Chapter IV
Golden Days at the AEC

A Close Community

Many of the original RTG team thought of the early years after Seaborg came to the AEC as the "golden days" of the AEC—before the big and costly space systems and missions of NASA involved increasingly large numbers of people and organizations in the RTG program.

From 1962 to 1965, the antinuclear movement was not yet vociferous, the future of nuclear power and its widespread uses looked promising, and the chairman of the AEC was a scientist who believed strongly in nuclear power and its wedding to space ventures. Moreover, Seaborg inspired loyalties and a sense of common purpose in the people of the AEC.

Carpenter* recalled that it was common to meet the top man in the halls at AEC's Germantown building and to be greeted by name and asked questions about the program: "We had a personal relationship with Seaborg, and we also had a close arrangement with the Commissioners." He added that problems on the Hill were few and that the program received support from both the AEC and the Congress, whose members pressed for a flight schedule on space nuclear propulsion, eager to see the SNAP-isotope technology get its chances to fly. In those years, according to Carpenter, the AEC allowed engineers to do everything from start to finish on their programs—at least on the small isotopic power program. The RTG group chose to have just a few hands holding all the reins. Carpenter recalled: "I prepared budget documents, defended them before Congress, ran my program and participated in the launches."[1]

Carpenter explained that few contractors were involved in the early days because the program was small and there wasn't a great deal of money available for space-isotopic power development. He indicated that SNAP-3 was built on a purchase order from the Martin Company to the 3M Company

*At that time head of the isotope office of the SNAP program under Armstrong, who reported to Pittman, director of the Reactor Division at AEC.

for a very small amount. Martin got involved in isotopic power, while others held back, because "they were into space in a big way and their programs were long range. A lot of other firms that got involved later came in when there was more money in the budgets. Like when we got going on Apollo."[2]

In the initial development period, the circle was limited, encompassing the small group at the AEC and small groups in other institutions: the isotope power experimenters and developers at Martin-Baltimore and their subcontractors at 3M; the fuel packagers at Monsanto's Mound Laboratory; and users such as the Applied Physics Laboratory of Johns Hopkins University which developed the Transit navigational satellite system for the Navy. This team proceeded to develop the SNAP-9A with its increased power requirements for the operational Transit scheduled for flight in late 1962. At the same time, a series of SNAP-7 devices were under development at Martin for use by the Navy, Coast Guard, and Weather Bureau for navigation lights and weather stations on earth.

NASA began to enter into contracts with the AEC to study possible applications of isotopic SNAPs to future space missions. Even before Apollo, NASA recognized that there would be unusually severe power system requirements for lunar missions "due to the weight and space limitations of payload, the 14-day lunar nights, and the variety of the intended experiments."[3] By the fall of 1961, NASA reconfirmed its requirements for an isotopic power unit for the Surveyor soft lunar landing mission and the AEC prepared to provide two SNAP devices—designated SNAP-11s—to NASA for missions scheduled to take place two years later.[4] In mid-1962 NASA began preliminary discussions with the AEC on the possibility that an RTG could provide primary power requirements for one of a series of satellites called Interplanetary Monitoring Probes. Along with foreseen technical advantages, NASA hoped to use the RTG to enhance its own "capability and experience in the use and application of nuclear devices."[5]

Reporting to the JCAE in September 1962 on space nuclear power applications, Commissioner Hayworth of the AEC stated "Nuclear power not only will enhance space exploration; its use, both for propulsion and for auxiliary power, is the key to extensive outer space exploration." He reviewed the developments and tests in the Rover program to develop nuclear rocket propulsion and admitted that there had been disappointments causing delays. Turning to the isotopic power side of the SNAP program, Hayworth reported with "considerable satisfaction" on program successes: launchings in June and November of the previous year of isotope power devices on Navy Transit navigational satellites. Looking to the future, he said, "We are continuing to work closely with DOD and NASA to satisfy their requirements for space SNAP devices, and... we have developed a plutonium 238 fueled 25 watt unit, SNAP-9-A, for use in the Navy's operational prototype Transit satellites." Hayworth also spoke of the work with NASA on the development of the SNAP-11, a 25-watt curium-242 fueled thermoelectric generator planned for powering the Surveyor soft landing lander.[6]

Thus NASA readied itself for the time when it would become the major user of the isotope units and the small RTG group would open its membership to growing numbers of people and organizations.

A Climate of Renewed Determination and Hope

Great Power confrontations affected the RTG program. The Soviets broke the nuclear atmospheric test moratorium that had been honored by the United States, Great Britain, and the Soviet Union since November 1958. President Kennedy ordered the resumption of underground testing. In April 1962, while the nation still hailed the triumph of John Glenn's first orbit of the Earth by an American, the president authorized the resumption of atmospheric tests off Christmas Island. The tests provoked considerable adverse public reaction around the world as well as at home.[7] The Cuban Missile Crisis in October marked the height of international tension. By the summer of 1963, Kennedy seemed determined on a course that would bring the Great Powers back from the brink of war and start them on a road of cooperation, at least on the issue of nuclear testing. Perhaps benefiting from international tensions, NASA and AEC research moved ahead while Great Power confrontations unfolded.

In June 1963, the president chose the occasion of a commencement address at the American University in Washington, D.C., to lay out a new course for the Great Powers to follow in the search for peace and accommodation of their differences. Was peace possible? "Our problems are man made—therefore, they can be solved by man" the president believed. Was it possible to be at peace with an aggressive communist Super Power? "No government or social system is so evil that its people must be considered as lacking in virtue " Moreover, the peoples of both countries shared a mutual abhorrence of war and had never been at war with each other Finally, turning to arms control, the president made two announcements

> First Chairman Khrushchev, Prime Minister Macmillan, and I have agreed that high-level discussions will shortly begin in Moscow looking toward early agreement on a comprehensive test ban treaty
>
> Second To make clear our good faith and solemn convictions on this matter, I now declare that the United States does not propose to conduct nuclear tests in the atmosphere so long as other states do not do so [8]

