology is likely to evolve in the next thirty years if it is developed internally in isolation as opposed to being openly purchased. We will also examine the Chinese political, social, and cultural context to explore possible motivations behind the Moon project and any further space aspirations they may have to see which strategy they will follow. This information may also give us insight into the organization and dynamics of the CNSA, and how it compares with respect to the existing NASA program and technological capability.

The next subject our group will research in detail is the Soviet Union. Both the politics and achievements in space technology by the Soviet Union will be researched. We will observe how close the Soviets came to winning the space race back in the 1960s. This aspect of our research will focus on Korolev, who was a very important early figure in the Russian space program. We will emphasize him because of his great contributions in the Cold War space race between United States and Russia. Research on a communist political structure will also contribute greatly to the project, since China also has a Communist regime that operates in secrecy and links its space program with its military production systems. This group will be able to consider the implications of this on the project and try to decide if communism, which claims to be a technocracy, was an obstacle or a boost to the space program, as compared to the open democratic system of NASA which answers to Congress.

This group will also research the technical abilities of NASA. One focus will be on the technology developed in the Apollo program and how long it took to develop it, lessons learned by the program, and a look at current technology. With this information we will try to determine what it would take to rebuild NASA into the agency it was in the Apollo years, and what NASA might be capable of in the next thirty years if that were done. Lastly our group will research into the political and bureaucratical aspects of the NASA during the past space race between USA and USSR and will try to figure out how NASA was managed during this period. Also the effect of the support of the American public on the past space race and the level of enthusiasm of the American public during the past space race will be researched. Keeping this in mind, we will try to predict whether Americans currently have enough public support to engage in such a race and what Americans need to be willing to do in order to get enough public support to gather the resources needed to beat the Chinese in a possible Moon race.

As a follow up to our project, we suggest either a study looking into the possible future of what would happen if there was cooperation between China and US or if the possibility of having each agency form competing coalitions emerged. Another good project would be to look into the social and political implications of our technical prediction for the whole of planet Earth.

Background:

United States:

Though humans have dreamed for centuries of space travel and exploration, only in the mid-20th century did this become technologically possible. The technology that made it possible was the rocket propulsion device, which was developed for military use in the form of the ballistic missile (Booker 2). Scientists soon realized that it could be used for another purpose and by the late 1950's, descendants of the V2 rocket were being used by the United States to send satellites into orbit. However, this was just the beginning.

In the late 1950's, speculation about whether it would be possible to put a man on the Moon in the near future was building, and in fact there was already some planning going on. The National Aeronautics and Space Agency, NASA, was formed, and it began the Mercury program to test the effects of zero gravity on humans. Alan Shepherd was sent into space on what was essentially a double-size V2 rocket, and then later Mercury missions used a modified Atlas ballistic missile (Booker 5). The Mercury program proved that humans could survive in zero gravity. This was a very important step, but it was also a small one.

It takes a lot more power to get to the Moon than it does to simply get into orbit, and, at the time, NASA didn't have a rocket capable of supplying this amount of power (Booker 20). Dr. Werner von Braun, director of the George C. Marshall Space Flight Center at Huntsville, Alabama had designed the Saturn I rocket, which was the largest one the US had at the time, but it soon became apparent that even it wasn't up to the task of putting a man on the Moon. The Rocketdyne Division of North American Aviation,

Inc. created the F-1 rocket, which was eight times as powerful as the rockets NASA was using at that time, to deal with this problem.

At the time, scientists saw three different possible means of getting to the Moon and back. The first idea was to make a rocket device large enough to carry everything including fuel for the return trip home to the Moon and back. They actually began planning to use this technique with a theoretical vehicle called Project Nova. However, it quickly became apparent that they couldn't design and build such a device within the timeline of the Apollo program, so this idea was scrapped.

The second possibility involved blasting off into Earth's orbit, and then refueling to go to the Moon. This would have been feasible, but because it might have been difficult to get two large vehicles to rendezvous in orbit, it too was abandoned. The third possibility was the one NASA ultimately went with: lunar orbit rendezvous. This technique involved leaving the fuel they would need to return to earth and anything else they wouldn't actually use on the surface of the Moon in lunar orbit and descending to the Moon in a separate landing module.

Using the new F-1 rocket technology and his past rocket designing experience, Von Braun began designing the largest rocket that could be developed in the Apollo timeframe. It was known as the Saturn V, and it used five F-1 rocket engines. This was the device that ultimately became our vehicle to the Moon, launching the Command Module which would remain in lunar orbit, and the Lunar Module which would actually land on the Moon.

The Mercury program was followed up by the Gemini program, which featured a two-man spacecraft. The Gemini program was also used to test orbital rendezvous

techniques. This experience would be necessary given the new plan for the Apollo mission, which was the lunar orbital rendezvous. The Gemini program also featured the first-ever space walk by an American.

The launch vehicle used for the Gemini program was the Titan II intercontinental ballistic missile. The actual spacecraft itself was considerably more complex than that of the Mercury program as well, having various independent sections. The McDonnell Aircraft Corporation was the primary contractor of Gemini equipment. There were some difficulties encountered during various Gemini missions, but overall they were a great success and many successful dockings were completed (Booker 31).

At the same time as the Gemini program, which featured manned missions in Earth's orbit, NASA began sending unmanned probes into lunar orbit and to the lunar surface. This was necessary to gain more knowledge about the Moon itself, in order to know what to prepare for in the actual Apollo missions, as well as practice a soft landing. There were three series of probes sent: the Rangers, Surveyors, and Orbiters.

The Rangers were by far the most primitive. They were simply satellites with a video camera, and a "survival pack" consisting of equipment to measure surface conditions. The probes would crash themselves into the surface of the Moon, returning video footage of the crash to scientists on Earth, and hopefully leave the survival pack on the surface to collect additional data. Ranger 7 was the first successful Ranger probe due to many difficulties.

The Surveyors were significantly more advanced. This probe was to be soft-landed rather than crashed. The video cameras on it could be controlled from Earth to focus on potentially interesting sites after landing. The Surveyors were also used to

determine the effects of rocket engines being fired on the Moon, when one of them took off and landed elsewhere. Based on this information, it was determined that the Lunar Module would be capable of landing on the Moon and then returning to orbit.

The Orbiters were launched concurrently with the Surveyor probes. They were designed to orbit the Moon and take detailed pictures of possible landing sites for the Apollo mission, in order for scientists to choose the most desirable sites. They selected five (Booker 35).

After gaining all this new information, NASA was ready to develop the equipment necessary for the Apollo missions. The spacecraft was designed modularly, just like Gemini. The Command Module was the first stage, and the Service Module which held the rocket engines and their fuel was the second stage. The third stage was the lunar module.

The first few Apollo missions (missions 4 and 5, for some reason) were used as unmanned tests for the Command Module and Lunar Module, respectively. These tests were both successful. Apollo 7 put a 3-man crew into Earth's orbit for 11 days, showing that men could survive inside the Apollo spacecraft. Then Apollo 8 featured a 3-man crew orbiting the Moon; the first time humans had left the Earth's gravitational field. Apollo 9 was a manned test of the Lunar Module in Earth's atmosphere, followed by Apollo 10, a test of the Lunar Module in the Moon's gravitational field. After Apollo 10, everything had been successfully tested.

Apollo 11 was the culmination of the project: the lunar landing mission. It was also highly successful, although the Lunar Module landed about 4 miles away from where it was expected to land. Neil Armstrong and Buzz Aldrin walked on the Moon,

performed some experiments, and successfully re-docked with the command module. The mission's goals had been achieved. Later Apollo missions also conducted experiments on the Moon successfully, but Apollo 11 was the first and most symbolic.

However, things have changed since the so-called Golden Age of NASA. The organizational culture of the employees has changed completely. In the Golden Age, space travel was new and exciting; it's now routine and boring. Risks were seen as necessary for advances, and the failures that went along with taking those risks were seen as acceptable. Nowadays, failure is deemed unacceptable, and thus NASA planners don't take the same risks that they used to. This obviously helps to perpetuate the rarity of new and exciting missions. (McCurdy 155).

During the Mercury, Gemini, and Apollo programs, NASA officials took pride in knowing exactly how everything worked. They outsourced as little as possible and kept tight control on what they did outsource. Today, much more work is outsourced to other companies, and not nearly as much work is hands-on. Additionally, all of the flight testing that went on in the early days is now seen as excessively costly and unnecessary, however recent mistakes should have shown how it could be helpful. (McCurdy 134).

Recently, President George W. Bush announced plans for a major change in direction of our space program. The new plans will shift NASA's focus from low orbit projects such as the space shuttle and the international space station to more ambitious projects such as returning to lunar missions, building a lunar base, and ultimately going to Mars. The timeline he suggests has the technology for the missions developed by 2008, manned test flights by 2014, and the United States putting a man back on the Moon by the year 2020. (Bush)

The technology to be used for these missions will be revolutionary. Different versions of the spacecraft, known as the Crew Exploration Vehicle, will be capable of low-orbit missions, Moon missions, Mars missions, and even deeper space missions (Morris). Actual details of what technology will be used are currently being worked out, but it seems as if it will likely be based on the modular technology used for the Apollo missions, rather than another space plane like the space shuttle. NASA has contracted both Boeing and Lockheed Martin to design the spacecraft, and it will select the better design and put it into practice (Sietzen).

One question on many minds is, without the Saturn V launch vehicle, what will be capable of lifting the CEV into orbit? Each company seems to have different plans. Boeing is planning to use a launch vehicle based on the Delta rocket (CES – Delta IV Heavy Launch Vehicle). Lockheed seems to be planning to use the Atlas rocket (Crew Exploration Image Gallery).

Experts are divided on how feasible all of this actually will be. Some think this is the push that will be necessary to return NASA to the frontier mentality of the Golden Age, and the technical advantages that come along with it. Others are worried that NASA is too set in its current ways to change back into a bold risk taking and highly capable organization. Still others are concerned that either the budget is too small for the project to be successful, or that the dates are too far off in the future to build the excitement needed to reinvigorate NASA (Bush's Space Vision Thing). Space Command is currently the bold and capable American Space Agency, but it specializes in unmanned technology and further militarization of space is to be avoided.

NASA came into existence with the National Aeronautics and Space Act of 1958 after the public and political outcry due to Sputnik. The purposes and policies of American space activities were:

- the expansion of human knowledge
- improvement of aircraft and space vehicles
- development of craft to carry instruments and living organisms into space
- separation of military and civil space activities to show peaceful intentions
- preservation of the United States as a leader in space science and applications
- cooperation with other nations
- optimal utilization of American scientific and engineering resources

The principles of NASA have changed little since 1958. The program has had its highs and lows throughout its existence of 46 years. But it seems that NASA is turning back to its early days when there was a big emphasis on manned exploration. An example of this is George W. Bush's announcement of his new Vision for manned US Space Exploration including a manned mission to Mars. This is a bold long-range plan that needs big commitments both politically and financially.

A Discussion on the New Vision of George W. Bush

It is debatable whether to take this new vision seriously, because in the past a former president, George H.W. Bush, proposed a similar program in 1989. His OMB director estimated its 30-year cost to be about $590 billion on a 2003 dollar basis. However, after the Reagan and Bush administrations, in the fiscal year 1992, the yearly deficit hit a record $290 billion out of a federal budget of $1.38 trillion (21% of the total)

and the national debt was mounting. Congress and the administration began cutting the budgets of 'less-high-priority' programs. NASA was not exempted from the budget cuts. NASA's budget decreased during the 1990s. On the other hand, it had increased during the 1980s in inflation-adjusted dollars.

Currently, the US is again facing a budget deficit close to $500 billion. President Bush has claimed that the projected increase in NASA's budget over the next few years will not affect his fiscal policy to contain discretionary spending at a 4 percent growth rate and to cut the deficit in half within five years.

During a U.S. House of Representatives hearing on Feb 12, 2004, there was a lot of skepticism, curiosity, and even some positive commentary about the President's new plan. The witnesses were NASA administrator Sean O'Keefe and the President's science advisor John Marburger. During the hearing a few Congressmen questioned the necessity of such a costly program "at this time of record-high deficit spending" and asked about the possibility of postponing the spending. On the other hand, one Congressman claimed that the U.S. is in desperate need of more young people to go into careers in science, math and engineering. President Bush claimed that this program would serve that purpose by inspiring young people to do just that. O'Keefe supported the new plan and reminded the Congress that in August 26, 2003, the Columbia accident investigation board observed the absence of strategy and national goals as being contributing factors in the space policy drift over the past three decades.

Neither Bush nor O'Keefe has yet put a price on the new space objectives and there are already many skeptical views on the new program. A Washington Post article on Feb 11, 2004 stated that Norman Augustine, the retired chairman of Lockheed Martin,

made a comment that NASA doesn't have enough money or bright young stars to achieve President Bush's goal of returning astronauts to the Moon and flying from there to Mars. Augustine said, "it would be a grave mistake to undertake a major new space objective on the cheap", he said. "To do so in my opinion would be an invitation to disaster."

Political History

Presidents since NASA was established:
Eisenhower, Dwight 1953-61
Kennedy, John F. - 1961-63
Johnson, Lyndon - 1963-69
Nixon, Richard - 1969-74
Ford, Gerald - 1974-77
Carter, Jimmy - 1977-81
Reagan, Ronald - 1981-89
Bush, George H.W. - 1989-93
Clinton, William J. - 1993-2001
Bush, George W. - 2001-present(may 2004)

NASA Administrators:
Dr. T. Keith Glennan, August 19, 1958-January 20, 1961
James E. Webb, February 14, 1961-October 7, 1968
Dr. Thomas O. Paine, March 21, 1969-September 15, 1970
Dr. James C. Fletcher, April 27, 1971-May 1, 1977
Dr. Robert A. Frosch, June 21, 1977-January 20, 1981
James M. Beggs, July 10, 1981-December 4, 1985
Dr. William R. Graham, December 4, 1985-May 11, 1986 (Acting)
Dr. James C. Fletcher, May 12, 1986-April 8, 1989
Richard H. Truly,May 14, 1989-March 31, 1992
Daniel S. Goldin,April 1, 1992-November 17, 2001
Daniel R. Mulville, November 19, 2001 - December 21, 2001 (Acting)
Sean O'Keefe, December 21, 2001- present(May 2004)

Accomplishments of Daniel Saul Goldin - NASA Administrator, April 1, 1992 - November 17, 2001

Despite lower budgets, Goldin's "faster, better, cheaper" approach has enabled the Agency to deliver programs of high value to the American public without sacrificing safety. When Goldin became Administrator in the spring of 1992, outside observers perceived the Agency to be a bloated bureaucracy pursuing missions that were too expensive, took too long to develop and flew too infrequently. NASA also was criticized for an imbalance between human and robotic missions, especially by its own space scientists. As an outsider who had worked on unmanned technology in the past, Goldin saw value in unmanned space capability and knew it costs ten to twenty times less to carry out an unmanned mission in deep space.

Through Goldin's aggressive management reforms, annual budgets have been reduced, producing a $40 billion reduction from prior budget plans. He implemented a more balanced aeronautics and space program by reducing human space flight funding from 48 percent of NASA's total budget to 38 percent and increasing funding for science and aerospace technology from 31 to 43 percent. During his tenure, the Agency's civil service workforce was reduced by about a third, while the Headquarters' civil service and contractor workforce was reduced by more than half. These reductions were accomplished without resorting to forced layoffs by using attrition and other methods. At the same time, NASA's productivity gains climbed 40 percent. However, dependence on outside contractors for core functions in operating the shuttle also grew considerably as in house capability was reduced.

Goldin also cut the time required to develop Earth sensing and Space science spacecraft by 40 percent and reduced the cost of these by two-thirds, while increasing the

average number of missions launched per year about four times. During the same time, space shuttle costs were reduced by about a third, while all safety indicators and mission capabilities have achieved significant improvements.

Management Problems in NASA

While the technical staff at NASA is still quite competent, the middle managers and the bottom workforces of NASA are reluctant to speak up and complain about problems they see. People are afraid of being moved to different and unimportant jobs when they speak up in ways that are critical and might delay a mission launch.

After the Challenger disaster, the board of inquiry found that NASA's managers were reputed to regard it as a failure when a launch is held up and intimidated those who were worried about system components such as the O-rings. The Rogers commission concluded that, on the contrary, they should have regarded it as a success not to go on with risky launches.

