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Chapter 17

THE BEGINNING OF THE U.S. SPACE PROGRAM: A MEMOIR*

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Although in the very early history of rocketry, one finds references to the use of rockets for space travel, especially to the Moon and beyond, it was not until World War II that practical rockets began to appear. The use of rockets for scientific research of upper atmosphere phenomena soon followed. From the high altitude sounding rocket to the Earth orbiting satellite was a relatively small step.

At the end of World War II, rocket research and development in the United States followed two paths. One aimed at producing simple, short-burning rockets for military applications. The other concerned larger, long-burning rocket engines with applications ranging from guided weapons to satellites. The work of Robert H. Goddard demonstrated the concept of the long-burning liquid-propellant rocket, but most of the development of useful rocket engines came from other sources.

In Pasadena, at the Jet Propulsion Laboratory (JPL), development of liquid propellant rockets led to the WAC CORPORAL which reached an altitude of 40 miles in 1945. After the War, German V-2 rockets were brought to the United States for extensive study of the V-2 engine.

The possibility of using long-burning rocket engines to propel vehicles to very high altitudes, and even to satellite orbits, became the driving force for much of rocket research. In the United States, the first serious analyses of satellite vehicles and missions were done by the Rand Corporation and the Jet Propulsion Laboratory in 1945-1946. Although these analyses made a good case for satellite programs, nothing was begun.

As stated earlier, an upper atmosphere research program was started in the U.S. after World War II. The German V-2 rockets were brought to the White Sands Proving Ground in New Mexico, along with a number of German experts headed by Wernher von Braun. With the help of the Germans, some 40 V-2 rockets were launched on near-vertical trajectories with scientific experiments as payloads.

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Other smaller rockets were also used for high altitude scientific experiments. For example, the AEROBEE Rocket, built by the Aerojet Corporation, was developed from JPL's WAC CORPORAL and proved a very useful research vehicle. A larger research vehicle, the VIKING rocket, was developed by the Naval Research Laboratory (NRL). A two-stage vehicle, a WAC CORPORAL on top of a V-2, reached an altitude of 250 miles in 1949. At the other end of the spectrum, James Van Allen of the State University of Iowa, used the very small, solid propellant LOKI Rocket. By carrying it to high altitudes with a balloon and then launching it, the rocket accelerated through low density air and reached an altitude of about 300,000 feet, close to its vacuum trajectory.

For about ten years after World War II, a great deal of scientific interest evolved in high altitude sounding rockets. Instruments and equipment were developed to optimize the data return from the relatively short time spent above the Earth's atmosphere. As time went on, it became increasingly apparent that longer duration observations were essential, and that satellite observing platforms were necessary. Because of the political sensitivity of discussing satellite missions, there was little public knowledge of such projects, but the studies became increasingly realistic with experience gained by actual rocket firings.

One study with which JPL was associated was Project ORBITER initiated late in 1954 as a joint Army-Navy venture. This involved a cluster of LOKI rockets atop a REDSTONE rocket. The cluster would constitute a three-stage solid propellant rocket and would have the capability of launching a 5-pound satellite into a 200-mile orbit. The Army would be responsible for the REDSTONE, and the Navy for the upper stages, the satellite, tracking facilities, and data acquisition and analysis.

Further study of this proposal by JPL engineers led to an alternative proposal using 6" diameter rockets, developed as scale models for the SERGEANT missile, instead of the smaller LOKI rockets. These scaled down SERGEANT rockets would give greater reliability and a payload capability of 30 pounds. The project would then become entirely an Army project. Work actually started to build this vehicle but ended in August 1955.

By 1955, the situation regarding the launching of small scientific satellites was as follows:

At the International Astronautical Federation (IAF) Congress in Zurich in the summer of 1953, S. Fred Singer, of the University of Maryland, proposed a Minimum Orbital Unmanned Satellite of Earth, project MOUSE, based on an earlier study by the British Interplanetary Society. Singer's proposal was discussed by the Upper Atmosphere Rocket Research Panel in April 1954. This Panel had been monitoring the U.S. Upper Atmosphere Research Program since 1946. However, Project MOUSE was never implemented.

