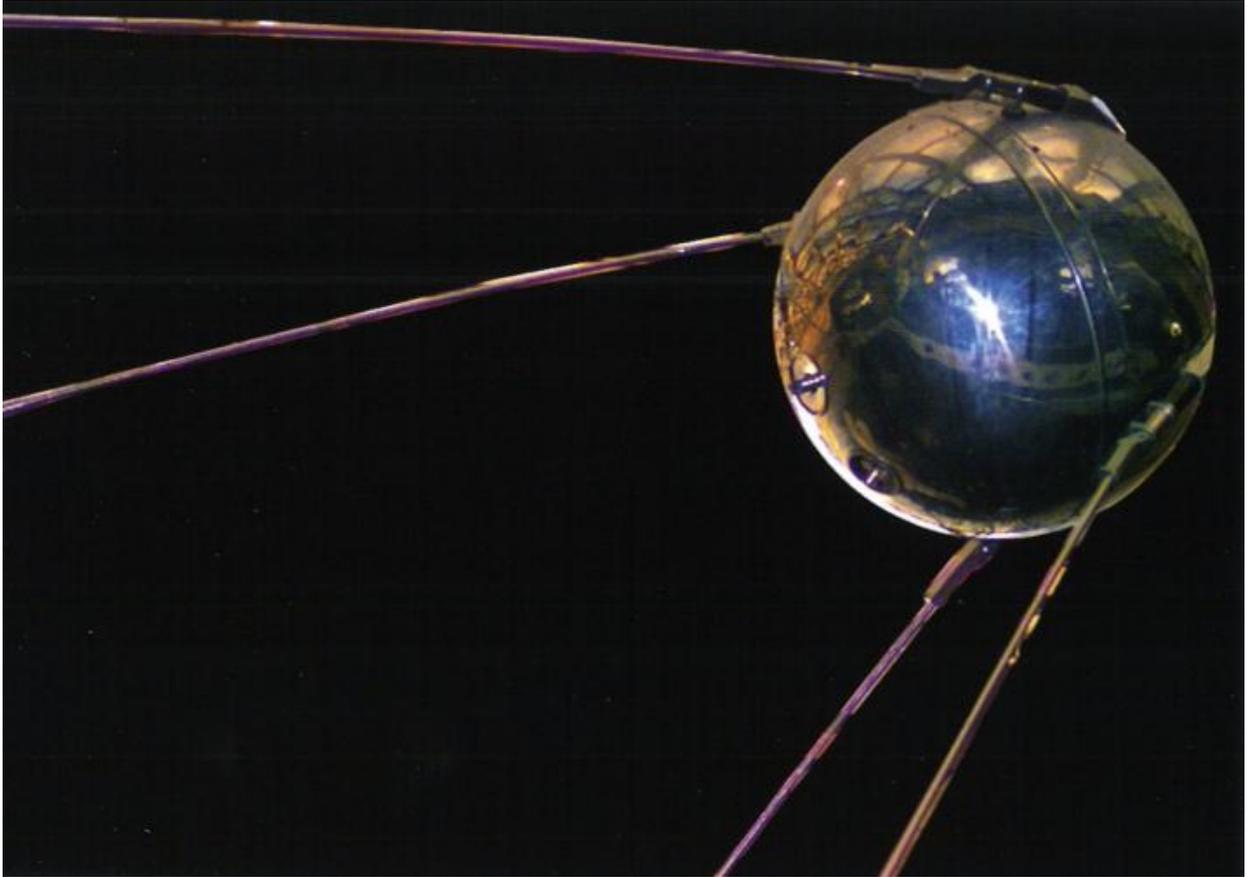


“Defying Gravity”

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Gravity exerts its will on all things and at all times. From the leaf falling from a tree, to the earth orbiting around the sun, to the Milky Way Galaxy being tugged around the Universe, all matter must submit to the universal awesome power of gravity. So it is no small thing when something or someone decides to take a stand in defiance of gravity and to exert their will, even for a brief moment, against its inexorable force. This paper describes one such heroic event: Apollo 11 and the mission to the moon. Here we will delve into the many seemingly insurmountable obstacles that the NASA engineers overcame over fifty years ago in 1969. We will discuss the struggle against the USSR, the construction of the lunar module, software glitches while landing, space suit technology and miscommunication during re-entry. In the process, we hope to learn not just about the engineering genius but also the power that some have to overcome barriers and do things that otherwise seem impossible.



