One Giant Leap:
How the Apollo Program
Navigated the Political System

by

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Abstract

The USC SAE 550 Class examines how the political process affects the design of large government funded engineering projects. The goal of this paper is to use the concepts presented in this class, called the Political Facts of Life, to analyze the political environment of one of the most challenging, expensive, and successful engineering feats the world has ever witnessed; Project Apollo. This paper will also show how NASA was able to navigate within that political environment and avoid many of the pitfalls that often doom large government projects. Finally, a brief discussion of the future of manned space exploration is presented.

The hopeful dreamer might wonder "Why can't the President just declare a national goal for a manned Mars mission like Kennedy did for the moon landing so we can get started already?" Well, there was much more behind Kennedy's proclamation than a brave spirit of exploration and the pursuit of knowledge. A bitter competition was escalating between the United States and the USSR that galvanized support for such an expensive endeavor. This coalition of support endured through the tumultuous 1960's, an aggressive schedule, numerous technical and logistical issues, and the staggering costs of the program. Project Apollo was able to navigate through the Political Facts of Life that tend to derail large programs, with a combination of a powerful motivating factor, a strong constituency within the government, a strong and organized leadership, and a clear singular mission. The end result is the crowning achievement of NASA that saw six successful landings on the moon, iconic images of American engineering superiority, and an incalculable residual benefit to society in the fields of computers, medicine, advanced materials, aerodynamics, etc. Through an examination of the politics of Apollo, the reader will gain an appreciation for how difficult it is to successfully complete a massive government funded engineering project.

NASA and the federal government have failed to repeat this level of accomplishment since the Apollo moon landing, and have even lost the ability to put an American in space without the help of other nations. The political process is largely responsible for this failure, and it has resulted in several decades of stagnation in the manned space program. The absence of a compelling motivator, like there was for Apollo, is a major factor in the inability of the political process to coalesce behind a clear mission or plan of action. Cost, as always, is also a major obstacle to progress in this area. NASA is beginning to relinquish its monopoly on civilian space activities and is currently subsidizing private companies for travel to low earth orbit. This is an effort to reduce costs and refocus that money toward deep space human exploration activities.

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Introduction

Project Apollo stands as a shining example of an enormous government funded engineering effort that met all of its objectives on time and on budget. Since the US government can be a tangled web of political posturing, backroom dealings, and befuddling bureaucracy, it would be helpful for future projects to know exactly how Apollo was able succeed in such an environment. The political system has an effect on every program that is primarily funded by the government. The USC SAE 550 class presents several political facts of life (FOLs) that explain this often confusing political system. They also provide a means for analyzing how and why Apollo was so successful.

The following analysis will show that Apollo was impacted by these political facts of life, but the negative effects of the FOLs were not sufficient to derail the program. The first FOL involves limitations that the political process imposes on technology, primarily in the form of budget and schedule. Apollo's advantage in this area was that the mission was well planned by NASA before it became the national goal, and the government was so eager for the accomplishment that it provided the necessary funds without much resistance. The second FOL plainly states that cost rules and it requires programs to fight for their funding every year. Apollo was no exception, but the space race mentality that spawned the project was so strong within government that minimal cuts in NASA's budgets did not threaten the completion of the mission. The third FOL states that a strong constituency is essential for success. This was perhaps the biggest reason for Apollo's success. The space race mentality affected the President, Congress, the public, and even the media to provide a huge base of support to get the program going, and it was strong enough to see the program to completion. The fourth FOL states that technical problems become political problems. Apollo did indeed have a major technical problem with the Apollo 1 fire that killed three astronauts. But, again, the constituency was strong enough to overcome the political fallout from the tragedy. Finally, the fifth FOL states that the best political solution and the best technical solution may not be the same thing. In Apollo's case, the politically motivated lunar mission and deadline was precisely the technical mission NASA was gearing up for. These and other examples of the political facts of life are explored in more detail in the analysis section.

Given this analysis, what can be learned from Apollo for the future of manned space exploration? In the 40 years since Apollo, there have been many NASA programs that have fallen victim to the political facts of life. The Space Shuttle was twisted and reshaped by the political process, but lived to see many years of service. The space station had some fitful starts and stops before it became a useful piece of space infrastructure. There is also a long list of new launch vehicle projects that have come and gone with no real progress being made, all due to their inability to navigate the political process for various reasons. The Constellation program, started by President George W. Bush in 2005, had lofty goals of new rockets and spacecraft to return to the moon. But, the current Obama administration cancelled it due to budget and schedule overruns. It is clear that the stagnation of the manned space program is primarily due to the lack of a major motivating factor like the space race was for Apollo. Without that motivator, NASA has taken a slow and steady approach, building knowledge and capability for future missions using smaller scale studies and a wildly successful robotic exploration campaign. NASA is also beginning to rely on the private sector for local space transportation. Will a private company propel a human to the moon or Mars or beyond, or will the threat of imminent destruction by an asteroid be the motivating factor to force the political process into action?

Historical Perspective

The story of the Apollo program begins during World War II. Wernher von Braun's work and research in rocket technology was co-opted by Hitler's war machine to create one of the most effective and feared weapons of the modern world, the V-2 rocket. About 2,600 V-2s were used to terrorize London and other cities with devastating effect.[1] Upon Hitler's defeat in 1945, the United States and the Soviet Union rushed in to claim the technological spoils of war. Known as Operation Paperclip, the Americans moved to secure von Braun and his team of scientists leaving the remains of the V-2 hardware for the Russians.[2] Only a few months later, the United States shocked the world with the detonation of atomic bombs on two Japanese cities to bring the war to a grim conclusion. These events would set the scene for the Cold War, the clash of super powers that would dominate world politics for the next 40 years.

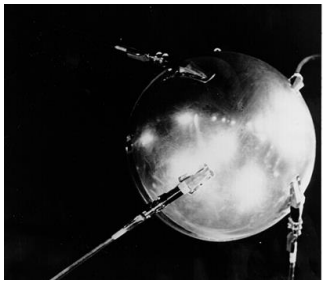

Figure 1: Sputnik I Satellite

The Soviet Union quickly developed their own atomic weapon to match the deadly power of the Americans. As both countries worked to perfect their deadly nuclear weapons, they also leveraged von Braun's rocket technologies to produce bigger and faster missiles with long range capabilities. These two technologies would soon merge to become nuclear tipped ballistic missiles, but in their quest to increase range and payload capacity, both countries began to explore the concept of artificial satellites. While the Americans struggled with multiple launch failures, the Russians proclaimed their technological superiority with the launch and orbit of Sputnik I on October 4, 1957. As seen in Figure 1 [3], the small satellite was a 2 foot diameter sphere weighing 184 pounds.[4] The sight of a streaking Russian star across the night sky sent shockwaves through the American public and all levels of government. The space race had begun and the United States was already way behind. In an attempt to save face, the U.S. launched the 3.25 pound Vanguard TV3 satellite in front of the world media on December 6. Unfortunately, the rocket blew up on the launch pad and became a national embarrassment dubbed "Kaputnik".[5] It was a political crisis on the global stage, and it required a legitimate response.

Figure 2: John F. Kennedy Sets National Goal

In July of 1958, Congress combined several national research centers to create the National Aeronautics and Space Administration. The move was specifically designed to regain America's reputation as a world leader in science and technology. Project Mercury was NASA's first high profile program aimed at beating the Russians to put a man in space. But, the Russians maintained their lead and, on April 12, 1961, Yuri Gagarin became the first man in space. This event marked a critical time in America's history. John F. Kennedy, only three months into his Presidency, was already wrestling with a decision on the direction of the space program. Russia's victory was yet another blow to America's position in the world, and Congress was in a panic. Only seven days later, Kennedy authorized the botched Bay of Pigs invasion, another national embarrassment. A bold move was needed, and Alan Shepard's successful space flight on May 5 as the first American in space gave the President the boost of confidence he needed to finalize the decision. Twenty days later, Kennedy gave his most famous speech, as seen in Figure 2 [6], and proclaimed to the world that the United States would land a man on the moon and return him safely to earth by the end of the decade.

[1] V-2 Rocket, http://www.nationalmuseum.af.mil/factsheets/factsheet.asp?id=894
[2] Operation Paperclip, http://www.operationpaperclip.info/
[3] http://history.nasa.gov/sputnik/sputnik1.jpg
[4] http://en.wikipedia.org/wiki/Sputnik_1
[5] 1st US satellite attempt fail, December 6, 1957, http://www.edn.com/electronics-blogs/edn-moments/4402889/1st-US-satellite-attempt-fails--December-6--1957
[6] http://www.space.com/11643-photos-jfk-kennedy-nasa-space-race.html

NASA, of course, was well aware of this ambitious goal and already had a head start with the Saturn launch vehicle program started a year earlier. Project Apollo was born, and the race to the moon had begun. It would consume approximately $20B and involve the efforts of 12,000 corporations employing 400,000 Americans.[7] With full funding by the Congress and the President, support of the American public, and an army of the brightest minds in the world, NASA proved it had the technical and managerial skills to execute the most challenging technological achievement the world had ever seen.

System Description

Project Apollo was a massive undertaking by any measure. The simple statement of "landing a man on the moon" does not convey the true nature of the technology and resources required to accomplish the task. At the time Kennedy declared it as a national goal, the United States had just barely been able to launch one man on a suborbital flight into space. The infrastructure for space launch operations to reach the moon simply didn't exist yet. What follows is a brief technical description of hardware and facilities that were required to accomplish the lunar mission.

Mission Design

The first major decision of the program was to determine exactly how to land a man on the moon and return him safely to earth. This problem involved an intricate analysis of mass, logistics, risk, complexity, cost, and schedule. There were three main methods proposed for the mission.

> *Direct Ascent* – One large spacecraft would launch from earth, fly directly to the moon, land, and then a portion of that vehicle would return to earth. Conceptually, this is the simplest method. But, the enormous booster, called Nova, would need to produce 40 million pounds of thrust. The cost and complexity of the booster alone was enough to rule out this method rather quickly.
>
> *Earth-Orbit Rendezvous* – This method involved launching the various modules of the lunar spacecraft separately into low earth orbit using a smaller booster, the Saturn, which was already in the planning stages. The pieces would then be assembled and refueled in orbit before the journey to the moon. This method offered an element of increased safety since the dangers of assembling and docking multiple spacecraft components would be done close to the safety of earth rather than in the distant lunar orbit. This method also implied the need for space station for the assembly and refueling process, a useful piece of space infrastructure that could serve future space exploration efforts in the future.
>
> *Lunar-Orbit Rendezvous* – One complete spacecraft system would launch from earth directly to the moon. From lunar orbit, a small lander would descend to the surface, land, and return a portion back to the main module still in lunar orbit. The advantage of this method was that it required only one launch of a Saturn booster, making it the cheapest and most achievable option within the President's schedule. Critics of this method pointed to the risk associated with the spacecraft maneuvers so far from earth and no margin for error.

As could be expected, opinions were mixed among the scientists and engineers at the various NASA centers. The debate dragged on for the better part of 1962, but time was running out. Contractors needed concepts and requirements to work towards and everything depended on the mission design. The decision was so critical that even Washington got involved in the debate. Finally, the decision was made in November 1962 to proceed with the Lunar-Orbit Rendezvous approach shown in Figure 3.[8] [9]

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[7] Nelson, Craig. *Rocket Men: The Epic Story of the First Men on the Moon*. New York: Penguin Group, 2009. ISBN 978-0-670-02103-1. Page 4.

