Historian's Corner

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Program Profile

This issue has part one of the profile for the third Apollo mission, the "successful failure" of Apollo 13. The next MARS STAR Historian Corner will examine the root causes of this failure and the corrective actions taken. The 50th anniversary of this mission was in April 2020. I originally intended to have a single Program Profile, but the Apollo 13 mission is so complex and interesting that I decided to create two profiles for two MARS STARs. Program profiles are always sourced from publicly available information that has been cleared by a government agency (e.g., NASA) and do not contain any classified or export-controlled information.

Apollo 13 Mission Overview

Launched: 04/11/1970 19:13:00 UTC LC-39A
Splashdown: 04/17/1970 18:07:41 UTC,
Southern Pacific, USS Iwo Jima recovery ship
Saturn V AS-508 Launch Vehicle
Hybrid/Free Lunar Trajectory Fly-by
CSM (Command/Service Module) Call Sign: *Odyssey* (CSM-109)
LM (Lunar Module) Call Sign: *Aquarius* (LM-7)
Intended landing site: Fra Mauro Crater and Highlands
Connection to Lockheed Martin/ULA: The contributions of our heritage companies to the Apollo program were listed in the MARS STAR article about Apollo 11.

On June 30, 1995, the feature film *Apollo 13* was released by Universal Studios and Imagine Entertainment during the all-important summer box office time frame. Directed by Ron Howard and based on the book *Lost Moon: The Perilous Voyage of Apollo 13*, written by Jim Lovell and Jeffrey Kluger, the movie was a huge box office and critical success. *Apollo 13* had an all-star cast, including Tom Hanks, Gary Sinise, Ed Harris, Kevin Bacon, Bill Paxton, and Kathleen Quinlan. It was nominated for nine Academy Awards®, including Best Picture, Best Supporting Actor (Harris – as Gene Kranz), and Best Supporting Actress (Quinlan – as Marilyn Lovell) and won two of those awards (Film Editing and Sound). It also garnered many other film awards and recognition as a top 100 "cheers" movie by the American Film Institute. In our household, it is a library film that we view quite often and consider it the best movie that Ron Howard has directed. Although the outcome is known when watching *Apollo 13*, the superb screenplay, soundtrack (by the late James Horner) and direction still create a credible atmosphere of tension and uncertainty upon every viewing.

So why is the Apollo 13 mission, which was intended to be the third lunar landing in the Apollo program, such a cultural icon, when there were six successful landings that had many dramatic stories of their own and also had the exotic explorations of the Moon? To hopefully answer that question, let's examine the mission in detail from launch to splashdown; in the next MARS STAR, the failure investigation details will be explored.

Apollo 13 Crew--Lunar Module Pilot Fred Haise, CM Pilot John "Jack" Swigert, Commander James Lovell
Credit: NASA

Apollo 13 was a mission that had several major crew revisions during its planning and final stages. NASA's Director of Flight Crew Operations, Deke Slayton, rotated out part of the original Apollo 13 primary crew due to crew discipline concerns (Gordon Cooper and Donn Eisele). The second primary crew had Alan Shepard as commander, Stuart Roosa as CM Pilot and Edgar Mitchell as LM Pilot. However concerns for Shepard's readiness, after surgery for Meniere's disease (an inner-ear ailment), meant another crew rotation was made, swapping the primary crews for Apollo 13 and 14. The final designated crew of Apollo 13 (Commander Jim Lovell, LM Pilot Fred Haise and CM Pilot Thomas "Ken" Mattingly) were the backup crew for Apollo 11 and were intended to be the primary crew of Apollo 14. The crew dynamics were again tested when Ken Mattingly was removed as CM Pilot two days before launch due to potential exposure to measles that struck backup LM Pilot Charlie Duke (Lovell and Haise were immune); this resulted in the last-minute substitution of Apollo 13 backup CM Pilot Jack Swigert for Mattingly. Mattingly never did get the measles and flew as CM Pilot on Apollo 16. Lovell and Haise did last-minute intensive training with Swigert to ensure crew readiness.

