Apollo XI
A giant leap

It took the professionalism, dedication and hard work of more than 400,000 persons around the world to make this *giant leap for mankind* possible.

This small write-up is dedicated to all those who, like me, had the privilege of participating in that incredible adventure and to those who, even not directly participating, lived those moments with expectant admiration.

Carlos González

Small write-up of the Apollo XI mission

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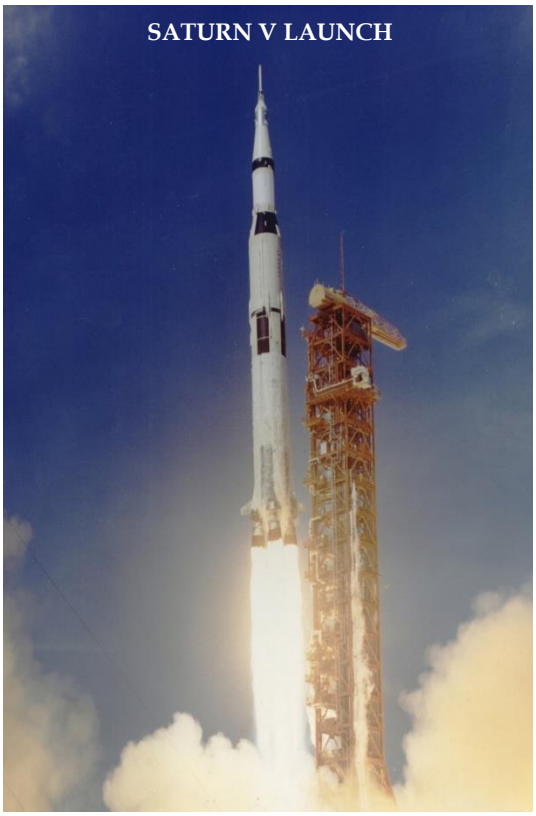


1. FOREWORD

This write-up couldn´t start without giving appropriate credit to the men that made the conquering of Space possible, either by dreaming of it long before it was thinkable or by making real all the theoretical studies about the subject,.

Among the dreamers: *Leonardo da Vinci, Jules Verne, H. G. Wells, Georges Mèliés, Edgar Rice Burroughs, Hugo Gersnback, Alex Raymond, Willy Ley, Chesley Bonestell, Robert McCall, etc.*

Among the theorist: *Konstantin Tsiolkovsky, Hermann Oberth, Robert H. Goddard, etc.*
And, of course, among the engineers and designers: *Wernher von Braun* and *Sergei Korolev*.

Von Braun was the central figure in Germany´s rocket development program while in his 20s and early 30s and made possible the designing of the V-2 combat missile during World War II.


WERNHER VON BRAUN

After the war was over, Braun went to the US as part of *Operation Paperclip* to work on the *intermediate range ballistic missile* for the Army.

When NASA was created, he became director of the Marshall Space Flight Center and was the chief architect of the Saturn V vehicle that propelled the Apollo Spacecraft to the Moon.


SERGEI KOROLEV

Sergei Korolev was a rocket designer and a key figure in the development of the Soviet Ballistic Missile Program.

He was appointed to lead the soviet space program and, after the success of *Sputnik* and *Vostok* projects, he was made a member of the Soviet Academy of Sciences.

By the time he unexpectedly died in 1966, his plans to compete with the United States to be the first nation to land a man on the Moon had begun to be implemented.

2. BEGUINNINGS

Let´s go to the Moon

After World War II, the relationship between the Soviet Union and the USA was anything but friendly. There was no formal declaration of war but the antagonism had reached a peak that could only be defined as a *cold war*. Both countries were increasing their production of nuclear weapons and Intercontinental Ballistic Missiles *(ICBMs)* to carry them, *(for retaliation)*, but had not thought much about conquering Space.

When, in 1957, the Soviets launched *Sputnik 1* and less than a month later *Sputnik 2* with *Laika*, they became the first nation to place manmade objects into Earth´s orbit. Although this action initiated the space race, it was not very clear what the term exactly meant.

In 1958, the US government created the National Aeronautics and Space Administration *(NASA)* to separate defense and scientific efforts and, with this creation, the American Space Program was underway. The fundamental idea was to place a human being onto the lunar surface and return him safely to Earth before the Soviets.

To be able to face this project, two programs were created. One to find suitable places for landing on the Moon; these were: Projects *Ranger, Lunar Orbiter,* and *Lunar Surveyor*. The second for the selection and training of future astronauts; these were: Projects *Mercury*, *Gemini*, and *Apollo*.

Project Mercury started by selecting an already well known launcher, *the Redstone,* which had been developed as a short range ballistic missile and deployed to defend Western Europe in case of an attack by the Soviets.

This launcher was used in a couple of occasions with manned capsules but was short of power to place objects in Earth´s orbit. It realized two suborbital flights while a new launcher, the *Atlas,* was being tested.

The selection process was not simple. NASA needed six astronauts and had to cope with the candidates coming from the test pilot schools only.

To their surprise, 508 candidates applied but after the first selection…

1. Be shorter than 1.70m and weight less than 70 kg.
2. Be less than 40 years of age and have an excellent physical condition.
3. Have more than 1,500 flight hours.
4. Be a certified test pilot.
5. Have, at least, a bachelor´s degree.
6. Be a qualified Jet pilot.

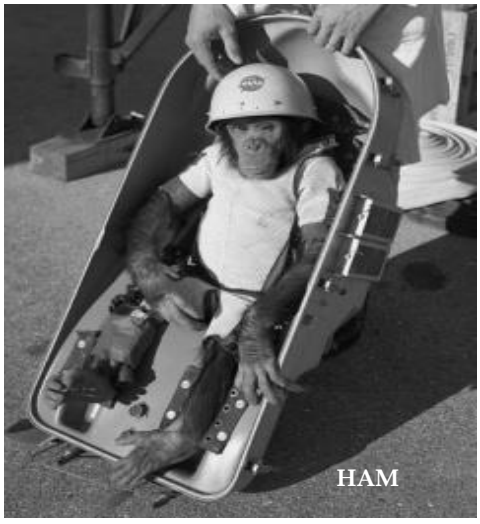
Condition 1 was a requirement related to the extremely small vital space inside a Mercury capsule (1 m³) due to the need to reduce vehicle weight the maximum possible.