In the meantime, organizating of the International Geophysical Year (IGY) had begun in 1952. In October of 1954, the Comite Speciale de l'Annee Geophysique Internationale (CSAGI), at its meeting in Rome, accepted an American proposal to include satellite experiments in the IGY program.

Early in 1955, the IGY Committee of the National Academy set up a technical panel on Rocketry, and this panel established a study group called the Subcommittee on the Technical Feasibility of a Long Playing Rocket. The Subcommittee consisted of John Townsend, Milton Rosen of NRL, and me. We noted that there were three possibilities for a satellite launch: One based on the Air Force ATLAS rocket then under development; one based on the NRL VIKING upper atmosphere research rocket; and, the Army proposal based on REDSTONE.

Shortly thereafter, the U.S. National Committee for the IGY did recommend a satellite program and requested high level governmental support. It was recognized that the project would have to be closely integrated with the ballistic missile development program, and Donald Quarles, Assistant Secretary for Research and Development of the Defense Department, set up an Advisory Group on Special Capabilities. This is usually referred to as the Stewart Committee after its Chairman, Professor H. J. Stewart of Caltech and JPL. The official announcement that the U.S. would have an IGY satellite program came from the White House on July 28, 1955. Four days later the Soviets made a similar announcement, and at the IAF Congress in Copenhagen on August 3, they announced that their satellite would be launched in 1957, and would be much heavier than the U.S. satellite.

The Stewart Committee had not yet made a decision regarding the U.S. launch vehicle. Their choice focused on the NRL's VIKING versus the Army's REDSTONE. Within a month, the Navy program had been chosen, and on 9 September, the Deputy Secretary of Defense announced that the Navy would be in charge, but that it would be a joint, three-service program.

The Army and JPL were very disappointed. Work, which had been going on at a low level, was terminated. However, Major General John B. Medaris, Commander of the Army Ballistic Missile Agency in Huntsville, Alabama, was developing the Army Intermediate Range Ballistic Missile, Jupiter, and he required data on the design of the reentry nose cone. A Reentry-Test Vehicle (RTV) was authorized, based on the ORBITER design. By using two stages of the three-stage solid propellant on top of the Redstone, a reentry nose cone could be propelled to the necessary velocity, and tracked to impact approximately 3000 miles down range. JPL, in addition to designing the upper stages and supplying the solid propellant motors, designed and built the tracking system known as "Microlock." Fundamentally, it was a very sensitive phase-locked loop ground receiver and a stable flight transmitter radiating about 10 mw. The Doppler shift in the received frequency gave a measure of the line-of-sight velocity of the vehicle.

This phase-locked loop receiving system has become standard for very long distance communication. For example, JPL's present VOYAGER spacecraft, now at a distance of more than 20 AU from Earth, is able to communicate to Earth at a bandwidth of 21 kilohertz, with only 20 watts of transmitted power. Also, accurate measurement of line-of-sight velocity by the Doppler effect has been developed into the principal datum for space navigation from Earth.

There were three RTV launchings from September 1956 to August 1957. The nose cone from the last vehicle was recovered from the Atlantic Ocean 3000 miles from the Cape.

After the President's announcement of the U.S. Satellite program for the IGY, the Stewart Committee continued to monitor progress of the VANGUARD program, as the Navy project was named. Because this program called for the development of a new rocket, it was inevitable that there would be delays and cost overruns. With the success of the Army RTV program, it was also inevitable that the Army, at every opportunity, offered to take over the satellite project.

In addition to the Stewart Committee representing DOD interests, the Upper Atmosphere Rocket and Research Panel, which had now evolved into the Technical Panel on the Earth Satellite Program (TPESP), represented the National Academy of Sciences and reviewed the plans for VANGUARD, including both budget and scientific payload. To develop ideas for scientific experiments, the TPESP organized a symposium on "the Scientific Aspects of Earth Satellites." As a follow-up, Jim Van Allen was asked to head a Working Group on Internal Instrumentation to make recommendations on priorities for the on-board experiments, and I was asked to Chair the Working Group on Tracking and Computation.