Lovell and Haise (and their backups John Young and Charlie Duke) did extensive geological training, on their own time and expense before this mission, learning much from their mentor Professor Leon "Lee" Silver, a world-renowned geology professor from Caltech (and CU graduate). Silver's expertise was recommended by astronaut-geologist Harrison Schmitt. The lunar mission profile included plans for two four-hour EVAs in the Fra Mauro region, thought to have been formed early in the Moon's history. The crew would also deploy a nuclear-powered ALSEP (Apollo Lunar Surface Experiments Package). Mattingly and Swigert had separate training by geologist Farouk El-Baz on photographing lunar features from orbit. The mission, originally planned for March 1970, was delayed a month and 1970 budget cuts resulted in plans for no more than two missions a year and also eliminated the Apollo 20 mission (the Apollo 18 and 19 missions were later eliminated from the manifest).

Apollo 13 launched on schedule on Saturday, April 11, 1970 at 2:30 pm EST, in good weather conditions. Stage I performance was nominal; however, during Stage II flight, the center (inboard) engine in the Rocketdyne 5-engine J2 cluster shut down two minutes early. The shutdown was caused by severe pogo oscillations, amplified on Apollo 13 by an interaction with turbopump cavitation. The pogo problem (vibrations cause by combustion instability in liquid rocket engines) was known and had a mitigation, but the design solution, requiring installation of pogo dampeners or accumulators, was not incorporated in time for this mission. A post-flight anomaly review determined that the engine was one cycle away from catastrophic failure when it shut down. Fortunately, the remaining four J2 engines and the third stage S-IVB engine burned longer and Apollo 13 was placed in a nearly nominal parking orbit. The "Go" was given for the Translunar Injection burn two hours later and Apollo 13 was on its way to the Moon.

Transposition, extraction and docking of the CSM *Odyssey* with the LM *Atlantis* was performed nominally by the rookie Swigert and the astronauts settled in to relax during their three-day coast to lunar orbit injection. At 30 hours into the mission, the CSM performed a hybrid trajectory burn with the SPS (Service Propulsion System) engine to allow access to higher latitude lunar sites after achieving lunar orbit; this burn removed the possibility of a free trajectory return to Earth (this becomes a critical point later in the mission). A humorous incident occurred during this timeframe when Swigert confessed that he had not filed his federal income tax return; he was granted a 60-day extension for "being out of the country".

A television broadcast 55 hours into the flight (approximately 178,000 miles from Earth) had the crew tour the LM *Atlantis* to show interested viewers; none of the three major networks carried this broadcast as space missions were now considered "routine". The families of Lovell and Haise had to go to Mission Control to see their loved ones demonstrating zero-g conditions and performing antics for the children (Swigert was the first bachelor astronaut and had no immediate family present). Shortly after the broadcast, Swigert was asked by the CAPCOM (Capsule Communicator) Jack Lousma to execute an attitude change to facilitate photography of nearby Comet Bennett. Swigert was also asked by the EECOM (Electrical, Environmental, and Consumables Manager) Sy Liebergot (through Lousma) to activate the stirring fans in the SM (Service Module) cryogenic tanks. Let's look at the actual sequence of events from the superb Apollo Flight Journal:

055:52:58 **Lousma**: 13, we've got one more item for you, when you get a chance. We'd like you to stir up your cryo tanks. In addition, I have shaft and trunnion…[Pause]
055:53:06 **Swigert**: Okay
055:53:07 **Lousma**: …for looking at the Comet Bennett, if you need it.
055:53:12 **Swigert**: Okay, Stand by.

At 55 hours, 55 minutes, 4 seconds into the mission, communications data shows that the spacecraft suddenly switches to wide beam communications. A strange crackle is heard on the otherwise very quiet recording of the radio loop, which can be interpreted as a disturbance of the radio link to the spacecraft due to the explosion. At a debrief after the flight, Lovell noted that "there was a dull but definite bang – not much of a vibration, though. I didn't think there was much vibration – just a noise."

055:53:19 **Swigert**: Okay, Houston…
055:55:19 **Lovell**: ...Houston…
055:55:20 **Swigert**: …We've had a problem here [Pause]
055:55:26 **Fenner** (GUIDO): FLIGHT, GUIDANCE
055:55:27 **Kranz** (FLIGHT): Go Guidance
055:55:28 **Lousma**: This is Houston. Say again, please
055:55:28 **Fenner** (GUIDO): We've had a Hardware Restart. I don't know what it was.
055:55:30 **Kranz** (FLIGHT): Okay, GNC, you want to take a look at it? See if you see any problems?
055:55:35 **Lovell**: (garbled) ***Ah, Houston, we've had a problem.*** We've had a Main B Bus Undervolt.