The discussions which began in Moscow in July led before the summer was over to a "Treaty Banning Nuclear Weapons Tests in the Atmosphere, in Outer Space and Under Water " This Limited Test Ban Treaty was approved by the U S Senate, 80 to 19, on September 24 and ratified by the Praesidium of the Council of Ministers of the U S S R on September 25 [9]

In a congressional reassessment of the nation's space program, the president's moves toward accommodation with the Soviet Union were seen not only as slowing the lunar race but also as undercutting overall support for the space program In an address at the United Nations in September, the president proposed that the two Great Powers conduct a joint manned lunar landing program Space technology advocates said this had "provided new arguments for further cuts in an already reduced space budget, and left the public puzzled as to whether Project Apollo still is an urgent national goal " *Aviation Week* expressed similar concerns

> President Kennedy has dealt his own national space program its hardest blow
>
> The immediate effects of the President's ill conceived invitation to the Soviets to join the U S Apollo program are twofold
>
> First, it will provide congressional opponents of his space program with the well sharpened ax they need to cut its Fiscal 1964 budget drastically and retard U S space progress even more than the restric

> tions of technical development....
>
> Second, it will induce a psychological drag into the vast program that has just begun to build promising technical momentum....[10]

By early November, the space journal pressed for a new national space policy and a Fiscal 1965 space budget "based on solid elements of national self-interest...."[11] A week later Khruschev put Russia back into the manned lunar landing race by his statement that Russia had not given up on its lunar program and that his previous statements of being ready to "consider" a joint manned lunar landing program had been misinterpreted.[12]

After Kennedy's assassination, editorialists tended to stress the positives of this "truly modern president." In his last major speech, at the U.S. Air Force School of Aerospace Medicine in San Antonio, the day before his assassination in Dallas, Kennedy related an anecdote of the Irish boys who, when in doubt about trying to get over an orchard wall on their treks across the countryside, tossed their hats over the wall and then had no choice but to follow them. The president had said: "This Nation has tossed its cap over the wall of space, and we have no choice but to follow it." One editorial concluded that "when the first American astronauts return safely from the moon, as they surely will, we should remember that it was John F. Kennedy... who tossed our caps over the wall of space and made us surmount it successfully."[13] The RTG program benefitted both from Kennedy's support of technology and from the national optimism.

Other events competed for attention during the last summer and fall of the Kennedy Administration. The massive "March on Washington" against poverty, the rioting of blacks for their civil rights, and the repercussions of the assassination of President Diem[14] of Vietnam predominated in the media. The next steps in moving the isotopic power devices toward space flight tests on an operational prototype satellite went almost unnoticed that fall. In late September, a Navy Transit 5B navigational satellite powered completely by an isotope power generator was launched from Vandenberg Air Force Base. Space journals in October[15] briefly recounted this flight debut of the SNAP-9A. Clearly, the headline-grabbing days of the pioneering SNAP devices were over. A successful SNAP-9A launch on another Transit on 5 December 1963 did not even receive mention in either the space journals or the popular news magazines.

The Technology Goes Forward

On the first anniversary of nuclear power in space, AEC Chairman Seaborg reminded the public through the press of this historic milestone for the Atomic Age. The SNAP-3A device was still operating successfully after one year, its plutonium fuel, which had half a life of 90 years, had the potential for powering a space transmitter for decades. Seaborg projected this vision of future uses for nuclear power in space:

> I firmly believe that nuclear energy provides the most feasible means of accomplishing long voyages in space and many other ambitious missions of our national space program. . . .
>
> Because of the exciting panorama of applications, the development of nuclear energy for space is most important. Mankind is only on the verge of the space age. Nuclear power will take us into this age—and close to the planets.[16]

High hopes and expectations in Congress still rode with nuclear propulsion and space reactor power generators. The quiet technology already had proven itself and the AEC made plans to explore other possible applications for the RTGs.[17]

In late 1962, NASA's ten-year forecast of potential requirements for RTGs for space missions included Interplanetary Monitoring Probes, Orbiting Astronomical Observatories, and Nimbus—a satellite system for providing 24-hour weather coverage on a global basis.[18] Preliminary work on RTGs for these systems began. Meanwhile, work proceeded on the SNAP-9A that would power the Navy's operational prototype navigational satellites. In the spring of 1963 Pittman, the head of AEC's Division of Reactor Development, reported to a Senate Committee that "...our most dramatic success has been with the relatively small isotopic SNAP devices....especially suited for space applications because they are able to operate under extreme environmental conditions of temperature and electromagnetic radiations, and are not dependent upon sunlight to generate power."[19] The AEC *SNAP Fact Sheet* of 1 September 1963 set down program developments to that date:

> The SNAP-7 program developed "prototype isotopic units fueled with strontium-90...for the Coast Guard and the Navy for use in coast

navigational aids, deep sea sonar devices and automatic weather stations." All of the devices in this series were for terrestrial uses in severe environments.

SNAP-9A was under design for use by the Department of Defense in the operational navigational satellites—formerly Transit, which flew in 1961 SNAP-3As. The SNAP-9A, like the 3A, was fueled by plutonium-238 and was designed for a life of five to ten years. It generated 25 watts of electrical power and weighed 27 pounds.

NASA's inquiries about using RTGs for Project Surveyor—the unmanned soft lunar exploration program—had led to work at the AEC on SNAP-11. This devise, to be filled with curium-242, would weigh 30 pounds, and would provide "a minimum of 18.6 watts of power continuously for 90-day lunar missions."

Also under development for the NASA Surveyor mission was the SNAP-13, which would demonstrate the feasibility of using an RTG in a cesium-vapor-thermionic-generator. This generator would produce 12.5 watts, in line with Surveyor requirements.

Under development for a classified mission was a SNAP-15—the smallest generator currently in the total program. It would use plutonium-238 and supply .001 watt of power for a design life of five years.

NASA's interest in RTGs for the Interplanetary Monitoring Probe stimulated work on a unit similar to the 9A but allowing "for easier fabrication and lower system weight." Designed for a satellite to chart the magnetic field between Earth and the Moon, these generators would produce approximately 25 watts and be fueled with plutonium-238.

