Apollo 8
40th Anniversary

The Essence of the Human Spirit: Apollo 8

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"Please be informed there is a Santa Claus"-- Jim Lovell (Post TEI December 25 1968)

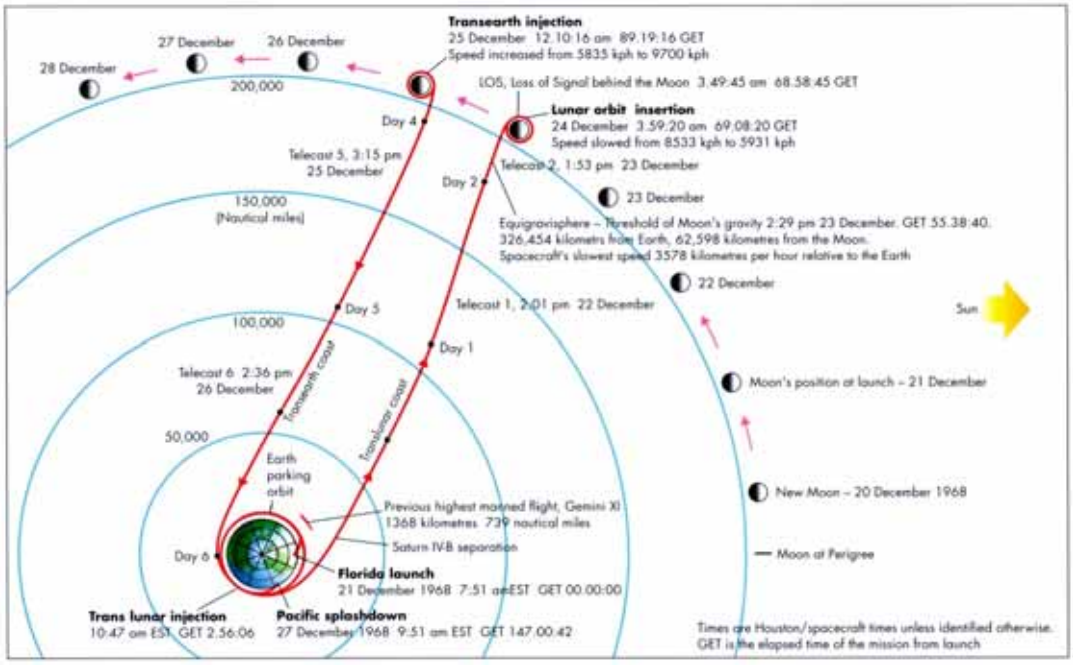
"Sir, it wasn't how you looked, it was how you smelled." -- Navy Seal frogman to astronaut William Anders, explaining his reaction to opening the Apollo 8 capsule.

Imagine that you have been mandated with going to the Moon before 1970 and you are faced with the following: a launch vehicle that had seventy anomalies on its last unmanned flight, three engines that had failed, and severe pogo problems, and yet it is required to fly with a human crew. You have a spacecraft that has not made a manned flight yet and has been re-engineered after a terrible disaster. You have a whole suite of on-board and ground software that has never been tested in a full non-simulation mission. You have a large ground tracking network not yet used to work a manned mission at the lunar distance. You have only four months to plan and train for a manned flight no one has ever done before. Four months out, the Pacific fleet was expecting a Christmas break, and no recovery ship might be available. The crew would have no Lunar Module 'life boat'. No human had ever escaped the gravity of the Earth. Facing a terrible array of unknowns, your decision? 'You' are George Low, Manager of the Apollo Spacecraft Program Office, no hesitation… an orbital flight to the moon! [1, 2, 5]

Problems with achieving a landing mission in 1969 to the Moon made themselves manifest in the spring of 1968 when the delivery of the Lunar Module slipped. However troubles with the Saturn V during the Apollo V launch test seemed on the way to being solved by late spring. The concept of circum-lunar flight goes back to Jules Verne with the technical aspects laid out by Herman Oberth in 1923. In the 1960's all the flight planning documents for the Apollo program had laid out all the astrodynamics of the trajectory [7]. Problems with the Lunar Module looked as if the first Moon landing might be pushed off into 1970. Placed against this situation, the Soviet Union was still actively pursuing a lunar landing, particularly the possibility of a circumlunar flight in 1968. In April 1968 both George Low of the Manned Space Craft Center (later JSC) and Director of Flight Operations Christ Kraft started thinking about a lunar flight in April 1968, and by August of 1968 George Low decided the only solution to a lunar landing in 1969 was to fly to the moon before the end of 1968. [1, 2, 5]