In our popular movie referenced at the beginning of this history profile, the writers elected to use the

misquote, (spoken by Tom Hanks playing Jim Lovell) "Houston, we have a problem", because they wanted to use the line expected by viewers. This perpetuated the misquote in the public's consciousness.

At this point, Mission Control was already seeing several anomalous instrumentation readings and was aware that something was amiss. Onboard Apollo 13, the effects of the explosion of O2 tank 2 knocked out two of three fuel cell units supplying CSM power. The pipework leading from O2 tank 1 was also damaged and O2 from that tank was leaking away into space. The Guidance computer restarted, and other alarms were showing up for the RCS thrusters and propellant systems, with many "barbershop pole" or fault indicators on the CM main panel. The RCS thrusters had fired almost continuously since the explosion to keep the spacecraft from tumbling, as the venting kept pushing them out of their desired attitude; concerns developed for RCS propellant depletion. A mere fourteen minutes after the first indications, the following transmission was made by Lovell:

056:09:07 **Lovell**: That's AC, okay [referencing the AC bus problem], Yeah, that's – that's a – good with AC and it looks to me, looking out the hatch, that we are venting something. We are – We are venting something out into the – into space.

Mission Control was shocked, because they were still assuming (or hoping) that this was a systemic instrumentation failure. Power-down sequences for the CM began, since two fuel cells appeared damaged, oxygen was leaking through Fuel Cell 3 and breathing oxygen levels were being evaluated, as Ox tank 2 was depleted (gone) and Ox tank 1 was leaking. Small oxygen surge and repress tanks were controlled and isolated, at least ensuring breathing oxygen at Entry Interface. Here's the conversation at this point in troubleshooting, an hour after the problem:

056:57:07 **Lousma**: Okay 13. This is Houston. It appears to us that we're losing O2 flow through fuel cell 3. So, we want you to close the Reac [Reaction] valve on fuel cell 3. It looks like fuel cell 1 and 2 are trying to hold up okay. You copy?
056:57:26 **Haise**: Are you saying fuel cell 1 and 2 – 1 and 2 are trying to hold up but we're leaking O2 out of fuel cell 3? And you want me to shut the Reac valve on fuel cell 3? Did I hear you right?

Fred Haise was stunned, just as Jack Lousma was earlier when Gene Kranz asked him to relay this message. Closing the Reac valves on one of the fuel cells would scrub any possible attempt at a lunar landing because of a mission rule requiring all three fuel cells for the CSM to be functional. The Black Team (Kranz) also started evaluating possible abort scenarios, including a direct return mode and possible burn with the LM DPS (Descent Propulsion System) engine to re-establish a free return trajectory around the moon (this was the option selected, because of fears that the SPS engine was damaged). The White team, with Flight Director Glynn Lunney, came on station to continue working with the spacecraft, while Kranz's Black Team worked behind the scenes reviewing more telemetry data.

At approximately 057:45 elapsed mission time, the Public Affairs officer makes this announcement to the press:

"We now show an altitude of 180,521 nautical miles. Here in Mission Control we're looking – now looking towards an alternate mission swinging around the moon and using the Lunar Module power systems because of the situation that developed here this evening. We now show a velocity of 3,210 feet per second. This is Apollo Control, Houston."

Now the networks were suddenly interested in the Apollo 13 mission. The failure happened in the late evening (Mountain Time) on Monday, April 13. I was 14 years old and had just returned home from a piano lesson and asked if I could turn on the TV to see how the mission was going (I was a total fanatic about the Apollo program). My parents and I were shocked to hear about the problems, and we stayed up for a while to hear more news, even though it was a school night.

