Air and Space this Week

Item of the Week

WHAT A DECADE: *MARINER 2* TO *APOLLO 17*!

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December 14, 2022, provides an interesting set of round-number anniversaries, an ideal opportunity to contemplate Solar System exploration's early days. That day is the 60th anniversary of the first successful planetary exploration of another planet, the fly-by of Venus by Mariner 2*. It is also the 50th anniversary of the making of the last human footprint on the Moon (at least for now!), by Gene Cernan of* Apollo 17*. In the space of one short decade, we went from our first faltering step at learning about the planets of the Solar System by visiting them, to the six successful Moon landings! And we did all that while dealing with the Viet Nam War, social changes, and a revolution in technology greater than any previous. Indeed, what a ten years they were!*

PRE-NASA

NASA's predecessor agency was the National Advisory Committee of Aeronautics, established on March 3, 1915, for the purpose of undertaking and institutionalizing aeronautical research. NACA oversaw the development of several fundamental advances in aeronautical engineering prior to WWII, including improved air intakes and ducting for engine cooling and more efficient airfoils. During WWII, NACA-coordinated research resulted in the low-drag laminar-flow wing (that made the P-51 Mustang a great fighter), and much more efficient propellor designs (*e.g.* the "paddle wheel" prop that vastly improved the performance of the heavy P-47 fighter). Advanced fighters of the time could dive at trans-sonic speed, resulting in a loss of control and often the destruction of the aircraft (leading to the myth that there was a "sound barrier"); NACA-coordinated research solved that problem, too.

NACA's birth was a difficult one; the initial legislation that would have set it up was defeated initially. But several key people realized NACA's potential value, including then-Assistant Secretary to the Navy Franklin D. Roosevelt and Smithsonian Secretary Charles Wolcott. Wolcott suggested that the language establishing NACA could be added to the Naval Appropriations Bill of 1915. It was snuck in as a rider, almost totally unnoticed, on March 3, 1915, the last day the 63rd Congress was in session. President Wilson signed it into law on the very same day. The language provided for an annual budget of $5000, and for the committee to have a total of 12 volunteer members. Its mission was to "supervise and direct the scientific study of the problems of flight with a view to their practical solution."

World War I showed the politicians the value of aeronautical engineering. President Wilson appointed Orville Wright to the NACA team, the mission was expanded to explicitly include the promotion of “military and civilian aviation through applied research that looked beyond current needs.” NACA oversaw the creation of a number of laboratories for aeronautical research, including the Langley Memorial Aeronautical Laboratory, Ames Aeronautical Laboratory, and the Aircraft Engine Research Center.

What an incredible bargain! NACA research was played a large part in the winning of WWII. From an economic perspective, NACA’s Return-On-Investment was absolutely ginormous, and NASA has carried on that tradition to this very day.

THE INTERNATIONAL GEOPHYSICAL YEAR (1958-1959)

A number of scientific disciplines expanded rapidly in the decade following WWII, and the political situation of time allowed for, perhaps even encouraged, international cooperation in research on a global scale.

One of the scientific fields of note was geophysics. On April 5, 1950, an English atmospheric scientist, Sydney Chapman, met with a small group of geophysicist colleagues in Maryland to discuss how the study of the Earth could be advanced. Their realization that the Earth’s oceans, geology, magnetism, and other factors were complexly-interrelated led them to propose and promote an international research effort that would become the International Geophysical Year, which ran for 18 months in the late 1950s. Participating countries would use the new tools available at that time to study the Earth and its systems, including radar, sonar, computing, and rocketry. The exact timing of the IGY was set to coincide with the peak of solar activity: July 1, 1957 through December 31, 1958. Little noticed at first was the rocketry part of the research; the IGY planners assumed that orbital flight and reconnaissance from low-Earth orbit would be possible!

The IGY proved to be an enormous success. A number of research stations were built in Antarctica and other hard-to-reach places, many of which are in operation today, and the IGY research efforts also led to the mission of follow-on organizations like the U.S. National Oceanic and Atmospheric Administration.