[8] Project Apollo: A Retrospective Analysis, http://history.nasa.gov/Apollomon/Apollo.html

[9] Apollo 11 Lunar Landing Mission Press Kit, NASA, July 6, 1969, http://history.nasa.gov/alsj/a11/A11_PressKit.pdf

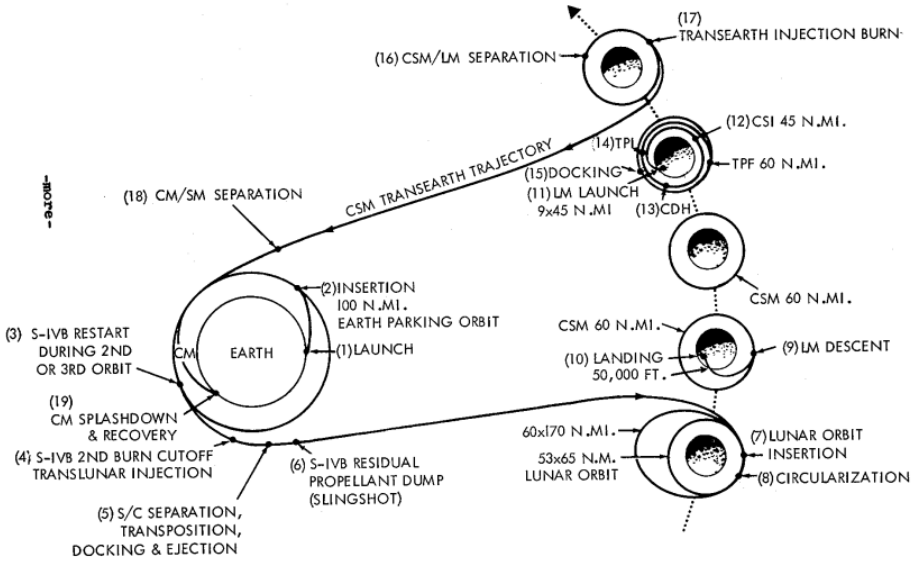

Figure 3: Lunar-Orbit Rendezvous Mission Profile

Apollo Spacecraft

The Lunar Orbit Rendezvous concept involved three astronauts, two to perform the actual moon landing and one to man the command module in lunar orbit. The primary spacecraft for this three man crew was the Apollo Command Module (CM). This would be the only part of the entire system that would return to earth. The CM was shaped like the 1-man Mercury and 2-man Gemini capsules, a short conical craft with a convex bottom about 11 feet tall and 13 feet in diameter. The CM was the nerve center of the Apollo system, containing the guidance, navigation and control system (GNCS), telecommunications, and emergency detection system, and other critical systems. The ship had a hatch on the side for normal entry and exit, but also a hatch at the tip of the cone for the two astronauts to transfer to the lunar module and back. The CM was capable of supporting the three man crew for up to two weeks in orbit, and weighed a total of 12,250 pounds.

A Service Module (SM) attached to the bottom of the command module contained additional equipment including fuel cells, cryogenic oxygen and hydrogen tanks to fuel the attached re-entry burn engine, reaction control thrusters, and communications equipment. The SM was cylindrical in shape, about 24 feet in length and the same diameter as the CSM, and weighed 51,243 pounds. When the service module was attached to the command module the assembly was called the Command Service Module (CSM). The Service Module was used to slow down the CM for re-entry and then it was discarded, leaving only the CM to burn through the earth's atmosphere and splash into the Atlantic Ocean under three parachutes.

One other key part of the Apollo system was the Launch Escape System (LES). Atop the command module sat an 8,910 pound 33 foot tall tower that contained three rocket motors that would propel the crew to safety in the event of an aborted launch. Upon successfully reaching orbit, the LES was jettisoned.

Finally, the Spacecraft-LM Adapter (SLA) was the structure that attached the CSM to the Saturn launch vehicle. This long slender cone weighed 4,000 pounds and was 28 feet long tapering from a 13 foot diameter at the service module to 22 feet at its base. The SLA also housed the lunar module during launch.[10]

[10] Apollo 11 Lunar Landing Mission Press Kit, NASA, July 6, 1969, http://history.nasa.gov/alsj/a11/A11_PressKit.pdf.

Lunar Module

Perhaps the most unique piece of equipment in the entire Apollo system was the Lunar Module (LM). A model of minimalist design, this spacecraft consisted of a descent stage and an ascent stage. The descent stage included the descent engine, landing gear, and storage for the scientific equipment. It was 10 feet 7 inches high and about 14 feet in diameter and would be left behind on the lunar surface. The ascent stage contained the crew compartment, ascent engine, and all of the navigation, communication, and control systems needed to both land on the moon as well as ascend into lunar orbit and rendezvous with the CSM. Combined with the descent stage, the entire lunar module was 23 feet tall, 31 feet diagonally across the deployed landing gear, and weighed a total of 33,205 pounds at launch. Since the spacecraft was not required to interact with an atmosphere, it took on an odd bug-like shape. Figure 4 [11] shows the Apollo CSM and LM side by side to show relative sizes.[12]

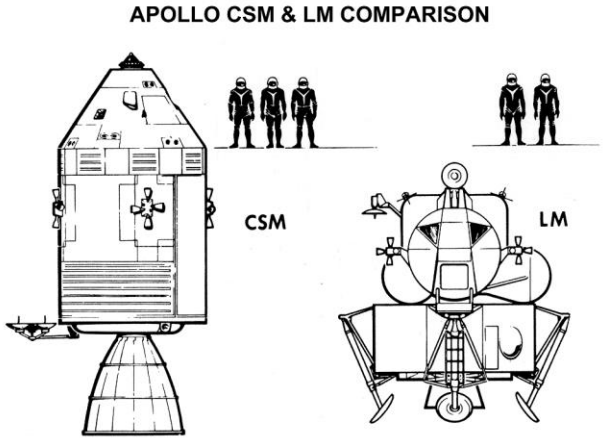

Figure 4: Apollo CSM and LM Size Comparison

Saturn Launch Vehicle

The combined mass of the lunar spacecraft required a booster several times bigger than anything the United States had ever built. The Saturn program, which began prior to the official announcement of the Apollo program, is regarded by many to be the key enabling technology of the program. The massive rocket consisted of three stages plus an instrument package, each made by a different contractor.

First Stage – The first stage was built by the Boeing Co. and contains five powerful F-1 engines that consume 2,230 gallons of propellant, RP-1 kerosene and liquid oxygen, per second at full power. The stage stood 138 feet tall and 33 feet in diameter, weighing in at five million pounds fully fueled. At full power, the first stage produced 7.6 million pounds of thrust making it the most powerful machine ever created by man.

Second Stage – The second stage was built by North American Rockwell Corp and consisted of five J-2 engines burning a mixture of liquid hydrogen and liquid oxygen. This new combination of propellants proved to be a difficult engineering challenge due to its volatile nature and difficult handling procedures. This stage added another 82 feet and one million pounds (fueled) to the towering machine and produced 1.1 million pounds of thrust.

Third Stage – Manufactured by McDonnell Douglas Astronautics Co., the third stage had only one J-2 engine and was smaller in diameter than the first two stages at 21.7 feet. It also burned LOX and liquid hydrogen to produce 230,000 pounds of thrust. The stage added another 58 feet in height and 27,000 pounds fueled.

[11] Apollo 11 Lunar Landing Mission Press Kit, NASA, July 6, 1969, http://history.nasa.gov/alsj/a11/A11_PressKit.pdf
[12] Ibid.

Instrument Package – Atop the three stages sat a 21.7 foot diameter 3 foot tall cylinder containing navigation, guidance, control, telemetry, communications, and other equipment for operating the massive vehicle. This segment weighed 4,306 pounds.

The complete Apollo 11 rocket assembly (Saturn V booster, Lunar Module, Service Module, Command Module, Launch Escape System, and fully fueled) towered 363 feet above the launch pad and weighed a total of 6,484,280 pounds. Only the 12,250 pound Command Module was recovered from the flight, with the rest of the mass either burned (5.7 million pounds of propellant to translunar injection), dropped back to earth (first and second stages and LES, then SM upon return), or was left on the moon (third stage and LM). [13] Figure 5 shows the scale and complexity of the massive machine. [14]

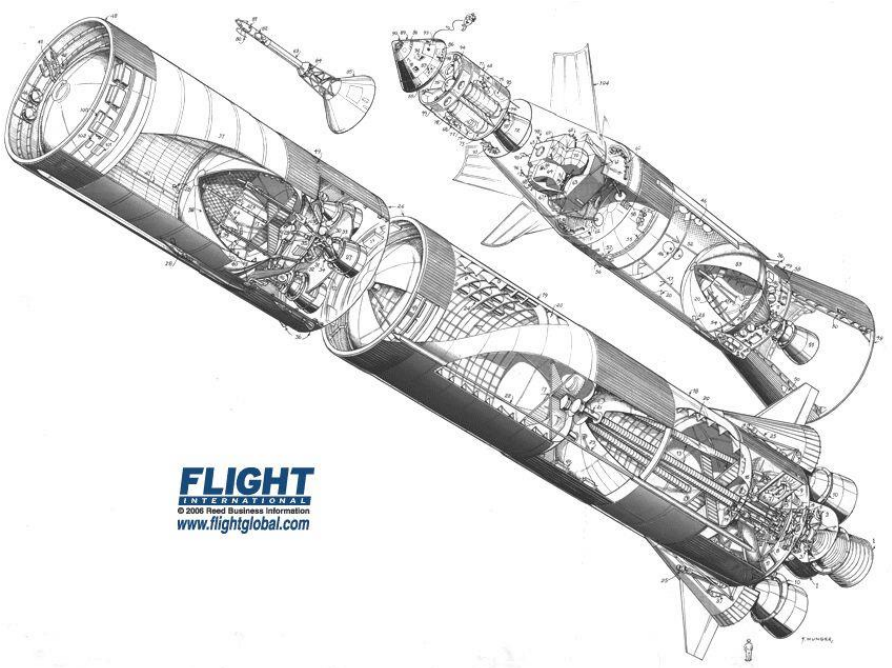

Figure 5: Cutaway Diagram of Saturn V Rocket and Apollo Spacecraft

Apollo Facilities

Another major component of the Apollo program was the construction of facilities and infrastructure. Over $2.2 billion was spent on the following facilities in the 1960s:

Manned Spacecraft Center in Houston, TX – The Apollo spacecraft and Lunar Modules were designed here. The site was also home to the astronauts and their training facilities, as well as mission control. In 1973 the site was renamed the Lyndon B. Johnson Space Center.

Launch Complex 34 at Cape Canaveral, FL – The massive Saturn rocket required a new launch pad and a new 36-story Vehicle Assembly Building. This site was renamed the John F. Kennedy Space Center in1988.