The 9th of August 1968 was a very eventful day; between 8:45 AM an 10 AM, Low, Gilruth (MSC director), Kraft, and director of Flight Crew Operations Donald K. Slayton after a breathless morning meeting at MSC set up a meeting at Marshall Space Flight Center with its director Wernher von Braun, Apollo Program Director Samuel C. Phillips and Kennedy Space

Upper right: Apollo 8 crew patch
Below: Apollo 8 trajectory (Figure used with permission of Hamish Lindsay)



Flight Center director Kurt Debus at 2:30 PM that same day. At this meeting they finalized a plan to present to senior NASA management that if Apollo 7 were successful Apollo 8 not just go circumlunar but into lunar orbit in December of 1968. [1, 2, 5]

On that same August 9th, Deke Slayton called Frank Borman and had him come to Houston from California to ask him if he wanted to go to the moon. He said yes, went back to California and told James Lovell and William Anders; they were enthusiastic. They all came back to Houston to start training. [1, 2, 5]

On August 15th Deputy Administrator Thomas Paine and Director of the Apollo Program finally got approval from the Administrator for Manned Space Flight George Mueller and NASA Administrator James Webb to go ahead with the Apollo contingent on the Apollo 7 mission. Therefore, before a manned version of the Command and Service Module had flown, a decision to go to the moon had been made. Planning and preparations for the Apollo 8 mission proceeded toward launch readiness on December 6, 1968. [1, 2, 5]

On September 9, the crew entered the Command Module Simulator to begin their preparation for the flight. By the time the mission flew, the crew would have spent seven hours training for every actual hour of flight. Although all crew members were trained in all aspects of the mission, it was necessary to specialize. Borman, as commander, was given training on controlling the spacecraft during the reentry. Lovell was trained on navigating the spacecraft in case communication was lost with the Earth. Anders was placed in charge of checking that the spacecraft was in working order. [1, 2, 5]

September, October and November of 1968 were three months of intense planning, training and work by Mission Planning & Analysis Division (MPAD), Flight Crew Operations Directorate (FCOD) and Flight Operations Directorate (FOD). The Manned Spacecraft Center, Marshall Spaceflight Center and the Kennedy Space Center had a lot on their plates! [1, 2, 5]

Marshall had to certify the Saturn V for its first manned spaceflight.

MPAD had to plan for the first manned vehicle to leave the earth's gravitational field.

MOD and FCOD had to plan and train for the first Lunar flight.

MIT had to prepare for the first manned mission using computer to perform guidance, navigation and control from the Earth to another celestial body.

The various Apollo contractors had to prepare every hardware aspect of a Command Module for both transfer in Earth-Moon space and orbit operations around the moon.

The MSC Lunar scientists had to formulate a plan for photographic exploration of the Moon from Lunar orbit. The science community had to examine and plan for the radiation environment in trans Earth-Lunar space.

KSC had to plan and train for the first manned Saturn V launch.

MSC and Apollo contractors had to plan for the first ever hyperbolic reentry into the Earth's atmosphere of a manned spacecraft.

Those were just some of the

Tracking stations

Apollo 8 was a milestone flight for the MSFN, since it was the first test of the network during a mission to the moon. Prior to the mission, concerns were raised regarding small terrestrial errors found in tracking tests that could be magnified to become much larger navigation errors at lunar distances. For assistance in the matter, MSC turned to JPL to look into their navigation system and techniques. JPL personnel, experienced in lunar navigation, proved very helpful as they assisted in locating tracking station location inaccuracies within Houston MCC
software. These erroneous values would have manifested themselves as large tracking measurement errors at lunar distances. The tracking station location fixes were implemented less than two days prior to the launch of Apollo 8.

Of special note was the Honeysuckle Creek near Canberra in *Australia.* It had a prime role for many of the first time critical operations, acquisition of signal after Lunar Orbit Insertion, prime for post Trans Earth Injection and prime for reentry. [3]

Honeysuckle Creek Tracking Station near Canberra, Australia

problems to be solved!