And then came Sputnik. The USSR launched a small satellite, *Sputnik 1*, on October 4, 1957 (the very day that *Leave It to Beaver* premiered!). Even though satellites were in the IGY plan, the launch caught many by surprise, in large part because the USSR used a military-grade ICBM as the launch vehicle, something definitely NOT in the IGY plans. *Sputnik 1* was tiny and not very sophisticated, but when the USSR launched *Sputnik 2* on 11/3/37, a satellite large enough to carry a hydrogen bomb, a reaction close to panic set in. Being able to put a basketball-sized object over our heads, with us being able to do anything about it, was bad enough. But being able to put an H-bomb over our heads without us being able to do anything about it was terrifying. Lyndon Johnson and a host of others were aghast, and the money spigots were opened wide. All three branches of the U.S. Armed Forces began working on their own rocketry programs.

Many pondered on how the Russians, assumed to be far behind the U.S. technologically, be first to orbit? Politicians perceived a "missile gap," and realized that the U.S. was not producing enough students educated in aeronautics, rocketry, and related fields, so a number of curriculum study groups were set up to address the shortfall. Education in the U.S. was in a state of flux anyway, as small rural school districts were being consolidated, and the study groups provided subject guidance, and in some cases, education products, to unify the effort. [The only such study group surviving to the present is the Biological Sciences Curriculum Study, now known as BSCS Science Learning, headquartered here in Colorado Springs.]

LBJ convened a series of Congressional hearings on the matter, and the political wheels began turning…

BETWEEN THE IGY AND NASA

Intense pressure was on the U.S. Armed Forces to demonstrate that we, too, could launch satellites into Earth orbit. The Navy's program, Vanguard, had been set up to be able to launch to orbit during the IGY, using civilian sounding rockets as their base vehicle. They were ready to launch a small satellite a month after *Sputnik 2*. On December 6, 1957, with the world watching, their attempt went comically awry. The Vanguard missile fired and lifted a few feet off the pad, then the rocket failed, and the whole missile collapsed into a fireball. The dunce cap-shaped nosecone toppled off, and the *Vanguard Test Vehicle-3* satellite fell beeping impotently. The press had a field day poking fun at the effort, calling it things like "Flop-nik" and "Stay put-nik." It's now in the collection of the National Air and Space Museum. The Congressional fear level increased.

The U.S. Army fared a bit better. The U.S. Army Ballistic Missile Agency at Huntsville, Alabama, had the advantage of having Wernher von Braun and a number of his "Operation Paperclip" engineers on staff. They were able to launch *Explorer 1*, a small satellite built by the Jet Propulsion Laboratory, on January 31, 1958. It carried a cosmic-ray detector designed by James Van Allen, which made the first observation of charged particles trapped in zones above the Earth by its magnetic field, zones known to this day as the "Van Allen Belts."

The Navy finally got on the scoreboard with a successful launch on March 17, 1958. *Vanguard 1* was the fourth satellite in orbit, and gives the Navy small consolation that it is still in orbit today. *Vanguard 1* was more sophisticated than the three satellites in orbit before it, being the first satellite to utilize power from solar cells.

A total of 11 years, 4 months, and 21 days would pass from the launch of *Explorer 1* to *Apollo 11* landing on the Moon. A lot of discoveries and explorations were conducted along the way. So many in just over a decade – a great record of success! But NASA would soon out-do that, as only NASA can.

THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

President Eisenhower recognized the importance of access to Space, the inefficiencies of having all three branches of the military working on the program independently, and the desirability of having any sort of Space program be seen as a civilian, rather than military, effort.

A lot had been happening on the political front after LBJ got involved. A number of government groups were in discussion, and by April 2, 1958, draft legislation that would make the Space program a civilian agency by expanding the purpose of NACA was sent to Congress. More hearings ensued, resulting in the passage of the Space Act of 1958 on July 29, 1958. Keith Glennan, a former member of the AEC and then President of the Case Institute of Technology, would be NASA's first Administrator, and Hugh Dryden, then head of NACA, was his deputy. NASA formally opened on October 1, 1958.