[13] Apollo 11 Lunar Landing Mission Press Kit, NASA, July 6, 1969, http://history.nasa.gov/alsj/a11/A11_PressKit.pdf
[14] http://www.flightglobal.com/airspace/media/apolloprogram/images/32455/saturn-v-rocket.jpg

Mississippi Test Facility in the southern Mississippi bayou –Saturn's F-1 and J-2 engines were tested at this facility. The deafening roar of the engines required a vast acoustic buffer zone of 125,000 acres.[15] This site was renamed the John C. Stennis Space Center in 1988.[16]

Apollo Missions

On July 20, 1969 astronauts Neil Armstrong and Buzz Aldrin landed the lunar module in the Sea of Tranquility. They explored the lunar surface, collected samples, set up several science experiments, and took hundreds of iconic photographs like the one shown in Figure 6.[17] A total of six successful manned landings were completed between July 16, 1969 and December 1972 in roughly six month intervals. In 1970, Apollo 13 had the distinction of being a successful failure when an explosion damaged the Service Module on its way to the moon, and NASA engineers frantically devised a way to bring the crew back to earth unharmed. The Apollo missions returned almost 900 pounds of lunar material[18] and set up 15 separate experiments on the lunar surface that included the study of lunar gravity, seismic activity, solar wind, and laser ranging from the earth.[19] The final three missions even included a four-wheeled lunar rover that the astronauts could drive to expand their area of exploration. But, perhaps the most memorable data collected from the moon were the hundreds of photographs of the barren landscape, the brave astronauts in their bulky space suits, and the beautiful blue marble of earth from 240,000 miles away.

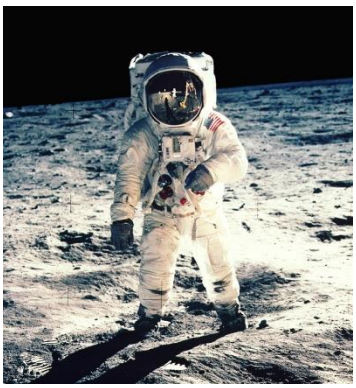

Figure 6: Buzz Aldrin on the Lunar Surface

Analysis

The main thrust of this paper is to determine exactly how such a complex and expensive engineering program was able to succeed while maintaining a demanding schedule and holding true to the estimated cost. The answer can be found by analyzing how the program existed within the American political system and how NASA handled its own internal politics.

The lifeblood of any engineering program is, of course, money. Without funding, there is no program. The United States government is involved with hundreds or thousands of projects and programs in any given year, so not all of these programs are going to get precisely what they need. As massive as it is, the federal budget does have its limits. The same holds for internal R&D projects within corporations. As a result, the grand designs and cutting edge technologies of scientists and engineers must be whittled down to something that can be afforded.

Technology can also be limited by impossible schedules imposed by the government. For example, let's say the Army needs a new UAV with three special capabilities, but they need it in three months. There is no conceivable way to meet that schedule without compromising something. So, the Army may get their UAV, but it might only have one of those capabilities.

Government regulations are another way that politics can limit technology. It might be an environmental regulation that bans a certain material or compound, or it could be a contractual rule that equipment and materials cannot be purchased from certain countries. In any case, if an adequate work-around can't be found, the final technology solution may be diminished.

Engineering programs are controlled with money, and money is controlled by politics. In almost all cases, a program is funded in one year increments. The federal budget is hammered out every year, and

[15] John C. Stennis Space Center , http://en.wikipedia.org/wiki/John_C._Stennis_Space_Center
[16] Project Apollo: A Retrospective Analysis, http://history.nasa.gov/Apollomon/Apollo.html
[17] http://history.nasa.gov/ap11ann/kippsphotos/5903.jpg
[18] http://en.wikipedia.org/wiki/Apollo_program
[19] http://en.wikipedia.org/wiki/Apollo_Lunar_Surface_Experiments_Package

programs routinely get their funding cut or cancelled completely. Every program must fight for its existence every year to maintain its funding. This is why corporations often hire lobbyists, CEOs make frequent trips to Washington, and Congressmen are invited to tour production facilities. These are all efforts to keep programs sold and keep the money flowing.

Quite often these funding battles involve programs that have rising costs or are falling behind schedule. This is a common occurrence because programs tend to underestimate costs and overstate their benefits. With so many other programs fighting for the same funding, this is often a necessary tactic just to get a program started. But, with a setup like that, future funding battles are almost certain.

Since so many programs are fighting for funding at the same time, the government generally tries to even things out. They would prefer to pay for a program with a level-loaded funding profile. This prevents one program from commanding a disproportionate amount at the expense of others. It also makes forecasting budgets much easier. Unfortunately, this funding method is at odds with program needs. An aircraft program, for example, typically starts at a lower funding level for R&D, ramps up to a maximum for capital investment to build up the production infrastructure, and then drops down a bit an levels off once production has begun. Limiting the peak investment phase can often lead to stretched schedules and higher overall program costs.

To get a program started and win funding every year, a strong foundation of support is essential. A program's constituency includes the users of the end product (aircraft, telescope, space station, etc), the company or companies producing it, and any other people or groups that could possibly benefit from the program's existence. The most successful programs are the ones with the strongest and broadest foundations of support, not necessarily the most technically sound. The constituency must be broad enough to command financial support, and strong enough to survive the inevitable internal issues that will arise in a diverse group with diverse interests.

In order to build a strong constituency, programs often seek to serve multiple agendas. The V-22 Osprey, for example, not only had the performance capability to interest all of the branches of the military, but it also promoted itself as a commercial transport. Another example is a bit more political. The F-22 program strategically spread out their production base across 44 of the 50 states, providing jobs and economic benefits, to gain the support of Congressmen eager to provide for their districts.[20]

The government also likes to call for systems that can perform multiple missions. Their goal is to procure one system that can satisfy the requirements of the Army, Navy, Air Force, Marines, and any other user. While this is a logical way to reduce costs and build a strong base of support, it always leads to requirements problems because the needs of each of the services are so different.

In the world of new technology programs, technical problems are an everyday occurrence. Unfortunately, these problems rarely remain purely technical and become quite political instead. For high profile, highly funded programs, the political impact of technical problems becomes magnified. Through the course of governmental oversight, and sometimes at the request of program opponents, technical reviews are conducted by various organizations such as the GAO, NRC, NAS, and others. The reports that are generated by these reviews often become ammunition for opponents of the program in a bid to limit funding.

Since most members of Congress have little to no technical background, they can often be swayed by a skillful presentation of the "facts". This fact can turn a minor technical blip into a full blown political crisis. Congressional hearings are held, witnesses are called to testify, and of course the ever present media are all part of the process.

[20] Lobe, Jim. *U.S.: New, Old Weapons Systems Never Die*, 2009, http://www.ipsnews.net/2009/07/us-new-old-weapons-systems-never-die/

The fundamental thought processes that govern science and engineering are not the same as those used in politics. What often looks like a sound, logical engineering solution to a problem can be the absolute worst political solution. While engineering values efficiency, quality, and a low unit cost, politics values negotiation, compromise, and appearances. In an effort to maintain affordability, the government often chooses to miss out on economies of scale to maintain a level-loaded funding profile. This can lead to longer schedules and higher overall costs, but yearly outlays are minimized.

Program work is often distributed with respect to jobs rather than cost or technical merit. An example of this can be found in the Space Shuttle program. The solid rocket boosters were sourced to a company in Utah for political reasons. The fact that the boosters needed to be transported by rail limited their size and design and ultimately limited the overall lift capability of the launch system.

The Apollo Program was one of those rare projects where the requirements set by government were crystal clear from the very beginning. In 1961, President Kennedy called for NASA to land a man on the moon and return him safely to earth within the decade. That simple statement takes care of the "what" and the "when", and then NASA was left to determine the "how". But, Kennedy's mission did not materialize from thin air. NASA had been developing plans since 1959 and, in February of 1961, a committee headed by George Low of NASA's Office of Space Flight Programs had determined that "no invention or breakthrough is believed to be required to insure the over-all feasibility of safe lunar flight."[21] The committee also estimated that the feat could be accomplished by the end of the decade and that it would cost approximately $7B through FY68. So, in this sense, Apollo was less about developing new technologies and more about managing manpower, money, and resources.

So, in what ways did politics limit what this technology was allowed to achieve if the technology did exactly what it was supposed to do? Well, one could view the simplicity of the objective itself is a limitation. The goal of landing a man on the moon was politically driven. Its purpose was to beat the Russians in a technological race for global dominance. Of course, there was scientific knowledge to be gained and spinoff benefits from the research to be done, but all of that was secondary to the political purpose. With this limited viewpoint, simply landing a man on the moon is a singular event and then it is complete. But, it could be seen from a broader perspective as a missed opportunity. What if the goal included the creation of a reliable space transportation system that could then be used to land a man on the moon? That mission would have created an important piece of infrastructure to serve the future of space exploration. Admittedly, at the time Apollo was conceived, the US was still taking baby steps in the manned space arena. So, the manned lunar landing was still setting the bar quite high.

The other part of Kennedy's mission statement, the schedule, was also a limitation on the technology. Initially, the end of decade deadline was actually provided by NASA itself. Based on early estimates, NASA thought it could be done by 1967. This was, in fact, the year cited in the original draft of Kennedy's national announcement. But, NASA Administrator James Webb felt that a margin of safety should be added for potential unforeseen problems, so he recommended an edit to the President. The deadline had been changed to "before this decade is out."[22]

With this global proclamation of the nation's technological abilities, the deadline based on good engineering judgment now took on a political meaning that would dominate every major decision in the program. By all accounts, Russia appeared to be well on its way to the same goal. This was a race to the moon, and it was going to cost billions of dollars. Earning second place would have been seen as a national embarrassment and a colossal waste of money. National prestige was on the line, so this schedule had to be met.

By the summer of 1963, the Apollo program was having problems and was approximately 4 to 6 months behind schedule. Apollo program director George Mueller was concerned that the president's

[21] Logsdon, John M. *The Decision to Go to the Moon: Project Apollo and the National Interest*. Cambridge, MA: The MIT Press, 1970. Page 61.
[22] Lambright, W. Henry. *Powering Apollo: James E. Webb of NASA.* Baltimore, MD: Johns Hopkins University Press, 1995. Page 101.

deadline was in jeopardy. New to the program, he believed that NASA was spending too much time testing individual components, a method known as the German model introduced by Wernher von Braun. This method resulted in multiple launches for testing individual spacecraft components separately before assembly into the final configuration. The objective, of course, was to guarantee the safety of the astronauts, but it took time and many launches. Mueller's idea was to launch the components together for a combined "all-up" test. This meant that the first launch of the Saturn V would also be the first flight of some of the stages and spacecraft modules. The daring move was approved by Webb and put Apollo back on schedule. Fortunately, the "all-up" testing method was successful, but the added risk could have been disastrous had something gone wrong.[23]

NASA's funding through the Apollo years was staggering, reaching a peak of $5.7B in 1967.[24] In the beginning, Congress was clamoring for NASA to achieve its lofty goal and restore America's technological reputation. During the House Committee on Science and Astronautics budget authorization hearings in 1961, Representative James Fulton said to James Webb "Tell us how much you need and we on this committee will authorize it."[25] Such was the giving mood among most in Congress during that time. But, the days of unlimited funding would not last forever.