Finally, the AEC noted that proposals had been invited "for development of an isotopic generator for space using strontium 90 as the fuel," a device to supply electric power for the Medium Altitude Communications Satellite of the Air Force.[20] Contracts for these devices were awarded in November to General Electric and the Martin Company, and provided for conducting the first phase of a program assessing strontium-90 as a fuel for RTGs in space.[21]

Gradually other companies were drawn into RTG development, but the Martin Nuclear Division remained the major developer. Martin felt the tight funding squeeze of the program and the restrictions of "hardware-oriented research" even as the company extended its work to new devices for both DOD and NASA. In a briefing of the AEC Commissioners in late 1962, R.D. Bennet, general manager of Martin, complained that funding was limited, that the development of SNAP devices was restricted to specific missions, and that the program lacked a broad research and development effort that should be directed particularly toward increasing power-to-weight ratios and insuring reliability as power requirements increased.[22] In retrospect, however, in spite of continuing complaints about lack of funding, proponents of the RTGs at the AEC realized that the strength of the program was in mission oriented research and development which focused on the requirements of specific missions.

Experiences in preparing for the launch of the SNAP-9A second generation RTGs during 1962 and 1963 were repeated many times in the following years as the developers of the quiet technology became accustomed to uncertain lead times and strove to be ready at the launch pads whenever the signal on a mission finally was "go." Changes in load requirements for the Navy satellites affected the converter design. Other problems arose in thermal cycling: in the course of long term vacuum testing, air entered into one of the units and oxidized the thermoelectric package. Moreover, the launch vehicle had been modified in October 1962 and a first launch date, originally set for December, was postponed to February and then to mid-May 1963.[23] Other postponements occurred. With launches finally scheduled for September, October, and November 1963, a process was instituted in August for receiving the Commission's and the president's approval for using the plutonium-238 fueled SNAP-9A generators on Navy navigational satellites flown out of the Pacific Missile Range.[24]

In response to last minute disagreements regarding safety, information on safety was developed and provided to reviewers almost up to launch time.[25] Following the Commission's approval a few days before the first launch, the Space Council advised the AEC of the president's approval. An AEC press release on the late September launch announced that the Navy navigational satellite launched from Vandenberg was the "First To Be Wholly Powered By Nuclear Energy."[26] In early December another AEC press release was headlined

"Second Satellite Wholly Powered By Nuclear Energy Launched Recently; Operating Successfully."[27] A February 1964 status report, however, recorded that useful doppler signals from the first launching were no longer being received, although the second SNAP-9A, launched two months earlier, continued to perform perfectly.[28]

As plans matured for the launch of the third and last SNAP-9A in the series, attention to safety issues was even more concentrated. A mission abort occurred on that launch, indicating that this attention was well placed. Procedures and mechanisms for handling potential hazards had placed heavy demands on resources throughout the development and use of the RTGs. Safety procedures became highly formalized before the manned lunar flights which required larger power supplies and multiplied the potential hazards of mishaps.

Evolution of a Safety Program

Dix, Finger's nuclear safety officer, commented "We always proceeded on the assumption that if we had one abort resulting in the release of radioactivity the program would be lost."[29] Tom Kerr, who came to the Joint Space Nuclear Propulsion Office in June 1962 as NASA's coordinator of safety reviews for all space nuclear systems, also reflected this determination to keep failures from destroying the program. Kerr documented the story of procedures for safety clearances following DOD and the AEC informal reviews of the two SNAP-3A launches:

> In preparation for the SNAP-9A launches in 1963, an expanded review group and procedures were implemented. NASA was invited to participate in the reviews; although the launches were for DOD navigation systems. At that time the responsibility for these reviews was made a part of the responsibilities of the joint AEC/NASA Space Nuclear Power Office.... It was during these early reviews and launches that efficient and comprehensive review and approval procedures were developed.[30]

Specialists were not prepared initially to work with the space nuclear environment. Procedures used for ground based systems could not be followed; the RTGs were lightweight and heavy shielding had to be avoided. Moreover, a number of situations had to be considered: launch failure on or near the launch pad, re entry following an unsuccessful launch, and short orbital lifetime leading to re entry and terrestrial impact in unknown and uncontrolled areas In addition, approval had to be obtained at the highest level Kerr noted "It was critical for the Department of State and the president and his staff to understand the potentials of these launches The potential for political repercussions was great in case of failure with impact and possible fuel release on foreign territories "[31]

During the period of SNAP 9A preparations, representatives from the AEC, DOD, and NASA outlined areas and procedures for improving the consistency and efficiency of the review and approval process They decided to use an *ad hoc* panel representative of the concerned agencies, rather than creating a standing interagency committee One factor influencing this decision was that a standing committee which included public participation would have difficulties handling classified information As early as January 1963 a model charter had been developed for a possible interagency review committee [32] Eventually the safety review panel was given the name "Interagency Nuclear Safety Review Panel" (INSRP) Although these panels were always newly constituted *ad hoc,* through many years of safety reviews Dix was the assigned AEC coordinator and Kerr the assigned NASA coordinator

In the spring of 1964 a report to the Commission by the General Manager and the Director of Regulation set down an interagency safety review mechanism close to the one that eventually was adopted [33] The procedures agreed upon relied on the creation of an *ad hoc* panel for each mission and included development of a public information package and safety report These prepared packages anticipated the mishaps that might occur and contained appropriate safety information for distribution

Basic considerations on safety began with the fuel used in the devices The AEC selected plutonium 238 as the fuel for the first SNAP space missions because it emitted primarily "alpha" particles (the least penetrating type of particles) and had a relatively long half life could not support a chain reaction and even in large masses presented no danger of nuclear explosions The danger lay in its poisonous qualities if inhaled or ingested by living organisms The AEC described the many tests, conducted on plutonium 238 fuel capsules for SNAP devices, that examined ability to survive launch pad accidents safely to withstand impact, and to burn up on re entry in the atmosphere [34] Dix said "We went with a 'burn up on re entry' concept in the early days because those in authority believed that the release from a highaltitude abort was an improbable event and if it did occur would only add a very tiny increment to the plutonium that was in the atmosphere from weapons testing.[35] The "burn-up" aspects of safety considerations, however, caused the most problems in obtaining approval for the 9A launches.