So, by 1986 NASA lacked an environment where people could speak up without the fear of retribution. NASA's top managers then leaned the other way after Challenger was lost and became safety conscious and too risk averse saying they are trying to encourage their employees to go out and now seek opposing views if no one raises questions. However, a sense of complacency and risk tolerance reemerged by the time of the Columbia disaster on February 1, 2003 claiming another shuttle and crew when steps could have been taken to assess the situation before letting a damaged shuttle attempt to land. A mindset had taken hold that the dangerous part of the mission was the launch and if it that succeeded there would be no more problems. NASA is currently reorganizing some of its space centers such as Kennedy to shake up ingrained habits sustained by

inertia. The space agency has become a typical bureaucracy and is no longer a high functioning model of what an agency should be.

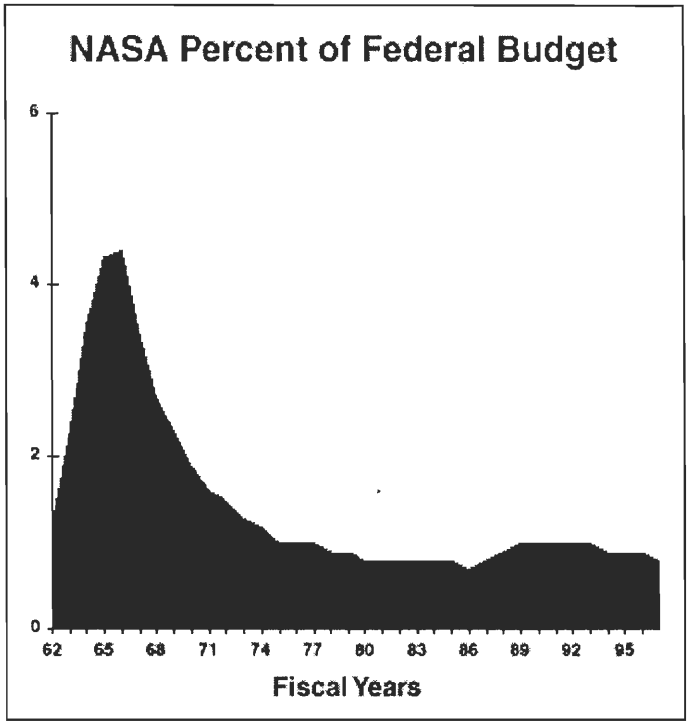
The leaders in NASA are criticized for not being accountable. The feedback loop between the leaders and their subordinates is not rapid enough and needs to be improved. There are people saying communication is an issue at NASA. Recently less than half of the workforce, the civil servant workforce, responded to a survey designed to assess the degree of change in NASA since the Apollo program.

The House has passed some new NASA work force legislation to improve NASA's ability to attract and retain the best and the brightest new engineers, scientists, astronauts, etc. This action suggests that there are concerns about the current state of the space agency.

Budget

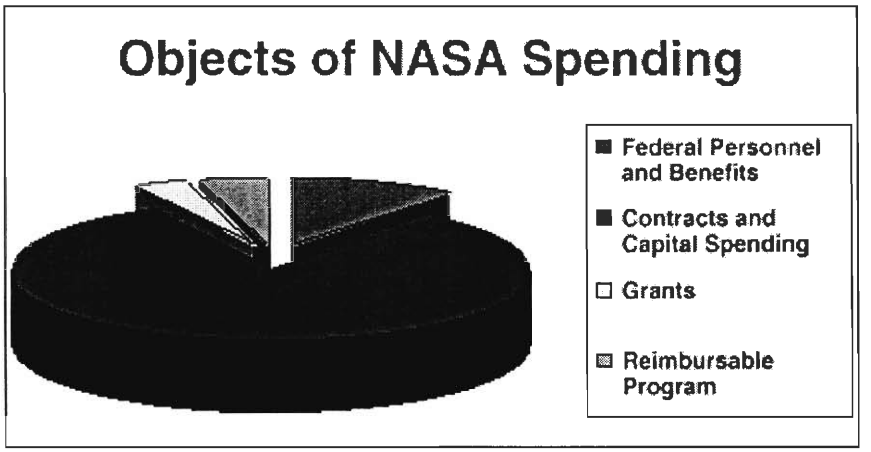
NASA Budget Trend

NASA's share of Federal spending has been declining from a high of 4.4% of the Federal Budget in 1966, at the height of the Apollo program, to about 0.7% currently. NASA continues to make significant scientific and engineering advances with fewer resources, but it is no longer the mover and shaker in the field that NACA was to the aviation industry.



How NASA spends its Budget

In accomplishing its programs, NASA spends the greatest part of its resources through contracts for a wide variety of support and services, plus the acquisition of capital assets. NASA supported a Civil Service workforce of 18,973 during 1997. NASA spends the rest of its resources through grants, principally research grants with colleges and universities, and for its reimbursable program with Federal, commercial and international agency customers.



Looking into the future

The federal deficit will hit a record $477 billion this year (2004) and get larger if lawmakers cut taxes or increase spending, the Congressional Budget Office projected in a report sure to become ammunition in the election-year fight over red ink.

The budget office also estimated that deficits for the decade ending in 2013 would total nearly $2.4 trillion. The August report foresaw deficits totaling $1.4 trillion over 10 years.

In fact, U.S. government funding for research and development has been cut in half when looked at as a portion of the U.S. Gross Domestics Product. In 1965, the U.S. spent over 1.8% of its GDP on scientific funding. By 1997, that amount had dropped to a mere 0.9% of the GDP. Private industry has filled many of the funding gaps that the government left behind, but funding from the private sector creates a new problem for scientists: they are nearly forced by their funding sources to pursue only those topics of short to medium term interest to the private sector sponsors. NASA has had a mixed record on the credibility of its budgeting for research and development, but in it's hey day it supported pure as well as applied science.

This will not be an easy year to start a major new initiative in the face of a growing deficit in the middle of a wartime mobilization. The President's budget is $16.2 billion and rising in the five year plan and is well within the President's fiscal policy to contain discretionary spending at a 4 percent growth rate and to cut the deficit in half within five years. All of those actions have been accommodated in the proposal the President submitted on February 2, 2004.

The maximum budget (coming in the year 2020) according to a report would be about $22 billion. $15 billion for the development of a crew exploration vehicle is a pretty big ticket item. Mr. O'Keefe said that NASA's budget charts indicate that there won't be U.S. funding for the International Space Station beyond 2016. On the other hand O'Keefe said then that NASA will continue the operation and maintenance of the ISS consistent with the U.S. space exploration goals.

In the past, Congress has often invested so heavily in NASA programs that it seems too late to cancel a program even after it proves to be troubled. We've seen an example of that in the space station. What milestones for assessment are built into the major aspects of the exploration initiative? At what point should NASA and the Congress reexamine the initiative, particularly CEV development to determine whether it is appropriate to proceed to completion? In the period of time of 2005 to 2009 the total projected amount of spending on this system is expected to grow to $86 billion. By then, there will be so much investment that the technology will have momentum and dependent companies to lobby for it.

Public Opinion

The government surveys that have come out since Apollo suggest that NASA is still considered the most desirable agency to work for in the Federal government. That is from the American University survey that was released fall 2003.

Public interest continues to support space exploration. During January 2004, the NASA web site received 6 billion hits. Over the span of this 40-day period that is more than twice the total number of hits NASA received in all of last year. All of last year was four times that which we've ever received before. This was the period of the Mars rover landings, the unmanned missions NASA sent to Mars to collect data.

Even at its height, the public doubted the value of the space program. Two-thirds of people in a 1971 poll by the Roper Organization said the government spent too much money on space exploration.

But most people weren't aware the budgets had been cut, the USA TODAY poll shows. It found only 29% of those polled believed that NASA's budget had shrunk over the past 10 years compared with the overall federal budget.

During the Apollo Project, NASA received unprecedented public support. Astronauts were heroes, and the space program moved rapidly toward its goals. (Byrnes)

Luckily for NASA - in a poll of 1,120 adults, approximately 80% said that the Shuttle Program should continue and 68% said that accidents were bound to happen sooner or later. 40% of those questioned believed that NASA was spending too much money, and 46% said that they would not support NASA if taxes increased to accommodate a need for increased NASA spending. However, these numbers were not much different than what they were in April 1981, just before the shuttle launchings

began. Americans saw Challenger as an isolated tragedy in the grand scheme of space exploration not as a symptom of fundamental flaws in the space agency.

One excellent example of the way in which scientists should conduct their public relations is the recent NASA Shuttle mission that marked John Glenn's return to space. Granted, every research endeavor cannot be as exciting as the return of an old hero, but NASA saw a chance to perform a mission that yielded many scientific benefits as well as capturing the public eye. Though it yielded enormous publicity, Glenn's return to space was inarguably not just a publicity stunt: his mission completed more than eighty scientific experiments and provided NASA with valuable data. Extensive research was done on the effects of aging in space, sleep patterns, and the repair of deteriorating body systems. (Bilstein) Also, NASA does not get credit for some of its greatest successes due to lack of media coverage of them. Hence, the public doesn't know what it is getting from NASA.

Scientists observed the biggest event in the history of the universe in the spring of 1997. At the far end of the universe, seven billion light-years away, two neutron stars collided, releasing as much energy in a few seconds as the sun will release in 10 billion years. Observations of the energy burst enabled scientists to solve a mystery that had been plaguing physicists since the dawn of the Cold War-where do gamma rays come from? Across the country, few newspapers carried the story. The New York Times, Los Angeles Times, and Boston Globe all addressed the discovery, but smaller newspapers, as well as television and radio outlets, failed to even mention this unprecedented occurrence.

There is a widespread belief in the scientific community that NASA can send approximately 1,000 robots to Mars for the cost of sending one human and bringing that human back. However, since NASA is strongly biased to manned space, robots are viewed primarily as data collection as a precursor to a manned flight.

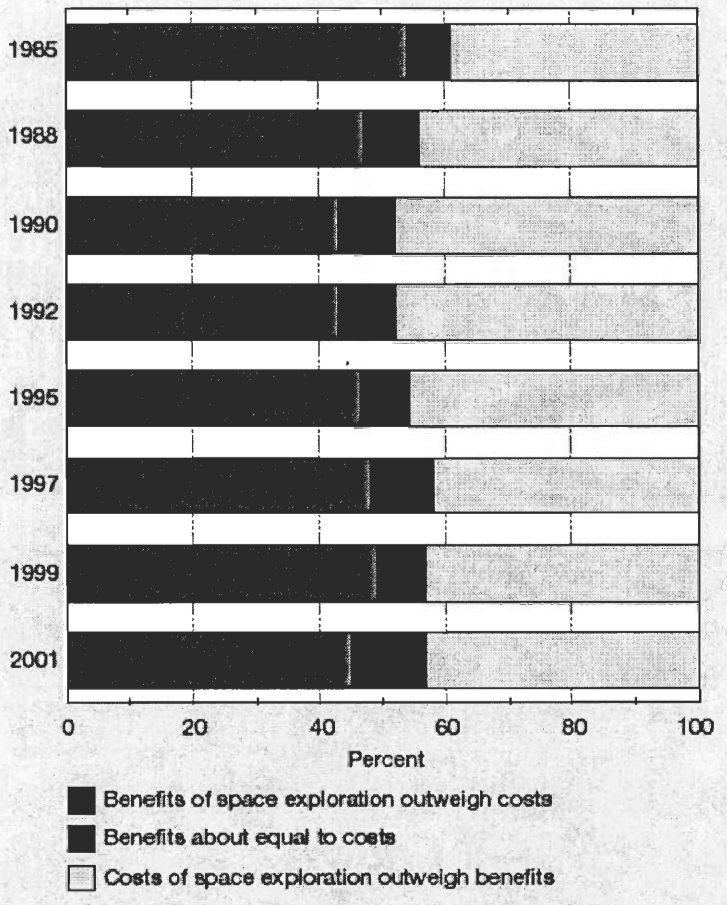
Private Sector

A recent survey stated that the contractors are feeling like they are being treated as second class citizens. During the 1990s, the budget cuts also affected the private aerospace industry. During this period, a European consortium, Airbus, became second in the market after Boeing and ahead of McDonnell Douglas. After this incident, NASA was criticized for allowing American dominance in the space and airlines industry to slip away.

Summary

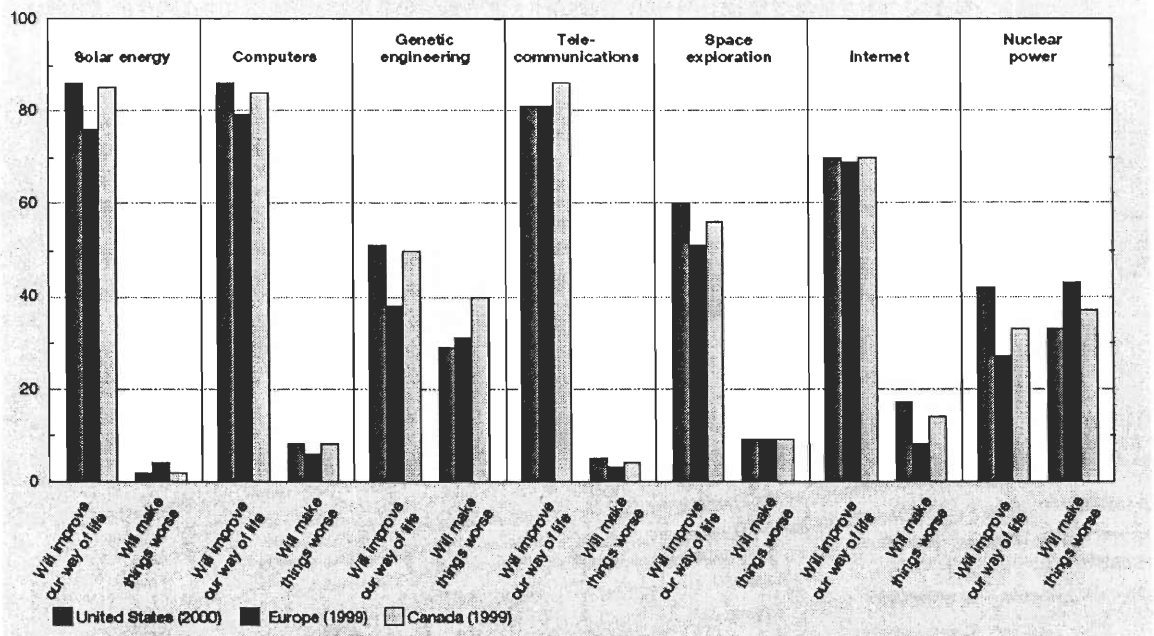
Today NASA is still biased toward manned space, but it is more centralized and sluggish than before. It is less capable of doing missions and unwilling to take new risks. NASA is no longer the high performance organization it use to be and needs to be "reinvented" since it has been overly focused on the shuttle as a means to build the space station for too long.

Figure 7-12.
Public assessment of space exploration: 1985–2001



See appendix table 7-25. *Science & Engineering Indicators – 2002*

Figure 7-11.
Public attitudes toward selected technologies in the United States, Europe, and Canada



SOURCES: Gaskell, G., and Bauer, M.W. (editors) *Biotechnology 1996–2000*, National Museum of Science and Industry (U.K.) and Michigan State University Press. The 1999 and 2000 surveys were conducted by George Gaskell, Martin Bauer, and Nick Allum for the European Commission; Susanna Priest, Texas A&M University; and Edna Einsiedel, University of Calgary.

Science & Engineering Indicators – 2002

Russia:

Korolev and his engineers had a dream; they were to create the world's first artificial Soviet satellite. The most important characteristic of this first mission was simplicity. They did not desire a complex and highly capable satellite. It was to have a radio system, an antenna, and it was designed to be spherical. Sputnik 1 was constructed for delivery by an R-7 rocket, it weighed 83.6 kg. R-7 was a strong rocket capable of carrying much heavier payloads so the light weight of Sputnik 1 was a major source of Korolev's confidence that this project would succeed. This satellite was launched on October 4, 1957, hence, on this date the space race commenced. The reaction of the Soviet Union was not as expected.

The launch of the first man-made satellite did not even make it to the front page on October 5, 1957. It was the next day that Soviet citizens became aware of what they had accomplished because the feat was acknowledged by the response of the rest of the world. They celebrated this accomplishment with great joy. It was right after that, that Sergei Nikita Khrushchev ordered Korolev "to send something new in space" for the celebration of the revolution's anniversary.

Korolev and his team had one month to prepare until the celebration. He had no time for a test flight, yet he still managed to create and launch Sputnik 2. It weighed 508 kilograms, Sputnik 2 carried the world's first space passenger too, a dog named Laika. Sputnik 3 was launched on February 1958 but this launch was not a success due to a rocket engine failure. The rocket went up about 13 kilometers and then parted with the satellite. On May 15, 1958 the second launch of Sputnik 3 resulted in a success. Sputnik 3 was 1.3 tons and was more complex than the first two Sputnik satellites. Sputnik 3 also removed any doubts regarding the ability of the USSR to launch an ICBM from the Soviet Union to the United States. The launch of Sputnik 3 forced the United States to spend more on manned and unmanned satellites and rocket motors with greater thrust.