In 1968, NASA experienced what Webb would call a "mass walkout of congressional support".[26] The reasons were many; the Vietnam War was raging, President Lyndon Johnson had decided not to run for a second term, both Martin Luther King and Robert F. Kennedy were assassinated, and social unrest were among the many distractions of an eventful year.[27] With some lingering political damage from the Apollo 1 fire a year earlier, NASA had quickly become a target for a Congress in the mood for making cuts. They requested $5.1B for FY68, the fifth straight request of $5B or more. Congress appropriated only $4.6B, a 10% cut.[28] At this point in the program, Apollo accounted for about 70% of NASA's entire budget.[29] Instead of allowing the funding cut to jeopardize Apollo's schedule, it was understood that the funds must be cut mostly from NASA's other projects.

The Apollo Applications Program took the brunt of this lack of support. The program was NASA's post-Apollo plan that called for utilizing Apollo hardware and keeping the infrastructure that was created for it up and running. Webb knew that President Johnson would not be willing to fund another massive space program so soon after Apollo, so this was a stop-gap measure that would keep production lines open to buy some time for a decision on a new national goal, such as a space station or a mission to Mars.[30] The program never had much political support, so in 1968 when the 10% cuts came, AAP was essentially stripped in order to protect Apollo. NASA was forced to sacrifice the future.

AAP wasn't the only victim of the FY68 budget cuts. The Saturn production line had to be shut down, leaving 15 launch vehicles for all of Apollo's test flights and planned lunar landing missions.[31] This left nothing for any future space station project or Mars missions. Voyager was one such program intended to send an orbiter and a lander to Mars.[32] It was an ambitious and expensive project that needed a Saturn V, but it became another victim of budget cuts.

Although NASA's budgets had started to dwindle, Apollo forged ahead. On July 20, 1969, Neil Armstrong stepped out of the lunar lander and into history, signifying the United States as the winner of the great space race. But, the celebration was short-lived and the political nature of Apollo became quite apparent. Just six months after the political goal had been achieved, Apollo itself was now vulnerable to

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[23] Lambright, *Powering*, 117.
[24] Levine, Arnold S. *Managing NASA in the Apollo Era*. Washington, DC: NASA SP-4102, 1982.Page 188.
[25] Kauffman, James L. *Selling Outer Space: Kennedy, the Media, and Funding for Project Apollo, 1961-1963*. Tuscaloosa: University of Alabama Press, 1994. Page 96.
[26] Lambright, *Powering*, 195.
[27] Lambright, *Powering*, 189.
[28] Levine, Arnold S. *Managing NASA in the Apollo Era*. Washington, DC: NASA SP-4102, 1982. Page 188.
[29] http://history.nasa.gov/SP-4029/Apollo_18-16_Apollo_Program_Budget_Appropriations.htm
[30] Lambright, *Powering*, 139.
[31] Lambright, *Powering*, 195.
[32] http://www.astronautix.com/craft/voyr1973.htm

cuts and Congress began cancelling missions. Apollo 20 was cancelled in January of 1970 to allow its Saturn V to be used to launch Skylab. Apollo 15 and 19 were cancelled later that year due to budget cuts.[33] NASA's political power had quickly faded after its primary objective was achieved.

One very common occurrence in politics is that programs often overstate their benefits and underestimate their costs. Apollo, however, is NOT a good example of this. Amazingly, perhaps the most challenging technological program in history was completed ahead of schedule for roughly the cost that was sold to the President ten years prior. As mentioned above, the George Low committee report in 1961 estimated that the mission could be accomplished by 1968 for about $7B. Other studies produced cost estimates between $8B and $12B. Administrator Webb took all of this into consideration when preparing his official recommendation to President Kennedy in May of 1961. As mentioned above, Webb changed the deadline from 1968 to end-of-the-decade. He also bumped the price tag up to $20B. Webb used "administrative realism to counter technical optimism in setting Apollo's deadline and price."[34]

This bold move was typical of Webb, but he understood the political climate at the time. The US government desperately wanted this program, and they would pay dearly for it. In a meeting with Lyndon Johnson on May 3, 1961, the Vice President practically demanded that Webb make an official recommendation for the project. When asked by Johnson if he was prepared to lead this effort, Webb answered in the affirmative, "but there's got to be political support over a long period of time, like ten years, and you and the President have to recognize that we can't do this kind of thing without that continuing support."[35] Perhaps for this reason, Webb was thinking that if he wasn't up front with the costs, staggering as they were, he would lose that support halfway through the program. If the President and Congress accepted it up front, there was a better chance the steep costs would not be opposed in later years. Webb's cost bogey turned out to be remarkably accurate. From 1959 through 1973, the total cost for Apollo was $20.4B in 1970s dollars.[36] James Webb's administrative realism turned out to be right on the money.

Now, what about overstating the benefits of Apollo? Since there were no other details set forth in the requirement, such as the number of men to land on the moon or what scientific knowledge would be gained, the technical benefits were icing on the cake as long as the basic objective was met. But, obviously, much more than a gold medal in the space race was needed to sell such an expensive project to Congress and the American people.

NASA's sales pitch included several concepts. The most obvious and immediate was the boost Apollo would give to America's prestige as a leader on the world stage. In this respect, the prevailing view was that supremacy in space was necessary for global supremacy. Kennedy himself said "No nation which expects to be the leader of other nations can expect to stay behind in this race for space."[37] There was not much opposition to this theory, but that in itself was not enough for many in Congress to justify the program.

NASA also noted the advancements in science and technology that would surely result from this endeavor. There was a vocal opposition related to this notion from the science community, and they claimed that robotic exploration could be much more effective at obtaining scientific data and it would be considerably cheaper. Philip Abelson wrote in a Science magazine article in April 1963 that "the cost of unmanned lunar vehicles is on the order of 1 percent of the cost of the manned variety."[38] In response to such a counter-argument, a memo to Webb from the NASA public affairs officer suggests he should answer "that a geologist spending thirty minutes on the moon would bring back more information than we would

[33] http://nssdc.gsfc.nasa.gov/planetary/lunar/apollo_18_20.html
[34] Lambright, *Powering*, 101.
[35] Lambright, *Powering*, 96.
[36] Lafleur, Claude. *Cost of US piloted programs*, March 8, 2010. http://www.thespacereview.com/article/1579/1
[37] Kauffman, *Selling*, 20.
[38] Hechler, Ken. *Toward the Endless Frontier: History of the Committee on Science and Technology, 1959-1979*. Washington, DC: U.S. House of Representatives, 1980. Page 170.

gain by placing 100 instrument packages on the moon."[39] That does sound like hyperbole, but few could argue the benefits of having the intuitive and adaptive nature of the human mind on such a complex mission.

President Kennedy also made promises of great benefits in education, claiming enrichment through "new techniques of learning and mapping and observation, by new tools and computers for industry, medicine, the home as well as the school." Webb's offering was a bit more pragmatic: "We hope to support and help schools and colleges in their efforts to build strong basic educational programs that are essential to our national progress." With these arguments, they had hoped to assuage some of the social liberals who would rather spend the money on social programs.[40]

The administration also tried to sell the space program based on its enormous potential economic benefits. They tried to frame it as an investment in America's future. Webb claimed that some of the funds would be spent on construction, maintenance, and repair of the country's infrastructure. Vice President Johnson went so far as to say that "outlays will yield $2 return for every $1 invested". Clearly a leap of logic, this statement was quickly challenged and NASA backed away from the claim.[41] They also touted the influx of space-aged products that consumers would see in their everyday lives. Webb mentioned in a speech in 1961 that the space program had already spawned over 3,200 space-related products. Johnson also predicted Americans would soon see the benefits of space research in their cars, offices, homes, and kitchens.[42]

So, do all of these promises add up to overstating the benefits of Apollo? Perhaps that is a matter of opinion. Certainly the accomplishment of a manned lunar landing greatly enhanced America's national prestige. We will never know if more scientific information would have been gained by robotic lunar exploration, but the science gained by Apollo was certainly valuable. In terms of education, Webb was a supporter of education initiatives before coming to NASA, and did funnel money directly to the educational system with his Sustaining University Program (SUP).[43] The economic effect of the project is almost impossible to measure, but there were certainly technology breakthroughs and useful products brought into the marketplace as a result of Apollo. Aside from great strides in rocketry, aeronautics, computers, and other sciences, the effects of the Apollo program can be found in medical equipment, exercise equipment, athletic shoes, home insulation, water purification, freeze-dried foods, and flame resistant materials just to name a few.[44] In total, it seems quite clear that NASA delivered on its promises, but perhaps some more than others.

A more obvious example of overselling the benefits came towards the end of the program when NASA and the Administration were trying to justify a continuation of NASA's large budgets after the lunar landing missions. The Apollo Applications program was a plan to use Apollo hardware for boosting small manned orbiting labs, and, as a result, keep the Apollo infrastructure intact. Some fairly outrageous claims were made regarding the manned space program's return on investment. In 1967, Wernher von Braun stated "Our surveys indicate that gains up to $83 billion a year can soon be available to humanity through knowledge spawned from space research." Later that same year, President Johnson claimed: "We have invested some $20 billion in the past 10 years. But the value to our nation of this $20 billion and this successful space program may be millions of times greater than the investment we made." These bold statements apparently didn't fool many legislators since the Apollo Applications program became a victim of the post-Apollo budget cuts.[45]

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[39] Kauffman, *Selling*, 22.
[40] Kauffman, *Selling*, 23.
[41] Kauffman, *Selling*, 26.
[42] Kauffman, *Selling*, 27.
[43] Lambright, *Powering*, 99.
[44] Apollo Spinoffs, http://spinoff.nasa.gov/apollo.htm
[45] Lapp, Ralph E., *A Case for Cutting NASA's Budget*, The New Republic. March 30, 1968. http://www.newrepublic.com/article/politics/case-cutting-nasas-budget#

The other aspect of the Cost Rules fact of life is that every program must fight for funding every year. Apollo was no exception to this. Naturally, Republicans and Democrats disagree on everything as a baseline, but some issues are able to bring the two sides together. Such was the case with the Cold War and the Space Race. NASA's first major appropriations bill for Apollo, FY63, was passed by the House unanimously, 343-0.[46] To avoid a bad precedent and a tarnished relationship with Congress, Webb refused to request a supplemental appropriations bill for FY63 that President Kennedy was recommending. Webb knew that the battle for FY64 was coming, almost $6B, and he didn't want to give Congress the impression that he was already mismanaging the funds.[47]

Indeed, the budget battle came, and NASA had to weather two issues, a political blunder by President Kennedy and a negative GAO report. These issues came at an extremely important phase of the program where facilities were being constructed and hardware production was ramping up. The President's budget request had already been cut by $600M by the house when Clarence Cannon, the Democratic chair of the House Appropriations Committee, joined with Republicans on the committee seeking an additional $900M cut. Webb worked his political magic to fend off the potentially devastating additional cuts. In spite of the negativity, the political motivations to beat the Russians still ran strong. In the end, NASA's request of $5.7B was reduced to $5.1B, a 10% cut. Fortunately for Apollo, NASA had the discretion to rearrange their priorities relative to other NASA projects and maintain Apollo's momentum.[48]