Russian Sputnik

The USSR provided the initial seemingly insurmountable obstacle. On October 4, 1957 the Soviet Union launched an intercontinental ballistic missile called Sputnik. It was the world's first artificial satellite as well as the first manmade object to be put in space. Sputnik was an unpleasant surprise to most Americans. Americans worried that Soviet movements into space would give the Soviets better ability to spy on the US and attack the US from space. Americans also worried that this meant the Soviets were better than the US at science and exploration. It seemed like they were so far ahead of us that we would not be able to catch up to them. Some may have even begun to give up and say that the Soviets were going to win the Space race.

This despair and loss of morale when confronting an obstacle is an important issue that we will develop in this paper. When facing a challenge, some react by giving up or saying it is too hard. Shakespeare captures this sentiment well in his quote from Measure for Measure: “Our doubts are traitors and make us lose the good we often obtain by fearing to attempt.” In other words, it is the doubts of people that limits people from doing amazing things. So how do we do great things? We ignore our doubts. We take on difficult and seemingly impossible challenges. This is exactly what the US did in this crisis with the Soviet Union.

On May 25, 1961, President John F. Kennedy gave a historic speech before all of Congress that set the United States on a course to the moon. In his speech he talked about a space exploration program which not only was meant to put a man on the moon but also had the daunting task of placing weather satellites, and other space related projects. “We choose to go to the moon in this decade and do other things, not because they are easy but because they are hard!” -John F. Kennedy, September 1962. President Kennedy ignored the doubts of the US public, he ignored his own doubts, he boldly predicted that we would make it to the moon and he gave a deadline for that prediction! This courage to take on difficult tasks is an essential element of success in overcoming barriers.

Fueled by the competition from the Soviet Union, the “space race” began. They began by building the Lunar Module which had one job: To get Buzz Aldrin and Neil Armstrong to the moon and back up to the Command Module in one piece. This seemingly simple task proved to be nearly impossible to perform. Here we will discuss

the challenges faced in designing this module and the methods used to overcome those barriers.

In 1962, NASA invited US aerospace contractors to bid on the construction of the Lunar Module. Nine companies entered the competition. In just two months, NASA selected Grumman Aircraft Engineering. Employees of Grumman were known as Grummies. Many were very excited to have gotten the job but soon they would not be so excited. The creation of this impossibly hard technological invention was even more challenging than any of them would have expected. Other companies were hired to build subsystems of the Lunar module. Bell Aerosystems fabricated the engine for the ascent stage, Aerospace giant Thompson Ramo Wooldridge manufactured the rocket engine for the ascent stage, Raytheon built the navigation computer, Hamilton Standard built the life support systems, and MIT's computer lab designed the landing software. The Grummies had to build the ladder of the Lunar Module and integrate all of the subsystems made by the other companies. The stakes were very high. Any mistakes made by any of these companies could result in the death of two astronauts and the failure of the United States in their mission.