During the design for the Apollo mission, the use of the LM as a lifeboat had been evaluated, but no emergency plans were created, except for a two-man crew plan for awaiting rescue if the ascent stage stranded them in lunar orbit. An internal memo in 1968 identified the possibility that three men could live on LM consumables for up to 45 hours if the CM was powered down and that could be as long as 57 hours if the LM could supply power to the CM through the umbilicals. Ninety minutes into the crisis, it was becoming more apparent that the O2 Tank 1 leak was not stopping, O2 Tank 2 was gone, and the breathing oxygen/power situation was critical. Normal operations required several hours and 59 pages of procedures to power up the Lunar Module. The rapidly decaying situation left the crew mere minutes to start their power up of the LM and they were ordered by Mission Control to transfer to the LM immediately. Shortcuts for power activation were relayed from Lousma to Swigert, who shouted them down through the interface module to Lovell and Haise in the LM. Swigert continued to power down the CM, which had only 15 minutes of power remaining; batteries were charged in anticipation of power up

before re-entry. Navigational data was also transferred to the LM. Two hours and forty-five minutes after the explosion, *Odyssey* was completely shut down. The crucial systems needed for re-entry appeared at this time to be good. Here's CAPCOM Jack Lousma communicating with the crew again:

060:22:58 **Lousma**: Okay. We'd like to brief you on what our plan is. We're, at this time, water critical in the LM. So, we'd like to use as little possible. To do this, we're going to plan to make a free return maneuver of 16 feet per second at 61 hours, which is 37 minutes from now. Then we're going to power down the PGNS [Primary Guidance, Navigation and Control System], and then we'll – at 79 hours, we'll go ahead and make another abort maneuver to kick what we got.

The first burn of the LM DPS was 34.23 seconds long at mission elapsed time of 61:29:43 and Apollo 13 was now back on a free return trajectory that would result in a splashdown in the Indian Ocean in four days. Concern for consumables and lack of recovery resources in the Indian Ocean led the FIDO (Flight Dynamics) team to request a PC+2 hours burn at 79 hours to save 12 more hours on the return and land in the Pacific. The burn would be two hours after pericynthion, the closest approach to the moon. Apollo 13 set a human flight absolute altitude record, still in place in 2020, for the furthest distance from Earth at pericynthion (248,655 miles). The four-minute, 23-second burn was nearly perfect, although Lovell had to use the limb of the Moon and the Sun for tracking and alignment due to the cloud of debris still following the spacecraft, obscuring some of the reference stars. The LM DPS engine reached 100% power, delivering 10,500 pounds of thrust; this unique liquid engine supplied by TRW for Grumman used Aerozine-50 and N2O4 and was designed for manual performance adjustments during operations, using flow constrictors in the fuel injector system.

Now that Apollo 13 was heading back to Earth, more problems cropped up. The concern for consumables meant the crew was drinking very little water and ways to heat up food were difficult. Because of the limited water drinking, Fred Haise developed a urinary tract infection. The temperatures on board dropped as low as 38 degrees F. The LM had enough breathing oxygen for the three men but had insufficient canisters of lithium hydroxide to remove carbon dioxide from the atmosphere for the duration of the return flight. The LM canisters (round) were designed differently than the CM canisters (square), which was a failure of imagination on the part of the design teams and system integration, not realizing that this contingency could occur. A team was formed to create a hybrid temporary design that would use the CM canisters and make them functional on the LM. The hybrid design clearly showed the critical functionality of having a big roll of duct tape on-board!

Jack Swigert demonstrates the design modifications to use the square CO2 canisters from the CM in the round LM adapter
Credit: NASA

Despite the accuracy of the PC+2 burn, Apollo 13 slowly drifted off course. Using a visual navigation technique observing the Earth's terminator, the crew performed another DPS burn for 14 seconds at 105:18:42 hours into the mission. A second burn at 137:40:13 hours, just before the SM was ejected, used the LM downward RCS thrusters. The RCS was used for the last correction because the LM supercritical helium tank pressures (helium is used for pressurization of the DPS propellants) reached critical levels and the tank burst disc released the helium, disabling any further use of the DPS. The vented helium did impart a small rotational velocity to the spacecraft. The crew also had to find time to troubleshoot a possible battery failure on the LM (isolated to a bad instrumentation indicator).