Apollo's next major budget battle came in 1967, a tumultuous year that resulted in another 10% cut for FY68. The patriotic feelings that fueled early enthusiasm had faded, the federal budget was straining under its own weight, and NASA had lost some of its clout in the aftermath of the Apollo 1 fire. In past years, the President was always there to shore up support for NASA. But, in 1967, President Johnson was seeking a 10% tax to correct the federal deficit which had soared from early estimates to nearly $30B. He was forced to endorse the $500M cut in NASA's budget recommended by the House Appropriations Committee. The President told Webb that he did not "choose or prefer to take one dime from [his] budget… and agreed to do so only because Ways and Means in effect forced [him] to agree to effect some reductions or lose the tax bill".[49]

The success of Apollo can really be traced to its solid base of support by its core constituency, the US government itself. NASA was created to be the civilian branch of the national space program, but it was part of the US government, with direct ties to the President of the United States. Its task was to develop plans and manage the execution of space exploration. The political challenge of the Soviet Union's advancements in space exploration became a driving force for Presidents Kennedy and Johnson and a vast majority of Congress, and they used NASA to wage war on "the most visible front of the technological Cold War with the USSR."[50]

President Eisenhower, whose term saw the beginning of Russia's ascension in space, was not a big believer in the importance of a large manned space program and denied any plans, and funding, for projects beyond Mercury. But during his term, shortly after the creation of NASA in 1958, both houses of Congress decided to form standing committees for dealing with issues of space policy. Then Senator Lyndon Johnson chaired the Senate Committee on Aeronautical and Space Sciences, which included some of the most powerful men from both parties. This gave Johnson a platform from which to launch his own rise to power and solidify his reputation as prominent space advocate. The House Committee on Science and Astronautics became extremely active in 1959 and 1960, holding some 265 hearings exploring the various benefits of a national space program. These committees became instrumental in building a strong constituency within Congress. They served as powerful advocates of space policy rather than merely performing oversight of NASA. In 1960, after a lengthy hearing regarding the importance of a national

[46] Kauffman, *Selling*, 16.
[47] Kauffman, *Selling*, 17.
[48] Lambright, *Powering*, 121.
[49] Lambright, *Powering*, 185.
[50] Lambright, *Powering*, 103.

space program, the House committee concluded that "this and future administrations must emphasize and accelerate space research as a necessary element to the continued leadership of the United States."[51]

These Congressional committees held countless hearings and heard hours and hours of testimony to "debate" the issue of funding the moon landing. But, many of their proceedings rarely questioned the need for the program and instead focused on how to sell it to the rest of Congress and the American people. The committee members attempted to solicit such justifications from the NASA officials before them, indicating it would gain them favorable financial support. Members also asked extremely leading questions that left no question where their sentiments lay. Representative Richard Roudebush once asked Administrator Webb, "would you say it was a fair statement that we are not necessarily spending these millions and billions of dollars in space because we want to but because we have to?"[52]

These committees and their subcommittees took on the job of selling the space program to the rest of Congress with vigor, but they also proved to be the first line of defense against Congressional attacks. This protective role was on display during the darkest days of the program, the investigation of the Apollo 1 fire. While the committees were indeed advocates of NASA and the program, they also had the duty to hold NASA accountable for the billions of dollars it was consuming. The fire triggered sadness and outrage within the ranks, and they demanded answers. The House Manned Space Flight Subcommittee took the lead for the Congressional investigation. Its chairman, Olin Teague, was a champion of NASA and its goal, but in this instance he knew he must conduct a thorough and tough investigation. As shocking details of deficiencies and poor workmanship came to light, and criticism of NASA exploded from all sides, chairman Teague kept the focus on the root of the problems and how to fix them. He would not allow this tragedy to derail the space program and Kennedy's mission. In 1978, Teague received NASA's Distinguished Public Service Medal. At the ceremony, NASA Administrator Robert Frosch said: "The dynamic leadership of Chairman Teague spurred a prompt identification of the issues and a clear-cut course of action to resolve them. Undoubtedly, more than any other single individual, Chairman Teague saved the program."[53]

The election of President John F Kennedy marked a major turn in the fortunes of NASA and its allies. One of Kennedy's first decisions was to give the responsibility of overseeing the space program to his Vice President Lyndon Johnson, a natural fit for the job. His next key decision was choosing James Webb as his NASA Administrator. The decision was favored by both Johnson and powerful Senator Robert Kerr because Webb was not a scientist or an engineer. Webb was known for his political savvy and his management experience in the industry. He was known as someone "who could get large organizations to run smoothly and who could avoid administrative conflict."[54] In the midst of the panic caused by Russian accomplishments in space, Johnson and Webb had tremendous influence on the President's decisions.

Kennedy was not a man of science and knew very little about the nation's space policy. But, Kennedy held a firm belief that the United States and the USSR were locked in a battle for power and that national pride and prestige factored into the equation. Once the President linked the space program with its potential for technological advances to this struggle, he became a strong advocate. In March 1961, he was still finding his way as a new President and was faced with a budget decision for NASA for FY62. With convincing arguments by Webb to expand the budget and begin NASA's ten year plan to catch the Russians, Kennedy was still on the fence. He approved the acceleration of the Saturn booster program but wasn't ready to approve Apollo.[55]

Everything changed on April 12, 1961 when the Russians proudly announced the successful flight and orbit of the first man in space, Yuri Gagarin. While the world applauded the technological feat, members of Congress went into full blown panic mode. The President's indecision regarding NASA's

[51] Logsdon, *Decision*, 25-26.
[52] Kauffman, *Selling*, 99.
[53] Hechler, *Toward*, 202.
[54] Logsdon, *Decision*, 84.
[55] Logsdon, *Decision*, 99.

budget now appeared to be a weakness in leadership. Kennedy quickly became the space program's biggest proponent and declared on May 25 that the United States would land a man on the moon by the end of the decade. Kennedy's bold proclamation became a seminal moment in American history. It was the political equivalent of Babe Ruth famously calling his shot in the 1932 World Series. Kennedy said in a speech in Dallas, the day before his assassination, "this nation has tossed its cap over the wall of space and we have no choice but to follow it."[56]

After Kennedy's assassination in 1963, Lyndon Johnson took the baton from the fallen President and was determined to do all he could to go get Kennedy's "cap". Johnson proceeded to support NASA's funding needs from 1963 to 1966, until the pressures of the economy and the war in Vietnam changed his priorities. But, until that time, Johnson did little to hinder the progress of Apollo. By the time the Presidential constituency had faded, Apollo had tremendous political momentum due in large part to Administrator Webb.

While James Webb set up a management structure to organize the technical challenge of Apollo, he also handled the delicate politics of the endeavor with care and precision. He knew that securing a solid constituency was critical to the long term success of the program. Fortunately, he was in control of several billion dollars with which he could distribute amongst contractors across the country. Webb knew that legislators "were interested in selling their influence with the space program for other kinds of benefits they could get in their districts and committees."[57] Webb had to walk a fine line of choosing contractors and infrastructure locations based on technical merit in order to succeed, but also generate support within Congress by spreading the wealth to many different states.

One such decision concerned the location of a new Manned Spacecraft Center. This was the mother lode of Apollo infrastructure because it was to be the center for all spacecraft development, astronaut training, and flight operations. The Space Task Group, which would be transformed into the MSC, already existed at the Langley Center in Virginia, but Webb decided to place the new center in Houston, Texas. Webb backed up his decision with a good technical argument with which the President agreed. But, when explaining to Bob Gilruth that he would be moving to Texas to head up the MSC he said: "We've got to get the power. We've got to get the money, or we can't do this program. And the first thing, we got to move to Texas. Texas is a good place for you to operate. It's in the center of the country. You're on salt water. And it happens to be the home of [Albert Thomas] the man who is the controller of the money."[58] Albert Thomas was the chair of the Appropriations Subcommittee that was responsible for setting NASA's budget.

As Webb, the executive branch of the government, and the space related Congressional committees campaigned for the support of Congress, steps were taken to capture the American people into Apollo's constituency. President Kennedy led the charge in this arena as he purposefully framed the race for the moon as a new frontier adventure in many speeches across the country. In a speech at Rice University in 1962, he referred to Apollo as "the most hazardous and dangerous and greatest adventure in which man has ever embarked."[59] The goal of this narrative was to tap into the public's affinity for harrowing adventure stories. It also brought forth the concepts of man's desire to explore the unknown and that it was our destiny to do so.

In addition to the President's addresses, the frontier adventure story was effectively conveyed on the pages of LIFE magazine, which was no coincidence. NASA knew the value of their astronauts as the public face of the program and in 1959 they contractually allowed LIFE to be the vehicle for their stories. The exclusive contract would last until 1970 and include the stories of the Mercury, Gemini, and Apollo astronauts, including many features on their wives to capture the female demographic. But, LIFE did not have free reign to publish whatever they desired. NASA's public relations department insisted, as part of the contract, that NASA and its astronauts had final approval authority over all personal stories, even

[56] Hechler, *Toward*, 176.
[57] Lambright, *Powering*, 103.
[58] Lambright, *Powering*, 107.
[59] Kauffman, *Selling*, 33.

allowing the astronauts to change their own quotes. NASA wanted to portray the astronauts in the most favorable light possible, and LIFE magazine was a willing participant in the strategy. The campaign was quite successful as the stories and images published in LIFE were extremely influential in shaping the nation's view of the space program.[60]

Even Congressional leaders played a part in engaging the general public to boost support for Apollo. Before NASA was formed, most of the nation's space activities existed in the military realm, and were not very accessible to civilians. Cape Canaveral was controlled by the Air Force, but after 1958 it hosted NASA's civilian operations as well. Since billions of taxpayer dollars were funding these new civilian activities, pressure began to build to allow access to the launch facilities. In 1963, the Department of Defense opened the site to motorists, but they weren't allowed to stop and hours were limited to 9AM to noon on Sundays. Olin Teague, chairman of the House Manned Space Flight Subcommittee, was a frequent visitor to the facility, and he often brought his Congressional colleagues and other VIPs to ogle the hardware and generate enthusiasm prior to budget debates. Teague had long lobbied for more public access and sent a letter directly to Webb in 1964 asking him to "permit the average American to get a glimpse of what is going on at this major center of our space effort. If more people were permitted to visit it and see for themselves, our space program might receive much benefit in the way of public support."[61] Webb was agreeable to the suggestion, but only after the Merritt Island Launch area was completed in 1965. Teague persisted and included $1M in the FY65 budget for the construction of a public visitor center. Bus tours began in 1966, and the visitor center was completed a few years later. Since the beginning of 1969, the number of visitors to Kennedy Space Center has exceeded 1 million, and visitor centers s at NASA's other facilities have been just as successful.[62]

In a program as complex as Apollo, there are bound to be technical problems along the way. NASA had absorbed the growing pains of Mercury and was making good progress on Gemini and Apollo. But, some technical problems on the Ranger program caused some early political trouble.

Project Ranger was started in 1960, and its mission was to crash unmanned spacecraft into the moon to collect data for use in future exploration, notably pictures of the surface as the spacecraft approached the moment of impact. The Jet Propulsion Lab in Pasadena was assigned the task and was given only 36 months to complete it. This ambitious mission was a response to the Russians who were already sending their own spacecraft to the moon. Ranger's primary sensor was to be a camera for capturing the images, but JPL wanted to include some other scientific instrumentation since they were flying into unexplored space.[63]

As could be expected, Ranger had some difficulties in the beginning. And by its sixth straight failure in 1964, Congress demanded to know what the problems were. By this time, Apollo was well underway and the imagery of the moon's surface was critical to the designers of the lunar lander. The failure of Ranger 6 was especially painful because it had performed perfectly and impacted on the lunar surface, but the cameras failed to turn on. JPL's internal investigation revealed that the cameras had turned on inadvertently during the ascent through the atmosphere which caused arcing and subsequent destruction of the television camera power system. The cause of the inadvertent command was never definitively determined. In any case, NASA was ultimately responsible for the project and Administrator Webb was called to testify before the House Space Subcommittee.