NASA's mission was eight-fold:

1. "The expansion of human knowledge of phenomena in the atmosphere and space;
2. The improvement of the usefulness, performance, speed, safety, and efficiency of aeronautical and space vehicles;
3. The development and operation of vehicles capable of carrying instruments, equipment, supplies, and living organisms through space;
4. The establishment of long-range studies of the potential benefits to be gained from, the opportunities for, and the problems involved in the utilization of aeronautical and space activities for peaceful and scientific purposes;
5. The preservation of the role of the United States as a leader in aeronautical and space science and technology and in the application thereof to the conduct of peaceful activities within and outside the atmosphere;
6. The making available to agencies directly concerned with national defense of discoveries that have military value or significance, and the furnishing by such agencies, to the civilian agency established to direct and control nonmilitary aeronautical and space activities, of information as to discoveries which have value or significance to that agency;
7. Cooperation by the United States with other nations and groups of nations in work done pursuant to this Act and in the peaceful application of the results thereof;
8. The most effective utilization of the scientific and engineering resources of the United States, with close cooperation among all interested agencies of the United States in order to avoid unnecessary duplication of effort, facilities and equipment"

NASA immediately began working on using low-Earth orbit for communications, meteorology, and Earth observation. It also took over aeronautic research, especially in high-speed flight. A few launches already "in the pipeline" were conducted, including the Air Force's Project SCORE.

Low-Earth orbit was not the only NASA objective; on March 3, 1959, NASA launched *Pioneer 4*, the first U.S. lunar fly-by (again following the USSR's successful lead).

NASA also began a manned Space program. The first seven astronauts selected for Project Mercury were announced to the public on April 9, 1959.

THE MARINER PROGRAM

NASA planned to follow up the success of *Pioneer 4* with the Mariner program, designed to fly-by Venus and Mars (and eventually Mercury). NASA was planning an exploration program using two basic spacecraft designs, each using a common spacecraft "bus" structure to reduce costs. The Pioneer series was more for the exploration of the conditions of interplanetary Space; the Mariner series was designed for planetary exploration. A total of 10 Mariner missions were flown, with seven being successful. Two were particularly important, *Mariner 4*, the first fly-by of Mars, and *Mariner 9*, the only Mariner mission designed to orbit its target rather than merely fly-by. I want to focus on the earliest two Mariner missions here.

MARINER 2

NASA wanted to follow up the successful Moon fly-by missions already conducted by the USSR and the US by flying by the nearer planets, Venus and Mars. The booster state-of-the-art at that time favored an initial focus on Venus, and prudent planning and risk management suggested that two more-or-less identical spacecraft should be sent out at each launch window. Launch vehicles were in their infancy, and electrical/electronic systems were, too, so having 100% redundancy was a good policy, one proved out three separate times over the course of the Mariner missions!

The first such demonstration of the need for redundancy came with the *Mariner 1* and *2* pair of spacecraft slated for a fly-by of Venus. *Mariner 1* was launched on July 22, 1962, on an Atlas-Agena launch vehicle. The rocket failed soon after launch, and had to be destroyed by the Range Safety Officer.

Its twin, *Mariner 2*, was launched on August 27, 1962. It carried a magnetometer, a charged particle collection device, a cosmic dust collector, and a solar plasma detector. Its mission was to return data regarding Venus' atmosphere, magnetic field, mass, and charged particle environment, and to also make measurements of the interplanetary medium while on the way to Venus.

One advantage of going to Venus is that the primitive solar power panels of the day had plenty of light to operate. That, and the fact that *Mariner 2* had two such panels, another example of the value of 100% redundancy, saved the mission when one of the two panels failed *en route*.