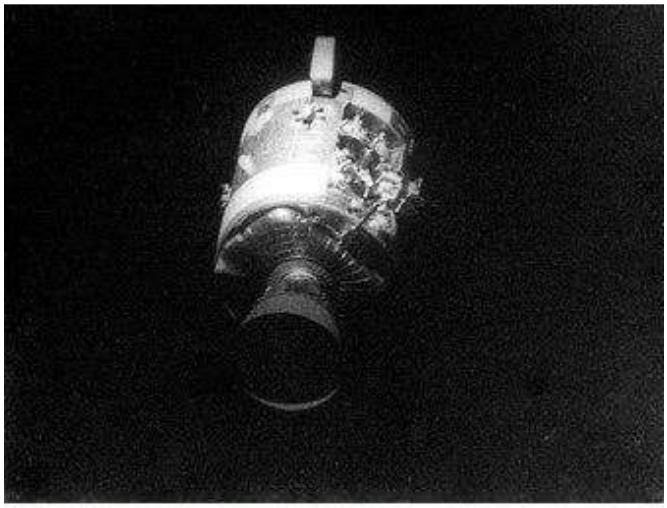
The final CM power-up sequence was now the key question and the astronauts anxiously awaited this information from the ground. Partial re-configurations of the CM were performed by Swigert to help in the development of the sequencing. The young "steely-eyed missile man" (recall his story from Apollo 12 during ascent) John Aaron (EECOM) had been working with Ken Mattingly, John Young and other key team members on creating a power-up plan for the CM, using some electrical power through the umbilicals from the LM. This multi-page procedure was finally tested successfully on the ground and the sequence of tasks

required was relayed to the crew starting at 125:33 minutes elapsed mission time; the checklist was a combination of new steps and redlines to the normal re-entry checklist for a nominal mission. The actual CM power-up would begin at 6-½ hours before Entry Interface. The crew spent over three hours receiving, recording, and confirming this information and their exhaustion was evident on the communications captured in the Apollo Flight Journal.

At 138 hours, 2 minutes, 8 seconds elapsed mission time, the crew separated from the Service Module (still attached to Atlantis). They rotated to view the Service Module and take photos of the shocking damage that occurred in the explosion. Let's look in on the dialog between Mission Control CAPCOM (Joseph Kerwin) and the crew:

138:04:33 **Lovell**: Okay, I've got her, Houston.
138:04:36 **Kerwin**: Beautiful, beautiful. And for your information, Jim, you'll be coming up on an RCS caution light for helium. No sweat, over.
138:04:36 **Lovell**: And there's one whole side of that spacecraft missing.
138:04:50 **Kerwin**: Is that right [pause]
138:04:57 **Lovell**: Right by the – Look out there, will you? Right by the high gain antenna, the whole panel is blown out, almost from the base to the engine.
138:05:09 **Kerwin**: Copy that [Long pause]
138:05:22 **Haise**: Yes, it looks like it got to the SPS bell, too, Houston.
138:05:28 **Kerwin**: Think it zinged the SPS engine bell, huh?
138:05:31 **Haise**: That's the way it looks, unless that's just a dark brown streak. It's really a mess…

The photograph shows the extent of the damage to the SM; this crew would have perished had this explosion occurred in lunar orbit, with Lovell and Haise on the surface, or on the way back.



Damage to right side of SM after separation
Credit: NASA

The power-up procedures continued, and the crew said good-bye to their lifeboat Aquarius at 141:30:05 elapsed time. Aquarius burned up in the atmosphere of Earth. Odyssey was functioning enough to get the crew through the Entry Interface. Odyssey crossed the Entry Interface at 142:40 elapsed time. The blackout period lasted longer than expected, possibly due to the shallow angle of re-entry. Mission Control waited tensely for acquisition of signal or a visual sighting. Finally, at 142:46:08, Swigert communicated with Joe Kerwin; the drogue chute and main chutes deployed nominally, and Odyssey finished their unbelievable successful rescue mission with splashdown southwest of American Samoa and near the recovery ship USS Iwo Jima at 142:54:56 total elapsed mission time.

The world was now interested in spaceflight again – an estimated 40 million people in the US alone tuned in to watch the splashdown. Over a billion people worldwide followed the developments while the mission was still in space. The Soviet Union offered assistance and had four rescue ships in the area of splashdown. President Nixon cleared his schedule to communicate with the families and monitor the situation at Goddard Space Flight Center. Pope Paul VI led 10,000 people in prayer for their safe return and prayers were said at ceremonies in India. The crew was greeted by President Nixon in Hawaii and received the Presidential Medal of Freedom, as did the entire operations team in Mission Control. It was, briefly, a triumphant moment for NASA, but the investigation into the causes of the near disaster was just beginning.