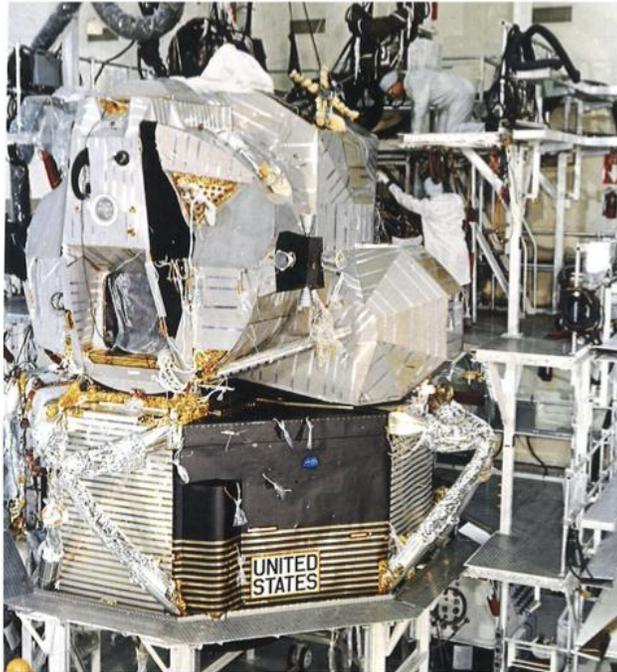
The lunar module started as a small wooden block with a dowel sticking out to represent the hatch. After months of hard work it turned into a large white painted ovoid crew cabin connected to a cylindrical landing stage. After initial design, they realized the great problem: The Lunar module was too heavy to complete its mission: Way too heavy. They needed a seeming miracle of engineering.

The Grummies and their teams took this barrier as a challenge. They used ingenuity and capitalism to drive the project forward. First, the Grummies replaced the

four large windows with two smaller windows. They also eliminated one of its five legs. This saved a lot of weight but not nearly enough. For every pound of module, there needed to be three more pounds of fuel.

By the end of 1965 the Lunar Module was coming together and some 50,000 drawings and schematics were created. But it still weighed too much. Kelly, the boss of many of the Grummies, set a bounty on weight, which pretty much meant that for every pound of the Lunar Module that anyone could shave off she would give them \$10,000. This bounty went for any Grumman employee from the lowest Janitor to the elite engineers. In this environment of excitement and reward, doubts faded and creativity emerged. Barriers were overcome. They realised that the module did not need to be symmetrical. This allowed them to save weight by using less wiring. 33 pounds were saved through the idea of making the Lunar Module asymmetric. They saved 88 pounds by making the hull of the Lunar Module paper thin. This was good in the sense that they saved 88 pounds and consequently 264 pounds of fuel. But the thinness of the hull did predispose it to developing potential problems such as an oil leak or potentially from being traumatized by a minute accident. In earth's gravity, the fall of a dropped screwdriver created enough force to break through the surface of the hull.

In the end they took 2,500 pounds off the Lunar Module and \$25,000,000 was awarded. The total weight of the Lunar Module was 33,000 pounds and 23 feet tall.



Lunar Module

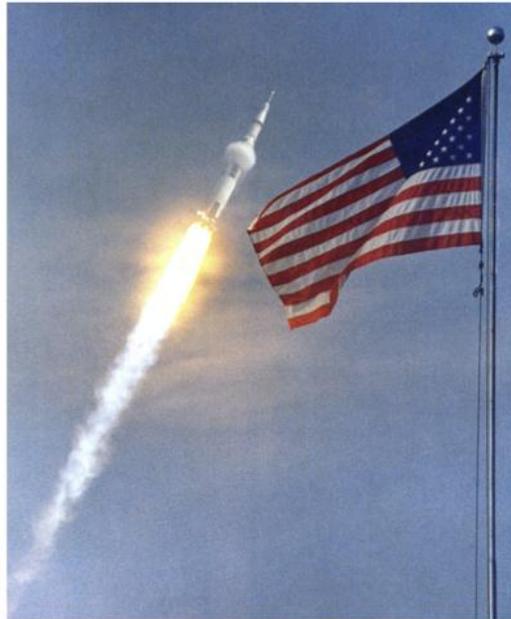
The lunar module is one of three main components of Apollo 11. The second component is the Command Module. This was made by the North American Rockwell group. The Command Module functioned as the part of the rocket ship that would stay in space with Michel Collins while Neil Armstrong and Buzz Aldrin would go to the moon on the Lunar Module. The third and final part of Apollo II was called the Service Module. It was made by the Rockwell international Manufacturing Company and the North American Aviation Manufacturing Company. The service module contained the main spacecraft propulsion system and supplied most of the spacecraft's consumables. The service module remained attached to the command module until it was released just

before reentry. It was then destroyed by the powerful force of reentry in the earth's gravity.