First Manned Missions (Vostok)

Korolev had in mind the creation of a manned space craft as early as 1948. However, the design of Vostok which would carry Cosmonaut Yuri Gagarin into space did not begin until 1958. Just like Sputnik, its shape would be spherical. Korolev thought that the spherical shape would be better since it would be symmetrical. Vostok was to have two components. The shape of the first component was spherical. It was in this component in which the cosmonaut would continue his journey. The second component

was under the rocket system. The weight of Vostok was 4.73 tons. Vostok was designed in such a way that very little responsibility was given to the human passengers. It was as if they did not know what shape the passenger would be in, so assumed the worst. Everything was operated by six simple buttons, these buttons were coded and had to be punched three at a time to override the automatic system. They did not want any failures resulting from human error; therefore they simplified and automated the whole operation. The codes for these buttons were given in envelopes to Cosmonauts right before the launch.

It was not only the system which was simple but the spacecraft. It lacked the instruments for a soft landing which would force the cosmonaut to parachute out of the capsule to reach earth safely. An ejection seat was installed as the central feature of the landing system. The cosmonaut would eject during his return flight and would be recovered separately from the spacecraft wreckage. This feature was initially a secret and a second Vostok was brought to the landing site so that Yuri Gagarin could be photographed emerging from the spacecraft. This deception was so that the first manned flight would meet all requirements of an international prize for first to launch into space and land safely back on Earth. Korolev never claimed the monetary prize, but the Soviet state wanted to pre-empt anyone else from getting it.

Since there was little need for intellectual ability on the part of the cosmonauts, perfect health was the priority when selecting among twenty pilots. Finally two cosmonauts were selected, Yuri Gagarin and Gherman Titov. On April 12, 1961 Yuri Gagarin achieved a magnificent victory for the Soviet Union in the space race. He was the first man to be in space. The duration of the mission was 108 minutes. After Vostok 1

on August 1961, Vostok 2 was launched. This time the cosmonaut was Gherman Titov. Vostok 2 was a much longer mission than Vostok 1, 25 hours. As the duration of flights increased, the confidence in the spacecraft and the mission controllers increased accordingly. There were many more launches of Vostok, but among these the Vostok 6 was very important because it was on this mission Valentina Tereshkova was sent to space. It was another first for the Soviet Union; she was the first woman to travel to space. After this flight the Vostok project was finally complete. The project Soyuz would now take the place of Vostok.

Soyuz Missions

This spacecraft was thought to be a descendent from the Vostok mission but actually it was a total redesign for a new mission. Korolev saw this spacecraft as a lunar orbit flyby spacecraft, but his main goal was to send a manned spacecraft to orbit. Something else would then land on the Moon. There were nine missions conducted from 1967-1970. The spacecraft (Soyuz A) was composed of three modules. They were orbital, descent and instrument. Soyuz A was designed as a manned craft. Soyuz B was an unmanned supply craft and Soyuz-V was an unmanned tanker. Our main concern is Soyuz A "the manned craft." This was the main spacecraft on which the whole hope of Korolev, and later his group, rested. Soyuz 1 was supposed to be the first manned spacecraft which belonged to the Soyuz family. Unfortunately Soyuz 1 resulted in a great catastrophe on April 24, 1967. Soyuz landed with such great velocity that it was impossible for the cosmonaut "Vladimir Komarov" to survive. Korolev had already died of a heart attack in 1965 and it was obvious that Soviet Union was suffering the loss of its chief designer greatly. It was on October 25 1968, Soyuz 2 was sent to space but as a

precaution it was sent unmanned. After the success of Soyuz 2, enough confidence was regained to launch Soyuz 3. This time it was a manned spacecraft which carried Gyorgi Beregovoi. Soyuz 2 and Soyuz 3 had a rendezvous and came very close to one another. This mission was a success and another great confidence boost for the Soviet Union in the post-Korolev period. However, it was clear that the Moon race was lost. Korolev had died before perfecting the N-1 Moon rocket. So, officials denied the USSR had ever been interested in the Moon and called for an unmanned Moon sample retrieval mission for the Moon. The Soviets then turned their attention to building a space station.

After this mission, Soyuz spacecraft was the official vehicle of Soviet space industry. On January 14-15 1969 "the world's first orbiting space station" was created. The successful docking of two manned spacecraft was a spectacular accomplishment for the Soviet Union. Soyuz 4 carried cosmonaut Vladimir Shatalov and Soyuz 5 carried cosmonauts Yevgeni Khrunov, Alexei Yeliseev and Boris Volynov. Soyuz 6, 7 and 8 were launched in October, the main goal of these launches was research and data gathering. Soyuz 7 and 8 were scheduled to dock with one another but this was never accomplished. Soyuz 9 was launched in June 1970, the goal of this project was also scientific research. After this era, there would be a new endeavor and goal for the Soviet space industry, the creation of space stations to be visited by Cosmonauts.

Salyut Space Stations

The Salyut space station period is comprised of two eras. The Salyut 1-5 space stations represent the beginning of space station construction. Salyut 6 and 7 are second generation space stations which led to the creation of a great space station MIR. Salyut 1 had four components. The first one allowed the transfer of cosmonauts into and out of

the space station. This eliminated the spacewalk which was a major design problem for the Soviets. The first component was used as a docking system. The second component was designed for the propulsion system. The propulsion system of Salyut 1 was similar to the Soyuz propulsion system but there were certain modifications. The third compartment was designed for working. In this work compartment optimum living conditions were to be maintained. A dinner table, sleeping bags, medical units, a library and other accommodations for the living conditions of cosmonauts were included. There was also another compartment designed for scientific research and data gathering. There were labs in this compartment which possessed scientific research equipment. Two launches were made to Salyut 1, but both of these launches resulted in failure. Soyuz 10 docked with Salyut 1 yet the cosmonauts still failed to enter Salyut 1. Soyuz 11 docked with Salyut 1, this time cosmonauts did manage to enter Salyut 1 and conducted experiments, but this mission resulted in tragedy because the crew of Salyut 11 was found dead upon the return to Earth. Salyut 1 was discarded and Salyut 2 was next sent, but this space station was also a failure because two unmanned flights resulted in failure to dock and provide supplies.

These space stations served two purposes, military and civilian. Salyuts 2, 3 and 5 were designed to serve military purposes, Salyut 4 (which had a similar design to that of the Salyut 1) served civilian purposes. It was the Salyut 3 that was the first successful space station in Soviet space history. Soyuz 14 had a successful mission with this space station and some medical experiments were conducted. Salyut 4 took the place of Salyut 3 and this space station (which served civilian purposes) was also successful.

Second Generation Space Stations

The first generation space stations created many problems for the Soviets. They had many failures as they acquired the necessary experience to create the second generation of space stations. Salyut 6 and 7 are the second generation space stations which marked a new era for the Soviets. Salyut-6 was similar to Salyut-4 in that they both were designed to serve civilian purposes. The only differences Salyut 6 had from Salyut 4 were that it had an extra docking system which enabled the docking of two Soyuz spacecraft and it had three solar panels for energy production. It also had certain modifications in the mounted accessories, a topographical camera and a resource camera were installed for earth scanning to serve the mining bureau and map making uses. There was also a telescope used for planetary observation.

Soyuz 25's mission was to dock with Salyut 6 but this mission resulted in failure because of a docking problem. There were always problems regarding the docking system. This last problem raised the question of a major engineering or production flaw in the docking system of Salyut. Soyuz 26 made all those doubts go away because the mission was a success. Cosmonauts docked with Salyut 6 and inspected the space station for certain flaws. Many more Soyuz missions were conducted on Salyut 6 (Soyuz 28, 29, 36, 35, 40). In those missions cosmonauts stayed in Salyut 6 for 96 days. Salyut 6 missions had 95 percent success rate in contrast with the first generation space stations which had a much lower success rate than that, more like 50%.

The positive results of Salyut 6 brought confidence for Salyut 7. There were great expectations from this station. Salyut 7 did have additional improvements like more solar

panels which made it more durable and efficient. The station offered a more comfortable environment for cosmonauts. Manned Soyuz-T missions were conducted to Salyut 7. These missions brought great success and there even was a great Cosmonaut endurance record of eight months. The Soviets now had sufficient experience and confidence to create a great space station which would enable them to continuously man a space station. This would be the famous MIR space station.

Third Generation Space Station (MIR)

The launch of the third generation space station was conducted on February 19, 1986. This space station was a modified version of the second generation Salyut. The reason second generation Salyut's were selected because these stations were proven systems, a reliable design. Their great reliability inspired confidence in these space stations. Therefore the Soviets modified this series to create MIR. The modifications going from Saylut to MIR were numerous. MIR had the ability to dock up to six spacecraft. The energy problems which were common in Salyut space stations did not exist in MIR because the solar panels on MIR were larger than the solar panels in Salyut models. MIR was a great creation; in this space station the Soviets reached the peak of their expertise in space station design and construction. Two Cosmonauts spent a year on MIR, which was the greatest record of endurance in a manned space station to date.

The space shuttle Buran was created specially for MIR. This space shuttle would have made the journey easier if it had ever been used for manned flight, but it was not. Buran was similar to the space shuttle of the United States in shape but was launched on a liquid rather than a solid rocket booster. The Soviets did not want to risk any failures,

therefore they built the shuttle very similar to the model of United States, but later decided the shuttle was not a good design and far too expensive. However, MIR was a great space station without any equal in its day and the Soyuz spacecraft might be expendable (one use) items, but they were now on a production assembly line basis and could be manufactured cheaply. Only the current International Space Station is larger and more elaborate. MIR was a testament to the great expertise of Soviet space stations at its high point.

Korolev

When we started working on this project the first source offered to me by my professor was James Harford's book on Korolev. He told me to read this book carefully and advised me that if there ever was a great man scenario in space history this would be it. As I read the book I could not agree more with my professor and the author. This book is a testament to show the world how a great man could change the fate of one nation. He was the chief director of the Soviet space program. He coordinated the missions of Sputnik, Vostok and Voskhod. All of these missions brought great success to the Soviet Union. Under the direction of Korolev, the Soviet Union achieved many space first victories at the time from the world's first satellite to the first man (and later women) in space.

Korolev was born in the Ukraine on December 30, 1906. He was a very smart child who grew up in a broken family. His parents were divorced so he did not grow up in a happy environment. He lived with his mother and did not see his father. His mother was also taking classes. This made things difficult for little Korolev since he grew up without a father and the frequent absence of his mother led to a rather lonely existence.

This forced him to show initiative and improve his inventiveness so that he was not bored with an uneventful solitary life. He turned to books for escape. Later, Korolev was an excellent student, his teachers said he had a wonderful memory and he was very good at arithmetic. He studied at Kiev Polytech, and then he was accepted to the Moscow Higher Technical School.

In Moscow, he had the privilege of working with great scientists and engineers and was later recruited by Tukhachevsky after proving that he had great potential. General Tukhachvesky was a very important figure not only in the Soviet Union, but also in Korolev's life. He funded the research of rocket engines and was the main supporter of Korolev and his research group. Tukhachvesky founded RNII, this was a Reaction Propulsion Institute. Korolev was assigned there to achieve the goal of "high velocity stratospheric flight ". The use of rockets in military weapons would also be researched at this institute. Since RNII was founded by Tukhachvesky, a very powerful military general working under Stalin, Korolev was now officially working for the military. The creation of ballistic missiles was going at full gallop under the supervision of Korolev and Tukhachvesky.

Korolev was very successful, and because of his good work, he was promoted to chief designer and coordinator of RNII. This promotion unfortunately did not bring luck to Korolev. Soon after this promotion he was arrested by the NVKD, the military intelligence unit of the Soviet Union. He was arrested on June 27 1938. At that time Korolev was thirty one years old. Although he was twenty years younger than the great American rocket scientist Robert Goddard, his achievements in rocket science nearly

matched those of Goddard at the time due to the greater support his research unit had been given. Only the Germans were farther along in this field.

The great question is why would such a successful scientist be arrested? Korolev would soon find the answer to this question. He would learn this answer in the Lefortovo prison in which he was tortured during his interrogation. He was accused of collaborating with the Germans and deliberately holding the liquid rocket project back. This accusation however was based on a larger one. This whole incident was caused by the arrest of General Tukhachvesky. This General was seen as a German spy. This accusation was made by the NKVD. The interesting part is that the NKVD got this information from the Germans.

NKVD was not aware of the fact that this was false information supplied by the Nazis to disrupt and slow down the Soviet rocket program. The Stalin era was one of official paranoia so "leaked" information was taken very seriously and actions were often taken rashly without verifying facts. Therefore, there was never a thorough investigation. The Nazis had a great victory since Tukhachvesky was more than a mere general. He was the man who modernized the Soviet army. He was the founder of RNII in which great weapons such as ballistic missiles were created. The arrest of Tukhachvesky not only brought the end of the modernization of the Soviet army, but also brought the demise of Korolev and other scientists working in Tukhachvesky's RNII.

Since Tukhachvesky was seen as a German spy, the paranoid minions of Stalin thought that everyone working for Tukhachvesky was a conspirator or a collaborator (refusing to report) a spy, therefore they were all arrested along with Korolev. Since they did not have proof for everyone, a fair trial was out of the question. The method of the

NKVD was to torture the accused until they admitted the accusations were true. Those who confessed were executed and those who did not were sent to the gulag to be worked to death serving the state. During the Stalin era, 5 million people were arrested and subjected to the method mentioned above. The main goal of Stalin was to evoke terror, he tried to terrify people in such a way that no one would ever dare to conspire against him. In this method, however, many innocent and talented people suffered unnecessarily. One of them was Korolev.

After refusing to confess under torture, a quick trial in Lefortovo resulted in Korolev being sentenced to 10 years of hard labor and sent to Kolyma gulag. In this gulag there was a gold mine and the prisoners were ordered to work in this mine. This was a very difficult chore which required great strength. The conditions of the gulag were terrible, it differed very little from the Nazi concentration camps. Korolev stayed in Kolyma for one year and very nearly died there. He was then moved to a Sharaga.

Sharaga was a different kind of penal institution. When Stalin arrested most of the scientists and engineers out of paranoia; he realized that the nation's improvements in technology suffered greatly. He therefore gathered all the scientists and engineers in one prison and forced them to work on military technology. Tupolev, who was Korolev's professor in Moscow Higher Technical Institute, intervened and brought Korolev to the Sharaga where he was working. Unlike the gulags, life in Sharaga was not that terrible. Decent food was given out and they did not do any exhausting work. They had time for rest and their health was an important issue for the NKVD, so the health care was much better than it was in the gulags.

Korolev worked under the team of Tupolev and they started working on Tu-2 light bomber. He then continued to work on the use of rockets in planes and weapons. He worked on the four chamber RD-1 rocket engine which was used on Pe-2 dive bomber. He continued to work in Tupolev's sharaga until the end of World War II. During his captivity he achieved magnificent successes. He made a lot of contributions to aviation and rocket science.

At the end the war he was sent to Germany to learn more about the V-2 rockets, as he was one of the few survivors of the break up of Tukhachvesky's RNII still professionally active. It was in Germany that the Russians captured some of the German scientists who worked under Von Braun and all their drawings and equipment. These scientists gave very helpful tips to Korolev and his new rocket group about ballistic missiles, to help them get back the time they lost due to the German plot against Tukhachvesky. Korolev did not integrate the Germans into his group. He had two parallel teams one German, one Russian and would give them the same assignment. The Russians would study and assess the German's work comparing it to their own. This went on until the Russian solution and technology was superior to that of the German team.

After these "tips" provided by the Germans, Korolev created the R-7 rocket which was the world's first Intercontinental Ballistic Missile (ICBM). The R-7 rocket could also carry a heavier payload than the German V-2 rocket so the R-7 was used in Sputnik missions. In the Sputnik missions Korolev achieved marvelous things but the most astonishing one was the preparation of Sputnik II which was completed in one month. After the Sputnik missions came Vostok and Voskhod missions which brought great

fame and honor to the Soviet Union. Korolev was the mastermind of all three of these missions.

At the time of his death, Korolev was trying to build a Moon rocket called the N-1. The handicap that he faced compared to the Americans was the lack of a booster comparable in power to that of the F-1. Without it had had to use 3 or 4 times as many smaller rocket engines and find a way to coordinate and balance them if one of the rockets failed, and 2 or 3 were expected to do so on any given launch. This problem was not solved at the time of his death, and indeed there was a spectacular explosion associated with the last attempt to get the N-1 Moon rocket to work.

