Air and Space this Week

Item of the Week

Explorer 1: America's First Satellite

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The Space Age began on October 4, 1957, with the launch of Sputnik 1 *by the USSR. The United States was shocked, and it wasn't until* ***January 31****, 1958 that we were able to "join the club." Less than 11 years later, Americans walked on the Moon. The scientific, economic, and societal benefits continue to this day.*

THE I.G.Y.

Two International Polar Years

The first half of the 1800s was a time of global exploration. Captain Cook and the early navigators had roughed in the map of the globe, and now expeditions to the less-accessible regions were taking place. The costs and logistics of such ventures went up with the difficulty of the voyage, and the scope of the necessary observations was large. By 1875, it was obvious that international cooperation in exploration and research would be beneficial to all involved. At least it was obvious to Karl Weyprecht, an officer in the Austria/Hungary Navy, who first proposed the idea. Georg Neumayer, the head of the German Maritime Observatory agreed, and organized an international effort to examine Arctic phenomena. There were a number of hurdles that had to be overcome, organizational, political, logistic, and more. It took seven years, but the First International Polar Year was held in 1882-3, with twelve nations participating. The observations and data collected were shared freely among the participants.

Advances in radio communications and other technologies during the two-decade period centered on WWI revealed unexpected problems relating to telegraph and radio signals, and to power transmission. All would benefit from the study and resolution of these issues, so a second International Polar Year was conducted in 1932-3, fifty years after the first. This time around, 44 countries were involved, and a lot of data were acquired about weather forecasting, terrestrial magnetism, and atmospheric science. Alas, the acquisition and analysis were less than they could have been because of the economic upheaval of the Great Depression. Worse, much of the data acquired in IPY2 was destroyed in WWII.

Lloyd Berkner

Lloyd Viel Berkner was born on **February 1**, 1905, in Milwaukee, Wisconsin. He enlisted in the U.S. Naval Reserve at the University of Minnesota, and went to aviation training in 1926. He was designated a Naval Aviator (Seaplanes) in 1927. After graduating from UM, Berkner was a

radio engineer for first the Department of Commerce and then for the Bureau of Standards, and he served as a member of the Byrd Antarctic Expedition of 1928-30. He was called to active duty just before Pearl Harbor, and he spent the War in a number of increasingly-important roles, including heading the Electronic Materials Branch of the national Bureau of Aeronautics, a performance that was recognized by a Legion of Merit and Naval Letter of Commendation. After the War, he organized the Army-Navy Joint Research and Development Board, in prestigious tasks give the obviously-critical role played by R&D in winning the War. The technological experiments he conducted in the polar regions on radar systems and wave propagation would help greatly in the design and function of the Distant Early Warning system.

Berkner's work with radio and the ionosphere showed him, like Weyprecht before him, that a proper evaluation of the subject required large-scale, cooperative, research. He proposed that an international effort like that of the International Polar Years was in order, not just atmospheric physics, but for a wide variety of other geophysical topics. He suggested that 1957, seventy-five years after the first IPY, would be a good date to aim for, especially because the Sun would be at/near its peak of the 11-year sunspot cycle, making Sun-caused ionospheric phenomena larger and more frequent. The International Council of Scientific Unions agreed two years later, and proposed participating nations conduct an "International Geophysical Year" patterned after the two IPYs. The U.S. National Academy of Science appointed a committee to plan the U.S. involvement in the IGY, and recommended research in atmospheric sciences, heliophysics, geomagnetism, oceanography, geophysics, and Antarctica.

The NAS also recommended that the United States include the launch of the first artificial satellite of the Earth as part of the IGY program, triggering a spirited design contest between the NAS/Navy team (Vanguard) and an Army/JPL team (Explorer). The Vanguard design was chosen in September, 1955, primarily because its selection would cause less interference with military rocket development. The USSR also announced that they intended to launch an orbital satellite during the IGY. The Space Race was on, and the Space Age hadn't even begun yet! Department of Defense spending on missile R&D/Procurement went from $1M in 1953 to $1B in 1957!