The success of Apollo 7, flown October 11-22, 1968, paved the way. On November 10 and 11 NASA studied the Apollo 8 mission, approved it and made the public announcement on the November 12.

Apollo 8 was launched from KSC Launch Complex 39, Pad A, at 7:51 AM EST, December 21, on a Saturn V booster. The S-IC first stage's engines underperformed by 0.75%, causing the engines to burn for 2.45 seconds longer than planned. Towards the end of the second stage burn, the rocket underwent pogo oscillations that Frank Borman estimated were of the order of 12 Hz. The S-IVB stage was inserted into an earth-parking orbit of 190.6 by 183.2 kilometers above the earth.

As Bill Anders later recalled: [4]

> Then the giant first stage ran out of fuel, as it was supposed to. The engines cut off. Small retro rockets fired on that stage just prior to the separation of the stage from the first stage from the second stage. So we went from plus six to minus a tenth G, suddenly, which had the feeling, because of the fluids sloshing in your ears, of being catapulted by -- like an old Roman catapult, being catapulted through the instrument panel.
>
> So, instinctively, I threw my hand up in front of my face, with just a third level brain reaction. Well, about the time I got my hand up here, the second stage cut in at about, you know, a couple of Gs and snapped my hand back into my helmet. And the wrist string around my glove made a gash across the helmet face plate. And then on we went. Well, I looked at that gash and I thought, 'Oh, my gosh, I'm going to get kidded for being the rookie on the flight,' because you know, I threw my hand up. Then I forgot about it.
>
> Well, after we were in orbit and the rest of the crew took their space suits off and cleaned their helmets, and I had gotten out of my seat and was stowing them, I noticed that both Jim and Frank had a gash across the front of their helmet. So, we were all rookies on that one.

Above: Apollo 8 spacecraft
Below: Apollo 8 crew, Frank Borman, William Anders and James Lovell

After post-insertion checkout of spacecraft systems, the S-IVB stage was reignited and burned 5 minutes 9 seconds to place the spacecraft and stage in a trajectory toward the moon, and the Apollo 8 crew became the first men to leave the earth's gravitational field. [5]

The spacecraft separated from the S-IVB 3 hours 20 minutes after launch and made two separation maneuvers using the SM's reaction control system. Eleven hours after liftoff, the first midcourse correction increased velocity by 26.4 kilometers per hour. The coast phase was devoted to navigation sightings, two television transmissions, and system checks. The second midcourse correction, about 61 hours into the flight, changed velocity by 1.5 kilometers per hour. [5]

In the words of Jim Lovell [4] :

> Well, my first sensation, of course, was “It’s not too far from the Earth.” Because when we turned around, we could actually see the Earth start to shrink. Now the highest anybody had ever been, I think, had been either—I think it was Apollo or Gemini XI, up about 800 mi. or something like that and back down again. And all of a sudden, you know, we’re just going down. And it was—it reminds me of looking—driving—in a car looking out the back window, going inside a tunnel, and seeing the tunnel entrance shrink as it gets— as you go farther into the tunnel. And it was quite a—quite a sensation to—to think about.
>
> You know, and you had to pinch yourself. “Hey, we’re really going to the Moon!” I mean, “You know, this is it!” I was the navigator and it turned out that the navigation equipment was perfect. I mean, it was just—you couldn’t ask for a better piece of navigation equipment.

The 4-minute 15-second lunar-orbit-insertion maneuver was made 69 hours after launch, placing the spacecraft in an initial lunar orbit of 310.6 by 111.2 kilometers from the moon's surface - later circularized to 112.4 by 110.6 kilometers. During the lunar coast phase the crew made numerous landing-site and landmark sightings, took lunar photos, and prepared for the later maneuver to enter the trajectory back to the earth. [5] William Anders had this to say [4] :

> …[T]hat one [view] is sunk in my head. Then there’s another one I like

maybe [and this is] of the first full Earth picture which made it again look very colorful. … [T]o me the significance of this [is that the Moon is] about the size of your fist held at arm's length … you can imagine … [that at a hundred arms' lengths the Earth is] down to [the size of] a dust mode. [A]nd, a hundred lunar distances in space are really nothing. You haven't gone anywhere not even to the next planet. So here was this orb looking like a Christmas tree ornament, very fragile, not [an infinite] expanse [of] granite … [and seemingly of] a physical insignificance and yet it was our home…

According to Frank Borman [4]:

Looking back at the Earth on Christmas Eve had a great effect, I think, on all three of us. I can only speak for myself. But it had for me. Because of the wonderment of it and the fact that the Earth looked so lonely in the universe. It's the only thing with color. All of our emotions were focused back there with our families as well. So that was the most emotional part of the flight for me.