During 1956 and 1957, VANGUARD had various difficulties and delays, not all of which were adequately reported to the TPESP. In fact, at the TPESP meeting in May 1957, the DOD, when asked why project ORBITER was not established as a backup for VANGUARD, stated that the project was on schedule, and the backup was not needed.

The Stewart Committee was also concerned with the progress of VANGUARD. They invited the Army to report on the performance of the RTV flights which could be obtained with ORBITER. As expected, some of these meetings resulted in considerable disagreement and some harsh words between Army and Navy representatives.

And so in October 1957, American scientists were uneasy about VANGUARD. The Naval Research Laboratory was working hard to solve the problems, and the Army was waiting on the sidelines. The American public knew little about the program and had, essentially, no interest.

On Monday, 30 September, a six-day conference on the status of the IGY, under the sponsorship of CSAGI, opened in Washington. Representatives of most countries involved were present. At the first session, general summaries were given, and Anatoly Blagonravov, the senior Soviet delegate, stated that the SPUTNIK would be launched in the near future. Nothing further was said, and on Friday, October 4, the Soviets invited the delegates to a cocktail party at their Embassy on 16th Street. During the evening, Walter Sullivan, a reporter for the *New York Times*, told me that his office reported that Radio Moscow had announced the launching of SPUTNIK. We huddled together with Richard W. Porter of the General Electric Company, and Lloyd Berkner, Vice Chairman of the IGY, and discussed and discussed the situation. Lloyd, as Senior American Scientist, approached Blagonravov and said he wanted to propose a toast. In the ensuing silence, Lloyd toasted the successful launching of SPUTNIK I. A short time later, most members of the working group on Tracking and Computation had quietly disappeared. Without any spoken suggestion, we all had the same ideas and left for the IGY office a few blocks from the Embassy. Reports of satellite sightings began to come in over the telephone. Most of them were obviously false, but we quickly began to get genuine reports of radio signals from the satellite. On the basis of these reports, we developed an orbit for SPUTNIK. Dick Porter, Jack Townsend, Homer E. Newell of NRL and I spent most of the night working with the scattered data which was arriving completely uncoordinated. No U.S. tracking network was functioning at the Sputnik frequency of 20 MHz. The official IGY satellite frequency was 108 MHz, and the Minitrack system to be used with VANGUARD was set for this frequency. Stations reporting reception of the SPUTNIK signals included amateur radio operators and the RCA transatlantic terminal on Long Island.

By morning we were confident enough of our data to put out a press release confirming that SPUTNIK was in orbit and giving its approximate orbit.

The United States reaction to SPUTNIK soon developed into a storm of criticism of the government. Overnight it appeared that the popular image of the U.S.A. as the leader in technological progress had been shattered. Concern was expressed at shortcomings of almost every U.S. institution, beginning with the schools and ending with the Federal Government. President Eisenhower tried to quiet the clamor by appearing on television exhibiting the nose cone recovered from the Army RTV launch, and by asserting that the SPUTNIK did not raise any concern about national security.

A month after SPUTNIK I, on November 3, the Soviet launched SPUTNIK II with a much larger scientific payload including the dog "Laika." Five days later, on November 8, the Army was given approval to prepare a satellite as a backup for VANGUARD.

Called to Huntsville by General Medaris, the division of responsibilities between von Braun who was in charge of the Army Ballistic Missile Agency, and me was established. von Braun's team was to build the modified REDSTONE first-stage booster, and JPL was to build the three solid propellant upper stages, the satellite, and the tracking system. The satellite was to be ready for launching in 90 days.

Of course the successful RTV program had demonstrated most of the essential features of the satellite vehicle. The upper stages were nested within a spinning "tub" on top of the REDSTONE. Spinning reduced the effects of thrust variations between the upper stage rockets, and also gave gyroscopic stability to the assembly. Careful quality control on the individual rocket motors and minimal dimensional tolerances also helped insure that the final stage would travel on the specified trajectory.