Webb, ever defensive of his organization, feared that a Congressional investigation could interfere with his management structure, weaken JPL, and ultimately harm Apollo. So, Webb chose to defend JPL before Congress and convince them that he would fix the issues that lead to the failures of Ranger. The result of the investigation found JPL to be mostly at fault, recommended tighter oversight by NASA, and

[60] Kauffman, *Selling*, 75.
[61] Hechler, *Toward*, 177.
[62] Hechler, *Toward*, 178.
[63] *Lunar Impact: A History of Project Ranger*, Chapter One, http://history.nasa.gov/SP-4210/pages/Ch_1.htm#Ch1_Top

left the details to be carried out by Webb. This was precisely the outcome Webb was hoping for. He was able to rework the contract with JPL, an independent lab, and shape them into an organization more like NASA's other facilities.[64]

Technical problems also come in the form of official reports by certain technical organizations. For Apollo, this came at a particularly bad time in late 1963 during debates over NASA's budget. The General Accounting Office released a report that had been requested by the House Committee on Science and Astronautics. The report criticized NASA for wasting funds and poor management. NASA also released its own report around the same time that documented quality issues with some of the equipment provided by contractors. This is precisely the kind of material that critics use to justify their attacks.[65]

Knowing that critical funding was on the line, George Miller, chair of the House Committee on Science and Astronautics and staunch backer of NASA, came to the program's defense. He attempted to minimize the importance of the GAO report and claimed that NASA had already addressed the problems. NASA also actively tried to limit the political damage by holding a press conference that included some of their top officials and even the VP of the McDonnell Aircraft Corporation. Their goal was to minimize the issue of poor workmanship by lauding the accomplishments of the Mercury program.[66]

The previous two examples pale in comparison to Apollo's biggest technical problem that occurred on January 27, 1967. On Pad 34 of NASA's new Saturn launch facility at Cape Kennedy in Florida, astronauts Virgil Grissom, Edward White, and Roger Chaffee were nearing the end of a long "plugs out" test of the Apollo spacecraft and its ground support equipment during a simulated launch. The astronauts were in their full pressure suits and sealed inside the Apollo spacecraft atop an unfueled Saturn rocket. A fire ignited in the 100% oxygen environment and the three men perished in the blaze. It was devastating blow to the nation and NASA, and one that could jeopardize the entire program.[67]

NASA acted quickly to control the political fallout. They immediately organized their own investigation team that included various respected technical minds within NASA who weren't directly associated with Apollo. Astronaut Frank Borman, pilot of Gemini 7, was on the team as well as a few others from other organizations outside of NASA.[68] The goal was to quickly find the truth about what happened and avoid any appearance of white washing the accident. Webb knew the political peril he was in, leading him to say to NASA's head of public affairs: "This is an event we have to control. We will conduct the investigation. We will get answers. There will be no holds barred. We'll issue a report that can stand up to scrutiny by anybody."[69]

Reports began to surface about shoddy workmanship and poor quality control in regards to the Apollo hardware. Some of NASA's own technicians were making such claims to the press, weakening Webb's tight control of information.[70] NASA's biggest problem involved its handling of the Phillips Report. Major General Samuel Phillips was the head of the Apollo program, and in 1965 he assembled a tiger team to investigate problems with North American and their performance on the Apollo spacecraft and Saturn's second stage. The team found numerous technical problems and that NAA's management was severely deficient. Phillips relayed the team's findings to George Mueller, the head of NASA's Manned Space Flight division, with the recommendation that "I strongly recommend that our only alternative is to move the work not being done well elsewhere." Mueller's response was to advise NAA to make drastic improvements in their technical and management structure, and he would monitor their progress. By 1966, NASA seemed content with the changes NAA had made and no further action was taken.[71]

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[64] Lambright, *Powering*, 134.
[65] Kauffman, *Selling*, 19.
[66] Kauffman, *Selling*, 19.
[67] Bergaust, Erik. *Murder on Pad 34*. New York: G.P. Putnam's Sons, 1968. Page 15.
[68] Bergaust, *Murder*, 26.
[69] Lambright, *Powering*, 144.
[70] Lambright, *Powering*, 150.
[71] Lambright, *Powering*, 153.

During the Congressional hearings after the NASA investigation, freshman Senator Walter Mondale got a tip from an NBC news reporter about the Phillips report and asked Administrator Webb about it. Caught completely off guard, Webb had no knowledge of the document, and even Mueller could not recall such a report. NASA quickly found the report in its archives, and, in the interest of protecting Apollo, Webb decided to keep it from public scrutiny.[72] In his subsequent appearances in front of Congress, he was quite evasive and not as forthcoming as many had expected. He was even caught in a lie about NAA being the top recommendation of a review board for the selection of the prime contractor for Apollo. The reputations of Webb and NASA were taking a beating, and it took a heavy political toll. The chairman of the House Space Subcommittee Ken Hechler told reporters after the hearings: "I for one am going to be much more skeptical of NASA in the future."[73]

In the end, the investigations concluded that there were many contributing factors to the Apollo fire disaster. In addition to the general quality issues, the 100% oxygen environment and an abundance of flammable materials like Velcro made the risk of fire in the cabin excessively high. The hatch design required too much effort and time to provide a fast escape in case of fire. The actual ignition source was never precisely determined, but it was widely believed to be a short circuit. North American took the brunt of the blame for their quality issues, but NASA's management was also brought into question. The political damage of the Apollo 1 fire coupled with an overall cost cutting atmosphere within Congress lead to the $500B cut in the FY68 budget mentioned above.

When viewed from a scientific perspective, the fundamental mission of landing a man on the moon seemed unnecessary and entirely too expensive to many scientists at the time. As mentioned above, robotic exploration of space was considered by many, even within NASA itself, to be much more efficient at gathering scientific data, clearly much less expensive, and did not put human lives in danger. But, the manned space arm of NASA performed many studies of the man on the moon mission and determined that it was technically feasible with current levels of technology. So, if the goal of the program was to gather scientific data about the moon, both solutions were viable. However, the robotic method was technically a better one. Engineering would strive to minimize cost, maximize efficiency, and gather the most scientific data. Sending men to the moon accomplished none of these goals, especially since only one of the 12 astronauts to eventually walk on the moon was a geologist, Jack Schmitt of Apollo 17.[74]

But, science was not the main goal of the program. Political victory over the Russians was the primary goal. On April 18, 1961, the day after the Bay of Pigs fiasco, President Kennedy penned a memo to VP Lyndon Johnson asking "Do we have a chance of beating the Soviets by putting a laboratory in space, or by a trip around the moon, or by a rocket to land on the moon and back with a man? Is there any other space program which promises dramatic results in which we could win?"[75] Johnson held a meeting on April 24 with several experts and key advisors, and they all endorsed the decision to put a man on the moon. The President was most interested in Webb's technical guidance, which was bolstered by NASA's successful May 5 flight of Alan Shepard. Webb, of course, officially recommended the mission that became the national objective.

Webb was not one to make such a recommendation without substantial technical backing. Webb said of the decision; "I think when you decide you're going to do something and put the prestige of the United States government behind it, you'd better doggone well be able to do it."[76] In fact, the logistics of the mission had been studied by NASA, Air Force, Army scientists for years. NASA had already selected a manned lunar landing as the logical next step beyond the Mercury progam based on technical grounds alone.[77] The Saturn heavy lift rocket program and a post-Mercury spacecraft (Apollo) plan were already underway. NASA was primed and ready for this mission. Seen from this perspective, sending a man to the

[72] Lambright, *Powering*, 153.
[73] Bergaust, *Murder*, 149.
[74] https://en.wikipedia.org/wiki/Harrison_Schmitt
[75] Lambright, *Powering*, 95.
[76] Lambright, *Powering*, 95.
[77] Logsdon, *Decision*, 40.

moon was the best overall solution, technically and politically, to the political problem of losing the space race to the Russians.

It could be argued that the politically motivated eight year schedule was not the best technical decision. When JFK declared this ambitious mission, NASA had only just been able to launch a man on a suborbital flight. Perhaps a more technically sound schedule would have allowed more time to test the spacecraft in operational conditions. It would also allow more data to be gathered on the moon and the potential harmful effects of long duration exposure to deep space conditions and zero gravity. The hard driving schedule was considered by many to be a "crash" program that incurred too much risk and too much money. In 1963, former President Eisenhower, who was not a big supporter of the space program in his term, wrote in a letter of protest regarding the decision; "This result should be achieved as a natural outgrowth of demonstrably valuable space operations. But having made this into a crash program, we are unavoidably wasting enormous sums."[78]

The aggressive schedule certainly appeared to have negative effects on the program. As mentioned above, quality issues nagged much of Apollo's hardware leading up to the Apollo 1 fire. Papers written by some of Apollo's technicians and engineers before the tragedy indicated that "the pressure of meeting schedules had tempted space project personnel to take shortcuts." Also, Jesse Bradley, a test engineer at the Marshall Space Flight Center, said in a paper: "In a program where millions of dollars worth of equipment is involved, and where a mistake could cause injury or death, pressure to meet unrealistic dates should not be a factor."[79]

On the other hand, it could be argued that the program would never have been completed without such a firm deadline. The eight years spanned three presidents and saw new Congressmen every two years. It is extremely difficult to sustain high levels of funding for such a long time. It is conceivable that a catastrophe like the Apollo 1 fire could have cancelled the program if Congress was looking at another 5 or 10 years of multi-billion dollar budgets. NASA itself had recommended the deadline in the first place, but as Webb advised, that schedule depended on continued high levels of funding. This may be a case where the best political solution and the best engineering solution struck a balance and happened to be the same thing.

A quote from Wernher von Braun, world famous rocket scientist and director of the Marshall Space Flight Center, sums up the wisdom of the mission defined by President Kennedy: "Everyone knows what the moon is; everyone knows what this decade is; and everyone can understand an astronaut who returned safely to tell the story. An objective so clearly and simply defined enables us to translate the vague notion of conquering outer space into a hard-hitting industrial program that can be orderly planned, scheduled, and priced out. It establishes a sorely needed, firm, nonvacillating goal which alone can serve as a basis for a long-range plan."[80] This may be the ultimate reason why Apollo succeeded where so many other large programs fail. Many aircraft programs get mired in unclear requirements which then extend their arbitrary schedules. This lack of focus can lead to the erosion of constituencies, technical problems caused by the moving goalpost, and rising costs. Apollo was able to avoid some of these pitfalls due to its clear focus on the mission and the deadline.

A much clearer example can be found in the contract award phase of the program. NASA was given the green light and the funding to start contracting for all the hardware. Nearly every major aerospace company in the country was signed up to build parts of the Apollo system. A 190-member Source Evaluation Board, composed of NASA technical experts, examined proposals for the Apollo command module, and they determined that the Martin Company was "the outstanding source for the Apollo prime contractor."[81] However, Robert Gilruth, director of NASA's Manned Spacecraft Center, advised Webb that he and other NASA officials involved with spacecraft development, including some of the astronauts themselves, believed North American was better suited to building the flying machine.