And so the number went down to 110.

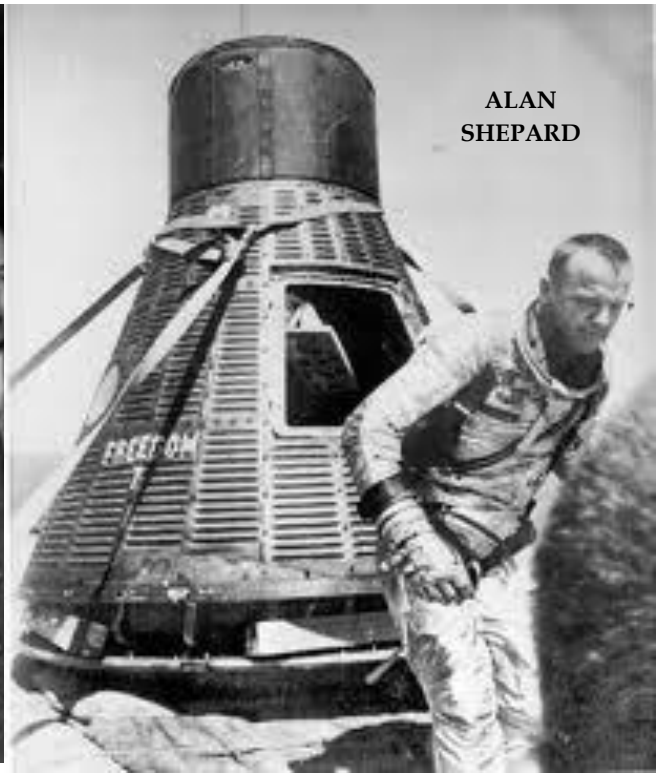
After the interviews with the instructors this number went further down to 69, and 37 more quit when they found out the economic conditions. Medical exams reduced the number to 18. Exhaustive physical tests with the help of Dr. Lovelace took the number to 7 and NASA decided to leave it at such.

The final candidates *(The Mercury 7)* were: *Alan Shepard Jr, Virgil (Gus) Grissom, Leroy Cooper Jr, Walter (Wally) Shirra Jr, Donald (Deke) Slayton, John Glenn Jr* and *Malcolm Carpenter.*

And while the future astronauts started their training, NASA was also training a chimpanzee *(HAM)*, as the first American being to flight into space.



Once again, soviets were first launching *Yuri Gagarin* into space aboard *Vostok 1* spacecraft, only 23 days before the first American designed to be the first of the seven to flight, Alan Shepard, was launched. Moreover, Yuri completed an Earth orbit while Shepard could only attain a suborbital flight lasting only 16 minutes.



The American president, John F. Kennedy, addressed a Joint Session of Congress on May 25, 1961, and requested political support and budget to get the Americans to the Moon, -*I believe that this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the moon and returning him safely to the earth*-, to show the world their economic and technological leadership. *Project Apollo* had officially begun.

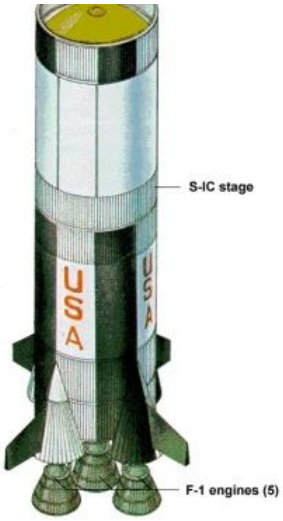
In the meantime, project Mercury finally placed a capsule into Earth orbit with astronaut Glenn *(1962)* by using the larger launch vehicle Atlas-D, while already working in the next project, *Gemini,* which would be the predecessor to Apollo.

The Soviets were not sleeping however, and sent the first woman, *Valentina Tereshkova,* into Earth orbit *(1963)*, and also achieved the first Spacewalk with *Leonov (1965).*

They were also busy with the design of a rocket that could get them to the Moon before the Americans.

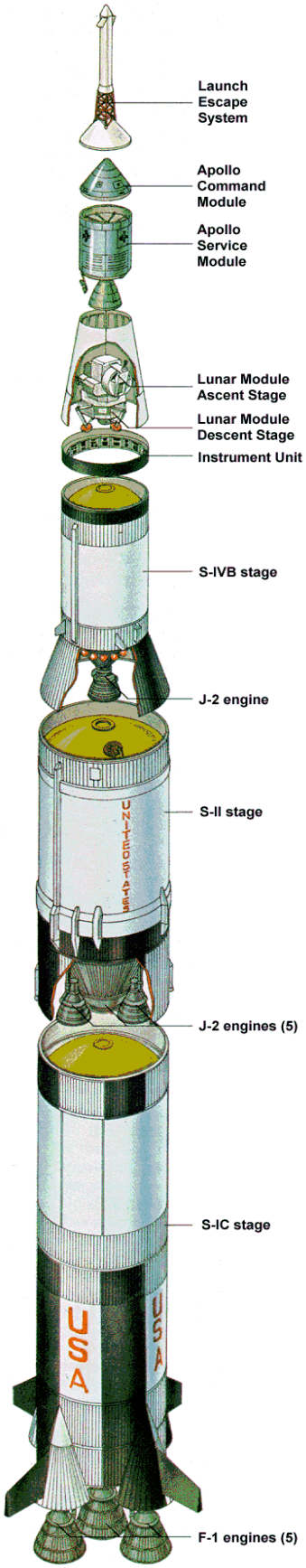
The American Moon project begins

The first designs for a rocket to send men to the Moon went from a missile large enough to leave Earth, land on the Moon, return to Earth and land safely at home *(NOVA)*, to the launch of several different rockets that would meet in Earth´s orbit, *(EOR)*, connect together, and continue the trip. And finally, to a *Moon rendezvous, (LOR)*, that would comprise a large Command and Service Module *(CSM)* with a smaller Lunar Module *(LM)* attached. The former would take the astronauts to Moon´s orbit and back to Earth while the later would be used to land on the Moon and return to Moon´s orbit to *rendezvous* with the CSM. This design was proposed by *Tom Dolan* and led by *John C. Houbolt*