The failure investigation and causal analysis will be explored in the next MARS STAR.

Crew biographies

James A. Lovell, Jr was born in Cleveland, Ohio, on March 25, 1928. His mother was of Czech descent and his father was a coal-furnace salesman who died in a car accident in 1933. He relocated to Milwaukee, Wisconsin with his mother. Lovell became interested in rocketry and models as a young boy and after high school entered the flying midshipman program, sponsored by the Navy, at the University of Wisconsin (Madison). He was accepted by the US Naval Academy in 1948 and went into flight training at NAS Pensacola in 1952. In 1958, Lovell entered the test pilot training program at NAS Patuxent River, Maryland (Pete Conrad and Wally Schirra were two classmates) and was one of 110 candidates for the Mercury program; he was rejected due to a minor medical issue. In 1962, Lovell reapplied and was accepted into Astronaut group 2, along with Pete Conrad. He was assigned as Pilot for Gemini 7, setting an endurance record at that time with 206 orbits over 14 days with Command Pilot Frank Borman; they also rendezvoused with Gemini 6A. Lovell had his first command on the last Gemini mission, Gemini 12, with pilot Buzz Aldrin. Lovell was the "LM Pilot" on Apollo 8 (which did not have a lunar module) and then, of course, commanded the Apollo 13 mission. Lovell retired from the Navy, with a rank of Captain, and from NASA in 1973. He worked in a variety of private industries and served on the board of directors of several companies. In 1994, Lovell and Jeffrey Kluger wrote "Lost Moon: The Perilous Voyage of Apollo 13" [I have a signed copy]. Lovell married his childhood sweetheart Marilyn Gerlach in 1930 and they had four children. Tom Hanks played Lovell in "Apollo 13" and Kathleen Quinlan played Marilyn Lovell; Lovell had a cameo at the end of the movie as the captain of the USS Iwo Jima. On a personal note, in addition to meeting Jim Lovell at his book signing, Steve and I attended a gala event a few years ago at Wings over the Rockies that featured Jim Lovell, Fred Haise, and Gene Kranz in a panel discussion about the Apollo 13 mission.

Fred W. Haise, Jr. was born November 14, 1933, in Biloxi, Mississippi to Fred and Lucille Haise. After high school and junior college in the Mississippi gulf region, he joined the Naval Aviation Cadet training program and served as a U.S. Marine Corps fighter pilot from 1952 to 1956. He left active military service and graduated with a degree in Aeronautical Engineering from the University of Oklahoma and served in the National Guard. Haise then went to work for NASA as a research pilot at Lewis Research Center and was called up for service during the Berlin crisis, spending ten months with the USAF. His top rank was Captain in the USAF. He completed post-graduate course at the USAF Research Pilot School at Edwards AFB. He was selected in the 5th group of astronauts in 1966 and served as a backup LM pilot for Apollos 8 and 11. He was assigned to the primary crew of Apollo 13 and was tentatively selected as the commander of the Apollo 19 mission, which was cut from the budget in late 1970. He served as the backup mission commander for the Apollo 16 mission, then moved over to the Space Shuttle program in 1977. Haise piloted the drop test vehicle Enterprise to three successful landings, but never had a space mission in the Shuttle. He retired in 1979 and became an executive and test pilot for Grumman Aerospace Corporation, retiring from Grumman in 1996. Haise had four children with his first wife, Mary Griffen Grant (they divorced in 1978) and is currently married to F. Patt Price. The late Bill Paxton played Fred Haise in "Apollo 13".