During the flight William Anders said, "Earthshine is about as expected, Houston." Kraft said he shook his head and wondered if he'd heard right. Earthshine! [1]

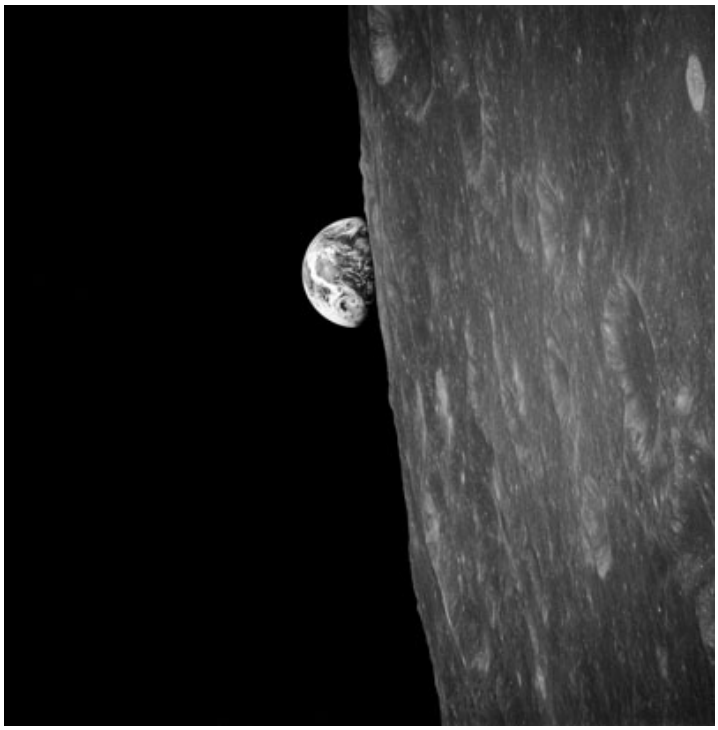
On the fourth day, Christmas Eve, communications were interrupted as Apollo 8 passed behind the moon, and the astronauts became the first men to see the moon's far side. Later that day , during the evening hours in the United States, the crew read the first 10 verses of Genesis on television to earth and wished viewers "goodnight, good luck, a Merry Christmas and God bless all of you - all of you on the good earth." [5]

On Christmas Day, while the spacecraft was completing its 10th revolution of the moon, the service propulsion system engine was fired for three minutes 24 seconds, increasing the velocity by 3,875 km per hr and propelling Apollo 8 back toward the earth, after 20 hours 11 minutes in lunar orbit. More television was sent to earth on the way back and, on the sixth day, the crew prepared for reentry, and the SM separated from the CM on schedule. [5]

Where will the S-IV go!

After the S-IVB executed the TLI maneuver, the CSM separates from the third stage of the Saturn V rocket, then performs the transposition and docking maneuver to extract the LM. An evasive maneuver was then performed to provide a safe separation between the CSM and the S-IVB. Then Trans Lunar Injection is performed, the Command Module is on a free return trajectory, meaning that if the Service Module engine fails a safe return to the earth is possible (if the Service Module power system does not fail as happened with Apollo 13!) A free-return trajectory is a path that uses the earth's and the moon's gravitational forces to propel a spacecraft around the moon and back to earth again. It's called a "free-return" because it is, in essence, automatic. With some minor course corrections, a space craft will automatically be whipped around the moon, and pulled back into the Earth's orbit, simply because the Earth's gravitational pull is so strong. The Earth's gravitational pull is so strong; in fact, that a spacecraft traveling at 20,000 mph when leaving Earth's atmosphere will have been slowed to less than 5,000 mph by the time it reaches the moon. The moon's gravity will temporarily grab hold of the spacecraft, but as soon as the craft rounds the moon, the Earth's gravity begins to pull it back again.