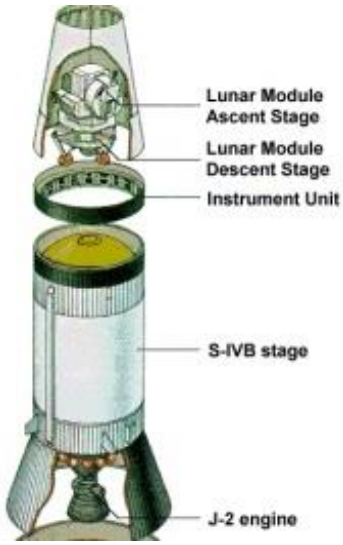
This last project was finally chosen and thus, the designing process was underway. First they needed a powerful enough launcher that would accelerate the CSM/LM combination to escape velocity so that it could leave Earth and be able to get to the Moon. And so, a giant three stage vehicle was planned and developed, the *SATURN V*.

The first stage was built by Boeing in New Orleans and was called the *S-1C*. It had 5 F-1 engines, the center one being fixed while the outer four were steerable. The propellants were RP1 *(a super refined kerosene)* and liquid oxygen and was able to produce a thrust of 3.5 thousand metric tons. This first stage burned for 2.5 minutes and placed the vehicle at an altitude of 67 km and at a speed of 8,600 km/h. The ignition sequence started 8.9 seconds before liftoff with the central motor igniting first and the outside motors following sequentially, in diagonal pairs, every 300 milliseconds. Once all five engines were at full thrust the launcher was released from the launch platform. 1 minute and 20 seconds after liftoff, the astronauts experienced a dynamic acceleration of 4 Gs. (1)

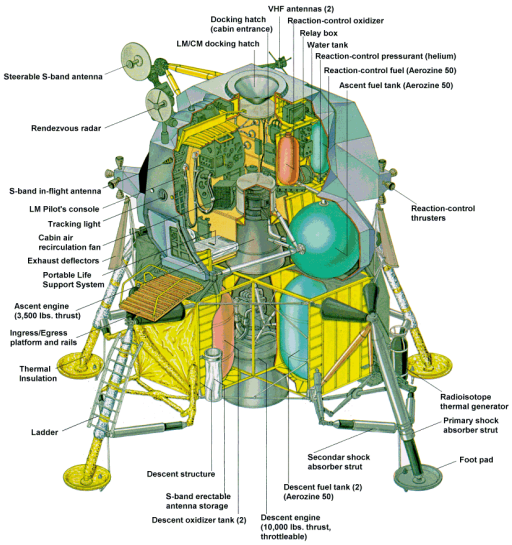


(1) G is the acceleration produced by Earth's gravity and it is equal to 9.8 m/s². A person under 4 Gs actually weights four times more than normal.

After the propellants were depleted, first stage separated from the rest of the vehicle and the second stage started ignition. At that time, the launch escape tower was jettisoned. North American Aviation in California built the second stage, called the *S-II*, which was comprised of five J-2 motors with the center one fixed and the outer four steerable as in the first stage. The propellants were liquid oxygen and liquid hydrogen, and burned for 6 minutes to place the rest of the vehicle at an altitude of 185 km and at a velocity of 20,600 km/h.



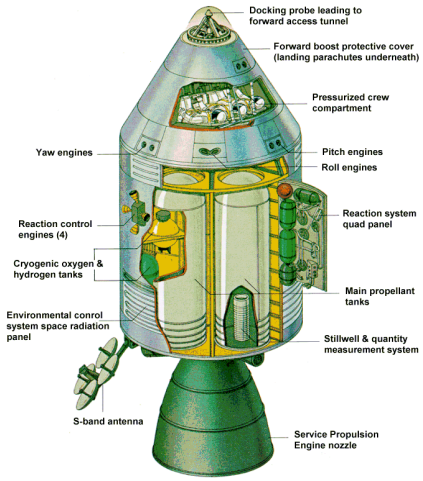
Apollo Lunar Module



The lunar module was 23 ft. tall and had a launch weight of 33,205 lbs.
(The Apollo 17 J-Series lunar module weighed 36,244 lbs.)

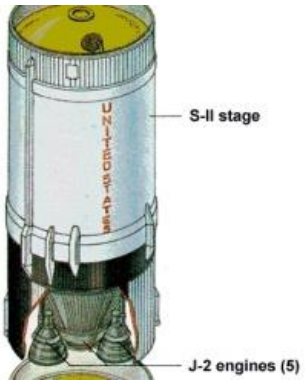
This was just a little less than needed to go into Earth´s orbit, so the second stage separated and the third ignited for 2.5 minutes giving the necessary increase in speed to achieve it. This was the *S-IVB* and was built by Douglas Aircraft in California; it used the same type of propellants of the second stage. It had a single J-2 engine which was re-startable, so it could be ignited again to place the vehicle on a lunar trajectory. Atop the S-IVB there was a ring called the Instrumentation Unit *(IU)*, built by IBM; it received information from multiple sensors in the vehicle and sent commands to different parts of the launcher based on this information. After the IU, a hatch concealed the LM, built by Grumman, which had the landing legs retracted while on the trans-lunar trajectory, and on top of the hatch, the CSM, built by North American Aviation, was attached. The LM used Propergol *(Mono-methyl hydrazine + Nitrogen tetroxide)* while the SM used Aerozine 50 *(hydrazine + unsymmetrical di-methyl hydrazine + Nitrogen tetroxide)* as propellants.