To convert an RTV rocket to a satellite rocket required the addition of the third upper stage rocket plus the satellite payload. The rocket was straightforward. Selection of the payload required some coordination with the VANGUARD scientific program. Van Allen and I had discussed the options some time before the

Army was told to go ahead. We had concluded that his cosmic ray experiment would easily fit into the Army satellite configuration. A meeting of the TPESP, at which Van Allen was not present, confirmed this choice, and I was authorized to make the arrangements with him. An additional VANGUARD experiment, the micrometeorite impact experiment of Maurice Dubin, was also authorized.

When I tried to reach Van Allen, I discovered that he was on a Coast Guard research vessel in the Antarctic. I tried to reach him by U.S. Navy communication channels, but after not receiving an answer for several days, someone suggested we try the normal commercial channel. Western Union reached him. We received an enthusiastic immediate "yes" from Jim, so we told his student, George Ludwig at the State University of Iowa, to bring all of the equipment to Pasadena. With the help of JPL engineers, the satellite payload was soon built, tested, and ready for flight.

Another decision that was made concerned the communication system. Although the Minitrack system of NRL was already being built for VANGUARD, we preferred to use our own Microlock system. Microlock operated with relatively simple ground stations which could be easily set up. We decided to operate stations in Florida and California and also in Singapore and Nigeria, two near-equatorial sites located approximately equally around the world from California. With the cooperation of the British National Committee for the IGY and local University groups, the stations were ready at the time of the launching.

Meanwhile, other space-related activities in the U.S. were taking place. In October, the American Rocket Society presented a program for outer space development, which would be conducted by an astronautical research and development agency somewhat similar to the National Advisory Committee on Aeronautics, (NACA), an organization which had operated very successfully since 1915. In November, the NACA set up a special committee on space technology, chaired by Guy Stever. A large fraction of NACA research was now space-related. On December 6, 1957, VANGUARD attempted a launching from Cape Canaveral. In full view of the television cameras, the rocket rose a few feet, then collapsed in a ball of flame.

The Army satellite was now really the focus of attention. Our launch attempt was set for the end of January. Because of other range schedules, only a few days were available. Of these, both January 29 and 30, 1958, had to be scrubbed because of very high winds in the jet stream aloft. On January 31, the winds had lessened, and General Medaris decided to launch at 10:48 p.m. local time.

Wernher von Braun, Jim Van Allen and I were in Washington, along with various officials, including the Secretary of the Army, in a small room in the Pentagon. Our communications with the Cape consisted of a teletype machine and a telephone. After the launch appeared to be successful, and the REDSTONE had completed its burn, Wernher turned to me and said "It's yours now, Bill." Reports from the Cape and the range tracking system appeared to show that we had attained a satellite orbit, but it was decided to make no public announcement until signals had been received from the tracking station in California. Our rough calculations showed that this would take about 100 minutes.

Shortly before the expected time, I called JPL on the commercial telephone circuit and was connected to Frank Goddard, who had a telephone link to the receiving station at Earthquake Valley near San Diego, so that he could relay the report to me. It happened that the satellite was in a higher orbit than expected, which meant the signals were received eight minutes later than we had calculated. I found those eight minutes to be excruciatingly long. The room full of people were silently watching me as I talked irrelevantly to Frank to keep the line open. Finally the word came through that EXPLORER I was successfully in orbit. We were ecstatic.

Von Braun, Van Allen and I were then driven to the National Academy of Sciences, where a press conference had been set up in the Great Hall. We found the room jammed with enthusiastic representatives from the press, radio, and television. We answered questions for at least two hours, and when we left, each knew that not only had we launched the first U.S. satellite, but our lives in the future would be deeply involved in the U.S. space program. Each of us knew that EXPLORER was only the beginning; the U.S. would certainly be in space exploration to stay.

During the rest of 1958, the U.S. launched seven successful space missions and had 10 failures. The Soviets had one successful mission and 1958 was the year when management of the U.S. program took on its present configuration. The first important action took place on November 7, 1957, when President Eisenhower announced the formation of the President's Science Advisory Committee under James Killian, President of MIT. This Committee served as a conduit for scientists to be heard at the very highest levels of government. One of its early reports, "Introduction to Outer Space, an Explanatory Statement," was released by President Eisenhower in March 1958. A month earlier, in February 1958, the National Academy of Sciences, through its IGY Committee and TPESP, had proposed a program of scientific research in space to continue beyond the IGY.