The Division of Licensing and Regulation of the AEC expressed strong reservations about the safety of the forthcoming SNAP-9A launches and challenged assumptions regarding burn-up on re-entry. It reminded the Commissioners that the SNAP-9A devices contained ten times the amount of plutonium fuel that had been flown in the SNAP-3A. These concerns were never completely dispelled even though the launch went ahead with Commission approval. Approval was accompanied by the acknowledgement that safety review by the Division of Reactor Development and the Division of Licensing and Regulation was to continue and that throughout the Transit series the Commission would be advised of any "untoward events" that occurred.[36]

The failure of the third Navy 5B satellite to achieve orbit caused some flurry and placed pressures on the safety team. A.R. Luedecke, AEC General Manager, reported to Chairman Seaborg:

> Preliminary data on the April 21, 1963 SNAP-9A abort indicate that the payload reached a high altitude (over 1000 miles) over the South Pole and re-entered over the Mozambique Channel at a steep angle....[37]

A press release from Seaborg reassured the public:

> From previous safety analysis and tests it had been concluded the re-entry will cause the plutonium-238 fuel to burn up into particles of about one millionth of an inch in diameter. These particles will be widely dispersed... and would not constitute a health hazard.[38]

There were few negative repercussions. In June the AEC Commissioners were reassured by Duncan Clark, Director of the AEC Division of Public Information, that "the USSR is the only country to voice reaction to the news of the SNAP-9A failure to orbit."[39] The issue stayed alive; inquiries from U.S. Senators seeking information and reassurances were received and answered at the AEC as late as October.[40] In the fall a review of the failure of the April launch was presented to the Space Council.[41] As results from high altitude balloon samples continued to be received, the AEC prepared and distributed a reassuring press release stating that the recently collected data "clearly indicates that the fuel of a space nuclear generator burned up as expected last April after its spacecraft failed to achieve orbit."[42]

Carpenter remembered: "We looked at aborts as 'good tests.'"[43] Dix recalled proudly: "We had done an analysis which spotted just where that RTG would go down—in the Mozambique Channel," (he also indicated that this predicted burnup analysis had been published in the open literature prior to the launch).[44] Strengthened by the "test" provided by the 9A abort, the safety program went forward as an integral part of the growing technology. As Kerr explained, the safety program pre-mission reviews and tests contributed to the design of the SNAP devices and thus contributed to a phenomenal record of successful missions while also predicting and controlling the hazards from the few failures.[45]

The 9A abort led to a change in the fuel form, according to Kerr.[46] Eventually, with larger radioisotopic fuel loads, the basic safety concept changed from "burn up and dispersion" to "intact re-entry." By the time that new concept was integrated into an RTG powered space mission, however, the mechanisms for interagency review and meticulous safety analysis were well established and in operation.

Crossroads for New Thrust and Directions

In late 1963, space and nuclear scientists and technologists attempted to foresee how the new President, Lyndon Johnson, would proceed with the space program. Johnson came to his new position with considerable legislative experience in space and military activities as a result of his committee assignments while a member of Congress and his chairmanship of the National Aeronautics and Space Council after his election as vice president. In his first address to a joint session of Congress on 27 November 1963, Johnson pledged to continue Kennedy's ideas and ideals including "The dream of conquering the vastness of space . . ."[47]

Johnson's first decision in space priorities was viewed positively by Aviation Week: "The national space program has taken a significant step forward with President Lyndon B. Johnson's decision to develop a military orbital space station."[48] Two weeks later, however, the president trimmed the FY 1965 budget, which led to the cancellation of nuclear flight programs. The AEC/NASA Joint Office estimated that 1,300 employees at Aerojet, Lockheed, and Westinghouse were affected by the cancellation of the reactor-in-flight test project and the stretch-out on Nerva, the nuclear engine for rocket vehicle application.[49]

Reasons for the budget cut became apparent as the months passed. In April 1964, space journals devoted much attention to the Vietnam War. Although Defense Secretary McNamara had said no decision had been made to extend the war, he rejected any suggestions that the United States withdraw from Southeast Asia.[50] Tensions on Capitol Hill surfaced, engendered by Secretary McNamara's defense of his program to develop weapons. An attack by Congressman Laird on the military budget indicated that "guns and butter" was an issue of partisan contention. Laird challenged Secretary McNamara for using dollar amounts to justify the classification of each program as major:

> Using this criteria, perhaps we should classify the war on poverty as a major new weapons system. After all, the requirements of a new weapons system all seem to have been met in this program. The cost is certainly high enough. And the war on poverty, like the weapons systems Secretary McNamara claims as new, is obviously a combination of already exisiting programs. And, of course, the program has been given a new name.[51]

Administrators of NASA and the AEC took steps to maintain the momentum of their programs and to cope with this threatening environment.

In January 1964 President Johnson asked Webb to review NASA's future space exploration plans with the object of relating hardware and development programs to prospective missions. The president also stressed the importance of coordinating research and development programs with the DOD and the AEC. Webb conferred with Seaborg and incorporated Seaborg's views regarding joint work between the two agencies into his report. Detailing the programs, their missions, and hardware, Webb layed out the panorama of development in which NASA was engaged, "a ten-year $35 billion program aimed at developing a national capability for operations in space." Attempting to save the broad programs, he discussed the many missions being considered and their coordination with other agencies.[52]

Seaborg had begun over a year earlier to prepare a case for the SNAP program and, as budget battles approached,[53] invited private contractors, the military services, and other government agencies to attend seminars about the SNAP program.[54] In response to the president's request, a draft report on the SNAP program was ready by January 1964. Commissioner Ramey criticized the report's apparent efforts "to lean over backwards to be fair to other types of systems like solar cells" and expressed reservations about the emphasis placed on nuclear safety.[55]

Distributed in February 1964, the report stressed the unique advantages of nuclear auxiliary power to a wide variety of space missions and maintained that the "*performance of ambitious space missions will require amounts of reliable power so large that they can be achieved only from nuclear systems.*"[56] Welsh, at the Space Council, offered to help defend the program vigorously, but made clear the priorities of the Council regarding the total SNAP program:

> My staff recognizes the usefulness of the isotope SNAP devices, but if anything is even more interested in the range of nuclear reactor work entailed in the total program. They feel very strongly that we must give every encouragement now to power development needed to support future missions. The Apollo landing will not be an end. Future possibilities include manned planetary explorations, a growing lunar base, and multi-mission advanced earth orbiting stations. All of these will have to have power sources of... magnitude above any available now. Only nuclear energy has this potential.[57]

Throughout 1964, the AEC and NASA moved toward closer coordination of both agencies' efforts in the space-nuclear field. The move was a response to many forces, including the economic squeeze; the emphasis on non-duplication of effort; the increasing need to justify mission requirements for research and development; and the anticipation of higher power requirements for future missions. In January 1965 a proposed agreement between NASA and the AEC to create a joint Space Nuclear Systems Division circulated for review in those agencies. The agreement stated the purpose and rationale of this reorganization:

> Recognizing that the development of nuclear energy systems and their application in space missions requires the technical and management capabilities, and involves the responsibilities, of both the National

> Aeronautics and Space Administration and the Atomic Energy Commission, these agencies agree that these activities require a joint effort and a joint organization to insure effective system development and to insure that the responsibilities of each agency are properly fulfilled. It is, therefore, the purpose of this agreement to establish such a joint organization and to define its functions.[58]

Negotiations and preparations for the new division, which would include research and development on power systems and integration of the conversion system with the isotope source, continued through the spring of 1965. In June the new Space Nuclear Systems Division, headed by Finger, was established. In his first meeting with the JCAE, Finger stated that very large ranges in power were needed, but it was inconceivable that money would be available to develop a unique system for every particular mission. Therefore, he proposed:

> It is... important I think that in the Commission program, we try to develop systems that bracket as broad a range of potential mission uses as possible, and parallel with this, continue to push the technology into more advanced areas in order to try to improve the performance and life capability of these systems.[60]

In the fall, at the annual conference of the Atomic Industrial Forum, Finger described the new AEC-NASA organizational arrangements, which included the coordination of Space Nuclear Systems programs among and between the AEC and NASA, as well as the AEC's Space Electric Power Organization (Figures 1 and 2.) A new juncture had been reached. As the small, self-confident, and persevering RTG group prepared to launch their devices on vehicles to go to the Moon and beyond, they found the drama of space nuclear power filled with growing numbers of actors—both individuals and organizations.