John L. "Jack" Swigert, Jr. was born in Denver, Colorado on August 30, 1931, to John and Virginia Swigert; his father was an ophthalmologist. He became a pilot by the age of 16 after watching planes take off from Combs Field [my father was a weekend warrior pilot for Combs-Gates starting in the late 1940s and checked out airplanes that were going to be sold by Combs; he might have crossed paths with Swigert]. Swigert graduated from the University of Colorado in 1953 with a degree in Mechanical Engineering and played for the football team. He later earned two master's degrees (Engineering and Business Administration) from Rensselaer Polytechnic University and the University of Hartford. After graduating from CU, Swigert joined the USAF and was assigned as a fighter pilot in Japan and Korea. He also served as a pilot with the Massachusetts and Connecticut National Guard units. He held positions as a test pilot for North American Aviation and Pratt & Whitney. Swigert was selected in the fifth group of astronauts in 1966 and was in the backup crew for Apollo 13 until two days before launch, when he was substituted for Ken Mattingly as CM Pilot. Swigert was caught up in the postal covers scandal that plagued the Apollo program in 1972 (that included the Apollo 15 crew) and was removed from assignment to the Apollo-Soyuz mission. He became the executive director of the Committee on Science and Astronautics for the U.S. House of Representatives. He resigned from NASA and ran unsuccessfully for the US Senate primary in Colorado in 1978 against Bill Armstrong, then decided to run as a Republican for the newly created 6th district in Colorado in 1982. He won the election with 64% of the vote, but never had a chance to serve, as he died of cancer on December 27, 1982. He never married. He is buried in Wheat Ridge, Colorado, next to his parents and is familiar to Coloradans who fly through Denver International Airport, as his statue (a replica of one in the House of Representatives) is in the train terminal in Concourse B. I had the privilege of meeting Jack Swigert in early 1982 at a Society for Women Engineers banquet in Denver. Swigert was played by Kevin Bacon

in "Apollo 13" and Gary Sinise (with a full head of hair) played the bald Ken Mattingly.

References for Apollo 13 article

Apollo Flight Journal: https://history.nasa.gov/afj/
NASA Apollo Program:
https://www.nasa.gov/mission_pages/apollo/missions/apollo13.html
Wikipedia (source of biographies, the information about "Apollo 13" and overview):
https://www.wikipedia.org

On This Date in History

This section has milestones retrieved from publicly available information for LM, ULA and heritage programs from 10 to 60 years ago (2010, 2000, 1990, 1980, 1970, 1960). Delta launches prior to the formation of ULA, unless it included an LM or heritage company payload or upper stage, are not listed. No classified programs are identified, even if the program is now considered unclassified, except for the Discoverer program (Corona). The events reflect milestone activity in the quarter before the release of the MARS STAR -- where appropriate, key press releases are also included; significant milestones are in bold. There will be gaps if no events occurred in that decadal year for that month (no events in July-September 1970, for example). The list is not intended to be all-inclusive due to historical record inaccuracies.

Events in July (10 to 60 years ago)

- **07/20/2010: Lockheed Martin Press Release: US Navy marks 50th anniversary of first submerged launch of Fleet Ballistic Missile built by Lockheed Martin (see related item for July 20, 1960); the 60th anniversary was in July 2020.**
- 07/14/2000: EchoStar 6 launched by LM Atlas IIAS, SLC-36B, CCAFS
- 07/16/2000: LM GPS IIR-5 launched by Delta II 7925-9.5, SLC-17A, CCAFS
- **07/25/1990: CRRES launched by Atlas I, LC-36B, CCAFS. Maiden flight of Atlas I**
- 07/15/1980: Lockheed DMSP-5D1 F5 launched by Thor DSV-2U, SLC-10W, VAFB. Launch failure
- 07/01/1960: MM HGM-30A Titan I launch, LC-20. Launch failure
- 07/02/1960: GD SM-65D Atlas launched, LC-11, CCAFS
- 07/07/1960: Lockheed UGM-27 Polaris A1 launched, LC-25A, CCAFS. Launch failure
- 07/15/1960: Lockheed UGM-27 Polaris A1 launched, LC-25B, CCAFS
- 07/19/1960: Lockheed UGM-27 Polaris A1 launched, LC-25A, CCAFS
- **07/20/1960: Two Lockheed UGM-27 Polaris A1 launched, USS George Washington, ETR – First submerged launch of a fleet ballistic missile**
- 07/22/1960: GD SM-65D Atlas launched, LC-576B-1, VAFB. Launch failure
- 07/28/1960: MM HGM-30A Titan I launched, LC-20, CCAFS. Launch Failure
- **07/29/1960: GD Atlas LV-3B, Mercury-Atlas launched, LC-14, launch failure (structural). Maiden flight of LV-3B.**
- 07/30/1960: Lockheed UGM-27 Polaris A1 launched, USS George Washington, ETR