The decision to turn off the rocket opposite to any one that failed was the probable cause of this failure. If more than 3 failed the system would be down more than 6 rockets and the great Moon rocket would never get off of the launch pad. The huge crater where the N-1 had been was visible from space to US spy satellites. Given this failure, the Soviet Government denied that there ever was a policy to try to reach the Moon in a manned flight before the Americans. The Russians went to the Moon and collected samples in an unmanned mission instead, using the proven Proton booster.

After the death of Korolev, the Soviet's accomplishments in space declined and a period of early failure in the new space station projects led officials to insist on complete secrecy until there was a success to proclaim. It is interesting that the political leadership completely lost faith in the space science and technology community and decided that without its great mastermind as "Chief Designer" they could not achieve the goal of getting to the Moon.

Actually, they had lost more than their space designer, his team at NPO Energyia had designed their land-based and submarine launched ICBM's as well. They gave up rather quickly on the Moon after a huge investment and turned to cover-up very soon after his death and that of a Cosmonaut in a crash two years later. The space program did not stop, as it turned to unmanned missions and perfecting their space stations, but with their booster expert gone they lowered their sights to what could be done with the booster technology they had.

At least in the eyes of the Communist leadership, Korolev was a great mind who really made a difference. He was irreplaceable and in a sense he was the only one who had such stature that he could force the various units in the far flung space industry to cooperate or else, and enforce his design concepts on everyone. Conflict and reduced funding plagued the program after his death. The great organizational integrator who instinctively knew what design was best was gone. No one else would be entrusted with a large discretionary budget. In that sense the whole success of the Soviet program rested on the shoulders of Korolev and the young people he trained after recruiting them straight out of the university. It was not that they were brilliant, but because they had the complete confidence of the leadership and their peers that they ran the Soviet program in a coordinated fashion. That confidence meant power over others and a discretionary budget under the control of just one man who answered only to the national leader, or his designated representative. Korolev met with Nikita Krushehev personally to get his Sputnik 2 orders. This pattern would continue despite the fact that Korolev, an ex-prisoner from the gulag, was not a party member. As such, his name was a state secret, so he had access but no public reputation or recognition.

Communism

Communism had many effects on the USSR, not only in the space race. This regime affected every branch of Soviet activity. Communism had pros and cons, but before we get into the benefits and harms of this ruling system, one should first consider the question of what communism is all about, as a system hosting a scientific and technical community.

Communism began with the ideas of Karl Marx. Marx believed that things take on value through the labor invested in them. Hence, he thought that property owning capitalists were expropriating the value created by the working clan for their own benefit. It was inevitable, in his view, that laborers would rebel at the alienation of their wealth, resent the property owners and take back the fruits of their labor through revolution. He believed that society could not avoid being oppressive without the laborers in control and believed the proletariat working class would displace the capitalists. The labor theory of value would justify the State's owning all factories, tools, ships and land in the name of the people, removing the oppressive capitalist managerial class. In Marx's view the only problem the proletariat would have in coming to power was that the rural peasants were all too often recruited, mobilized, or drafted into an army capable of subduing the urban working class. In Marx's view they did not know where their own self interest lay, so they were deluded into serving the interests of the property owning capitalists. The communist dictatorship of the State was only a temporary phase, in his view, as the state would fade away when all men were taught to put the common good before their own self interest. The goal was a society of new and selfless people that distributed goals to each according to their need rather than their social class, income or productivity. "From each

according to their ability, to each according to their need" was the rally cry of Engel's "Communist Manifesto".

Marx believed the strength of the workers whose main advantage was that they were a majority in the population and their own physical labor would lead the Soviet Union to surpass the capitalist states as the international socialist movement took over the world. Tsarist Russia was in turmoil, peasants and workers were unhappy due to the totalitarian repressive and often unjust rule of the Tsar and his nobles. The serfs were near slaves and tied to the land in Russia long after other nations had given the masses citizenship rights.

WWI was going badly for the Russians. The Germans were invading successfully but feared their ability to conduct a two front war for long. They wanted Russia to stop fighting and let them concentrate on England, France and Italy. So, they released the Marxist (Lenin) Russian they had in prison on the understanding that he would leave the country, go home, and start a revolution. He saw no reason the working classes of Russia and Germany should be fighting one another. So he agreed.

Meanwhile, the Tsar fell from power and a democratic republic took control of Russia. It was modeled after England and France, and refused to abandon the allied cause in the war. The Marxist Bolsheviks formed a revolution against this government and concentrated on subverting the loyalty of the military units that the Russian government would have to call upon to put down a peoples rebellion.

The Bolsheviks then seized the radio stations and one naval vessel, which trained its guns on the capital buildings. The government feared that if they called Army units back from the front lines the soldiers would be more likely to join the revolution than put

it down, since a Bolshevik Victory would end the war and let them go home. A few loyal divisions would have been enough to put down Lenin's revolution, but they did not have loyal units near Moscow so the government fell to Lenin. The Bolsheviks then killed the Tsar (Nicholas II the last Romanoff) and his family and signed a peace treaty with the Germans. Lenin achieved this at the expense of great territorial loss of lands thus held by the German invaders but certain reforms were more vital than land for Lenin. In order to achieve these reforms, he needed a state of peace because Russia was about to enter an era of change which would shake the country both economically and socially.

Lenin first seized the estates of landlords and gave them to the control of peasants who were organized as collective farmers. The factories were also collectivized, now being controlled by workers. The equality of women and men was emphasized. One of the most important changes that Lenin tried to establish was free provision of health care, education, and housing.

Under the rule of Lenin many economic actions were taken, the government nationalized banks, insurance companies, railroads, and large factories, forbade most private commerce, and seized grain from the rural population to support the urban working class, thereby undermining peasant support for the regime. Lenin also did not allow economy, finance, transportation, heavy industry, and foreign trade to be run by any companies except under state rule. Domestic companies were allowed internal trade, small-scale manufacture and farming. Although the country came through a revolution, with the economic reforms Russia emerged from a financial crisis the resulting economy was not stronger than during the pre-war Tsarist period. All of these revolutions however proved how important the role of the party and the ideology of the chairman played in the

formation of the economic policies and social priorities of the USSR. After the death of Lenin we will see how the ideology of the chairman and of the party could affect the USSR's direction of development.

Stalin was a different leader than Lenin, although he had worked with Lenin for many years, Stalin used far more brutality against his opponents than Lenin. An example of this would be the treatment of Trotsky. Leon Trotsky was originally a co-ruler with Stalin. Stalin got him ousted and exiled and Trotsky was assassinated in 1940 while in exile in Mexico. People who opposed Stalin's policies were also punished severely. People were sent to the "gulag" for the reason of an opposing opinion to official policy expressed in public. Disloyalty only had to be suspected and Parents were sometimes jailed after being informed on by their children at school. The era of Stalin was total terror; many people were shot or sent to their deaths in forced labor camps because of the paranoia of Stalin.

After Stalin came Khrushchev, he worked very closely with Stalin but when he came to power he tried to change everything created by Stalin. Gulags were closed, the severities of the punishments were reduced and even the past actions of Stalin were criticized. Khrushchev had other ideas. Therefore he tried to change everything Stalin stood for. He tried to do this by bringing back the ideologies of the forefather Lenin and the martyred Trotsky. He was however unsuccessful because going back to Lenin's ideology and single party rule. Such concentration of power was too much for the survivors of the Stalin era to accept. Khrushchev was therefore replaced by Brezhnev. During the era of Brezhnev, the Soviet Union entered a term of tranquility and stagnation. Change was needed but it was blocked by one or another power block and in this period

the economy started to shrink. The budget for the space industry was also greatly reduced because of this fact.

Brezhnev did not want drastic changes; he wanted to maintain the current situation of the Soviet Union. This result was very negative since the economy steadily declined during the period of this status-quo policy. The system was eroding.

After Brezhnev, Gorbachev took the reins promising reform, restructuring, and openness. However because of his policy of shifting toward a more decentralized market oriented socialist system, the whole system suddenly collapsed. He moved too far, too fast and the Socialist hard line leftists rebelled and took Gorbachev prisoner. After Gorbachev was released the people went to the streets to protect the reforms under the inspiration of Moscow's Mayor Boris Yeltzin. The Army refused to fire on the people of Moscow and the hardliner rebellion was over. Gorbachev tried to keep the party alive, but was pushed aside by Yeltzin and others who wanted a rapid change to a democratic capitalist, free market state. Yeltzin then became President of Russia, the in a new Confederation of Independent States.

When we observe all the leaders, we can make out a fact related to communist rule, at least as experienced in Russia. The party leader's ideology decides the success or failure of his era. The whole nation's path and destination is based on the beliefs of the party leader. The problem with this method is that no stability could be achieved in such a system. Lenin's work was changed by Stalin; Stalin's work was undone by Khrushchev, and so on. The space industry was also affected by this problem of massive sudden change.

Korolev was first sent to the gulag because of his ideologies under Stalin. When Stalin realized that he had killed nearly every valuable space scientist, his only option was to put the few he had left, especially Korolev back to work. Therefore he took Korolev out of the gulag and sent him to a "special" prison. The Zek became the state secret "Chief Designer" with near total control over all aspects of the space and missile program under Kruschev, as he no longer had any peers in his field other than those who trained him and were retiring. He would have to train a whole new generation of experts to help him continue the program.

This action is also a good example to show how unbalanced the system was, by not to valuing Korolev continuously, and by not requiring solid evidence to imprison him. He first mastered the V-2 rockets by closely observing the German scientists, but an all Russian team was also formed and given all the same assignments. They were allowed to question the German's until they could surpass them. He then created R-7 rockets which would be used in the Sputnik mission as well as being ICBM's. He was really the mastermind behind the whole Soviet space program and he designed ICBM's too. There is no comparable figure in the NASA Apollo program, not even the highly respected Von Braun.

Korolev and his team was such that he set up the Sputnik 2 mission in one month and this mission was a great success for the Soviet Union. However, much time was lost in dealing with the unreasonable demands of the politicians who were his patrons. In one case they complained to him that the Americans had a 3 man spacecraft and the Soviet's was designed for 2. Months were lost as they reconfigured the 2 man space craft to carry three people just once, for purely political reasons.

Korolev worked with Khrushchev and in this era he was very well supported and thus the Soviet Union had many space firsts. The Sputnik and Vostok missions brought great success to Korolev and great glory to the Soviet Union. Korolev died in 1965 and after the death of this great man the Soviet space program declined dramatically. The Soyuz mission had great failures, some of which, as in Soyuz I resulted in loss of life. During the Brezhnev era, the economy declined and funding for the space industry was substantially cut back. Brezhnev's status quo policy was the main reason for economic crises in the space program. However, it is worth noting that Nixon was doing the same thing to NASA at the same time, cutting back on space to pay for the war in Vietnam.

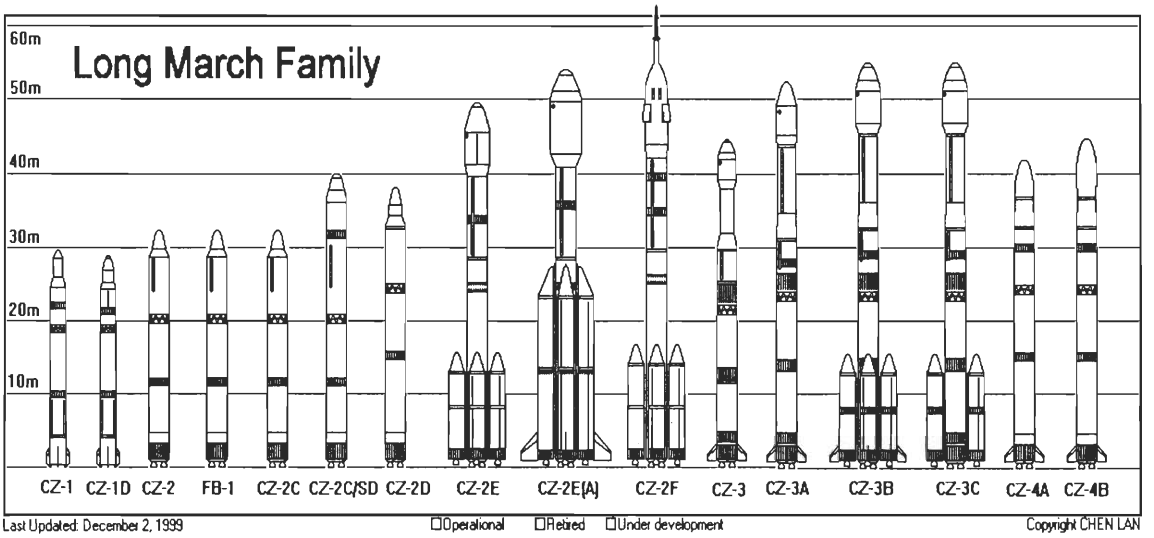
Communism as a system for technological endeavors made both positive and negative contributions to the Soviet space program. The possibility of cheap slave labor was probably the most important advantage of communism. Workers were not given much money yet Korolev could reward his favorites and punish slacking with a phone call or two. He controlled access to privileges in a command economy so people could be rewarded by other means than salary increases. Those privileges could be very important, such as a more comfortable house than the ones other citizens had access to, or the use of a car. For a young engineer, being moved to the top of the apartment waiting list over 2 years long could mean the chance to marry and start a family. Since this was an authoritarian regime, people could be forced to take a given job, live in a given area and even physically work more to avoid losing what they had.

The negative side of the system is the unstable environment. A long standing policy could change very quickly. This spontaneous environmental change had a very negative effect on the space industry. Also a general lack of funds and small number of

capable contractors caused many problems for Korolev and his team. They had to do many things themselves. They were the underdogs in this race, but while he lived, they ran neck and neck with the better funded Americans who had three times as much money, twice the manpower and much better computer facilities, and contractor support.

China:

Since the Soviet Union and the People Republic of China have the same political system and share technological information, knowing Russia's past technology will be important in assessing China's present and future technical capabilities. In evaluating the technical capability of the Chinese it is important to know the history of China's delivery rocket the Long March (LM) in English and Chang Zheng (CZ) in Chinese. A brief history will describe the skill and speed with which the Chinese have evolved their rocketry. This will give us a better understanding of China's current abilities in rocketry and how far the Chinese will likely get in thirty years.



(Go Taikonauts, geocities.com)

LM-1 and LM-1D

The LM-1 was used to launch the first two Chinese satellites, the Dong Feng Hong (DFH) 1 and 2 into space. (tbs-statellite) The DFH 1 supposedly broadcast their national anthem "The East is Red". The LM-1 can carry a 300 kilogram payload to 400 km with 70% incline. It launched on April 1970 (DFH 1) and March 1971 (DFH 2). The LM-1 had one failure in November 1969. The LM-1D is an enhanced version on the LM-1 that can carry heavier payloads. The LM-1D can carry 900 kg into a Lower Earth Orbit (LEO). It had its first launch in 1991.

LM-2 series

The Long March-2 (LM-2) was launched in 1970, but was a failure because the vehicle lost altitude after liftoff and was destroyed. The LM-2 was quickly replaced by the LM-2C which had a successful launch on November 26, 1975 carrying the DFH 4 (Dong Feng Hong). The LM-2C is China's oldest operational rocket and has a reported 100% success rate. It can carry a payload up to 2,640 kg into LEO (lower earth orbit) and had Motorola IRIDIUM as an anchor customer with seven launches of communication satellites from the Taiyuan Satellite Launch Center (TSLC). To handle Motorola's double launch schedule the LM-2C was modified to the LM-2C/SD with a new upper stage called, a Smart Dispenser (SD), which allowed two satellites to be launched at once. (fas.org)

The LM-2E started development in 1988 and is the first rocket in the LM-2 series designed to reach a geo-stationary orbit (GTO). It is an upgraded version of the LM-2C and one of the most powerful rockets that the Chinese have developed. It is capable of

carrying approximately 9,200 kg into LEO and 3,500 kg to GTO. (Go Taikonauts, geocities.com) This new stage, the perigee kick motor (PKM), was used to carry payloads from LEO to GTO.

In 1990 the LM-2E had its first test flight and successfully delivered a 50 kg Pakistani piggy-back satellite, but failed to carry the Optus dummy cargo to GTO. The next mission on August 13th 1992 was successful in carrying Optus B1 into GTO. On January 25, 1995 the LM-2E exploded on the pad killing seven workers and injuring another twenty-seven with debris. Though it has faced some troubles, the LM-2E is still a cornerstone of Chinese satellite launches.