A number of popular books and articles describing satellites and the physics behind them, possible crewed spacecraft, and even a Space Station, were released in the mid-1950's. A spate of movies, TV shows, and even a set of Disney shows starring von Braun, prepared Americans for the day an artificial moon would orbit the globe.

The military ramifications of orbiting satellites were not lost on anyone involved, either. Nor were the propaganda ramifications overlooked…

THE DAWN OF THE SPACE AGE

Work on satellites and launching systems continued apace in the few years preceding the start of the IGY. The Russians were holding their cards very tightly to their vest [see the Siddiqi reference for a LOT of details]. There were difficulties with the Vanguard program that were not widely publicized, but the IGY was far enough away that there was a lot of confidence in

American know-how when it came to such things. Even though the USSR was catching up to the USA in military weaponry, they were doing just that, catching up. So when the IGY started, on July 1, 1957, we were looking forward to the research, but also to demonstrate national technical prowess.

America in 1957 was in the throes of the Baby Boom and a number of other societal changes. It never was really like "Happy Days," except in nostalgic memories, but it was a time of growth and optimism for the future. The burgeoning Hollywood TV industry reflected a conformist view desired by many, with shows like "Father Knows Best" and "Make Room for Daddy," never mind "I Love Lucy."

On Friday, October 4, 1957, a new show would premiere on CBS, about the "typical" American family, Hollywood version. The stay-at-home mom did housework in heels and make-up, and larger societal issues were ignored. The two sons were opposites, the older was smart and athletic, and the younger got into mild trouble a lot. It became a popular show, and those of us who can remember its run during our formative years can find it a useful calendar "touch stone" to tie together the memories of our youth.

But Beaver Cleaver wasn't the only introduction made to the American public that day. The USSR surprised the world by launching the first-ever orbital satellite, *Sputnik 1*. They followed it up the next month with the launch of *Sputnik 2*, and that one really shook the American military and political leadership (especially LBJ, who was then the Senate Minority Leader), even though the CIA had briefed Ike on the Russian satellite program (remember, this was before Francis Gary Powers got shot down….).

Sputnik 1 weighed only 184 pounds, but *Sputnik 2* was much larger, big enough to have carried an atomic bomb. Over our heads. And there was nothing we could do about it. At least right away.

AMERICA'S RESPONSE

The initial reaction of the media and the public to the Sputnik launch was somewhat tepid. Our side wanted to downplay the accomplishment, and their side's leadership was concerned that a major public announcement might compromise military information. But in the coming days, the leadership of both blocs realized what a symbolic victory *Sputnik 1* was, and the rank-and-file Americans were shocked that the "primitive" Soviets were actually ahead in missile technology. The propaganda mills on both sides got wound up. The Sputnik rocket booster had also gone into Earth orbit, and it was big and shiny and could easily be seen from one's backyard. *Sputnik 1* itself was small, and even though it was highly-polished, it was too small to be seen easily, especially with the unaided eye. But anyone with a radio receiver could hear the "beep, beep" of the first satellite as it came over.

Enormous pressure to perform fell upon the Navy Vanguard people. Their reputations, and national prestige, was a stake. The Russians had not announced either Sputnik launch beforehand, preferring to reveal success with the risk of failure to the public. The USA took a

different approach, in large part to demonstrate the openness of the American system in contrast to the Soviets, and it bit us. Our first launch attempt would be public, even televised live. On December 6, 1947, the *Vanguard TV3*, aboard a Scout rocket, rose slowly off the pad at Canaveral. After a few feet of climb, the Scout faltered and crashed back onto the pad in a sea of exploding flame. The nose cone of the rocket fell to the side comically, and the satellite itself dropped to the ground, pitifully beeping away.

The press had a field day poking fun at the failure, reporting it as "Flop-nik," "Stayputnik," and worse. The public was embarrassed and dismayed. Space exploration was a common theme in the mid-1950's TV shows (*e.g.* here) and movies; everyone watching them here expected those astronauts to be American. Congress was outraged that we could have a "missile gap" and be so far behind, not only in the race to Space, but in the perceived educational and technological superiority of the Soviet system.