The mission was largely successful. *Mariner 2* data showed that the surface of Venus was extremely hot, its atmospheric pressure was extremely high, carbon dioxide was its atmosphere's principal constituent, and that it had essentially no magnetic field. These were amazing additions to our knowledge of "Earth's Twin." The mission data also allowed scientists to refine their measurement of the mass of Venus, (and hence) the Astronomical Unit, and provided now information about the solar wind. All with barely-post-transistor technology!

Mariner 2 flew by Venus at a minimum distance of 34,773 km on **December 14, 1962**.

TO THE END OF THE APOLLO PROGRAM

NASA had been enjoined by President Kennedy to "land a man on the Moon, and return him safely to the Earth, before the decade was out" on May 25, 1961, and the three programs, many successes, and a few tragic failures resulted in six successful Moon landings. They have been covered in some degree by previous Items of the Week, and by many, many books, movies, etc. I won't delve much deeper into this material here.

I will make an exception for *Apollo 17*, the last manned lunar landing (at least for now!).

Apollo 11 and *12* were mostly engineering missions, establishing the functionality of the spacecraft involved and demonstrating the ability to land where planned. *Apollo 13* – then *14* were targeted at retrieving ejecta from the Imbrium Basin impact ejecta; dating the material in a lab would help work out the stratigraphy of the lunar surface (the sequencing of geologic events that have affected the Moon).

The Apollo program had been planned for ten Moon landing missions, but budgetary cuts announced after the Apollo 14 mission caused the cancellation of the final three missions, forcing NASA to revisit, re-evaluate, and change the targeting of the remaining landings. *Apollo 15* was already too deep in the planning process to be changed; it would go to look at part of the lunar "seas" – large outpourings of basaltic rock.

If only two Moon landings were forthcoming, the question became finding which two provided the best lunar science? A consensus was building that another mission to a lava plane was less important than a set of landings in the lunar highlands. Several objectives could be made that would affect landing site selection; NASA wanted both to examine the highlands materials in detail back home, and to find and return older, once-more-deeply-seated materials might have been ejected from nearby craters.

Apollo 16 was targeted for the highlands near the Crater Descartes, a prime objective since Apollo 12 because it could return samples of two large impact ejecta blankets for dating, which would help scientists better understand the timing of the sequence of events that shaped the lunar highlands.

As you might imagine, a LOT of thought and discussion went into site selection for the final Moon landing! The planners came up with five objectives:

1. Sampling highland materials older than the Imbrium Basin
2. Sampling "young" volcanic rocks
3. Orbital coverage (more an operational than scientific concern)
4. Detailed measurement of the lunar gravity field over a wide surface area
5. Installing a sophisticated ALSEP package

A volcanic center on the edge of Mare Serenitatis was selected for Apollo 17. Named "Taurus-Littrow," the site allowed the likely sampling of materials in the first two objectives above. The landing site was in a valley lying perpendicular to the edge of the Serenitatis Basin, likely a down-dropped groove formed by collapse into a fracture caused by the Serenitatis impact.

THE *APOLLO 17* CREW

The Commander of was experienced astronaut, Gene Cernan. All lunar astronauts had received considerable training in terrestrial locations that would give them an inkling of what they might face on the lunar surface, but, let's face it, they were pilots, not geologists. Lunar scientists had been clamoring for some time about how NASA should send a geologist to the Moon. They got their wish with the selection of Harrison Schmidt for the mission's Lunar Module Pilot. Rookie astronaut Ron Evans would be the Command Module Pilot.

Eugene Andrew Cernan had been a Naval ROTC student at Purdue, becoming a naval aviator after graduation. He was selected for the third cadre of astronauts, in October, 1963. He and fellow Group 3 guy Thomas Stafford were named as back-up crew for *Gemini 9* as their first assignment. Alas, when prime crew Elliot See and Charles Bassett crashed and died in a NASA T-38, Cernan and Stafford became the *Gemini 9* prime crew. The two stayed together in the Apollo program; both flew the *Apollo 10* lunar module on the Moon landing's "dress rehearsal."