The last configuration in the Long March 2 series is the LM-2F, which is much like the LM-2E with four strap-on stages and 2 core stages. However, the LM-2F is specifically designed to support manned space and has been the rocket for all the Shenzhou program missions. The LM-2F has two unique systems: its fault monitoring system and its escape system to ensure the safety of the Taikonaut. (Space daily)

LM-3 series

The LM-3 was introduced in 1984 with a new third upper stage able to reach a geostationary orbit (GTO) from a low earth orbit (LEO) with up to 1, 500 kg payload. It is a three stage rocket; the first two stages are identical to the LM-2C, but the third stage is a restart-able liquid hydrogen and liquid oxygen engine. With launches from 1984 – 2000 the LM-3 has a lot of history in China. In 1984 on its first flight its 3rd stage failed to ignite, but the next six missions were a success. On June 10, 1997 the LM-3 was used to launch China's first geosynchronous weather satellite the Dong Fang Hong 45, which was replaced by a newer meteorological satellite on June 25, 2000, the DFH 49. (tbs-

statellite) In 1994 a LM-3 was joined with an upgraded version the LM-3A capable of bringing a 7,200 kg payload to LEO and a 2,600 kg payload to GTO.

The next rocket in the LM-3 series is the LM-3B which is the most powerful rocket to date that the Chinese have tested. It is actually a hybrid between the LM-3A and LM-2E because it uses the LM-2A 3 core stages with the LM-2E four strap-on boosters. (fas.org) Its payload is said to be 13,500 kg to LEO and 4,000 kg to GTO, which is more than any other Chinese rocket to date. Its first mission on February 14, 1996 carrying the Intelsat 708 satellite, which failed due to an electrical failure, it hit an apartment complex killing six people and injuring 57. However, the rest of its missions (a series which ended in 1998) were all successful.

LM-4 series

The LM-4 also called LM-4A is a 3 stage rocket designed for carrying payloads to a sun-synchronous orbit and is also capable of carrying multiple payloads. The LM-4 has only had 2 launches, with its first launch on September 06, 1988 carrying China's first sun-synchronous weather satellite. The second launch occurred on September 03, 1990 and carried three meteorological satellites into sun-synchronous orbit for studying the upper atmosphere. The LM-4B is the most popular of the LM-4 rockets and has had a 100 % success rate with six successful launches since 1999. Its first launch was in May 10, 1999 and carried two satellites, the first was a meteorological satellite and the second was a military telecommunications satellite.

The Shenzhou

The Shenzhou, China's manned spacecraft successfully brought China's first Taikonaut, Yang Liwei, through space on October 15, 2003 in the Shenzhou V. The Shenzhou capsule was built by China Aerospace Science and Technology (CAST) and is said to be a precursor to a space station. (SpaceToday) The Shenzhou V orbited the Earth 14 times for a total distance of around 600,000 kilometers and each orbit took about 90 minutes to circle the Earth. As mentioned before, the Long March 2F was used to carry the Shenzhou into space. The Shenzhou capsule is 8.86 meters in length, weighs 7,790 kg, and has 52 engines for complete control of the spacecraft. The capsule is made up of three sections: a descent module, and orbital module, and a propulsion module. (chinapage)

The orbital module is where the Taikonauts live and work, but it can also be used as a payload storage area. The module is 2.8 meters long with a 2.25 meter diameter and has two access hatches at either end. One is for access to the descent module and the other end is equipped with a docking system to dock with a space station. Also the orbital module holds most of the science experiments that will be conducted in space. The orbital module stays in space an extra six months after descent module returns to Earth. (spacedaily)

The middle section of the craft is the descent or re-entry module. It is 2.059 meters long, is 2.5 meters in diameter, and has three seats to carry three Taikonauts into space. The outer surface of the module is covered with an ablation material, which is the heat shielding structure for the spacecraft. The final module, the propulsion or service

module has two deployable solar panels, which are closely monitored to analyze their power supply network.

The most promising feature that the Shenzhou has (and it was mentioned earlier) is the docking system at the end of the orbital module. This technology gives China the potential to dock in space with another capsule or even a space station such as the International Space Station (ISS). Observers believe this is the key as to where their technology is headed. Another interesting technology that the Shenzhou V is said to be equipped with is an alarm system for avoiding chunks of floating debris. (space.com)

Pace of Development

When attempting to make a grounded (but still speculative) forecast about the future, it is important to know about the pace of the program in the past and at present. It seems that since 1970 the program has averaged 2.3 launches every year with a total of 76 launches of the Long March rocket, but does not include the FB-1 with 11 launches. For China to be a competitor in a global race this pace doesn't seem promising. However, 55 of the 76 launches have occurred since 1990 and from 1990 to 2003 the average launch per year is 4.23 launches. Clearly the majority of China's total launches have occurred in the last fourteen years out of the thirty-four years of the program's existence. Only one launch has occurred so far in 2004 and it was a LM-2C launched on April 18, 2004.

Looking excusively at the manned space program, the program has averaged one Shenzhou every year on average with five launches in five years. Clearly China's rocket technology is picking up with more commercial launches and no failures since 1996. However, the manned space program still has not sped up and will need to, to be able to

meet some of their announced (and our forecasted) goals. Having a successful space program will depend on getting experienced Taikonauts and with only one launch per year developing an expert Taikonaut corps. could take a long time.

Technology

One criticism of China's technology is that the Shenzhou spacecraft looks just like the Russian Soyuz. Critics claim China copied the Soyuz. This is true. Even the Chinese admit that the Shenzhou was modeled after the Soyuz rocket, but they claim that it was designed and built on their own. There are many design differences from the Soyuz to back this up. For example, the boosters on the Shenzhou are different than the Soyuz. The Chinese escape system is much better than the Russian's. The Chinese escape system allows for an escape from a failing launch at high altitudes where as Russian Cosmonauts can only escape at lift off. (space.com) The Shenzhou is also a larger spacecraft than the Soyuz designed for three people, not two. Lastly the orbital module of the Shenzhou is very different from the Soyuz; it is released from the re-entry module before descent and can be controlled separately from Earth to stay in orbit for an additional six months. With all of the upgraded features of the Shenzhou it seems even safer than the Soyuz. Due to these improvements, the Shenzhou is not just a copy of the Soyuz. It is the next generation of incremental improvements of it.

Failures

The biggest disaster that struck the Chinese space program as mentioned earlier was on February 14, 1996 after an LM-3B carrying an Intelsat 708 communication satellite had an electrical failure and crashed into an apartment complex. According to Chinese officials six people were killed and fifty-seven people were injured. However, a

video taken of the wreckage makes it seem likely that the death toll was probably larger than announced, unless residents of the apartment complex were extremely lucky. (CNN.com). The other major disaster that China endured was on January 25, 1995 when an LM-2E exploded on the launch pad killing seven workers and injuring another twenty-seven with debris. Out of all 76 Long March launches there have been 8 failures giving the Long March approximately a 90% success rate from its beginning, which is a pretty impressive success rate. Social motivation for going into space is the driving force for the Chinese space program. Therefore, to fully understand the space program one most also look at the social and political structure of China.

Social Support and Political Rationale

One needs at least two areas of knowledge to attempt a reasonable forecast of the Chinese capability to execute a successful manned Moon mission, then to compare it to NASA's capability. These areas are the technical feasibility, and the social dynamics. Knowing that the Chinese National Space Agency (CNSA) has or will have the technical means to go to the Moon is inadequate support for a prediction that they will do so. The decision to go to the Moon needs to have a socio-political rationale and strong political and public support, i.e. motivation to be on a firm enough foundation to persist and succeed. Why and how the giant of the Far East chooses to justify the Moon mission on a social, political, and economic basis is just as important as the question of whether they can actually do it technically. Understanding the motivations behind such an ambitious project is unlikely unless one has some idea about their economics, politics, and general culture. This connects the relevant recent history of the Peoples Republic of China and

the roots of the actual space agency to their mutual sense of mission on Earth and beyond it.

With over five thousand years of tradition, China has the oldest and most continuous culture in the world. Only Egypt comes close to rivaling it for continuity. However, since most of this history is irrelevant to the topic at hand, only the time period starting from the communist revolution (1949) will be examined in detail. Yet approaching this study and omitting the foundation of China, which is considered to be the religious philosophy of Confucianism, would be foolish. Even though Confucianism is not as dominant in people's lives as it was in pre-revolutionary China, it still remains influential in government policy and in many geographical and cultural areas. Hence, a brief introduction to this body of belief must take place. (Johnson-Freese, 1998)

Confucianism had three core principles in the traditional sense that were adopted from the highest levels of government down to the family units. The first principle advised people not to look progressively forward but to seek present harmony, which basically means to be distrustful and skeptical of anything new. Secondly, Confucianism favors hierarchical political and social organization, and thirdly, the core of Confucianism is a requisite understanding of "correct" conduct by all members of the population; the governing of the hierarchical relationships is by rules and standards. Aside from outside invasions, the first core principle is an influential factor behind China's desire for isolation, disinterest, secrecy, and a "closed door" policy to foreign nations. The third principle limits the individual, designating one's obligation only towards his personal "web" of responsibilities. The goal of Confucius was social harmony and inner stability, both of which are things that the Chinese people have

historically pursued but always struggled to accomplish. (Johnson-Freese, 1998) The result is an attitude toward time and continuous striving over time that is very different from the short time horizon in western lands.

1949 was the year of victory for Mao Zedong and the Communist party. Mao and the communists had won the hearts of the majority of the public through their resistance to the Japanese incursion and the regional Nationalist-supporting warlords. After centuries of imperialistic occupation by European nations and Japan, and a shaky democratic independence movement, Mao had restored a much-needed sense of community, pride, and strong nationalism into the hearts of the Chinese common people. The People's Liberation Army took about one out of every four applications, and was respected by the people as a professional defense force.

Mao had claimed leadership over a nation of peasants, and so naturally his goals were industrialization, modernization, and national defense. It was this period in Chinese history when strong ties with the Soviet Union existed and the first exchanges of space and militarily significant information took place. After hundreds of years of occupations and attempted incursions by foreign nations, Mao wanted to develop a nuclear bomb to prevent history from repeating itself. Gaining respect for China's military strength was important, dominating the region was secondary, but the Korean War intervention was in part an effort by China to get US Army away from its doorstep. Cooperation in Korea between Chinese ground forces and the Russian air force paved the way for other common defense pacts. Mao was able to acquire support and assistance from the Soviets in the development of nuclear capability for the aim of national defense.

As part of the national defense agenda, a space program was started around this time as well. In 1956, China opened its first institute on missile and rocket research, the No. 5 Research Institute attached to the Ministry of National Defense, with Qian Xuesen, a Chinese scientist who returned from the United States, as the first director. This was mainly a response to U.S. threats of attack, a situation that was related to the defense of Taiwan. From the very beginning the space program and nuclear projects were symbiotic because they were both critical to national defense and national prestige.

In the late 1950's Mao pressed on with his industrialization agenda to the extreme with the Great Leap forward. This was a program designed to speed up industrialization by taking the peasants out of their regular farming schedule and forcing them to work on industrial type tasks, such as metal production. The Great Leap Forward resulted in one of the worst famines in human history.

In 1960 Maoist China had broken off relations with the Soviet Union, and China was once again technologically on its own. In 1966 Mao became concerned about his image, as the Great Leap Forward had put a dent in his reputation and people were questioning him and Communism in general. Certain party officials and a significant part of the public became vulnerable to western ideology about the need to urbanize and modernize. As an effort to consolidate his power, purify the party, and to restore unity between people and his idealized vision of China, Mao launched what was known as the Cultural Revolution. During this decade Mao made direct appeals to the public, especially students and military personnel to bring elitism under the control of the people. Widespread fighting and destruction in universities and cities took place between cultural revolutionists and counter-revolutionists during this period. This was caused by Mao's

attempts to take back control from the managers and professionals. College professors were sent to farms in the fields to get back in touch with the purifying effects of physical work and the lives of the people. These were the most ideologically radical years of recent Chinese history, often expressed as the ten wasted years because the revolution had set the nation even further behind developed countries in terms of professionals and specialized experts. Schools were destroyed socially as well as politically, the country was unstable, and the economy had severely declined. The revolution had ruined any progress towards modernization and industrialization that was accomplished from 1949 to 1965. (Johnson-Freese, 1998)

By the end of 1976, the young space program had felt similar impacts, many offices, labs, and personnel were situated in universities which happened to be in the eye of the storm. Before Mao had died in 1976, he announced economic reform and modernization as the number one priorities for the Chinese people. Thus, his successors have not denounced him or his legacy. To this day, economic growth, sustainability, and inner stability are still number one priorities for China.

Today's China is very different from the Cultural Revolution times. When Deng Xiaoping succeeded Mao, he knew how important it was for China to open up its doors to the world, to cooperate economically and abolish the traditional sense of xenophobia and isolation. As a result, western influence spread across the People's Republic of China. Today, one finds what some consider still an underdeveloped nation in terms of economic development, while others cringe and refuse to categorize such a dynamic and growing economy as "underdeveloped". The reason for this is because even though 70% of China is still rural and requires much modernization, China is slowly becoming an economic

power. It has had the fast growing economy in the last 10 to 15 years and it continues to develop at a rapid pace as a result of introducing capitalist reforms. Some critics of the political system are almost frightened by the pace at which the efficient and productive industrial sector that always eluded the Russians under Communist rule seems to be emerging in China.

China has by far been the most successful in transitioning to a western influenced economic model of all the former Communist states. Presently, China's economic model is one that is highly confusing, and can be best described as a mixed economy, i.e. a hybrid between capitalism and communism. Some experts say it is so complex right now because the nation is undergoing a transitional period from communism to capitalism, and it is undergoing this transition phase by phase, a more gradual approach than the Eastern European (Russia, Poland, Hungary, etc.) "crash" approach where the whole economy was revamped at once. The difference in approach is probably the reason why China's recent economic history has been a study of success. However, one should not forget that China is still a Communist state politically, and the Communist party is in firm control of the nation. Also, whether China will make capitalism a goal or whether it will maintain and improve the current economic model is subject to one's interpretation.

The situation that is fairly common there right now is industrial enterprises and entrepreneurs in which the industrialists are able to benefit from social programs that protect workers without the factory owners having to pay extra for them. This is similar to the teenager who lives at home yet has a full time job. This situation is a byproduct of a hybrid economy, something the Chinese are happy to maintain since it gives them a

competitive edge with western capitalists. They are hoping to sustain the best of both worlds.

However not everyone is happy, there are social problems emerging, mainly between state-owned enterprises and private business, and between coastal (rich, urban, modernized) provinces and the mainland (poor, rural, 70% of population) which need to be taken seriously. As any Chinese historian will be quick to say, almost all of the revolutions and uprisings, spring from unhappy peasant groups in the interior. They cannot be left out or kept at a disadvantage for long, or the rural population is likely to migrate or rebel.

Social harmony is very important to the Chinese; it is the very fiber of Confucianism. Even though China is much more open than in the past it is not *that* open. While the Communist party is in control politically, it is also very much in control of many powerful state-owned corporations, which are the roots of Modern China and the foundation of the Peoples Republic.

As a testament to China's growing economical and political prowess, in 2003 China has become only the third nation in history to put a man in space (aboard the Shenzhou). As stated earlier, the space/military program began circa 1956 as part of a buildup of national defense capability. In 1957, with the launch of Sputnik, the social and political effects it had for Russia were notable and surprising, hence satellite interest also began to grow in China. However, the main focus from 1958-1964 remained one of national economic growth and defense, primarily against the U.S., and its allies in the Philippines, Japan, Taiwan, and Korea. Therefore, efforts were concentrated on long-range ballistic missiles as a warhead delivery system. The DF missile program was the

first to be placed in service, and it was also at this time that the *incremental* approach to technological development was established. It was not until the DF-5 was developed that China had long-range missiles capable of reaching the U.S. Around the same time that the Soviet Union and People's Republic of China parted political company (1960-1965), the Chinese began to develop surface –to- surface (CSS) missiles without Soviet aid. It is from this project that the famous Long March rocket was derived. Currently the DF, CSS and Long March are still in service.

Meanwhile, the pursuit of commercial satellites for economic advantage and modernization (communications, remote sensing) purposes was being developed in parallel fashion. The symbiotic nature of the military and space program allowed people to work on the development of a missile and launcher for military as well as commercial aims. Remarkably, in 1970, amidst the Cultural Revolution, the biggest achievement of that time period came when China became only the fifth country in history to launch a satellite into Earth orbit. This was a scientific and experimental satellite powered by a Long March rocket. The Long March has become a very important commercial player, since 1985, when it entered the international launch market.