Something Had To Be Done!

The US government went to work. The Advanced Research Projects Agency (the precursor to today's DARPA) was established. The 1958 Space Act replaced NACA with the new National Aeronautics and Space Agency. The 1958 National Defense Education Act led to the consolidation of a lot of tiny school districts and the adoption of much-improved curricula and teaching methods, including the establishments of Curriculum Study Groups in various topics (math, physics, chemistry, biology) to create and promote learning materials. [I had a PSSC textbook for high school Physics and a BSCS textbook for Biology (and still have both today – I almost never throw away a book!); perhaps you had them, too. Only the Biology group is still in action today, right here in Colorado Springs.]

The CIA/Navy Vanguard program had taken a horrific and very public black eye. Eisenhower immediately authorized their domestic competition, the Army Ballistic Missile Agency/JPL team, to get to work on their Explorer satellites and modified Jupiter missiles. They had gotten pretty far along during the proposal competition phase they lost to Vanguard, and they had the highest priority call on resources, and an intense pressure to succeed. The Vanguard program would ultimately have a number of successes before NASA took over, but for now they were in the dog house.

The ABMA/JPL effort was centered in two places: Huntsville, Alabama (rocket) and Pasadena, California (Explorer satellite). Both were staffed with excellent teams; the Redstone Arsenal at Huntsville had Wernher von Braun and many of his WWII German engineers, and JPL had Director William Pickering and program manager Al Hibbs and a lot of talented engineers.

Von Braun had become familiar with publicity and "managing up" during WWII. He had realized by 1954 that the full propaganda value of their Explorer satellites would be greater if they had an actual science mission, not just a beeping radio or a doomed dog (poor Laika!). The senior scientist on his team concurred strongly, recommending that one of our top scientists build a meaningful experiment package to be included on the first US satellite.

Von Braun was not alone in his assessment of the scientific benefits of satellite-borne detectors. NACA had come up with a comprehensive research plan, an effort led by Jimmy Doolittle and Hugh Dryden. They knew that a science-based, civilian-led effort would be best, even if the rockets used were based on military designs. They were also attuned to the world political situation, and that an Open Skies policy would be needed (and still is).

Dr. James Van Allen of the University of Iowa got the call, and what a good thing that turned out to be! He had written in the mid-1950s about the advantages of making cosmic ray observations above the Earth's atmosphere.

Van Allen was no stranger to technological research with military applications. During WWII, he was a key part of the team behind the development of the proximity artillery fuse at the precursor to today's Advanced Physics Lab at Johns Hopkins University, helping how to build the necessary electrical circuits that could survive the g-forces subjected to a fired artillery shell. Lloyd Berkner also played a role in the fuse development, developing separate transmitting and receiving circuits. [The fuse was particularly important in anti-aircraft weapons, especially those aboard ships. Hitting a fast-moving target with bullets are artillery shells was extremely difficult, but the fuse would detect the radio echo from its target and detonate the shell in front of the plane, which would then be downed by the shell fragments as it flew through them. It's like shooting skeet with a rifle versus a shotgun. Proximity fuses racked up a huge score late in the War. Van Allen donated one of the test fuses to NASM, and the last time I looked, it was still on display in Space Hall, just aft of the *Discovery*.]

Van Allen was on sabbatical at Princeton when Von Braun's engineer came to call in 1954 about the prospect of putting a cosmic ray detector on a sounding rocket, or in Earth orbit, but he was notoriously cautious, and took a wait-and-see attitude. He later said of the meeting that he couldn't tell if the pitch to him was not on the level, or that the Von Braun team had "something fantastic." Taciturn during the presentation, he was thrilled inside. When President Eisenhower chose the Vanguard program over ABMA's in mid-1955, Van Allen immediately proposed to put a cosmic ray detector on a Vanguard satellite, so it was easy for him to transfer over to the ABMA/JPL team when they got the nod. He kept up his interaction with the Vanguard folks, and had instruments aboard some of their satellites later.