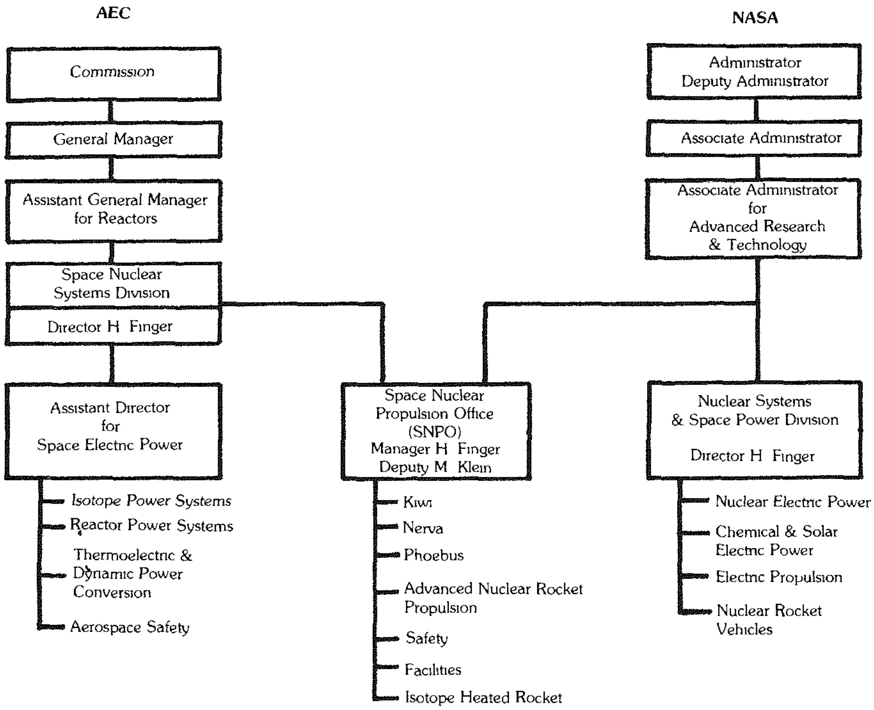


Fig 1 Organization of Space Nuclear Systems Programs

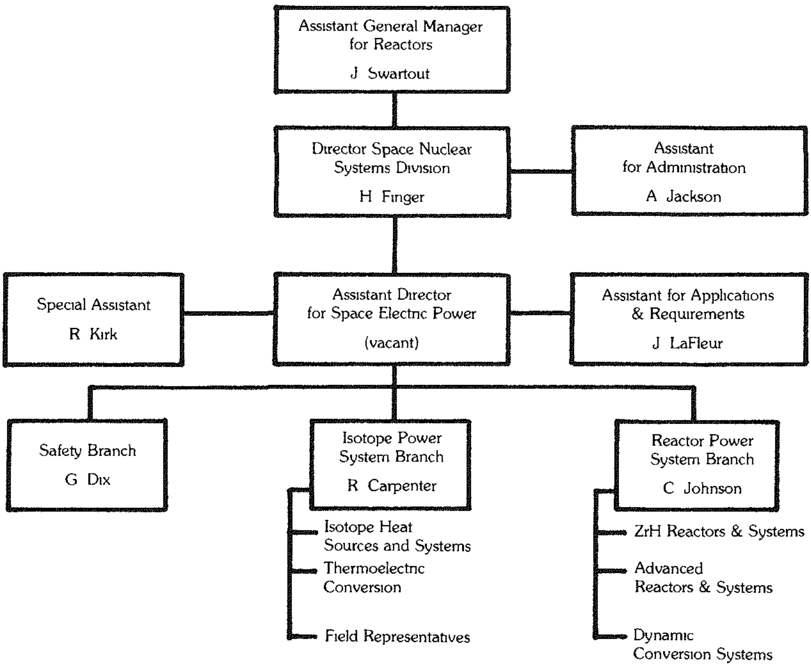
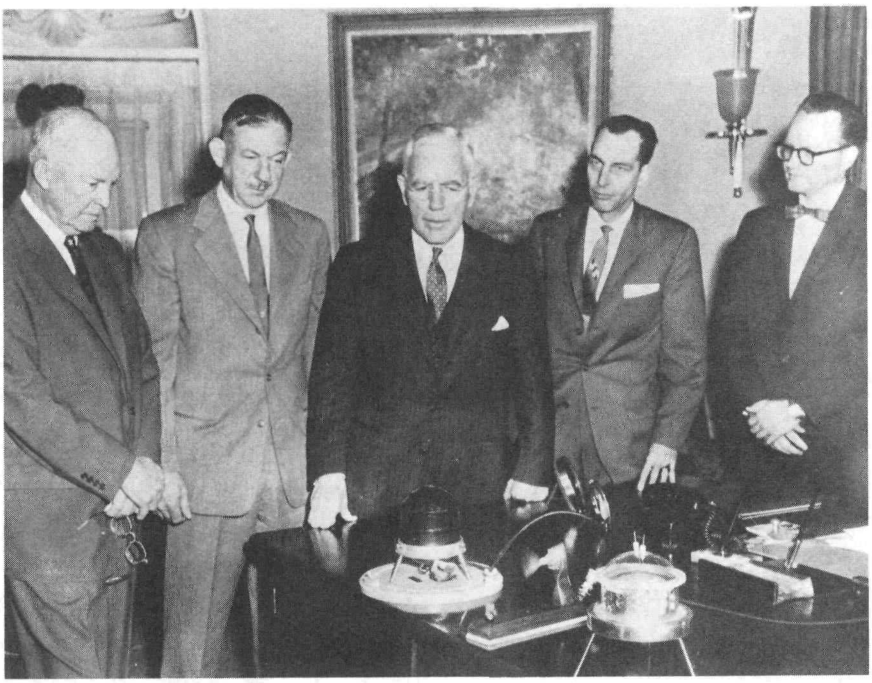
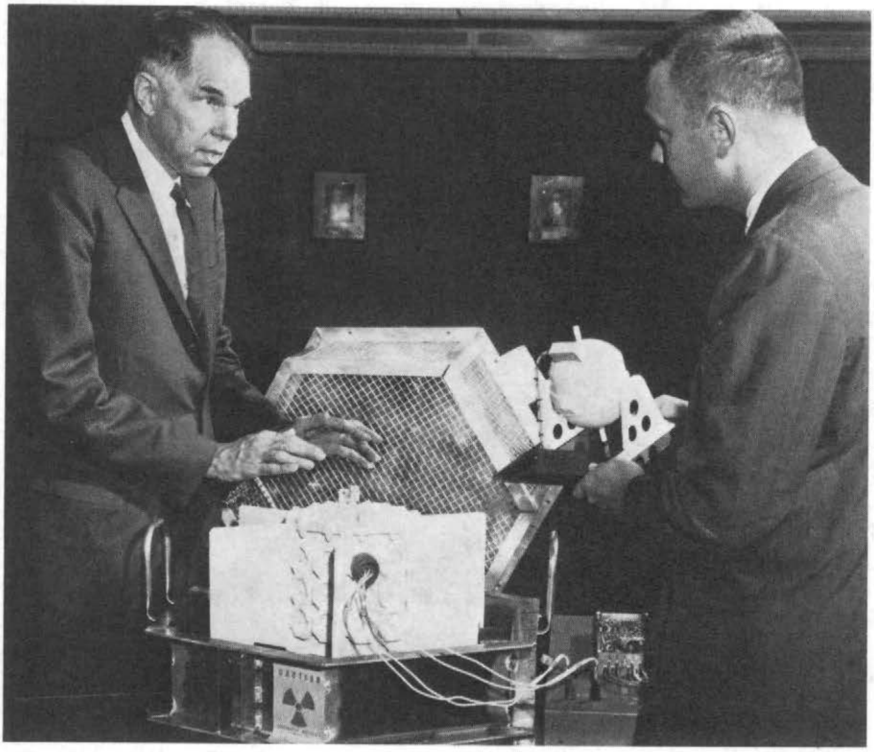