The Chinese hoped to offer launchings to the world as a means of generating revenue and to proclaim itself as a technological presence. However, the LM had a poor launch success rate, dipping to around 70-80% in 1996. This was nearly a 30% failure rate, which was far too high by international commercial standards. As a result, insurance rates reached 30% of the satellite value. What seemed to be the number one stabilization, rocket guidance and control problems for the Chinese then has since that time been resolved. Shortly after this success two US corporations Hughes Electronic

Corp. and Boeing Satellite Systems were fined 32 million dollars by the US government for 123 violations of export control laws governing militarily significant technology. (Gerth, 2003) The success rate for Long March currently is over 90%, making it a first-rate launcher. Considering the fact that they are able to produce these rockets at about 80% of the market value, the Chinese can offer lower cost launch services to the world market via the "Great Wall" corporation. This makes the space program potentially capable of paying for itself by undercutting the prices of Arianespace. The cash flow is not only positive for the economy, but important for the manned space program, as it helps to cover its costs and improve the payload capability and gain launch experience with this mature technology.

Like the national economic structure, China's space program is very involved and minimally visible. It is both a military and civil/commercial program, however unlike NASA and Space Command in the USA, the Chinese programs diverge only at the applications level sharing an identical technology base. Aside from these dynamics, the sheer number of organizations involved in the overall space program combined with the confusing (maybe on purpose) habit of unconventional naming and then renaming which has resulted from decades of restructuring and reform, has at least clouded the organizational structure to outsiders. There is some knowledge of the inner workings, but, much of it is still in secrecy. This is hardly surprising when one considers the symbiotic nature of their secret organization with the defense sector. The danger of releasing potentially sensitive information regarding national defense capabilities, even though dealing with civilian commercial equipment, discourages most scientists from speaking in public forums.

It is known that the Chinese *compartmentalize* their organizations like the Soviets did in their hey day. Compartmentalization is a system where each department or branch is provided with only the information it is required to maintain in order to satisfy the function they are meant to serve. This is basically what westerners call, "a need to know basis." This is perfect for the control of information flow which the Chinese are very keen on. However, such strict regulation of information flow without an understanding of how the work fits together has a strong tendency to generate communication problems between agencies and departments, and slow down the rate of innovation to a steady walk, rather than being suitable for a race at sprinter pace.

The Chinese Aerospace Science and Technology Corporation (CASC) and CNSA have the primary roles in the space program. The CASC exercises daily control over the national space program, while the CNSA serves as an interface with other national and international space agencies, basically the CNSA deals with external issues while the CASC handles internal matters. Although the operational structures of the CNSA and CASC differ, they are in effect a single organization that splits responsibilities for policy making and executive activities. The two organizations share personnel as well as responsibilities. For example, the President of CASC, Liu Jiyuan, was also the Administrator of CNSA.

Examples of CASC's activities include research, design, manufacture, and testing of various space technologies. In 1997 the CASC was composed of approximately 270,000 employees, 100,000 of which were engineers. There are currently 28 organizations under the CASC. The State Science and Technology Commission are responsible for macro-level policy concerning space, mainly dealing with research and

academics. The rest of the agencies (at least 13) deal with either more specific or general issues, such as the Long March rocket, telecommunications, commercial related matters, national defense, and so on.

China's White Paper on Space states that the space program is intended "to meet the growing demands of economic construction, national security, science and technology development and social progress, protect China's national interests and build up the [sic] comprehensive national strength." (Lieggi, cns.miis.edu) There is no single clear motivation behind China's attempt at project Chang'e/Shenzhou. A plethora of politically, militarily, nationally and economically significant agencies support it for various reasons.

From a political standpoint, the Communist party is eager to show to the world (and its people) what it is capable of producing and to increase its legitimacy. In a culture where symbolism is as important as substance, China wants the international prestige, the recognition as a world power, a technological giant, and a military powerhouse. After centuries of occupation and disillusion, it is important for the Chinese people to have their "face" or pride restored. "Images of the *Shenzhou* have been placed on phone cards, water heaters, and other items as part of a marketing strategy aimed at making the *Shenzhou* program a source of national pride." (Lieggi, cns.miis.edu)

However, some of the public has displayed a growing indifference, accusing its leaders of wasting money on manned space flight while the majority of the nation still suffers from sub-standard living standards. Regardless, Chinese leadership expects a return on their large investments in space and believes the technological advancements associated with it will contribute to economic growth and stability, the two primary goals

of the regime. In addition, there are certain entrepreneurs who are examining the possibilities of new industries in space. Funding has been limited for the space program in general because of higher priority Chinese issues like modernization and development. However, the political leadership does not mind committing resources to the manned space program if it is successful. Also one should not forget that commercial services of the Long March rocket launches continue to provide capital that helps cover the expenses of the manned spaced activities. (www.guardian.co)

Since there is no division between the civil and military space programs, many experts believe there is a military driven motivation as well. The Shenzhou project is overseen by the PLA's (People's Liberation Army) General Armament Department. "The Chinese have admitted that the *Shenzhou* (manned or unmanned) has reconnaissance capabilities and many analysts point out technological gains from the manned program could be used for military space programs, such as development of anti-satellite weapons." (Lieggi, cns.miis.edu) Even with probable military spin-offs, a primary military motivation is unlikely while economic growth and stability are the priorities.

Methodology:

Our method for making a forecast of what will occur in the Chinese and American space programs over the next 30 years will be comparative across time and place. We'll look at what happened in the previous space race between the United States and the Soviet Union and make a projection, taking into account things that will be different this time around. In order to do this effectively, this team will be looking at the entire situation surrounding the previous space race, and isolate individual factors that had the biggest effect on what the results of that space race were in terms of technological innovation and public support. The team will look at these same factors in the current situation, and evaluate what effect the differences might have on the efforts of both the United States and China over the next 30 years. After this step, we will have the information pulled together enough to make our forecast.

Previous Space Race:

Soviet Union:

The Soviet-American space race began shortly after the end of World War II. With the defeat of Nazis, there were only a few powers left to influence the world, but one was now a superpower with global military reach in close collaboration with the British, well known to be imperialists, but now dismantling the empire for economical reasons. India, in particular, would soon be independent. By contrast, the Soviet sphere of influence initially seemed limited to its main theater of operation, Eastern Europe. After the war the Soviets focused on the recovery of territory lost to Germany during WWI and the establishment of buffer states in Poland, Czechoslovakia, Hungary, Romania, and Yugoslavia. After that the Soviets moved into Asia, resulting in China

becoming Communist in 1949. United States influence was felt through NATO in Western and Southern Europe, which included Turkey, but the war with Japan had also resulted in a great ocean navy and bases all over Asia and the Pacific especially Japan and its former possession, South Korea. Ideological lines were drawn, and both countries wanted their ideologies to dominate the whole world. Soviets thought Communism was the answer to the inequalities in society, while the United States defended their constitutional republic and capitalism, which promised more individual freedom and opportunity. The clash of ideologies created a constant tension between both countries that periodically threatened to flash into war, possibly a nuclear war. A particularly sensitive area of conflict was Latin America. There were several efforts by Cuba to export its revolution to other nations, most notably its efforts in Bolivia and Sandinista movement in Nicaragua.

The United States was the first country to create an atomic bomb and then a hydrogen bomb. These were delivered by bombers. The USSR created bombs but was not sure it could deliver them in the face of US air superiority. The Soviets responded to this threat with creation of world's first ICBM to break through the ring of European and Pacific air bases from which American bombers threatened their homeland. This step brought new horizons for both countries as they could strike anywhere in the world with weapons based at home. Who would have thought that a weapon whose sole purpose is destruction and death would open a new area of competition? Korolev, who created world's first ICBM, the -R-7- rocket, thought of this weapon in a different way. The R-7 was designed as a strong rocket with great payload capacity which could reach space.

This interpretation of R-7 created a new era for Soviets. R-7 was the rocket which carried Sputnik I to the orbit. Sputnik I was world's first artificial orbital satellite. After observing the reaction of the world and high praise, the Soviet's leadership decided that space would now be the new area for competition. The Space race was beneficial because the propaganda value of space missions was great, and unlike the arms race it did not increase the danger of war though it was a statement of technological capability with military implications.

After the launch of Sputnik I, Korolev was summoned by Khrushchev, who simply told Korolev to "send something new in space" so that the birthday of the revolution could be celebrated in style. Khrushchev did not even understand the use of satellites, but he was well aware that by achieving victories in space, Soviets could convince the rest of the world that they were as technologically advanced as the United States, and were not to be trifled with. Even if this was initially a bluff, it would freeze up other nations, because they were not really sure of what the USSR's military capability was. Meanwhile the actual capability claimed would be developed.

The next goal was to send a man to the space. Achieving firsts in space race was vital because it brought more attention, respect, and name recognition from other countries looking for the best economic system under which to modernize rapidly. Korolev was assigned to make a political statement yet again, and he achieved another first, viewed as a socio-political victory, through the series of Vostok missions.

Yuri Gagarin became the first man in space and this was a great achievement for mankind, not just the Soviets. They achieved a very important goal, and showed the world one more time that Communism was an effective system of government in terms of

bringing technological advancement in areas of political and military significance in a short period of time. Achievements in the space race were used as a vehicle to spread Communism throughout the world, but they were also a warning about the growing capabilities of Soviet ICBM's.

Korolev continued his victories in Voskhod mission. The success of the Vostok and Voskhod missions forced the United States to take the space endeavor more seriously. The United States was now aware that Soviets were sending unmanned space vehicles to the Moon. The Soviets planned to send a man to the Moon, and this new "first" would be embarrassing for the United States, since they had been beaten by Soviets three times already. A victory of this magnitude would certainly change the tide of the competition for the long run. The United States wanted to set a goal far enough beyond the Soviet's capabilities so that the US could catch up and be on the victorious side this time, and they wanted to stay on top for a very long time or at least be tied. The mastermind of Soviet space program died in 1965, and although he planned the Soyuz missions which were designed to be a lunar orbital vehicle for a manned mission to the Moon, he could not be present for the planning and execution of those missions. This was a very unfortunate development for the Soviets.

After the death of Korolev, the Soviet space program suffered greatly. The United States mobilized, out spent them, and had existing German experts available to design the Saturn 5 rocket and reach the Moon first. This was a terrible blow to Soviets. They had worked very hard to get to the Moon, but after Korolev, there were catastrophic accidents during the Soyuz missions. They somehow were never able to build big enough rocket engines to reach the Moon with just a few of them. They tried several times to get

the N-1 rocket, which was powerful enough to reach the Moon to work, but in the end they failed and the government denied they had tried to even the score with United States, manned lunar landing program.

After more failures, the Soviets admitted the fact that they could not estimate how long it would take them to get to the Moon, so they would be long after the Americans. This simply meant that they gave up on manned missions to Moon. However, they did not totally give up on the space race, they simply turned to a different area. Von Braun had wanted to build a space station before going to the Moon. The United States did not see the need to do so just for a visit so the Soviets wanted to exploit this by creating the first-ever orbital space station instead of going to the Moon.

The Salyut missions were for the purpose of creating the first space station. The Soviets achieved this goal, but the space station, Salyut 1, had many problems. However, Soviets managed to surprise United States and other countries yet again. They continued to work on space stations while United States continued to go to the Moon repeatedly. The near catastrophic mission of Apollo 13 was an attempt to land on the Moon that failed and almost cost the crew their lives.

The Soviets concentrated entirely on occupying near space continually through the use of space stations. Endurance records were broken by second generation space missions of Salyut 6, 7, and third generation MIR. The goal of these missions was to show the world that although the Moon was not reached, Soviets were still technologically advanced, and very competent in space. For Soviet leadership, the main goal was always propaganda and to show the world that they were the technological equal of the United States in militarily significant fields such as jet aircraft, rockets, space

exploration, and later atomic submarines. The manned space program was part of the hero image they sought to project to the world.

However, at home, the government of the Soviets was built on terror and discipline. Exacting and efficient labor practices were not always present but one of a kind production of mission equipment (where cost was no object) they could do well. Mass production was another matter the only major success having been to out produce the Germans in terms of tanks in WWII. Especially during the Stalin era, the public was afraid to criticize government actions. The public did not at first pay attention to the launch of Sputnik. The official government newspaper published right after the launch of Sputnik did not even publish this news on the first page. It was the day after when this news was fully exploited. This delay was because the party officials did not understand how great their achievement really was. They realized this great propaganda opportunity when they became aware of the praise and attention of other countries. The public could easily be deceived about what the rate of failure was because the media was under the control of the Politburo so only the successes were widely known. Public support was very strong for the space race in the Soviet Union. This made it easier for the government to shift disproportional resources to the space program at the expense of producing consumer goods, and report only the good news.

The budget of the space program was a relatively high percentage of the GDP in the Soviet Union even compared to the already favored military sector of the Command Economy. Because the USSR did not have as many resources as the United States, the space race was quite difficult for the Soviets when it came to finances and funding. A perfect example of this occurred during the installation of R-7 ICBM's, which cost half

million rubles for each site. Khrushchev complained to Korolev about this high price, he even said "what will we do, we will be without our pants?"

They attempted to balance this high cost of manufacture by paying very low salaries to the scientists and engineers. The scientists and engineers had to be kept content so that maximum performance could be reached, though. The low salaries were compensated by giving out certain privileges to the staff. These privileges were given only to important people who were vital to the government. A house or a car, even luxury food was a privilege in Soviet Russia during the Cold War. An ordinary Soviet citizen could not even dream of a personal car or a comfortable house. By granting them these privileges, and even tolerating some mild dissent from physicists, engineers, and mathematicians, the experts needed by the state were being kept content, and some of the burden of high cost was being avoided by the low salaries. Access to luxuries and other rewards for good work, such as being moved up the housing list, to shorten a two year wait to two months could be arranged by Korolev, during his reign as "Chief Designer".

Although there had always been financial problems in Soviet Union, the space program progressed at an astounding pace. The improvement of technology during the Korolev era was especially striking. The time interval between the simple satellites of Sputnik and the manned missions of Vostok and Voskhod is so small that the genius of Korolev is immediately apparent. After the death of Korolev, the pace of technological improvements declined sharply. There were, however, incremental improvements in the Soyuz spacecraft, which was a redesign of Vostok spacecraft. However, the newly redesigned Soyuz was not that successful; there were many accidents with the Soyuz

spacecraft. The improvement in space stations after Korolev was still a great achievement for the Soviet Union.

When we observe the difference between first generation Salyut space station and third generation space station, MIR, we see the great improvement in Soviet space station technology. Although this improvement is wonderful, it took sixteen years for the Soviets to reach this level. That is a long time compared to how Korolev leaped from one generation of equipment to the next. When the necessary experience was gathered, they did not hesitate to show their expertise and make improvements. Korolev seems to have been in a position to take a big risk, fail, and survive with his authority and funding intact, as long as he did not fail too often. His successors could not afford a high rate of failure and became cautious, perhaps too cautious.

The military support of the Soviet space program was consistent and generous. We can observe this fact with the early creation of rockets and ICBM's in Soviet history. In the ICBM area Korolev was wrong to insist on larger and more complicated (but easier to control) liquid fueled rockets. The problem was not so great on land, though it did take longer to prepare for launch and could not be left on station as long as the solid rocket fuel systems favored by the USA. The problem was when one wanted a submarine launched ballistic missile. Then the size, complexity, and preparation time of the missiles were critical constraints. Korolev's prestige was such that he slowed down adopting a superior technology design in an effort to stay with what he knew best and could vouch for, from personal experience. Korolev was ultimately overruled and other ICBM design centers emerged to serve the Navy.

NKVD was always in charge of scientists who worked in sharaga. Sharaga was a prison in which rigorous technological research was carried out on national priority projects. Since the first satellite was carried by an ICBM, the part which military played in the Soviet space program had always been large. Tukhachevsky, a very important General of the Red Army, started the RNII institute, at which the greatest minds were gathered for a sole purpose of advancing avionics and rocket science. The military had thus laid the foundation of Soviet space endeavor before WWII. The bases in which scientists worked on spacecrafts also belonged to military, and the cosmonauts selected for those crafts were pilots in the Soviet army. Military support went so far that generals who played an important part in Soviet military could have an opinion about how to conduct the space program and where the launch sites should be.

The Soviet space program was built on a single goal; propaganda to show the superiority of the system that produced such technological prowess. Soviets acknowledged with success of Sputnik that achievements in space race not only brought honor to a nation, but showed the whole world that they were technologically advanced. Since they wanted to spread their ideology to the rest of the world, what greater vehicle was there to transport the greatness of Communism as a form of technocracy which was superior to democracy, than victories in the space race? They also had the chance to prove that they were as advanced as the rich democratic United States, and had achieved equality with their adversary very rapidly. The space program was an area for propaganda which was a relatively harmless way in which both superpowers could compete without the result being a war that would kill a lot of people. A few would die, as heroes, but they would all be volunteers seeking glory and serving their nation.