Harrison Schmitt was the only Apollo astronaut with a significant level of geological training. He earned a BS at Cal Tech and a Ph.D. in Geology from Harvard. He joined the USGS Astrogeology Branch in 1964, where he helped NASA develop lunar geological field methods. He was selected in NASA's Scientist/Astronaut candidate program in 1965. He learned to fly high-performance jets and helicopters with the Air Force as part of the program, while helping train early Moon landing teams. He was slotted as the back-up Lunar Module Pilot on *Apollo 15*, and advanced to *Apollo 17* when it was clear it would be the final chance to put a geologist on the Moon.

Astronaut Ronald E. Evans, another Space rookie, was the Command Module Pilot for *Apollo 17*. Like Cernan, he had been a Naval ROTC, but at the University of Kansas. He, too, became a carrier-based naval aviator, in both fighters and the F-8, including combat action over Vietnam. His squadron rotated home, and he was selected to be an astronaut in April, 1966. By then, he had over 5000 hours of flight time in high-performance aircraft. Like Schmitt, *Apollo 17* would be his first and only Space mission.

The *Apollo 17* Moonwalkers roamed more than 35 km over the lunar surface, laid out the ALSEP properly, collected a lot of geological specimens (34 kg!). Their mission was a total success. As they ended their final EVA, Schmitt entered the LM first, while Cernan remained behind, contemplating the gravity of his situation as the person who was about the make the final human footprint on the Moon for an undetermined amount of time.

As Cernan stepped on the landing leg pad in preparation of climbing the ladder to the hatch, he said, "…I'm on the surface; and, as I take man's last step from the surface, back home for some time to come – but we believe not too long into the future – I'd like to just (say) what I believe history will record. That America's challenge of today has forged man's destiny of tomorrow. And, as we leave the Moon at Taurus-Littrow, we leave as we came and, God willing, as we shall return, with peace and hope for all mankind ...."

Cernan's statement was both heartfelt and clever. The *Apollo 17*'s Command Module was named "America," and its Lunar Module was named "Challenger." See how worked that into his speech?

Astronaut Bill Anders on *Apollo 8* took one of the most famous pictures from Space, the famed "Earthrise," that showed everyone how small and fragile our home planet is in the vast cosmic void. But *Earthrise* was not the only iconic picture of the Earth that came out of the Apollo program. The *Apollo 17* crew took an equally-impressive and popular image of Earth that became known as the "Big Blue Marble." Gene Cernan's picture of Harrison Schmitt, with the American Flag and the partially-illuminated Earth overhead is one of my favorites, too. Check all three pictures out here.

The* Challenger *lifted off on December 14, 1972, fifty years ago this week, and exactly 10 years after NASA made its first successful earlies step in the exploration of other planets with the fly-by of Venus by* Mariner 2*.

And, in a final really nice touch, December 14 is also the 550th birthday of the famous astronomer Tycho Brahe. His observations were the basis for the mathematical analysis by Johannes Kepler that led to his famous Three Laws of Planetary Montion, a fundamental foundation for spacecraft exploration!

It took 11 years and four-some months for NASA to go from *Explorer 1* to *Apollo 11*. But it only took 10 years, exactly, to go from *Mariner 2*'s Venus fly-by to the Last Footstep on the Moon!

DOING THE AMAZING, AS ONLY NASA CAN!

CODA

***Apollo 17* Sample Analysis and Artemis:** In the 50 years since fresh boot prints were made on the Moon, the samples returned by the Apollo moonwalkers have been extensively studied with the state-of-the-art equipment of the times. NASA had the good foresight to anticipate future analysis opportunities, and they set aside some *Apollo 17* samples in vacuum-sealed containers for analysis when more sophisticated and capable equipment and techniques would likely be available. The Apollo Next Generation Sample Analysis program at JSC, using some of the preserved lunar material, proved to be an excellent "dress rehearsal" for the analysis of samples to be returned to Earth by the upcoming Artemis missions to the lunar south polar region. See also: https://skyandtelescope.org/astronomy-news/apollo-17-artemis-return-moon.

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NACA AND THE BIRTH OF NASA

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