[78] Hechler, *Toward*, 171.
[79] Bergaust, *Murder*, 30.
[80] Kauffman, *Selling*, 35.
[81] Lambright, *Powering*, 107.

North American, the Source Evaluation Board's second choice, had already been tasked with designing and building the second stage of the Saturn V, so adding the Apollo spacecraft to their workload could strain the company's resources to the breaking point. Although opinions differed within NASA, overall, Martin seemed to be the better engineering solution.

James Webb was now faced with a tough decision. He was getting pressure from a North American lobbyist named Fred Black who had indicated that NAA would increase their activity in Oklahoma. By giving the contract to NAA, millions of dollars would pour into the state, making its Senator and chair of the Senate Space Committee, Robert Kerr, a very happy man. Kerr's position in Congress obviously made him extremely important to the future of NASA and Apollo. Webb made the decision to award the contract to NAA. Although NAA may have been a solid technical choice, the investigation of the Apollo 1 fire called attention to the political undertones when Webb claimed that NAA was the Source Review Board's top choice for the Apollo spacecraft contract. The truth came out that the board's recommendation was actually the Martin Company and Webb was caught in a blatant lie.[82] The media also uncovered some potentially scandalous financial connections between Webb, North American, Black, Kerr, and Fidelity National Bank in Oklahoma.[83] Webb successfully deflected the allegations, but the whole episode gave the appearance that the NAA contract decision was made for political reasons rather than on pure technical merit.

One more challenge occurred in 1969, prior to the successful moon landing of Apollo 11. NASA was well aware of the political realities of the day and realized that the future of the space program was in danger. They decided to put forth three budget options for NASA's continued funding. A barebones budget of $4.2B would only allow the bare minimum sustainment of ongoing programs. An optional budget of $4.7B would be "required to maintain world leadership in space."[84] Finally, $3.76B was the amount approved by the Bureau of the Budget. NASA's two figures were calculated from a technical perspective. Congress, of course, saw the situation from their political perspective and chose the most frugal solution, a full half billion dollars below NASA's minimum. They concluded that the government simply could not afford an Apollo scale space program going forward.

Apollo benefitted from good timing on several occasions. The first event of this type set the program off on a fast start. The year was 1961, and the beginning of Kennedy's expansion of the space program was in motion. As mentioned above, Kennedy had approved the acceleration of the Saturn rocket program and some other rocket projects and facilities, but he chose not to pursue Apollo just yet. While the House Committee on Science and Astronautics commenced budget authorization hearings for NASA's FY62 funding, news came of another Soviet technical and political victory. On April 12, Yuri Gagarin rode the 5-ton Vostok spacecraft around the world and became the first man in space. The Soviets wasted no time in using the achievement to claim global superiority in science and technology and promote the success of socialism.[85]

The event shook the US government, especially those Congressmen serving on the various committees that had already been promoting expansion of the national space program. The fervor drove some to make outlandish comments that one would never expect to hear from an elected official. Representative, and Republican, James Fulton said "I believe we are in a race, and I have said many times, Mr. Webb, tell me how much money you need and this committee will authorize all you need."[86] Fulton even tried to force NASA to take more money to accelerate the program even after he heard testimony that it could not move any faster. Victor Anfuso also made unreasonable demands of a faster schedule, complaining: "I want to see what NASA says it can do in 10 years done in 5."[87] Naturally, NASA's funding request was approved with a unanimous vote of the House, and Kennedy was swayed to make the lunar mission the national goal.

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[82] Bergaust, *Murder*, 147.
[83] Bergaust, *Murder*, 155.
[84] Hechler, *Toward*, 208.
[85] Logsdon, *Decision*, 101.
[86] Logsdon, *Decision*, 103.
[87] Kauffman, *Selling*, 96.

Another example of good timing helped Apollo. The unmanned test flight of Apollo 6 was launched on April 4, 1968. Officially, the flight met all of its test objectives and was considered a success. However, two minutes into the flight, the launch vehicle experienced "lengthwise oscillations…producing a chugging motion like a car with bad spark plugs, decelerating and accelerating." This pogo effect was severe enough that it could have caused injury to the crew and a possible mission abort. Also, two engines in the second stage and one in the third stage failed to ignite.[88] Since the next flight was intended to be manned, this was a major technical problem.

Sadly, an unrelated tragic event happened on the same day, which took the focus away from the technical problems of Apollo 6. Martin Luther King, Jr. was assassinated in Memphis, and an outraged black community protested in several cities, even sparking pockets of rioting. This obviously dominated the attention of the country, and the technical problems of the Apollo 6 flight went unnoticed. NASA worked feverishly to find the source of the problem and fix it, expending several weeks and "31,000 man-hours on the pogo problem alone." NASA was satisfied that there were no lingering serious problems with the hardware and proceeded toward the "all up" test of Apollo 7 a few months later.[89] The coincidental timing of the King tragedy allowed NASA to take care of its technical problem while avoiding any political interference.

The success of the Russian space program created a political problem for the United States. The two countries were fighting a non-violent war of ideologies, and they both sought to position themselves as the world's leading super power. Beginning with Sputnik in 1957, the USSR was putting the US to shame with its space program. The Soviet list of firsts included the first satellite into orbit, the first living being (a dog) into orbit, the first pictures of the far side of the moon, first spacecraft to Venus, and of course the first man in space. Russian historian Matthew Brzezinski noted that after the launch of Sputnik "it was as if, overnight, his nation had been vaulted to a pre-eminent position atop the global hierarchy. The Soviet Union, in the eyes of the world, had suddenly become a genuine superpower…a true and equal rival of the United States."[90] The American response, of course, was to match these accomplishments and surpass the Soviets with an amazing first of their own. This posed a bit of a technical problem for NASA, but one for which they were eager and willing to take on.

When "man on the moon" became the national space objective, naturally the "men" who would actually walk on the moon became national heroes. NASA's astronauts, mostly members of the armed services, commanded respect and admiration for their bravery, skill, and intelligence. Shorty Powers, NASA's public affairs officer, said: "After we had the initial press conference in April 1959, and the (original seven) astronaut's pictures appeared on the cover of LIFE magazine, everybody in the world knew who they were and nothing was sacred."[91] They became the heroic face of the space program and both the media and the public adored them.

Thus, the astronauts became crusaders for the space program. As mentioned above, NASA had struck deal with LIFE magazine in 1959 to publicize the astronaut's personal stories and capitalize on their tremendous appeal. LIFE was able to present the frontier adventure of space exploration, with the astronauts as the brave explorers, in a much more dramatic fashion. NASA's official reports and news conferences full of technical jargon were not nearly as engaging as LIFE's stunning pictorial layouts and exciting stories of these modern pioneers. Even their wives were featured numerous times, an added bonus to NASA's publicity machine to include the female demographic. The contract would benefit both parties, but NASA's aim was to put the space program in a positive light and foster the interest and support of the general public and Congress.[92]

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[88] Lambright, *Powering*, 197.
[89] Lambright, *Powering*, 197.
[90] Nelson, *Rocket*, 122.
[91] Nelson, *Rocket*, 163.
[92] Kauffman, *Selling*, 72-73.

Members of Congress were equally smitten with these men of action, and indeed their opinions regarding the space program and NASA were persuasive. During the Congressional investigation of the Apollo 1 fire, five astronauts, including Frank Borman who was a member of the NASA investigative team, were invited to a House committee hearing. When asked about his confidence in the program, Borman replied "we do have confidence in our leaders. I am embarrassed because it appears to be the party line. The response we have given is the truth." The testimony of Borman and the other astronauts appeared to have changed the minds of some members of the committee who were prepared to delay Apollo by as much as 5 years.[93]

Just as Apollo began ramping up with large funding increases, President Kennedy made a political blunder that could have derailed the program. On September 20, 1963, Kennedy addressed the General Assembly of the United Nations to discuss avenues for peace in the Cold War between the US and USSR. He suggested that the two nations could work together in a "joint expedition to the moon" so that "immense duplications of research, construction, and expenditures" could be avoided.[94] Rather than the peaceful cooperation angle Kennedy was feeding the UN, his real motivation was to propose a way to reduce the costs of the expensive program to make it more palatable to Congress.

The effect was just the opposite. This shocking suggestion angered many in Congress, including many of the space program's biggest supporters. National prestige and a technological victory over the Russians were Kennedy's primary selling points for Apollo, and he had just undermined both of them. Chairman of the Manned Space Subcommittee Olin Teague was moved to write an angry letter to the President wondering "whether or not this national goal is being abandoned or changed." Teague was also noted as saying of the proposed cooperation with the Russians "I'd just as soon attempt to cooperate with any rattlesnake in Texas."[95]

Kennedy was smart enough to back away from the notion of cooperation and recommit to the mission, but the damage had already been done. Coming at the same time as the Independent Offices Appropriations Subcommittee debated NASA's budget, this political blunder was one of the contributing factors in the $500 million dollar cut in NASA's $5.1B request for FY64. Included in the appropriations bill was a restriction that prevented any funds from being spent on "expenses of participating in a manned lunar landing to be carried out by the United States and any other country without consent of Congress."

[93] Lambright, *Powering*, 169.
[94] John F. Kennedy: "Address Before the 18th General Assembly of the United Nations.," September 20, 1963. Online by Gerhard Peters and John T. Woolley, *The American Presidency Project*. http://www.presidency.ucsb.edu/ws/?pid=9416.
[95] Hechler, *Toward*, 175.

Unquestionably, James Webb's leadership as NASA Administrator was absolutely essential to the success of the Apollo program. He was the focal point of the technical management decisions of NASA's biggest challenge and the funnel through which Congress poured billions of taxpayer dollars. Many men would have folded under the pressure or failed to navigate the delicate political landscape of the executive and legislative branches of government. But, Webb was up to the task.

After graduating from the University of South Carolina with a degree in education, Webb served in the Marine Corp as an aviator. He then worked as an assistant to Congressman Edward Pou and learned a great deal about power and politics in Congress. He then got a taste of leadership when he took a job as personnel director at the Sperry Gyroscope Company at the age of 30. He became the company's vice president seven years later. Sperry provided equipment for the aircraft industry which allowed Webb to be involved with contractors and the government, and it also provided a means to be an advocate for aviation in general. After a brief stint with the Marines again during the last year of World War II, Webb returned to Washington and wanted to pursue a career in politics.

In 1946 Webb was appointed by President Truman as the director of the Bureau of the Budget. Then in 1949 he was appointed under secretary of state. These "six years of bureaucratic combat" made Webb a "Washington veteran: seasoned, scarred, and immensely experienced."[96] Webb then worked for Senator Bob Kerr, a very powerful man in Oklahoma. Kerr was also president of Kerr-McGee Oil Industries, and hired Webb in 1953 as president of one of his new acquisitions, Republic Supply Company. His goal was to turn the faltering company around, and Webb accomplished the task in his five year stint with the company, making a powerful ally in Kerr. Webb also used this time in Oklahoma to foster his desire for public service. He founded the Frontiers of Science Foundation and became its president. The foundation utilized donations from wealthy local businessmen to enhance science education in the state's high schools and universities. His foundation was so successful it even gained the attention of President Eisenhower who lauded it as a "superb mechanism for the mobilization of the needed resources to strengthen our pursuit of scientific knowledge."[97] Webb's successes lead him to look for opportunities for public service on a larger stage, so he moved back to Washington in 1960.