As early as January 1958, Hugh Dryden, Director of NACA, proposed a space program with both civilian and military participation under the joint control of NACA, DOD, NAS, NSF. The Department of Defense (DOD), established the Advanced Research Projects Agency (ARPA), in February 1958, to be in overall charge of the U.S. outer space program. However, the IGY program had established civilian scientific interest in space, and on April 2, 1958, President Eisenhower sent to Congress proposed legislation for the establishment of a National Aeronautics and Space Agency (NASA), which would absorb the NACA. The new agency would be responsible for civilian space science and aeronautical research. Civilian projects under ARPA would be transferred to this agency.

Congress responded quickly to the President's proposal. On April 14, 1958, bills were submitted to both houses, and a Select Committee on Astronautics and Space Exploration of the House of Representatives began hearings. By July 24, the NASA bill was signed by the President. On October 1, NASA officially began operations.

The old NACA was transferred to NASA. The NASA Laboratories became Research Centers. DOD responsibilities for civilian space programs were transferred to NASA, and two weeks later NASA requested that the Jet Propulsion Laboratory be acquired from the Army. The Jet Propulsion Laboratory is a government owned facility, which is staffed and operated through a contract with the California Institute of Technology. In 1958 JPL was under contract to the Army Ordnance Department through Caltech. The laboratory had been developing rocket technology and short range ballistic missiles for the Army. However, when the opportunity to participate in the satellite program arose, JPL strongly supported the proposal. After the success of EXPLORER I, we were sure that our future lay in space, and we closely followed the progress of space planning in Washington.

The Army was upset because NASA wanted both JPL and the von Braun team in Huntsville. A compromise was reached with JPL to be transferred in December 1958 and ABMA a year later.

Keith Glennan, Administrator of NASA, and Hugh Dryden, his Deputy, came to Pasadena, and arrangements with both Caltech and JPL were quickly finalized. It was agreed that JPL would continue work on the Army SERGEANT missile, but that this would be phased out as soon as possible.

NASA at this time consisted of the head office in Washington, four former NASA Research Centers, the new Goddard Space Flight Center near Washington, and JPL. The flight program that was rapidly evolving could be divided into near Earth satellite projects, deep space projects, and manned flight projects. A role for JPL had to be determined. We argued for, and were given, the deep space projects.

This was an appropriate choice for a laboratory closely tied to Caltech. Both the science and the engineering required for these missions would be at the very forefront of technology. The close connection to the teaching and research activities at Caltech was expected to be extremely valuable.

As far as the campus was concerned, Lee DuBridge, President of Caltech, was delighted that our work was moved from the highly classified work for the Army to the completely open program of NASA, particularly since we were to work in this challenging scientific field. As it turned out, both Lee and I were disappointed that relations between laboratory and campus were not as close as we had originally expected. This came about because selection of science experiments was, quite properly, a Washington decision, and experimenters from the U.S.A. and other countries were invited to participate. Consequently, Caltech scientists had relatively few flight opportunities. The engineering problems associated with spacecraft had to be solved on a timetable fixed by flight dates, and thus Caltech engineering participation was primarily on an *ad hoc* consulting basis. Nevertheless, the Caltech contractual relationship was very important for the staffing and research standards set at JPL.

One of the first tasks for the Laboratory under NASA was to develop a space program for missions to the Moon and planets. A report, published in April 1959, outlined an ambitious series of flights. The emphasis was on spaceflights which would take place at every planetary opportunity. Two Mars flights would take place in 1960, two to Venus in 1961, and so on. Flights on the Moon would take place between the planetary missions, and would primarily be test flights for the planets. Obviously we grossly underestimated the problems of flying to the planets.

In retrospect, this report was useful in that it wrote a program for a consistent set of launchings. It showed how the planetary program had to relate to an astronomical timetable, and it indicated how planetary exploration would progress from fly-by missions to orbiters and then to landers. The general nature of scientific experiments for each type of mission was indicated. The engineering problems which had to be solved were also described. JPL and NASA spent most of 1959 trying to establish a realistic deep space program. By the end of the year, this had become the RANGER program to the Moon and the MARINER missions to Venus and Mars. There were problems concerning the choice of a launching vehicle, but for the initial launchings an ATLAS rocket with an AGENA upper stage was selected. Later missions substituted a CENTAUR for the AGENA upper stage.