Apollo Command and Service Modules



Apollo CSM Facts

The Apollo Command Module was 10.6 ft. tall and 12.8 ft. at its maximum diameter, and typically weighed 13,090 lbs. with astronauts. The Service Module was 24.3 ft. tall and 12.8 ft. in diameter and weighed 54,074 lbs.. The Service Propulsion System engine delivered a thrust of 20,500 lbs..

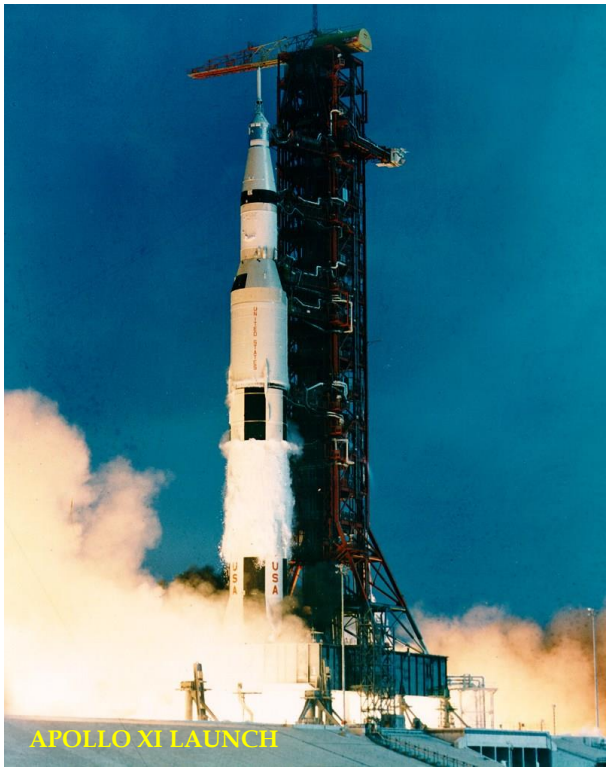


The LM was comprised by two stages, landing and ascent. The landing stage was left on the surface of the Moon.

3. APOLLO XI

A GIANT LEAP

It was the fifth Apollo Program manned mission and the first planned to actually land on the Moon.


APOLLO XI LAUNCH

On 16 July, 1969, at 13:32:00 GMT the most powerful rocket ever built, a Saturn V *(SA-506)*, lifted off from Launch Pad 39-A at Kennedy Space Center, Florida.

The mission: To set two astronauts on the surface of the Moon as the late President John F. Kennedy had urged Congress in 1961 when he said, *I believe that this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the Moon and returning him safely to the Earth.*

The project started early before 1960 with the two predecessor projects, Mercury and Gemini. Then, on 27 January, 1967, an accident on Apollo I *(SA-204)*, scheduled for launch 21 February, killed three astronauts while on a simulation at launch complex 34. The accident delayed the whole project for 20 months while the cause was analyzed.

The prime and backup crews for this flight were:

Prime:

Position	Astronaut
Commander	Neil A. Armstrong
CM Pilot	Michael Collins
LM Pilot	Edwin E. Aldrin Jr.

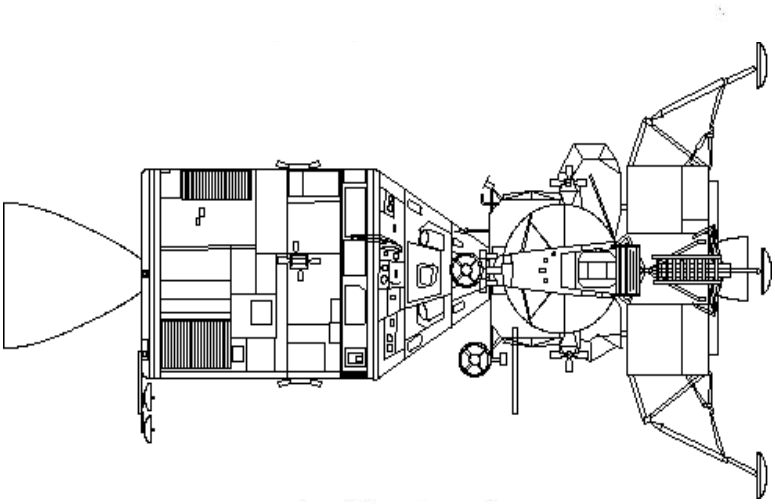
Backup:

Position	Astronaut
Commander	James A. Lovell Jr.
CM Pilot	William A. Anders
LM Pilot	Fred W. Haise Jr.

To the Moon

The third stage had placed the vehicle in Earth orbit, while ground Control and the astronauts verified all equipment and instruments performance. At the proper point in the trajectory, the third stage ignited again for about 6 minutes allowing the vehicle to reach escape velocity.

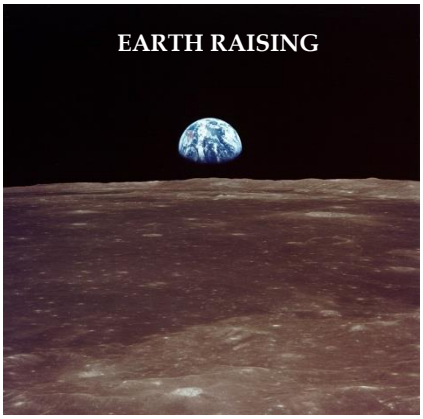
This last ignition was called *TLI (Trans Lunar Injection)* and Apollo was on its way to the Moon. After all the parameters, equipment and variables were checked the hatch of the third stage opened displaying the LM. The CSM made a slow evasion maneuver, turned 180° and returned to attach to the LM and retrieve it from the S-IVB.



NORMAL APOLLO CSM/LM CONFIGURACIÓN

Another slow evasion maneuver and the Apollo spacecraft, composed of the SM, CM and LM, was on its *TLC (Trans Lunar Coast)* to the Moon. The S-IVB trajectory was then changed to avoid a collision with Apollo

The next three and a half days were uneventful. Four mid-course correction maneuvers were scheduled but the trajectory was so accurate that only one was performed. In addition the crew performed a color TV transmission to Earth.