United States:

The United States engaged in the space race for the sake of regaining and maintaining its' prestige worldwide and their national security. There was a great public outcry and "media riot" after the Soviets launched Sputnik. However, great suffering had resulted from falling behind the Germany and Japan in military spending, and the US was not about the repeat that error. After Sputnik, the Eisenhower Administration was reluctant to accept the link between satellite-launching-space-boosters and long-range ICBMs, but the logic was inescapable that the bombers would become obsolete as the Soviets learned how to shoot them down with jets and rockets. Even a high flying U2 spy plane was finally brought down by a Soviet SAM. The administration preferred a technological race in space to a military showdown on Earth. Eisenhower and the Congress responded to the growing pressure from the public with the creation of NASA, a civil space agency without any military intentions.

Sputnik was a huge blow to national pride of Americans and, with this event, their goal for the following years was naturally set to catching up with and then surpassing the Soviet Union in the space race. In a Congress hearing in 1960, Werner von Braun who initially had worked for the Army prior to NASA's creation compared the space efforts of American and Soviet Union. Von Braun warned the Congress that the Soviet Union's lead in space threatened American national security. He urged Congress to respond to that threat by strongly backing up NASA and the American space program. His unit was transferred to NASA from the Army's control, after it launched America's first satellite. This was not America's first attempt to respond to Sputnik. The Navy was given the first chance to launch a satellite with all American Vanguard rocket technology. After several humiliating public failures by the Vanguard team, the Army was ordered to have their

German team match Korolev's feat. Von Braun's team properly did so, and became the leaders of the new NASA organization.

The public, the presidents, and the members of the Congress of the Mercury era were all quite supportive of NASA and eager to catch up to the Soviets. Congress was more than willing to give money to the space program. NASA had a tremendous political support from the public and an "unlimited" budget from the Congress through the early 1960s.

Kennedy saw the potential to beat the Soviets in space race after failing to overthrow Castro when the Bay of Pigs invasion of Cuba failed. The Russians, sure that he would try again, decided to deploy medium range missiles to Cuba, to deter another CIA funded and inspired invasion by Cuban exiles. The result was the Cuban Missile Crisis in which the world faced destruction on a grand scale. This experience made Kennedy more enthusiastic than Eisenhower in viewing the manned exploration of space as the proper outlet for the US-Soviet rivalry. Eisenhower was more interested in the military implications of space, especially for surveillance and intelligence gathering, although he accepted the idea that a military race in space would be more risky than a civilian race.

Eisenhower was already taking risks to gather intelligence using the U2 spy plane, and Kennedy would send them over Cuba as well. Sooner or later the Soviets would figure out how to shoot the U2 and its successor the "Blackbird" down and he wanted spy satellites in place as an alternative when this finally happened. Given US capabilities at the time, this was going to have to be a light and compact satellite system. Korolev was called on to respond to this threat and create spy satellites for the Soviet Union. Since he

already had a proven man rated capsule and a rocket capable of lifting a few tons into orbit, he simply loaded cameras into the existing system designed to accommodate a Cosmonaut and had room to spare for experimental observation systems. His rapid and effective responses endeared him to the military and political leadership, which rewarded him with extraordinary discretion over how to use the manned space exploration budget.

Kennedy was urged by his science advisor to place more emphasis on unmanned exploration which was more productive and cheaper than a manned mission. However Kennedy wanted more achievements that would have great symbolic importance. Kennedy asked NASA Administrator James Webb in 1961 where and when U.S. could catch up to the Soviets. The answer turned out to be a manned lunar landing. This was as glamorous as Kennedy wanted, yet it was technically possible with a big budget. Kennedy hoped that U.S. would beat the Soviets to the Moon, but at least it would "catch up" at that technical capability.

A 1961 poll showed that most Americans were willing to pay for an ambitious space program. 26.5% said that the government should spend more money on space exploration, 28% said the current spending levels should be maintained. Only 32.1% wanted less money spent during the space race's opening stages. Another poll in 1963 showed that 69% of the public favored either maintaining or increasing the pace of the lunar program, while only 31% wanted to give it a lower priority.

During the Mercury era, NASA's budget was massively increased. The agency's budget authority rose from $117 million in fiscal 1958 to $3.7 billion in fiscal 1963. These figures are very impressive when translated to current dollars. NASA's share of

federal budget reached an all-time peak of 4.4% of the total federal spending in 1966; today it is around .5%.

With essentially a mandate to spend as much as they needed to get to beat the Soviets to the Moon, NASA's projects were able to move forward at an incredible pace. Three separate design teams would be assigned to solve a problem and then their approaches would be compared. They went from the first satellite in 1958 to the first man in space in 1961, only three years. From here, it took them only eight more years to land on the Moon in 1969. Between 1961 and 1969, there were a total of 27 manned missions: six Mercury missions, ten Gemini missions, and eleven Apollo missions. That's an average of over three missions a year. All the while the Germans working with Von Braun were pushing for more testing, more experience, and small steps in making each mission more ambitious than the last. A robust system emerged from much innovation and exhaustive testing by a highly competent NASA staff. Korolev responded by taking bigger steps with fewer missions. He took more chances, but would attempt to do more in one mission than the Americans did in three and bested them again by doing the first space walk. It was a close call though, as the space suit expanded so much that the Cosmonaut was nearly unable to get back into the spacecraft on the first attempt. He was exhausted and had nearly given up when he finally succeeded because the wear and tear on the suit was enough fit back into the capsule and survive a close call.

The biggest technological breakthrough of the U.S. Moon landing concept was the revelation of using a separate spacecraft to land on the Moon, and leaving the command module and the fuel required to return to earth in lunar orbit. Without this breakthrough, we almost certainly wouldn't have been able to land on the Moon within

the timetable set by Kennedy (Booker 22). Korolev had a similar concept in mind for the Soyuz system, if he had gotten that far.

Another very important innovation was the development of the mighty Saturn V launch vehicle, which ultimately did provide the necessary power to send the Apollo missions to the Moon. The Saturn V was based on the F-1 rocket, which was several times more powerful than any rocket the US had previously developed. This is an early example of NASA contracting a key technological development to an outside company and then having von Braun's in Huntsville team configure a working design based on this key component.

NASA administrators during the Mercury and Apollo era gave nationalistic speeches to Congress and the public, and reminded both that America cannot be first in the world and second in the space. In 1964, the agency said, "The ultimate objective of the manned space program is to provide the capability for a broad program of exploration which will achieve and maintain a position of space leadership for the United States."

Those who were supportive of the NASA during the climax of the space race often said that the pioneering journey of NASA trying to reach the unexplored vastness of space resembled the 19th century frontier-men who opened the west and also Christopher Columbus exploring The New World. Indeed, Space was expected to be the key to a new Renaissance period. NASA spokesmen also added that exploring the unknown is part of human nature. This organizational mindset would shape NASA decisions and priorities for years to come, as the agency focused on manned space and dreamed of colonies on other planets as well as a Moon base.

Overall, it seems that space was initially just an arena where the two super powers of the time could show their technological, and therefore military, prowess. The nuclear deterrent made a war between the both sides unthinkable; but nevertheless both the United States and the Soviet Union tried to show their technological might to the world. In the end, it was not just the clash of two nations but the clash of two different ideologies and political systems that supported science in different ways. It was the moral equivalent to war with all its mobilization, but without millions of deaths. However, the participants, such as Korolev and Von Braun, like Goddard before them, had other plans for their technology, one that would exalt the human experience and take civilization to new heights. The cultural expression of this was "Star Trek" and the message reached millions of Americans. That was essentially the NASA mind set. Naturally, the leaders of both sides and the public at large could not possibly have accepted the superiority of the other nation. Eventually, the nationalism of both nations led to a no holds barred, full speed ahead space race under these circumstances.

Current:

China

As mentioned earlier China has a very successful space program with a 90% success rate on the launches of the Long March rocket. However, their pace of development is very different from that of the United States when its program started. As mentioned in the section on United States, it took only three years to go from their first satellite to their first man in space. In comparison the Chinese launched their first satellite on April 24th 1970 and got their first man into space on October 15th 2003 with a gap of thirty-three years. It may be unjust to compare these figures, because the United States was in a race with the Soviet Union at the time. However, even when examining the time

between the first Shenzhou launch and the one that put Yang Liwei into orbit it was still four years. (tbs-satellite) There is no denying that the Chinese space program works at a slower pace than the United States or Russia, but their pace has been constant or possibly steadily increasing in speed.

Technology wise China still is about twenty years behind the United States at present.(space.com, Johan-Freese) However, the Shenzhou (for a first orbital spacecraft) is a rather well equipped vehicle, complete with a docking system bought from Russia and a debris-avoidance system. China has had the advantage of getting technologies already developed. For example, the Shenzhou is designed after the Russian Soyuz. This is important because China was able to jump from nothing directly to a third generation Russian spacecraft. The Shenzhou has many differences from the Soyuz as mentioned before, but being able skip over steps that both Russia and United States had to take is a nice shortcut and has allowed the Chinese to make bigger steps.

In November 2000, China had released its "White Paper", in it officials presented reasons and goals of their space program.

"- Adhering to the principle of long-term, stable and sustainable development and making the development of space activities cater to and serve the state's comprehensive development strategy. The Chinese government attaches great importance to the significant role of space activities in implementing the strategy of revitalizing the country with science and education and that of sustainable development, as well as in economic construction, national security, science and technology development and social progress. The development of space activities is encouraged and supported by the government as an integral part of the state's comprehensive development strategy."

Though China's intention for having a manned space program is probably to show their greatness and gain the respect from the international community, reports have been made claiming that China intends to exploit the mineral resources on the Moon. (news.bbc.) This is not surprising because economic growth and stability continue to be the primary goals for China. If this is China's intent, then China's reasoning for going into space seems very different than the initial intent of both United States and Russia. Neither justified going into space in terms of turning a profit from the program. It is hard to believe that going through the immense expense of getting to the Moon, occupying it, and sustaining a base will be justified in terms of a profitable return. Some insiders also suspect a military driven motivation that would make them willing to sustain a considerable loss, "While one of the strongest immediate motivations for this program appears to be political prestige, China's manned space efforts almost certainly will contribute to improved military space systems in the 2010-2020 timeframe." (nwc.navy.mil, Johnson-Freese) A U.S. Department of Defense (DOD) report also suggested that China may be developing a direct-ascent anti-satellite (ASAT) weapon, systems to jam U.S. navigation satellite signals, and ground-based lasers to damage optical sensors on satellites. (spaceref.com, smith) While military motivations may not be a major driving force behind the Chinese manned space, their military is involved with the space program. National security (as outlined in White Paper) is certain to benefit through spin-offs, if not directly. There is no question that the US military is increasingly dependent on its assets in space, and the ability to counter threats or remove them would improve China's military position and political leverage versus the USA.

Much of the Chinese public takes great pride of the recent international recognition and attention their space program has received. Even the youth have displayed great enthusiasm and desire for contribution, "Student interest in space is said to have exploded in China." Although most of the Chinese are proud and pleased with their prestigious space program there has been some public questioning of its relative importance. In a country which some consider still third-world, some people would prefer to see funding and resources allocated more conservatively. This skeptical position is not expected to be influential. Unless things reach a point of a threat of popular revolution, public support is not a critical factor in a Communist state. The current situation of the space program is a positive one in that the current political leadership seems to fully support it. In a centralized government this kind of priority translates into an environment where bureaucratic obstacles to moving in a certain technological direction (in a sustained way) will be removed by the highest authority. Other nations may face difficulty holding to a direction in the face of events and shifting public opinion, but a Communist state can push forward single mindedly with overwhelming public support. The problem a Communist state faces is continuity between leadership changes. If the top authority changes his mind about priorities things can change on a dime. China seems to be in a Krucshev type era now but that could change.

The Military and CNSA/CASC may be treated as a single organization. They are state-owned enterprises, and so funding comes from allocations by the political leadership, as is usually the case with a centralized government. Using current numbers, China has a GDP of 1266 (billion) USD, much less than the US GDP of 10,446, but

respectable. Currently the entire space program budget gets around 2.3 billion USD annually (numbers unavailable for further breakdown). In a crude comparison of the space program budgets, NASA receives 15 billion USD. However, one must remember that this difference in budgets may be irrelevant as living costs in China are far lower (average engineer in China makes $400-$800 per month).

NASA

Today, NASA is still heavily involved in manned exploration of space. Nearly half of NASA's budget in 2004 was devoted to space exploration. Shuttle operation and missions cost NASA nearly 30% percent of its budget. The shuttle fleet which originally expected to be profitable at a level of activity with weekly or biweekly launches never reached that profitable level. It turned out to be an expensive and hard to maintain launch system. The international space station also went way over budget and ran very late.

NASA's long-term goal is to eventually reach Mars. This was first evident after the Apollo program. President Bush's New Vision of Space Exploration eventually aims to reach Mars; however neither Bush nor NASA's current administrator O'Keefe has put a price tag or date on the program yet. The new plan includes stopping shuttle missions around 2010, shutting down ISS in the late 2010's, and developing the Crew Exploration Vehicle.

The goals for the new NASA space initiative are bold. A base on the Moon is a massive undertaking, as is a mission to Mars. These tasks may seem daunting, but, on the other hand, they may be just what NASA needs to get itself out of the slump that Howard McCurdy wrote about. One of the primary reasons that NASA was so effective in the early days was that everyone was determined to get to the Moon and debated only

the means to do so, not the end, or whether it was worth the cost. These ambitious goals could help restore that kind of achievement oriented thinking. It certainly won't happen overnight and most likely take a few years to get back into the highly effective organizational condition and attitude of the space agency in its hey day.

In order to meet the time frame set by Bush in his speech, NASA has just over 10 years to return to the Moon. This is in line with the speed of the original NASA program, rather than what we have seen of late. Despite technological improvements since those days, I question whether NASA can keep to a schedule like that. There are the budget concerns, which are certainly a challenge, but the greater obstacle may be NASA's organizational culture (McCurdy 155).

As I, Kemal, said before I believe that bold goals might help to restore some of the more effective Apollo era culture, but it will take time. I agree with Sietzen that the contracting out of technology development will be a big benefit to NASA in terms of the pace of its development (Sietzen). I think that both Boeing and Lockheed Martin are in a better position to get this next-generation technology developed rapidly than NASA could on its own, and the aerospace corporate culture may help NASA hold to the schedule, if NASA can control and coordinate it's contractors rather than depend on them for both core expertise and administrative support.

It looks as if NASA is actually taking a step backwards technologically, in that the plan is to use Apollo-style technology for these missions, instead of the space plane model represented by the space shuttle. This does have its advantages though, as the space shuttles turned out to be much more costly and less reliable than was expected.

The modularized system may help NASA to achieve its goals on today's much more limited budget.

The propulsion technology used in the launch vehicles for these new missions (at least based on current plans) doesn't involve much innovation compared to those used in the Apollo program, but presumably they will be more powerful. One area where technological innovation is evident is Boeing's plan for the CEV model that would be built on the Moon and sent to Mars.

Skeptics are claiming that this long-term program involves huge costs and should not be done cheaply, due to safety issues. Norman Augustine, the retired chairman of Lockheed Martin, recently made a comment that NASA doesn't have enough money or bright young stars to achieve President Bush's goal of returning astronauts to the Moon and flying from there to Mars and said, "it would be a grave mistake to undertake a major new space objective on the cheap, he said. To do so would in my opinion be an invitation to disaster." Furthermore, a recent survey stated that the private sector contractors are feeling like they are being treated like second class citizens by NASA. Another poll showed that 10% of the private sector does not want to do business with NASA, due to its reputation for weak, bureaucratic management.

NASA is currently going through a transition period in its management system to make it more efficient and safe. NASA is looking for long-term objectives and commitment from the public, the presidents, and the Congress. During Apollo program, NASA achieved its ambitious goal of landing a man on the Moon. NASA administrators were eager to go on to Mars with the same pace; however that was not be possible due to decreasing political support during early 1970s and constrained budgets. President Nixon

was given 3 choices for NASA's next objective: shuttle, space station or lunar settlement. Nixon wanted to save money and opted for unmanned and commercial missions to save money. NASA then promised to deliver a manned program on the same budget as unmanned. NASA promised to develop the shuttle, which would be re-useable to save money and would give them the "space truck" they needed to build a space station. Nixon approved the plan, but this shows that NASA was no longer a high-priority program.

National Science Foundation's 2002 Science Indicators showed that the public thought then and still thinks now that the benefits of space exploration slightly outweigh its costs. Surveys also showed that public support towards NASA increased after both disasters and big achievements by NASA.