During 1959 and 1960, the U.S. successfully launched eight satellites under NASA direction and 19 under DOD auspices. One of the NASA satellites was the ECHO balloon, which was plainly visible when it passed overhead just after sunset or before sunrise. I remember seeing it while attending the IAF Congress in Stockholm shortly after the launching in August 1960. The Congress participants were attending an entertainment at Drottingholm, and ECHO passed over while we were all on the terrace partaking of refreshments.

Even with this program, there was a general feeling in the federal government that the U.S. should have a major dramatic space mission to demonstrate to the world that we could respond to the challenge of the Soviet Sputnik. Then, on May 25, 1961, President Kennedy announced the APOLLO program to put a man on the Moon before then end of the decade. The APOLLO decision had two consequences for JPL. Obviously the JPL Lunar program, which now included the SURVEYOR lander as well as the RANGER fly-by, would be re-oriented to support APOLLO. Schedules became very important, and science was subordinated to APOLLO needs. The other consequence was that JPL technological know-how would be provided to the APOLLO project. This support took the form of a team from JPL being assigned to NASA Headquarters. The group was under the direction of Charles W. Cole and became known as Cole's Rangers.

The early RANGER flights were plagued with misfortunes. The first two engineering tests could not be satisfactorily completed because of troubles with the AGENA upper stage. The next three flights suffered various spacecraft difficulties. NASA and the Congress were very concerned with JPL performance, and various committees were appointed to look into the situation. Fortunately for JPL, the first spacecraft to Venus, MARINER II, was launched successfully on August 26, 1962, and flew past Venus on December 14. The design of MARINER II had much in common with RANGER. The successful flight to Venus showed that the essential features of the RANGER design were sound, and under JPL direction, the spacecraft could work.

The flight of RANGER VI on January 30, 1964, was a disaster for JPL. The mission was to send television pictures back to Earth for the last 15 minutes before the craft crashed into the Moon. The launch and journey to the Moon were perfect. But the television system did not work.

A NASA review committee was set up to review not only the technical problems of RANGER, but also Laboratory management and policies. In the process, the committee reviewed and criticized some aspects of NASA management. The next few months were very difficult for the laboratory, but on July 31, 1964, RANGER VII was launched and worked perfectly, returning excellent television close-up photographs of the Moon.

RANGER VII was a turning point in the history of JPL. Since that mission, the Laboratory has had an excellent record of successful missions to the Moon and the planets. RANGER VII and MARINER II also represented major milestones in the U.S. space program. John Glenn was rocketed into orbit in February 1962, and the man-in-space program was moving toward the APOLLO journey to the Moon in 1969. RANGER and MARINER represented the deep space exploration side of the space program. These projects demonstrated the U.S. objective to conduct a broadly based civilian scientific program. They showed that man had the capability of sending complex automatic machines on journeys of exploration far beyond the limits of Earth. These machines were responsive to the scientists and engineers at home on Earth. They and their descendants have taken us exploring throughout our solar system. They have shown us worlds beyond our imagination.

Today, 29 years after SPUTNIK I, journeys into space, both manned and unmanned, are almost routine in spite of the unfortunate CHALLENGER accident. Unmanned vehicles have visited all the planets known to the ancients and also Uranus, which was not known. Communication satellites are used routinely for worldwide telephone and television communications. Space vehicles are launched not only by the super powers, but also by many other Nations.

The first SPUTNIKS and EXPLORERS now seem very crude and archaic, but the surge of public interest engendered by those flights continues to make possible the large financial and technical resources needed to carry out space programs of growing complexity and ever more ambitious goals.

The United States responded very quickly to the SPUTNIK challenge. Within a year NASA had been established and a national civilian space program started. Within little more than two years the APOLLO program to send a man to the Moon, a bold commitment indeed, had been initiated. Space research and exploration had become a part of the Nation's agenda.

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