EARTH RAISING

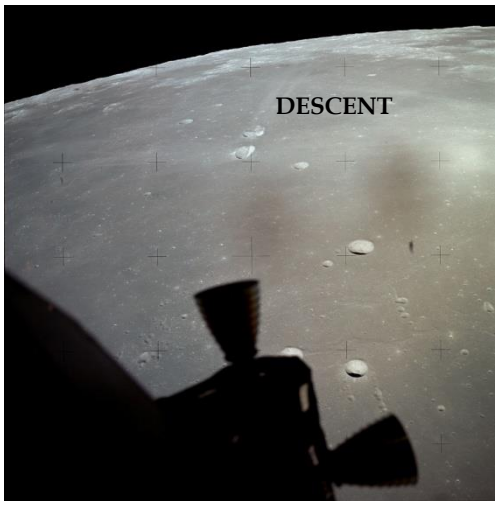
On 18 July, Armstrong and Aldrin donned space suits, went into the LM to check out the vehicle and made the second TV transmission.

On 19 July, Apollo was captured by Moon´s gravity and *LOI (Lunar Orbit Insertion)* took place at a *MET (Mission Elapsed Time)* of 75 hours and 50 minutes by performing a retrograde firing of 357.5 seconds. This maneuver placed the vehicle in an elliptical orbit of about 200 by 100 km, a second firing circulated the orbit at about 100 km.

On 20 July, 1969, the lunar module *(LM) Eagle* separated from the command module *(CM) Columbia*. Michael Collins, alone aboard Columbia, inspected Eagle, as it pirouetted before him, to ensure the craft was not damaged.

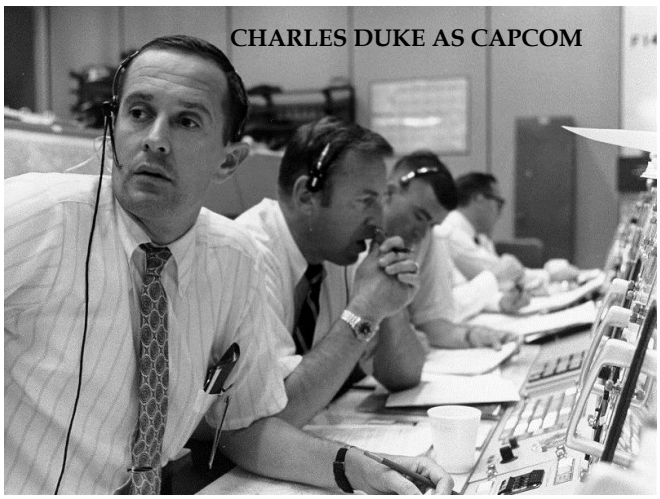

LM AFTER SEPARATION

As their descent began, Neil Armstrong and Buzz Aldrin found that they were passing landmarks on the surface 4 seconds early so they reported that they were *long,* they would land kilometers west of their target point. Five minutes into the descent burn, and 1,800 m above the surface of the Moon, the LM navigation and guidance computer produced the first of several unexpected *1202* and *1201* program alarms. The computer engineer at Mission Control Center in Houston, *Jack Garman*, told guidance officer *Steve Bales* it was safe to continue the descent. These alarms were indications of *executive overflows*, meaning the guidance computer could not complete all of its tasks in real time and had to postpone some of them.

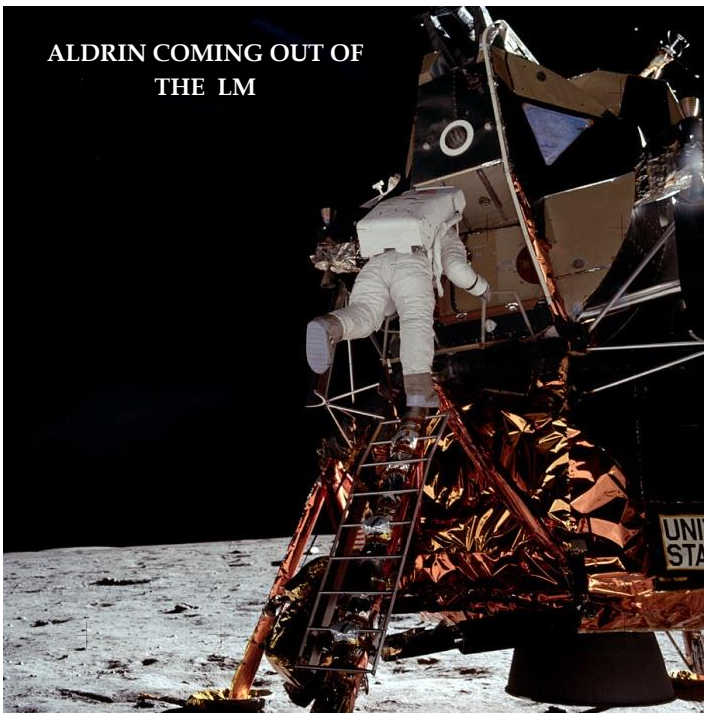

DESCENT

When Neil Armstrong again looked outside, he saw two things. First, that the computer's landing target was in a boulder-strewn area just north and east of a 300 m diameter crater *(later determined to be West crater)* and. Second, the landing surroundings were full of rocks. He then took semi-automatic control, and with

Buzz Aldrin calling out altitude and velocity data, landed at 20:17 GMT on 20 July, 1969, with about 17 seconds of fuel left.