Now that everything was made and tested it was time to go to the moon. Buzz Aldrin, Michel Collins, and Neil Armstrong had all been quarantined for multiple days prior to prevent them from bringing sicknesses and other bacteria on Apollo 11. July 16, 1969 the crew got up at 4:00 AM and ate the usual pre-flight breakfast that consisted of steak, eggs, toast, juice and coffee. They then boarded the rocket ship. Hundreds of Millions of people were watching from either at home or they were there in person, waiting to see the fate of the rocket ship that everyone has been talking so much about. Everyone knew that this was America's last chance to fulfill the promise made by the previous President John F. Kenedy to make it to the moon before the end of this decade. But it was risky to go because the Lunar Module is not like fighter jets where you produce thousands of them and you get to learn from your mistakes, instead you only have one shot at the Lunar Module.

A few days before lift-off, one of the pipes started leaking dangerous and corrosive fuel. This was very dangerous for the Lunar Module. The fuel had the potential of weakening the integrity of the extremely thin hull of the Lunar Module causing it to potentially break down during the mission. The Grummies had to trace the pipes looking for pinhole defects. If and when they found the leaks, they patched them with tiny metal rings. This too could have been an insurmountable barrier for them. They could have cancelled the whole mission and decided that they needed to rebuild the piping system. They could have worried about the liabilities and the possibility of failure, but they had the courage and confidence to patch the system together.

340 feet in the air, these three brave men sat in the Command Module waiting and praying for the ship to blast off without incident. Before lift off, they had a check list of 417 steps that they needed to follow exactly or else something could go wrong. They then waited ten agonising seconds as Apollo 11 was preparing to blast off. “The eagle has wings.” Neil Armstrong said as they blasted off into space at 10,208 MPH.



Apollo 11 Ascent

Once they were in the middle of space, Apollo 11 sped unhindered by gravity coming steadily closer to the moon. Finally they made it to the moon's atmosphere. Neil Armstrong and Buzz Aldrin entered the Lunar Module and prepared to be blasted off to the moon. Shortly after they departed from the Command Module, flashing red lights suddenly appeared on their monitor. They quickly looked at the monitor to see what was wrong and it just said “Executive Overflow”. “It’s a 1202” said Neil Armstrong. But nobody knew what it meant until Steve Bails, a guidance officer, realised what it ment. It

was important yet harmless. Basically the message meant, “I’m receiving too much information. If I don’t reset myself, I may crash. So I will toss some of my tasks and continue with the really important ones after I sulk for a while.” By the time the ruckus was all over Neil Armstrong realised that they were way off course. Furthermore, they were running out of fuel and fast. They only had 25 seconds of fuel. He did not panic. He did not let his doubts overtake him. He made a decision to break from the plan and land on the closest most suitable land available to him. He saw a semi flat piece of terrain and took a chance and landed the Lunar Module. He overcame the obstacle through ingenuity, courage and by not panicking.



Apollo Photograph of the Moon

Meanwhile, people on earth at mission control waited to hear of the landing. The suspense was rising, silence filled the air waiting anxiously for the fate of Apollo

11. “The eagle has landed.” replied Neil Armstrong as he successfully landed on the moon.