Events in August (10 to 60 years ago)

- **08/14/2010: LM AEHF-1 launched on ULA Atlas V 531, SLC-41, CCAFS. Maiden flight of Atlas V 531 and first AEHF. Apogee motor failed on AEHF-1, requiring orbital attainment using 0.27 Newton Hall thrusters. Motor failure attributed to FOD (cloth) left in a fuel line.**
- **08/25/2010: First successful Corona Remote Sensing Satellite built by Lockheed Martin marks 50th Anniversary (see related Discoverer item on August 18, 1960). The 60th anniversary was in August 2020.**
- 08/17/2000: Classified launch on LM Titan TIVB (403), SLC-4E, VAFB
- 08/01/1960: Lockheed UGM-27 Polaris A1 launched, USS George Washington, ETR. Launch failure
- 08/04/1960: Lockheed UGM-27 Polaris A1 launched, LC-25A, CCAFS
- 08/08/1960: GD SM-65D Atlas launched, LC-12, CCAFS
- 08/10/1960: Discoverer 13 launched, Thor DM-18 Lockheed Agena-A, LC-75-3-6, VAFB
- 08/10/1960: MM HGM-30A Titan I launched, LC-19, CCAFS
- 08/12/1960: GD SM-65D Atlas launched, LC-11, CCAFS
- 08/12/1960: Lockheed UGM-27 Polaris A1 launched, LC-25A, CCAFS
- **08/18/1960 Discoverer 14, 14 SRV launched by Thor DM-18 Lockheed Agena-A, LC-75-3-4, VAFB**
- 08/19/1960: Lockheed UGM-27 Polaris A1 launched, LC-25A, CCAFS
- 08/30/1960: MM HGM-30A Titan I launched, LC-20, CCAFS

Events in September (10 to 60 years ago)

- 09/21/2010: Classified launch, Atlas V 501, SLC-3E, VAFB
- **09/30/2010: Lockheed Martin Press Release: Lockheed Martin ends External Tank Production at NASA Michoud Assembly Facility**
- 09/08/2000: STS-106 (Atlantis) launched, LC-39B, CCAFS (Spacehab, 7 astronauts)
- 09/14/2000: LM GE-7 (AMC-7) launched by Ariane 5G, Kourou ELA-3, French Guiana
- 09/21/2000: LM NOAA-16 (L) launched by LM Titan II 23G, SLC-4W, VAFB
- 09/02/1960: Lockheed UGM-27 Polaris A1 launched, LC-25A, CCAFS
- 09/12/1960: GD SM-65D Atlas launched, LC-576B-3, VAFB. Launch failure
- 09/13/1960: Lockheed UGM-27 Polaris A1 launched, USS Patrick Henry, ETR. Launch failure
- 09/13/1960: Discoverer 15, 15 SRV launched by Thor DM-18 Lockheed Agena-A, LC-75-3-5, VAFB

- 09/15/1960: Lockheed UGM-27 Polaris A1 launched, USS Patrick Henry, ETR
- 09/17/1960: GD SM-65D Atlas launched, LC-11, CCAFS
- 09/19/1960: GD SM-65D Atlas launched, LC-14, CCAFS
- 09/22/1960: Lockheed UGM-27 Polaris A1 launched, USS Patrick Henry, ETR
- 09/23/1960: Lockheed UGM-27 Polaris A1 launched, USS Patrick Henry, ETR. Launch failure
- 09/23/1960: Lockheed UGM-27 Polaris A1 launched, LC-25A, CCAFS
- 09/25/1960: Pioneer P-30 (lunar probe) launched by GD Atlas-Able, LC-12, CCAFS. Launch failure (second stage exploded)
- 09/28/1960: MM HGM-30A Titan I launched, LC-19, CCAFS
- 09/29/1960: MM HGM-30A Titan I launched, LC-15, CCAFS
- 09/29/1960: GD SM-65D Atlas launched, LC-576B-2, VAFB. Launch failure

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Next Edition

Check back in the next MARS STAR for part two of the story of the Apollo 13 mission. The History on the Road is suspended at this time due to the difficulty in traveling and visiting museums.

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