CHARLES DUKE AS CAPCOM

Armstrong completed the post landing checklist before calling Mission Control in Houston: *Houston, Tranquility Base here. The Eagle has landed*. Neil Armstrong´s abrupt change of call sign from *Eagle* to *Tranquility Base* caused momentary confusion at Mission Control and Charles Duke remained silent for a couple of seconds before expressing the relief of Mission Control: *Roger, Twan-- Tranquility, we copy you on the ground. You got a bunch of guys about to turn blue. We're breathing again. Thanks a lot.*

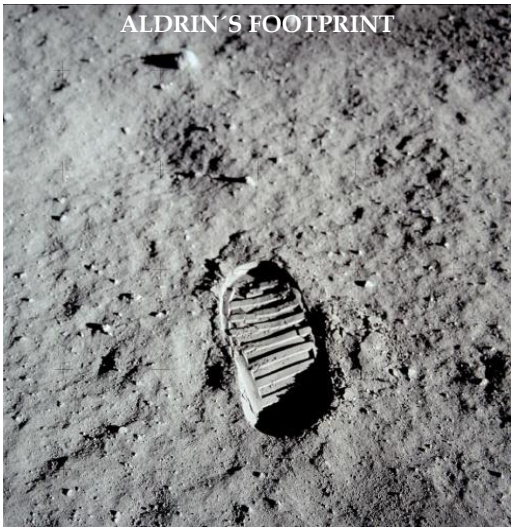

ALDRIN COMING OUT OF THE LM

At 02:39 GMT on Monday 21 July, 1969, Neil Armstrong opened the hatch, and at 02:51 GMT began his descent to the lunar surface. The Remote Control Unit placed on his chest kept him from seeing his feet. Climbing down the nine-rung ladder, Armstrong pulled a D-ring to deploy the Modular Equipment Stowage Assembly *(MESA)*, folded against Eagle's side, activated the TV camera, and at 02:56:20 GMT he set his left foot on the surface of the Moon.


ALDRIN SALUTING FLAG

After describing the surface dust as, *very fine-grained* and *almost like a powder*, Neil Armstrong stepped off Eagle's footpad and uttered his famous line ***That's one small step for [a] man, one giant leap for mankind.*** Buzz Aldrin joined him 13 minutes later, and described the view as *magnificent desolation.* They erected the US flag and started collecting lunar rocks and other material *(21.55 kg)*. They also deployed a solar wind composition experiment, that was later

recovered, and a scientific station *(EASEP)*, which included a passive seismic experiment and a laser ranging retro reflector.



While on the surface of the Moon, they received a telephone call from U.S. President Richard Nixon who described the call as: *The most historic phone call ever made from the White House*.

The total lunar surface stay time was 21 h 36 min and at 17:54 GMT, they lifted off in Eagle's ascent stage, carrying 21.5 kg of lunar samples with them. As they ascended, Aldrin looked up in time to see how the exhaust from the engine knocked over the American flag they had planted. Once in lunar orbit, the LM rendezvoused with the CSM and performed a successful docking. CMP Collins was happy to see them back aboard Columbia as he had had little to do, while they were on the surface.

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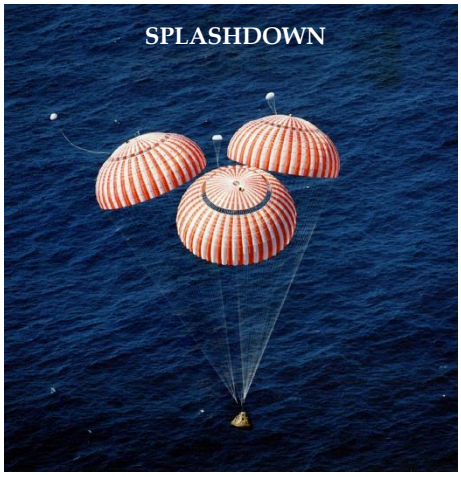
After all lunar samples had been transferred to Columbia and the hatch had been closed, Eagle was jettisoned. Now it was time to return home, and the astronauts began preparations for the trip by stowing all loose equipment, materials and the lunar samples. Then, they readied the computer and entered the ignition parameters.

The return home

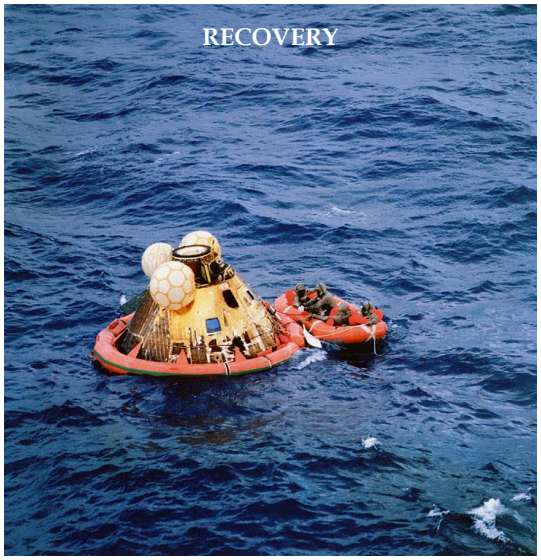
After an attitude reorientation maneuver, the CSM was ready to start the return trip. While on the back side of the Moon, they performed a *TEI (Trans Earth Injection)* by firing the SM motor to acquire escape velocity. And then, another three and a half days of *TEC (Trans Earth Cost)* while in PTC *(Passive Thermal Control)* attitude.



On 23 July, the last night before splashdown, the three astronauts made a television broadcast and started the preparations for re-entry.

First they donned their space suits and then, after checking the correct entry angle, they ejected the SM.

On 24 July, at roughly 16:44 GMT, the drogue parachutes deployed and at 16:51 GMT the Command Module struck the Pacific Ocean. The astronauts splashed down, just before dawn,



The command module landed upside down but was righted in several minutes by flotation bags triggered by the crew. *Everything's okay. Our checklist is complete. Awaiting swimmers* was Armstrong's last official transmission from the *Columbia*. A diver from the Navy helicopter hovering above attached a sea anchor to the command module to prevent it from drifting.

Additional divers attached flotation collars to stabilize the module, and positioned rafts for extracting the crew. Though the chance of bringing back pathogens from the lunar surface was considered remote, it was thought possible. So, as part of the extraordinary precautions NASA required, divers provided the astronauts with Biological Isolation Garments *(BIGs)* at the recovery site which they wore until they reached isolation facilities onboard the Hornet.