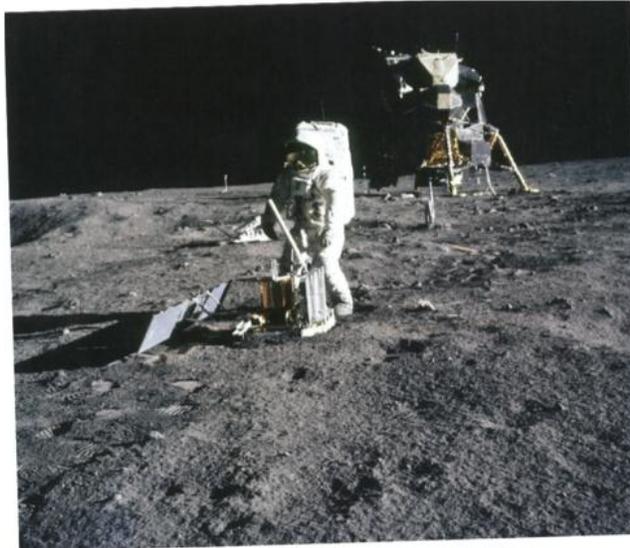
The next challenge that they faced was trying to get out of the confinement of the small Lunar Module. Buzz Aldrin said “We felt like we had two full backpacks trying to change positions in a cub scout pup tent”. Finally leaving the Lunar Module, Neil Armstrong began slowly walking down the ladder. As he touched the ground he said, “One small step for man, one giant leap for mankind!” That step may have been the biggest barrier broken in the history of everything!



Aldrin's Dismount

2 hours and 37 minutes later Neil Armstrong had collected 20 pounds of moon rocks and placed down satellites and the EASEP. The EASEP used two solar panels to run. It's job was to track and record the moon's motions and “moonquakes” another

word for earthquakes on the moon.

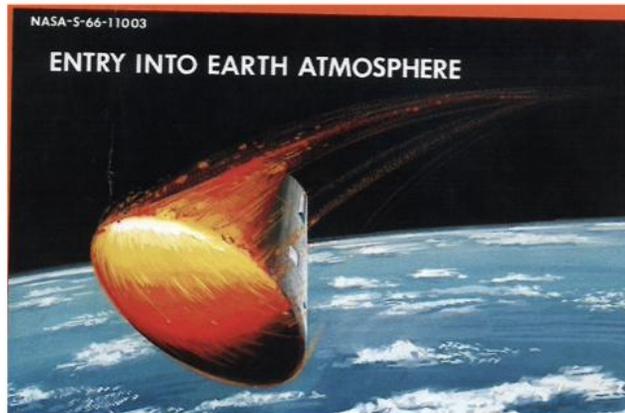


Moonwalk

Surviving in the extreme temperatures of the moon was another obstacle for their team. Their space suits controlled these temperatures to make moon walking possible. Aldrin and Armstrong spent 21 hours, 36 minutes on the moon at a site they named Tranquility Base before lifting off to rejoin Columbia in lunar orbit.

A short time later Apollo 11 was just getting ready to enter back into the earth's atmosphere. Upon entry a lot could go wrong. They were speeding at 10,000 MPH in 5,000 Degrees Fahrenheit. The friction between earth's atmosphere and Apollo 11 created a plasma field that began forming around the ship. This plasma field blocked all radio and therefore all communications with the outside world. This created unforeseen problems. First, if they angled Apollo 11 just a little bit off course then know one would know where they were. Second, Apollo 11 could burn up upon reentry due to extreme

heat. As they entered orbit all of this was coursing through their minds, not knowing if they would make it or not, Neil Armstrong took control. He bravely started the descent, angling it just right so they could land in their designated spot.



Reentry

When they were getting close to the water they deployed three parachutes, slowing their descent. They landed in the ocean making them the first people ever to land on the moon and come back to the earth, breaking many barriers along the way.

In traveling to the moon and back, Neil Armstrong, Buzz Aldrin, Michael Collins and the NASA team overcame many barriers. They overcame the challenge of the USSR, made the Lunar Module lighter, fixed corrosive pipe leaks, overcame software glitches, survived in moon temperatures, and navigated earth reentry. They did all of this through courage and confidence. They did not let their doubts control them. They defied gravity.

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