Discussion of Results: Considerations Leading to a Forecast

China

With China's access to newer technology, many questions have been raised about how long it will take China to reach the Moon. The first thing to analyze is the Soyuz and its capabilities. Though we know the Soyuz is a successful spacecraft, whether it has the capability to make trips to the Moon is questionable despite Korolev's hopes for it. As the Shenzhou is equipped right now with its docking system, it seems more geared for docking with a space station than traveling to the Moon. However, it is made of three sections, which would allow for detachment and descent to the Moon's surface, though the modules are not equipped for this type of use yet. Furthermore, the Soyuz has never been proven in any type of mission like that, so it is hard to know if the Shenzhou would be able to do it.

For the Chinese, there may be some difficulties adapting the Shenzhou for Moon missions. They have only the United States model to go by because the USA is the only country to have actually sent a manned spacecraft to the Moon. The Chinese have no real experience on building a craft to land on the Moon since the Russians never took that step with a unmanned system. What Russia has experience in is space stations and inhabiting space for over 20 years. Since China was able to leapfrog spacecraft development, they were able to save a lot of resources and concentrate on development of a more advanced spacecraft.

Another limitation for the Chinese is the number of manned missions they can conduct in a year on their budget. Since having experienced Astronauts/Taikonauts with time in space is important for succeeding in more complicated missions, China is put at a disadvantage to the US with its astronaut corps has done the Hubble repair mission, built

a space station, landed on the Moon and so forth. China is still currently a developing nation; it seems to only be able to afford one manned mission a year, and if this trend continues it will be some time before China has an experienced staff. However, this is very normal for China, since they have been developing their rocket technology slowly but steadily from its start in 1970.

A problem we have identified within the program is that China may not have enough money for mobilization if the race breaks into a sprint. Currently China has all the political and social support needed for a fast paced approach, but the budget may be the bottleneck and currently is limited to an annual 2.3 billion USD. A key ingredient to China increasing its pace is experience, which corresponds to launches of manned missions. Perhaps if China is able to devote more capital and resources to bump up the launch rate per year then it can then achieve a greatly increased pace. This is heavily dependent on the condition of the economy. As the number one issue, it will not be sacrificed for a successful space campaign (the Chinese are not going to risk another Great Leap Forward). However, if the economy is booming, then the space program will be among the first to benefit. Under such circumstances, we estimate that a Moon landing by 2018 is quite possible.

With doubled effort into manned missions, China could have a trained and capable staff by 2012. Also, for developing the technology needed to make the Shenzhou capable of landing on the Moon, an increased pace would give more resources to put toward this task. Lunar orbiters and probes will be sent by 2010 to give the Chinese important information on space travel outside of the Earth's gravity. However, even at

China's best pace they won't be able to develop their technology and get experienced staff too much faster than their current pace as long as the budget is limited.

China's slowest pace would be if China's economy worsened, and this would force the political leadership to decrease, terminate, or simply pause the space budget and in order to keep its priority development projects on track. They would do this only reluctantly as the lesser of two evils and restore the budget as soon as possible. With a decreased budget, the pace is expected to decrease proportionally, but maintain progress. With only one mission every year or less and very limited budget, China would develop very slowly with little technological upgrade and little experience gained in space over the next 10 years. This slow development would lead China to be unable to reach the Moon until 2030.

It is likely that China's economy will grow exponentially as it has over past years, and the space program will grow incrementally with relation to the economy. With the space program slowly increasing in resources, manned missions will also increase to give China a steady increase in experienced Taikonauts. The increase in pace is attributed to the expected continual of economic growth. With economic growth, the full support of leadership, and social enthusiasm for space, is more than likely that there will be an increased budget. Along with this, technological growth would also grow at a steady rate, making China capable of landing on the Moon by 2020.

NASA

It was noticed that one thing that was persistent throughout history was that the U.S. was never willing to let other nations take technological lead in any strategically important aspect of technology. The reasoning for this conclusion can be traced back to

NACA, the predecessor of NASA. NACA was born in response to European progress in aeronautics in 1915 (Bilstein, Orders of Magnitude, p17). Although the U.S was the first to invent motorized flight, it did not build on this as fast as the Europeans did. Hence, the government stepped in to create NACA and return to world class research in aviation. NASA, as mentioned several times earlier in this project, was founded on the NACA model in response to Sputnik when the Army and Navy were not cooperating effectively on rocketry. In both cases, the U.S. surpassed its rivals. More recently, during 1990s, a European consortium, Airbus, became second in the market after Boeing and ahead of McDonnell Douglas. After this incident, NASA was criticized for focusing on space and allowing American dominance in the airlines industry to slip away.

Another observation was that the U.S. has been attracting bright foreign scientist and engineers for a long time and the U.S. was willing to employ these people and fund their projects. NACA profited through the employment of Europeans like Munk and Theodorsen, while the army and later NASA profited from Werner von Braun and the German scientists and engineers.

It can be noted that there has always been an urge by the public, administration, and Congress to maintain or achieve American dominance in all aspects of technology with defense or military implications. In cases where U.S was behind in a certain technology, funds and political support were made available to the needed programs. Therefore, the U.S is very likely to respond to any Chinese challenges in space technology in the future. The chances that U.S will totally disregard Chinese intentions to settle on the Moon are very slim. One type of response could be that the U.S will say: "We have been to the Moon and we do not need to go there again". This type of response

seems to be very unlikely due to the fact that NASA wants a lunar settlement as a stepping-stone to Mars. Settling Mars has been the ultimate dream of NASA's manned space exploration program for some time. The International Space Station cannot be used as a launch pad for Mars since it is in the wrong orbit (LEO not GTO). The fact that it can be brought up to the right orbit for this purpose contradicts with Bush's new Vision of Space Exploration program which states that ISS will be shut down by late 2010s. It also contradicts the idea of internationalism, as it was placed in this orbit for easy-access by the Russians from their base at Baikonur, the one that supplied MIR.

At this point, it will be useful to try to predict the next natural and logical step for NASA. After the Apollo program, NASA pushed for a manned lunar base, a large orbiting space station and a new space transportation system to service it, and a manned mission to Mars (Byrnes, Politics and Space, 90). The president at the time, Nixon, decided on the cheapest option which was the shuttle program. The shuttle program was considered economically promising, because it was supposed to launch weekly or bi-weekly. During the Reagan administration, the International Space Station was initiated. Later on, the United States asked for international support due to massive costs. It seems that both the shuttle and space station options have been followed from the proposal of NASA after Apollo era. The remaining mission goals are a manned lunar base and a manned mission to Mars. It is very likely that the next big project for NASA is going to be a manned lunar base. This is a very logical step since the next goal is a manned mission to Mars. It would be a good training ground for those going on to Mars, a trip of about three years.

It will be hard for NASA to get the funding and the political support for a manned lunar base; but they should succeed in the end one way or another. Throughout its history, NASA has devoted around half of its budget to manned space exploration. This is a huge amount, and once the shuttle program is stopped early 2010s and ISS is shut down late 2010s, the funding for the shuttle program and ISS will go to manned lunar base project. Under these circumstances, the U.S. is very likely to reach the Moon again by 2025 at the latest. In case of a national race between the Chinese, the U.S. is very likely to devote more funding to the manned space exploration and it is very probable that this will decrease the time estimate by half a decade.

Technologically speaking, the United States is ahead of China, but would still need to do some major work to get back to the Moon. The Bush plan involves development of a next-generation spacecraft to get to the Moon and developing this technology alone will take time. As mentioned previously, NASA hasn't been operating in a mode capable of such a large and ambitious project recently. Even if one assumes that it is possible for NASA to get back into such a mode (Howard McCurdy seems to think it's unlikely, but this team thinks this goal is large enough to get them back on track), it will still take a few years for the transition.

However, they are contracting out the development of this new technology. Contracting out always has its drawbacks, such as NASA employees not fully understanding all aspects of the technology. Despite these drawbacks, I see contracting out as a positive thing in this situation. The companies in question have been consistently developing new space technology for the Air Force, or commercial ventures. This is

necessary to survive in the capitalist market. Thus, they won't have the same mobilization issues as NASA, and the technology can likely be developed sooner.

Factoring all of this together, I would say it will take around six years to have this new Crew Exploration Vehicle completed. Given that estimate, the technology should be ready around 2011. This puts them several years behind Bush's schedule. Simply having the technology isn't the only thing necessary to return to the Moon, though.

The Apollo program involved many flights leading up to the actual Moon landing. The Mercury and Gemini missions of the previous Moon race were primarily used to gain information on humans in spaceflight and experience with just how docking mechanisms would work, and things like that. This information has already been collected, so these flights would not have to be repeated. The early Apollo missions, however, involved testing the specific technology used to put astronauts on the Moon. The technology we plan to use in the new Moon missions is being newly developed, and thus will be untested upon completion. For the safety of the astronauts, and for the success of the program, the Apollo flights, or at least a subset of them, would need to be repeated. This is another two and a half years.

Based on this, the fastest we could technologically get to the Moon would be around 2014. However, a pace this fast would require more support than NASA is likely to receive. Additionally, this would require NASA to abandon all of its other tasks and devote all resources to the Moon mission immediately. This simply isn't realistic.

NASA is currently working on other major projects such as the Mars probes and the International Space Station. It is also working on many lower profile projects. Dropping all of these immediately would be a disaster, both for the scientific

commitments, and the financial losses of the money we've already spent on them. Bush's plan calls for a slow transition of resources towards the Moon project, which makes a lot more sense.

Based on Bush's plan, the Moon mission will be taking the spotlight around 2010, when the space shuttle program is scrapped and the International Space Station is complete. This is good timing, because it not only is in line with my estimate of completion of the CEV, it will also give NASA an adequate number of years to get back on track as a high performance organization.

Taking into consideration the slow shift of focus, and the slowly increasing budget, I would push the whole process back by around 5 years. This puts United States astronauts on the Moon around 2020 as the most likely scenario. Once we reach the Moon, we can begin the next phase of the program: the development of a lunar base.

The United States doesn't have a lot of experience with developing extraterrestrial habitats. The International Space Station is probably the best estimate of how long it would take for the United States to develop a lunar base. It took us about 15 years to develop ISSA, and I would put a lunar base in about the same timeframe. This means that around 2035, I expect the United States to have some form of lunar base completed.

This is only a rough estimate, as there isn't much information out there on just how complex our first attempt would be. If we were to put something up just to put something up, we could get it done much sooner, and if we were to go straight to something even more complex, such as the base that would be used to assemble an even more complex nuclear-powered CEV for Mars expeditions, it may take considerably longer to complete.

Conclusion: The Forecast

As mentioned above, we are expecting both China and the United States to reach the Moon by 2020. This is because we believe the countries will keep pace with each other throughout the race, and the countries will land on the Moon within a year of each other. When looking at the United States, as mentioned above the US will not let another country take the lead from them. Since the U.S. is also technologically superior at the outset, the Chinese are at a severe disadvantage. However, the U.S. plans to spend a great deal of time developing a more advanced spacecraft before heading back to the Moon and thus a disaster could shut down the program for a few years as Apollo 1 and Challenger did. This could give the Chinese a chance to get ahead. It seems that the Chinese are planning to create and inhabit a space station before heading to the Moon judging by how the Shenzhou is currently equipped. Thus, both countries will likely be at about the same place along the path for most of the race. A tie with the US would make China look good, and raise questions about NASA's unwillingness to be cooperative with China.

Considering both the fact that both countries will likely be prepared for a Moon landing around the same time and the fact that the United States is more capable of making a final last-minute push due to its more advanced technology and stronger economy, we predict that The United States of America will land back on the Moon before the Chinese, but Chinese will land on the Moon less than a year afterwards.

2030: A Speculative Scenario

China

In 2030 China has a very strong presence in space and is just two years behind the United States in setting up a Moon base. Construction is still underway, but as of right now, the Chinese have two space stations, one around Earth and one orbiting the Moon. It takes nearly three days to travel from one space station to the other. From the lunar space station a team of their Taikonauts can enter a decent module to go down to work on the base that is being constructed. The lunar space station was established in 2027, only seven years after they landed on the Moon. Since then the Chinese have planned to construct a lunar base which started in March of 2029.

The base is being constructed next to a crater at the pole to mine the water frozen underneath the surface in the shadow of the crater. On the Moon water is the single most important resource in being able to have a self sustaining colony. Even oxygen is easier to obtain than water. When the construction of the base started in 2029 there was a huge discovery. The Chinese discovered deposits of platinum, cobalt, chromium, and other precious metals which are thought to be from the impact of the comet or asteroid that created the crater. (Lewis, 1996)

Currently China has changed toward a more economical view of the Moon by planning to equip their self sustaining colony with mining equipment for mining the Moon for these precious metals. Though this has not been done yet, it would be very easy to do in the near future. When the base is completed, work on mining these metals can be accomplished to help offset the cost of the venture.

At this point a total of seven Taikonauts are working on the base. This was a very taxing job because the base had to be underground to protect the Taikonauts from the radiation of solar flares. So far the main area of the base is nearing completion meaning it will be completely air tight with an access hatch in the coming two years. This main section is going to be a greenhouse to provide oxygen and food to the later occupants of the base. After that work is completed, the wings off of the main section will be constructed. This area is where the Taikonauts' living quarters will be in the future. The completion of this base is expected around 2040. When the base is completed, it will hold up to twenty people, but only ten to fifteen are planned to occupy it at once.

Once the base is completed there has been talk among the Chinese leaders of a Mars mission. However, the United States has already started to execute a plan for a Mars mission and it is questionable if the Chinese will shadow them. China has already proven itself to the world as a powerful nation. In an attempt to join the US and make Mars a joint venture, the Chinese have offered to share their resources on the Moon. In exchange for these resources, China wants the first crew to orbit Mars to be Chinese, or at least include a Chinese crew member.

NASA

In 2030, the United States is in the process of constructing a large lunar base capable of serving as an assembly area for spacecrafts for use in missions outside of Earth's orbit. The smaller gravitational pull of the Moon is much easier to escape, meaning significantly less fuel is needed for such missions than required to leave from the Earth's equator. The ships will be modified versions of the same Crew Exploration Vehicle that American astronauts used to get to the Moon in 2019, eleven months ahead

of the Chinese. These ships will be powered with a nuclear drive for deep space travel. These ships will be used in missions to Mars in the near future, and possibly to explore the moons of Jupiter at a later time.

The base obviously needs to be rather technologically advanced to carry out the assembly of these spacecraft, and thus it has been a challenge to construct the hanger-like structure. It will be the largest manned base ever to exist anywhere off the Earth's surface. The experience of building large parts of the International Space Station helped a great deal, as did the access to Soviet records from their space station projects in the past. Probably the biggest help was the experience gained from building the first two, more temporary lunar bases.

Just months after landing on the Moon for the first time in nearly 50 years, the United States began setting up its first lunar base in the year 2020. This was rather symbolic, in that the United States managed to set up a base before the Chinese were even able to make a lunar landing. They used the inflatable base designed by the Boeing corporation, and the astronauts stayed there for approximately three weeks. After that, the supplies began to run out and there were dangers of a solar flare, so they returned to Earth. The purpose of this base was essentially just to prove to the world that the United States was capable of setting up a habitat in a hostile space environment with light enough materials to be carried to Mars. However, the next base was more sophisticated and designed for lunar context.

The United States began construction on the second generation lunar base just 6 months later. Using the first base to live on while they worked, the second base was constructed on the Moon by a crew of 7 astronauts. The living quarters were built

underground to protect from radiation, and the lead-shielded above-ground section was used for conducting scientific experiments. Supplies were sent up with unmanned CEVs, and astronauts were supplied there continuously for two years. With this major success, the United States decided to take it to the next step: the base they are currently building.

This new base is being built near the equator to make it a good blast-off point for deeper space missions. It is being built out of a polymer newly developed on Earth that has been found to shield radiation caused by solar flares. This allows for an all above-ground hanger-like structure, which is easier to build than an underground base. The outside of the structure is coated with solar panels to power the construction equipment. Like the previous base, supplies are sent via unmanned CEVs from Earth. Manned CEVs will rotate the personnel every 6 months after completion. If all goes according to schedule, the base will be completed in the year 2038, and the first manned mission to orbit Mars and attempt a landing, if possible. The Hermes mission should be leaving from the Moon for Mars sometime around 2040.

Future work:

There are many possible follow ups to this project. As mentioned above in the introduction we suggest either a study looking into the possible future of what would happen if there was cooperation between China and US or if the possibility of having each agency form competing coalitions emerge. Another good project would be to look into the social and political implications of our technical prediction for the whole of planet Earth. Also, looking into details on what the Moon will be like once humans occupy it would be interesting. We also note that our approach to forecasting did not consider the possibility of a technological breakthrough. Proposing one and considering its implications by redoing our forecast would be an interesting spin off as well.

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