Additionally, they were rubbed down with a sodium-hydrochloride solution and the Command module was wiped with Betadine to remove any lunar dust that might be present. The raft containing decontamination materials was then intentionally sunk.

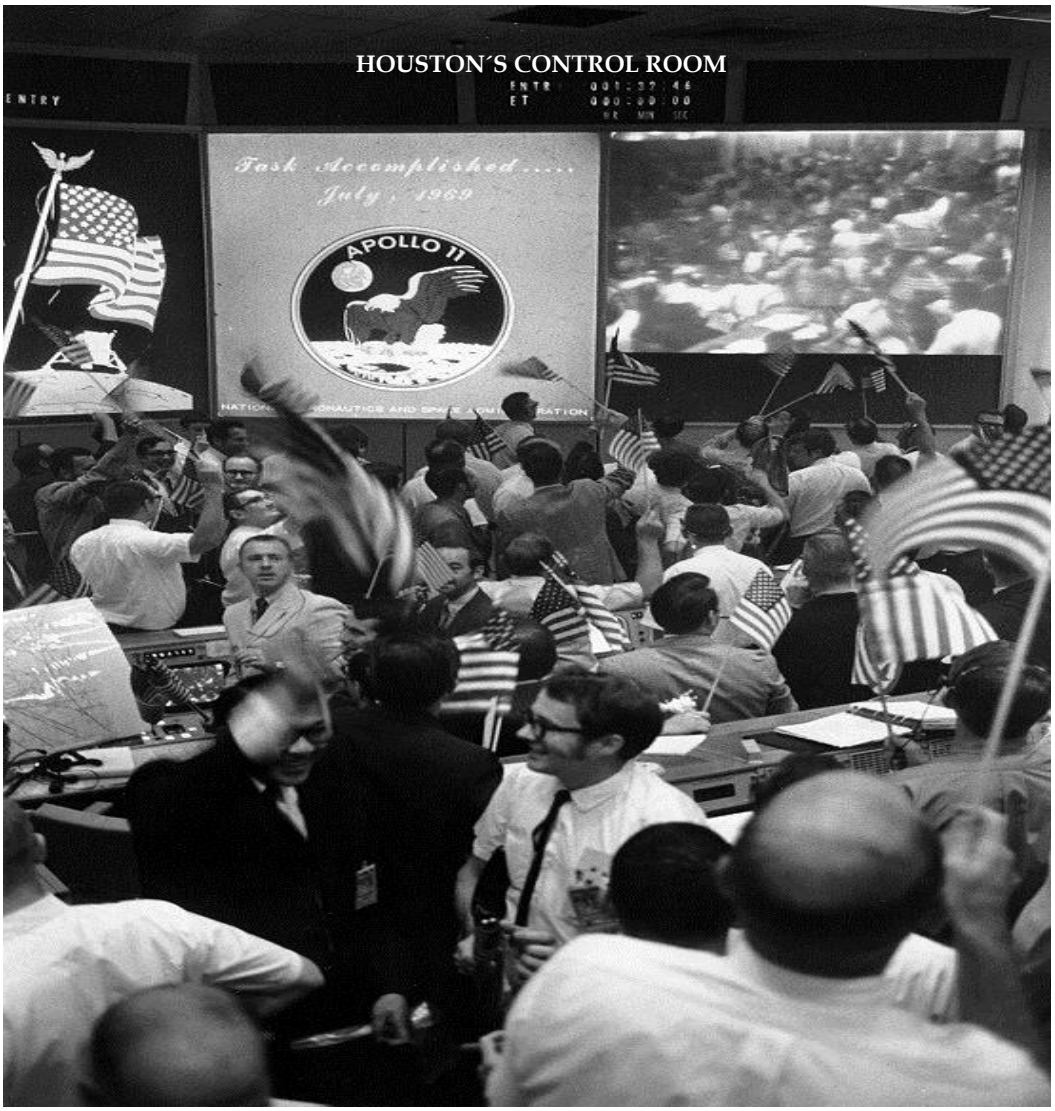
A second Sea King helicopter hoisted the astronauts aboard one by one,

where a NASA flight surgeon gave each a brief physical check during the 930 m trip back to the Hornet.

ASTRONAUTS TALKING WITH PRESIDENT NIXON

After touchdown on the Hornet, the astronauts exited the helicopter, leaving the flight surgeon and three crewmen. The helicopter and they were then lowered into hangar bay # 2 where the astronauts walked the 9.1 m to the Mobile Quarantine Facility *(MQF)*. They would spend the next 21 days there in quarantine