Fig 2 SNS — SEPO Organization



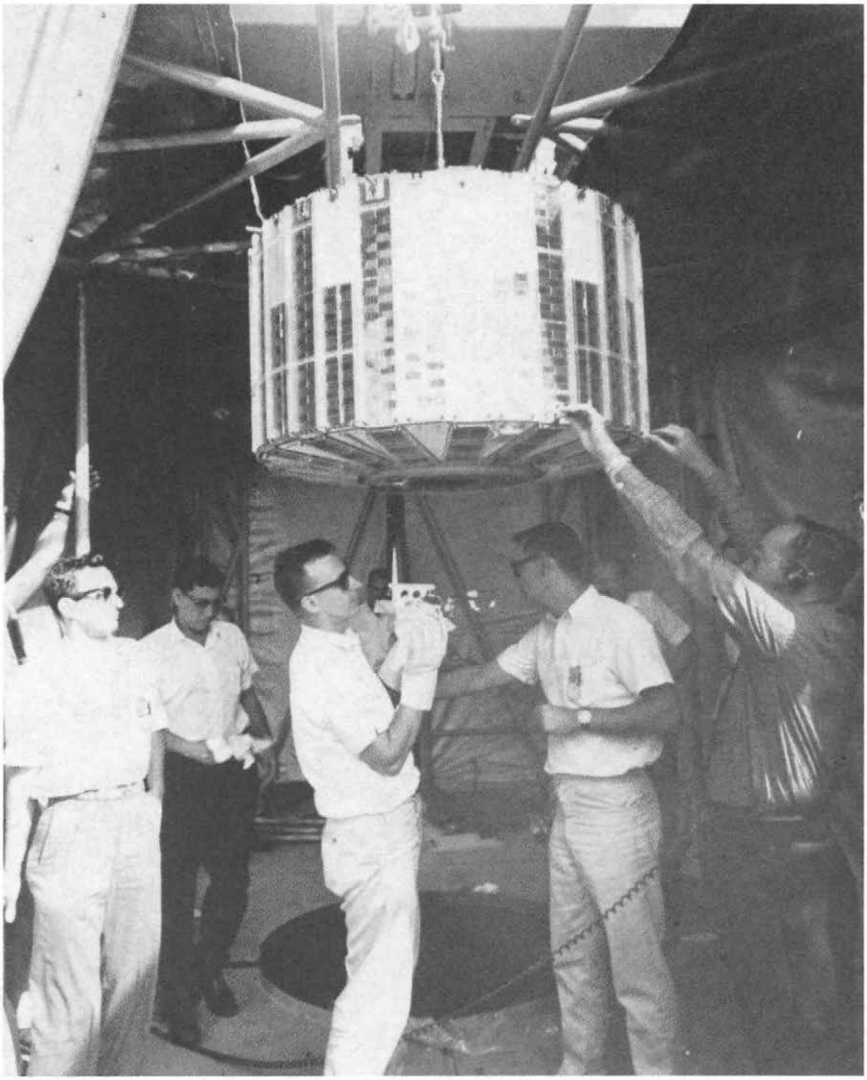
1

Public debut of the RTG technology, 16 January 1959. Viewing the SNAP-3 demonstration device displayed on President Eisenhower's desk are (left to right): President Eisenhower and (from the Atomic Energy Commission) Major General Donald J. Keirn, Assistant Director for Aircraft Reactors, Division of Reactor Development; John A. McCone, Chairman, AEC; Colonel Jack L. Armstrong, Deputy Assistant Director for Aircraft Reactors, Division of Reactor Development; Lt. Colonel Guveren M. Anderson, Project Officer, Missile Projects Branch, Division of Reactor Development. (Source: Department of Energy Archives.)



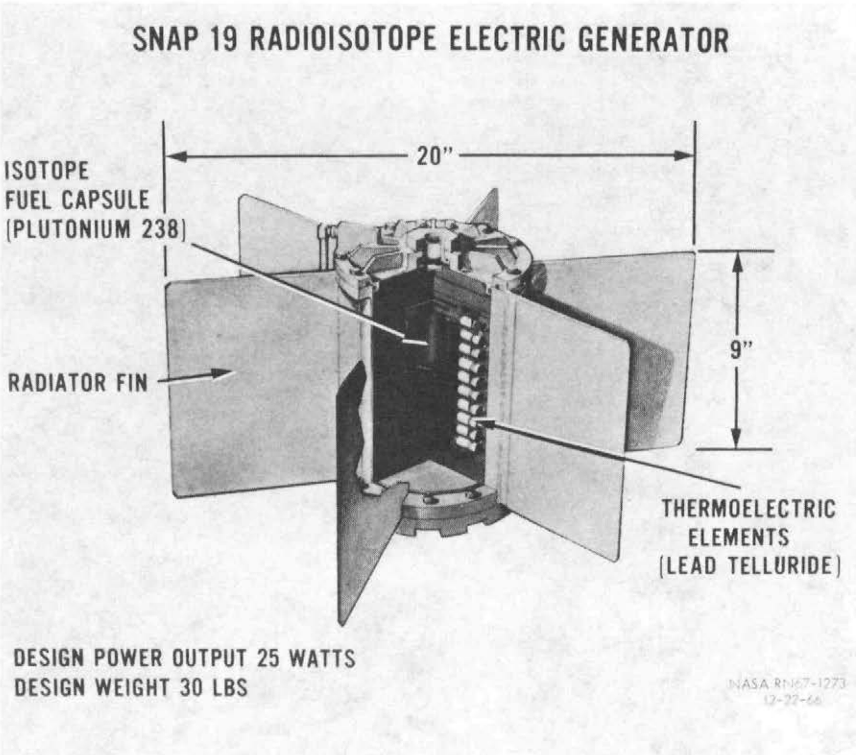
2

Glenn Seaborg (on the left) is shown the SNAP-9A by Robert Carpenter, of the RTG program, shortly after Dr. Seaborg took over as Chairman of the AEC early in 1961. (Source: Department of Energy Archives.)