But where does the S-IVB go? It also comes back to the Earth! For a while no one had thought about this, the possibility of a danger from impact on the earth is small, it would most likely go into an ocean. To obviate any risk the S-IVB makes a tweak maneuver that places it on a sling shot trajectory into Solar orbit. (After Apollo 11 the S-IVB impacted the Moon for seismic measurements.)



Above: The first photograph taken of Earthrise over the moon. Note that this photograph is in black and white.

Be sure to check out the Apollo 8 flight journal at http://history.nasa.gov/ap08fj/

The Apollo 8 CM made the first manned 'hot' reentry at nearly 40,000 km/hr into a corridor only 42 km wide. Parachute deployment and other reentry events were normal. The Apollo 8 CM splashed down in the Pacific, apex down, at 10:51 AM EST, December 27, 147 hours and 42 seconds after liftoff. As planned, helicopters and aircraft hovered over the spacecraft and para-rescue personnel were not deployed until local sunrise, 50 minutes after splashdown. The crew was picked up and reached the recovery ship U.S.S. *Yorktown* at 12:20 p.m. EST. All mission objectives and detailed test objectives were achieved. [5]

Frank Borman said [4]:

> We hit the water with a real bang! I mean it was a big, big bang! And when we hit, we all got inundated with water. I don't know whether it came in one of the vents or whether it was just moisture that had collected on the environmental control system. ... Here were the three of us, having just come back from the moon, we're floating upside down in very rough seas -- to me, rough seas."
>
> Of course, in consternation to Bill and Jim, I got good and seasick and threw up all over everything at that point.

To which William Anders responded [4] :

> Jim and I didn't give him an inch, you know, we [Naval Academy graduates] pointed out to him and the world, that he was from West Point, what did you expect? But nonetheless, he did his job admirably. But by now the spacecraft was a real mess you know, not just from him but from all of us. You can't imagine living in something that close; it's like being in an outhouse and after a while you just don't care, you know, and without getting into detail... messy. But we didn't smell anything…

Christopher Kraft recalled in the Apollo oral history:[4]

> The firsts involved in Apollo 8 almost were unlimited, if you stop to think about it, from an educational point of view, from a theological point of view, from an esthetic point of view, from an art point of view, from culture, I don't know, you name it, that event was a milestone in history, which in my mind unless we land someplace else where there are human beings, I don't think you can match it, from its effect on philosophy if you will, the philosophical aspects of that.

References

[1] Kraft, Chris . *Flight: My Life in Mission Control*. New York: Dutton, 2001

[2] Gene Kranz, Failure Is Not an Option, Simon and Schuster, 2001

[3] Hamish Lindsay, Tracking Apollo to the Moon, Springer, 2001

[4] Oral History Project , Johnson Space Center, 1997 – 2008 (Ongoing)

[5] Apollo 8 Mission Report, MSC-PA-R_69-1, February, 1969.

[6] Robert Zimmerman, Genesis: The Story Of Apollo 8, 1998.

[7] APOLLO LUNAR LANDING MISSION SYMPOSIUM, June, 25-27, 1966 Manned Spacecraft Center Houston, Texas

Personal Note: I was 28 years old in December 1968 and had aimed myself from when I first read the Collier's magazine spaceflight series. The first issue was March 22 1952 when I was 11 years old. The series came to an end in April 30, 1954 issue, Can We Get to Mars? I was 13 then and remember Werner Von Braun writing that it would take 25 years to get to Mars, I was downcast! That was too long. I came to the Manned Spacecraft Center in Jan 1966 and in time became an instructor for the Lunar Module training simulator. I did not train the Apollo 8 crew but I was in Building 4 Christmas Eve at a second floor small remote control room listening to the flight controller's loop. It was very exciting, after Lunar Orbit Insertion, to hear acquisition of signal and confirmed orbit at approximately 4 am Houston time. I walked over to building 2 (building 1 these days) and got a cup of coffee. On the way back I looked into a cold, about 35 deg F clear Houston night sky at a Waxing crescent Winter Cold Moon for about 15 minuets and thought wow! There are humans in orbit up there.