This long resume of experience put James Webb in a position to be the perfect candidate for the job of NASA Administrator, to which he was appointed by President Kennedy in 1961. His powerful presence and political skill made him a force to be reckoned with in Washington. He knew how to treat certain powerful officials to get the outcomes he desired. Webb also had quite a knack for organization and management. NASA was a newly formed agency combining numerous organizations from around the country. Webb was able to create a management structure that included the strong leaders of the various centers and allowed decisions to be made quickly and with technical validity. The NASA that Webb created was able to coordinate the work of thousands of companies across the country to execute an incredibly complex and expensive mission on a difficult timetable. James Webb was a gifted political quarterback that led his team to a resounding victory.

[96] Lambright, *Powering*, 11-68.
[97] Lambright, *Powering*, 79.

Summary

This analysis of Project Apollo has shown that it was subject to the same political facts of life that every other government program must deal with. One of the goals of this paper was to explore the reasons why the program was so successful while so many other programs never reach the finish line. Aside from the brilliant work of scientists and engineers across the country, its success is a result of Apollo's unique traits in relation to other programs. First, it was one of the rare examples of a program that accomplished its requirements within budget and on time. The fact that Apollo was one of the most expensive and complex programs in history makes this achievement even more astonishing. Apollo was also unique in the simplicity of its requirements and schedule. While many programs languish in an endless loop of ever changing requirements and redesigns, Apollo's mission was crystal clear from day one. It could be summed up in one brief statement, send a man to the moon and bring him back safely by the end of the decade. Finally, the project that was born during the Cold War benefited from a surge of national competitive spirit. The thought of losing to the Russians in a technological race for supremacy was not acceptable to the President, Congress, or the American people.

These factors were essential in avoiding the pitfalls of the political facts of life that can lead to funding cuts and cancellation. As seen earlier, funding cuts did occur for NASA, but Apollo was only one part of NASA's overall budget. The space race mentality still prevailed, and it was understood that NASA's other programs would suffer the budget cuts rather than give up on Kennedy's mission. One pitfall that many programs fall into is overstating the benefits and understating the costs in order get the program sold. This can lead to severe political problems later on when costs go up and schedules slip. Apollo obviously avoided this in part by having such a clear objective. As von Braun said, this clarity of purpose allowed NASA engineers to provide a solid projection of the actual costs and schedule. The constituency of Apollo, including Presidents Kennedy and Johnson and the powerful committees within Congress, was perhaps its greatest strength. The motivation of the space race mentality was pervasive throughout government and strong enough to carry the program, and it allowed Apollo to avoid political pitfalls. The space race mentality was even strong enough to survive the tragic deaths of three astronauts during testing of the Apollo system. Although this technical problem did cause considerable damage to the reputation of James Webb and NASA, the program did survive. Finally, Project Apollo was able to avoid many political pitfalls in part to the great leadership of James Webb. He was influential in setting the clear national objective that was simultaneously the best technical and political solution to the problem of the race for technological superiority.

Certainly there were examples of the political facts of life that had a negative impact on the program. NASA still had to fight for funding every year, and it did not always receive the full amount of its request. Budget cuts and the aggressive schedule led to the riskier all-up method for testing. Other NASA programs and post-Apollo missions suffered due to tightening budgets. Webb's political maneuvering regarding the selection of North American for the Apollo spacecraft could be viewed as a contributing factor to the Apollo 1 fire and the political mess that followed. But, all of these negative effects were not substantial enough to derail the program. Project Apollo was able to successfully navigate the complex political system, while being fully integrated within it, to achieve an amazing feat of engineering.

Future of Manned Space Exploration

So, what can we learn from this analysis to apply to the future of manned space exploration? Is there a possibility that this country can repeat this level of organization, effort, and funding to return to the moon, Mars, or other far off destinations? The fact that no one has set foot on the moon in the 40 years since Apollo demonstrates that our previous success is no guarantee of future performance. Science and technology are clearly not a limiting factor. Surely advances in these areas will be needed to send man to Mars and beyond, but if history teaches us anything it's that we can overcome such technical barriers. Politics stands as the limiting factor on our manned space endeavors.

Apollo's driving political force was the Cold War. America was losing in a global competition, and most people in this country wouldn't stand for that. Does that mentality still hold in this country? A 2011 Pew Research report indicates that each new generation of Americans is becoming less patriotic.[98] Yet another Pew Research Center poll in 2013 showed that a majority of people in 39 different nations believe that China will be the world's next superpower.[99] However, we are not battling China in a Cold War of ideologies like we did with the Soviet Union. How would the US government and its citizens react if China succeeded in landing a man on the moon? What if China claimed the prize of the first man on Mars? China is in fact making important strides in space with their launch of three astronauts for a 15 day visit to their own orbiting space lab in July of 2013.[100] However, it seems unlikely that a Cold War level of competition would develop between the US and China.

There could be other motivating factors that arise in coming years. After the shocking meteor explosion over Russia in 2013 and several near misses of other large meteors in recent years, there has been a surge of interest in the detection of potentially dangerous near-earth objects. NASA just proposed a mission to identify and capture a small asteroid and tow it back to earth orbit for future human exploration.[101] This is just a stepping stone in NASA's manned space plans, but it would include an increased ability to identify and classify near earth objects. What if a large asteroid was detected that was on a sure collision course with Earth? Would the US government be sufficiently motivated to commit to another crash program to save humanity?

In the absence of these political drivers, lofty Presidential space exploration goals like Kennedy's become little more than words. President George H. W. Bush put forth his Space Exploration Initiative in 1989 that called for the construction of Space Station Freedom, a permanent settlement on the moon, and a manned Mars mission by 2019 with a combined estimated price tag of $500B over two to three decades. These initiatives had no support in Congress and were never explored in much detail. His son George W. Bush proposed a similar Vision for Space Exploration in 2004 calling for a return to the moon by 2020 as a precursor to future Mars mission. The Constellation program was initiated to support these goals with a new spacecraft (Orion), new heavy lift launch vehicles (Ares I and Ares V) based heavily on Apollo and Shuttle technology, and even a lunar lander called Altair. When Barack Obama took office, he commissioned a review of the nation's space policy, and this Augustine Committee found the Constellation program over budget and behind schedule. To the consternation of many Constellation supporters in Congress, Obama decided to cancel the program and begin anew with another version of a heavy launch vehicle and yet another vision for exploring the moon and the planets.[102] It seems every new administration has a new vision for space exploration, and that is because there is no clear overriding motivator like there was for Apollo to unify the various government entities.

The political facts of life have severely impacted every major manned program since Apollo. Right on the heels of the moon landing, funding for Apollo follow-on programs disappeared. For budget reasons, President Nixon essentially forced NASA to choose between the space shuttle and a permanent space station, in spite of the fact that the usefulness of one is greatly dependent on the other's existence. Without the space station, the space shuttle struggled to find a purpose and ended up costing much more per launch than expected. The tragic loss of shuttles Challenger and Columbia severely degraded NASA's once lofty reputation. Along the way, proposed Space Station Freedom stumbled for a decade without producing anything meaningful. This work eventually turned into the International Space Station, a

[98] A generational gap in American patriotism, http://www.pewresearch.org/fact-tank/2013/07/03/a-generational-gap-in-american-patriotism/
[99] China may become top superpower, but US has a better image: Global poll, http://articles.economictimes.indiatimes.com/2013-07-18/news/40657420_1_china-superpower-east-asia
[100] Medical quarantine over for Shenzhou-10 astronauts, http://news.xinhuanet.com/english/china/2013-07/11/c_132533087.htm
[101] Official Confirms NASA Plan to Capture an Asteroid, http://www.universetoday.com/101287/official-confirms-nasa-plan-to-capture-an-asteroid/
[102] 50 Years of Presidential Visions for Space Exploration, http://www.space.com/11751-nasa-american-presidential-visions-space-exploration.html

program plagued with massive cost increases and schedule delays.[103] With the retirement of the Space Shuttle in 2011, NASA's only option for transporting people to and from the International Space Station is by hitching a ride on the Russian Soyuz spacecraft. The fact that there is no successor to the space shuttle for manned space flight is due to the failure of a long list of proposed launch systems, cancelled due to underfunding, technical, problems, or lack of support. The National Aerospace Plane and the X-33 are just two examples of these programs that could not overcome the political facts of life.[104] As mentioned above, President Bush's Constellation program was the latest victim of the political process in 2010. As of 2013, NASA is pushing forward with the Space Launch System and the Orion spacecraft to continue the nation's manned space program, but it is uncertain if they will survive the political facts of life.

Unfortunately, recent economic difficulties have led to major cuts across all government agencies including NASA. In times like these, it is extremely difficult to justify massive manned space initiatives. And without a dominant motivating factor, NASA has no choice but to take the slow and steady tortoise approach to its long term goals. On limited funding, NASA has managed to pull off some amazing feats of engineering to prepare for a manned Mars mission. Mars Reconnaissance Orbiter, Mars Exploration Rovers Spirit and Opportunity, and the most recent Mars Science Laboratory and its Curiosity rover have been wildly successful and have gathered massive amounts of information about the red planet. These robotic explorers were also able to capture the attention of the American public with their incredible photos of the alien landscape and the exciting sky-crane landing of Curiosity in 2012. Meanwhile, NASA is also performing low level studies and experimentation on other aspects of an extended Martian mission including in situ resource utilization, inflatable habitats, and a manned pressurized rover.[105] These efforts are intended to acquire the knowledge and technologies they will need when a manned mission to Mars becomes politically viable.

Could the answer come from the private sector? President Obama has chosen to lean on private enterprise to fill the void left by the space shuttle's retirement, with the goal being reduced costs through competition within the industry. Called the Commercial Crew Program, NASA is tapping companies like Boeing, SpaceX, and Sierra Nevada to provide new launch vehicles and spacecraft for affordable low earth orbit transport. SpaceX has already completed several resupply missions to the ISS for NASA on its Dragon spacecraft and Falcon 9 launch vehicle. The company is also working on its Falcon Heavy launch vehicle for crewed moon and Mars missions, and its Dragon capsule is currently slated to be man-rated in 2015.[106] The founder of SpaceX, Elon Musk, is a visionary and has big plans for his company as a leader in future manned space exploration. It may be a long shot simply based on economics, but at least SpaceX has a clear mission, a strong leader, and an opportunity to succeed in the vacuum left by NASA and the federal government which seems to have none of these. While Apollo was a triumph of organization and technical skill that demonstrated what capitalism and a democratic government can do, it will be interesting to see if private industry can someday match that accomplishment.

[103] Smith, Marsha. NASA'S Space Station Program: Evolution of its Rationale and Expected Uses, http://history.nasa.gov/isstestimonysmith.pdf
[104] Chow, Denise. Why There's No Replacement for the Space Shuttle, April 12, 2011, http://www.space.com/11363-nasa-space-shuttle-replacement-30-years-anniversaries.html
[105] http://www.nasa.gov/externalflash/human_space/
[106] http://www.spacex.com/