The ABMA team had already developed the Redstone missile, designed to carry "tactical atom bombs" a few tens of miles (the first two Mercury missions, both sub-orbital, used the Redstone). They were developing a longer-range ICBM, the Jupiter, which was a Redstone with two upper-stages comprising a cluster of solid-fuel rockets, making it almost capable of putting a small payload into low Earth orbit. [The ABMA called the three-stage version the Juno missile, but usually both two- and three-stage variants are known as the Jupiter-C.] The first Jupiter-C test flight was on November 16, 1956. It was a success, and had it carried a working fourth stage, its payload would have made orbit.

The Pentagon then intervened and ordered the Jupiter-C program to cease test launches, since Vanguard with the chosen path to Space. Undaunted, the enthusiastic von Braun team

continued to develop the missile technology infrastructure that would allow access to orbit, including asking Van Allen to make a cosmic ray detector for their Explorer program.

Von Braun was hosting a reception for the incoming Secretary of Defense when the word about *Sputnik 1*'s launch came in. With an abundance of situational awareness, he buttonholed the new guy, Neil McElroy, and told him, point-blank, that his ABMA/JPL/Huntsville team could have a U.S. satellite in orbit in 90 days or less.

He almost made good on that prediction!

EXPLORER 1

Everybody involved with the ABMA/JPL Explorer effort had to really move fast. A number of Van Allen's team had to get to JPL ASAP, and Van Allen himself was on a ship off New Zealand when the penny dropped. Fortunately, von Braun's team had their act together at Huntsville, and it looked like a Jupiter-C would be ready soon. The plans for the Explorer version of Van Allen's cosmic ray instrument were already complete, and it looked like that it could be ready for launch soon, too. But a myriad of other things that had to happen before a launch could be attempted.

There was no Deep Space Network in those days, so JPL had to quickly establish several communications stations from which any LEO satellite could be tracked. Several temporary stations were set up in a variety of locations, including what is now Anza-Borrego State Park in California, and a larger facility that would grow in a few years to become the Goldstone Deep Space Station.

After yeoman work by all concerned, *Explorer 1* was atop a Jupiter-C, ready for launch, in mid-January, 1958, about 106 days after the *Sputnik 1* launch. Some additional testing and preparations were needed, and by January 29, *Explorer 1* was ready to go. But the weather wasn't cooperating. High altitude winds aloft prevented a safe launch and the 1/29 effort was scrubbed, as was one the following day.

Finally, on **January 31**, 1958, *sixty-four years ago*, at 10:48:16 PM EST, the Jupiter-C lifted off the pad, and a few minutes later, *Explorer 1* was in orbit.

Or was it? Al Hibbs was pestered by the ABMA leadership for info, but Al could only shrug. Everyone would have to wait for *Explorer 1* to almost complete an orbit before the temporary stations in southern California would hear its signals, if all had gone well. Suspense was heightened as the appointed time neared, then past. The Jupiter-C had over-performed, placing *Explorer 1* in a higher orbit than expected, making its orbit period longer by almost ten minutes.

Finally, a cheer came from the control trailer. One of the temporary stations heard the signal, at 12:46 AM EST, followed in short order by reports from other stations. Success!

[ASIDE: There is some confusion over just exactly which station actually made the first reception. Some sources say the announcement coming in was "Goldstone has the bird!" But the precursor to the Goldstone station did not go by that name at that time. Others say the call

was “Gold has the bird!” The JPL temporary stations were named after colors. But the first call actually came from Station Red, not Station Gold, in the Earthquake Valley, southern California. But it really doesn’t matter much; the United States had finally joined the Space Age!]

Explorer 1 weighed all of three pounds, compared with ~1100 pounds of *Sputnik 2*. But that didn’t really matter much either; the United States had finally joined the Space Age!

Van Allen’s cosmic radiation instrument didn’t get much of a chance to study cosmic rays, but it did detect an abundance of charged particles trapped in Earth’s magnetic field. Subsequent satellites detected a second such zone. The two zones are to this day known as the “Van Allen radiation belts.”

Several Vanguard and other satellite successes soon followed, and by 1960, we were launching meteorological, weather, and spy satellites.

Then we went to the Moon!

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