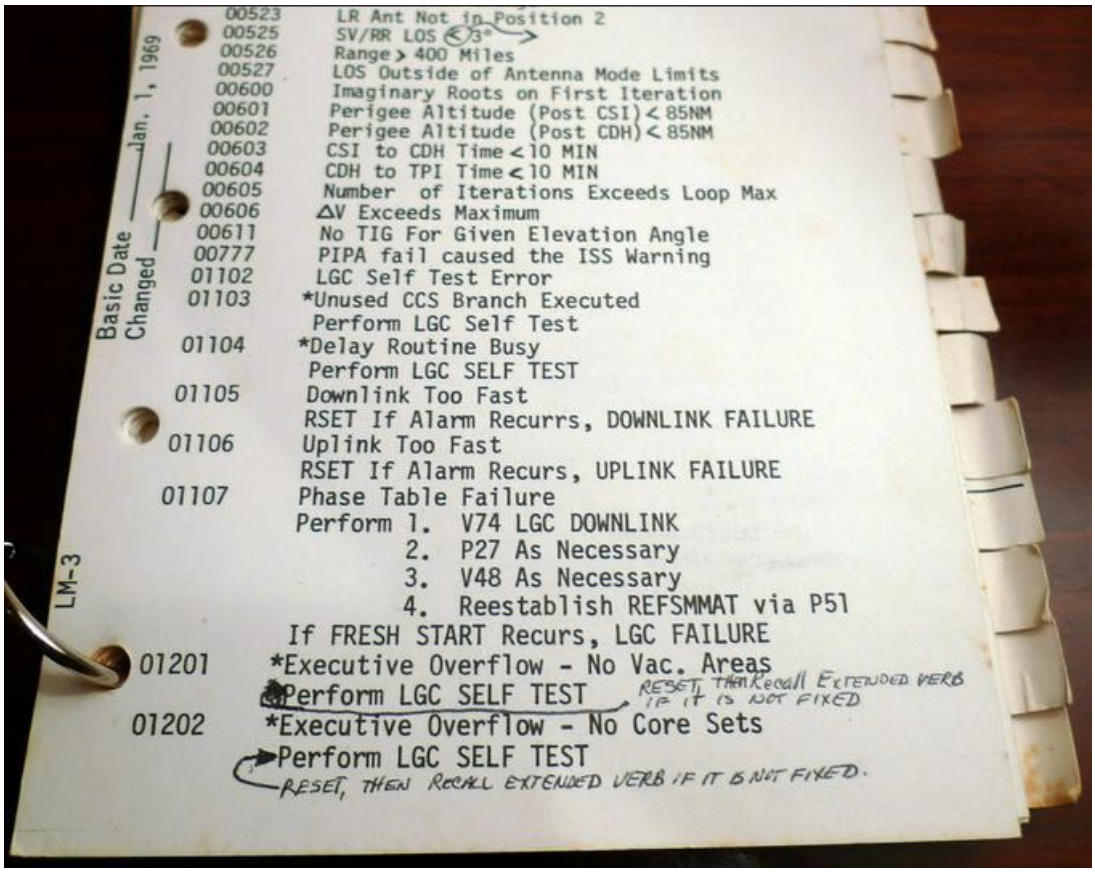
President Nixon, who had boarded the Hornet to personally welcome the astronauts back to Earth, told them, *As a result of what you've done, the world has never been closer together before*.



HOUSTON´S CONTROL ROOM

Additional facts of the Apollo XI flight

a. The cause of the 1202 and 1201 alarms during the mission was diagnosed as the rendezvous radar switch being in the wrong position, causing the computer to process data from both the rendezvous and landing radars at the same time. However, in 2005, software engineer *Don Eyles* concluded in a Guidance and Control Conference paper, that the problem was actually due to a hardware design bug that had been seen previously on testing of the first unmanned LM.



b. LM also experienced comm. problems with Houston that were minimized using the CM as a relay. LM´s high gain antenna automatic positioning system had a masking programming error that made the capsule to block the signal.

c. Another small problem appeared due to sloshing in the liquid fuel tanks that constantly changed the capsule´s center of gravity confusing the computer.

d. Armstrong initially had some difficulties squeezing through the hatch with his Portable Life Support System *(PLSS)*. A redesign of the LM to incorporate a smaller hatch had not been followed by a redesign of the PLSS backpack, so some of the highest heart rates recorded from Apollo astronauts occurred during LM egress and ingress.

e. Armstrong said that moving in the lunar gravity, one-sixth of Earth's, was *even perhaps easier than the simulations... It's absolutely no trouble to walk around*. Aldrin joined him on the surface and tested methods for moving around, including two-footed kangaroo hops. The PLSS backpack created a tendency to tip backwards, but neither astronaut had serious problems maintaining balance.

Loping became the preferred method of movement. The astronauts reported that they needed to plan their movements six or seven steps ahead. The fine soil was quite slippery. Aldrin remarked that moving from sunlight into *Eagle*'s shadow produced no temperature change inside the suit, though the helmet was warmer in sunlight, so he felt cooler in shadow.

f. When President Nixon spoke to the astronauts while on the Moon, he originally had a long speech prepared to read during the phone call, but Frank Borman, who was at the White House as a NASA liaison during Apollo XI, convinced Nixon to keep his words brief, and to respect the lunar landing as Kennedy's legacy.
g. During the EVA period, Mission Control used a coded phrase to warn Armstrong that his metabolic rates were high and that he should slow down. He was moving rapidly from task to task as time ran out. However, as metabolic rates remained generally lower than expected for both astronauts throughout the walk, Mission Control granted the astronauts a 15 minute extension.
h. Aldrin entered *Eagle* first. With some difficulty the astronauts lifted film and two sample boxes containing more than 21 kg of lunar surface material to the LM hatch using a flat cable pulley device called the Lunar Equipment Conveyor *(LEC)*. Armstrong reminded Aldrin of a bag of memorial items in his suit pocket sleeve, and Aldrin tossed the bag down Armstrong then jumped to the ladder's third rung and climbed into the LM. After transferring to LM life support, the explorers lightened the ascent stage for return to lunar orbit by tossing out their PLSS backpacks, lunar overshoes, one Hasselblad camera, and other equipment. They then pressurized the LM, and settled down to sleep.
i. While moving within the cabin, Aldrin accidentally broke the circuit breaker that would arm the main engine for lift off from the Moon. There was concern this would prevent firing the engine, stranding them there. Fortunately a felt-tip pen was sufficient to activate the switch. Had this not worked, the Lunar Module circuitry could have been reconfigured to allow firing the ascent engine.
j. They also left behind a memorial bag containing a gold replica of an olive branch as a traditional symbol of peace and a silicon message disk. The disk carries the goodwill statements by U.S. Presidents Eisenhower, Kennedy, Johnson and Nixon, and messages from leaders of 73 countries around the world. The disc also carries a listing of the leadership of the US Congress, a listing of members of the four committees of the House and Senate responsible for the NASA legislation, and the names of NASA's past and present top management. *(In his 1989 book, Men from Earth, Aldrin says that the items included Soviet medals commemorating Cosmonauts Vladimir Komarov and Yuri Gagarin).* Also, according to Deke Slayton's book *Moonshot*, Armstrong carried with him a special diamond-studded astronaut pin from Slayton.

Note

All photographs depicted in this essay are from public Internet publications and, in no way, they will be used to collect any income.