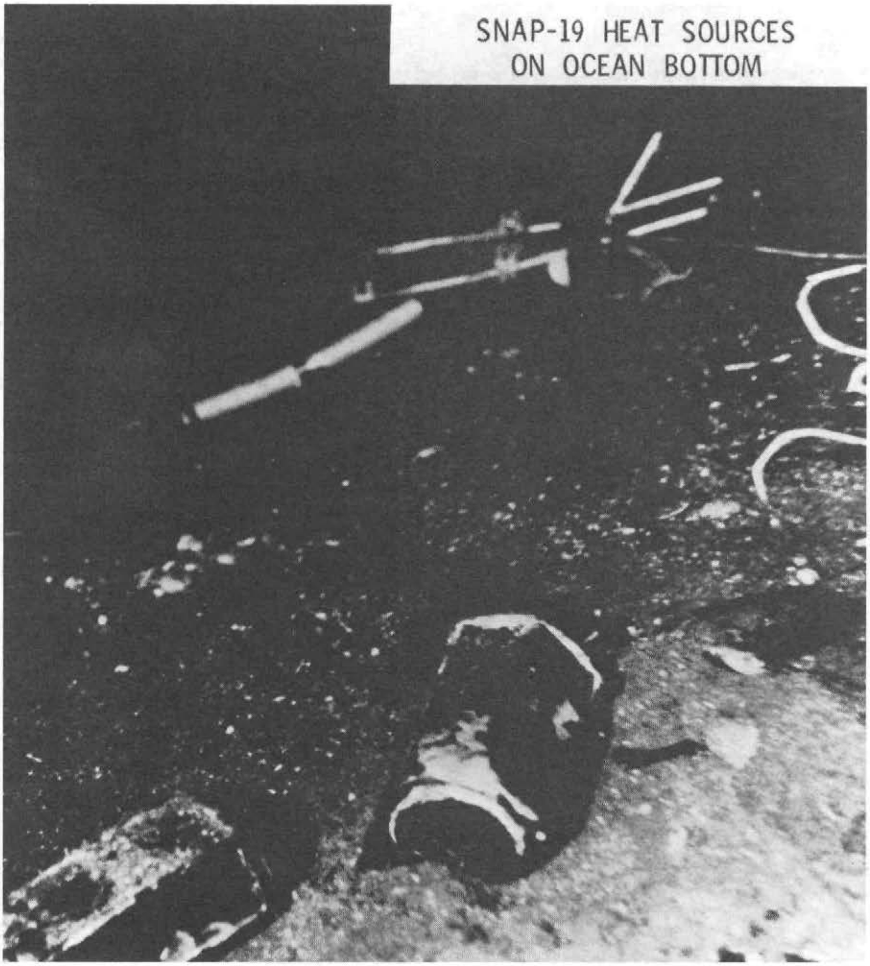
3

Paul J. Dick of the Martin Marietta Nuclear Division prepares to attach the SNAP-9A generator to the base of the Navy's Transit satellite prior to the launch on 29 June 1961 which marked the first use of atomic power in space. (Source: Teledyne Corporation.)



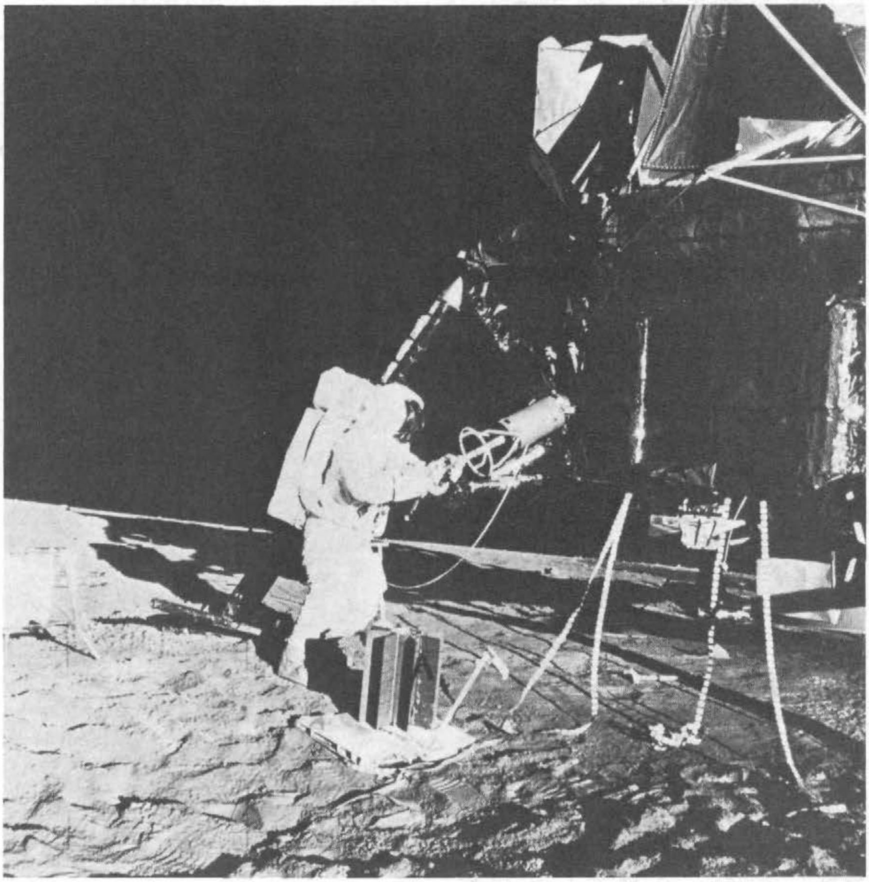
4

Cutaway illustration of essential features of the SNAP-19, developed by the Martin Marietta Nuclear Division and used, with modifications, on NASA missions beginning with the Nimbus weather satellite and including Pioneer to Jupiter and Viking to Mars. (Source: Department of Energy.)



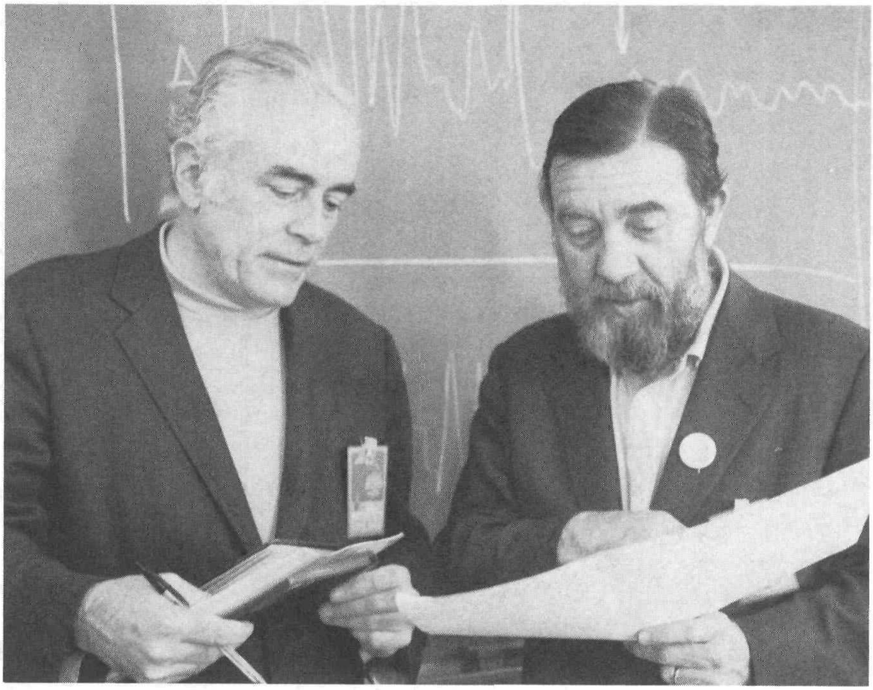
5

SNAP-19 heat sources photographed on the ocean floor of the Santa Barbara Channel after abort of the Nimbus weather satellite mission (launched on 18 May 1968) testing the first use by NASA of RTGs. Heat sources were recovered and re-used and a subsequent Nimbus launch provided a successful test of the RTGs. (Source: Department of Energy Archives.)



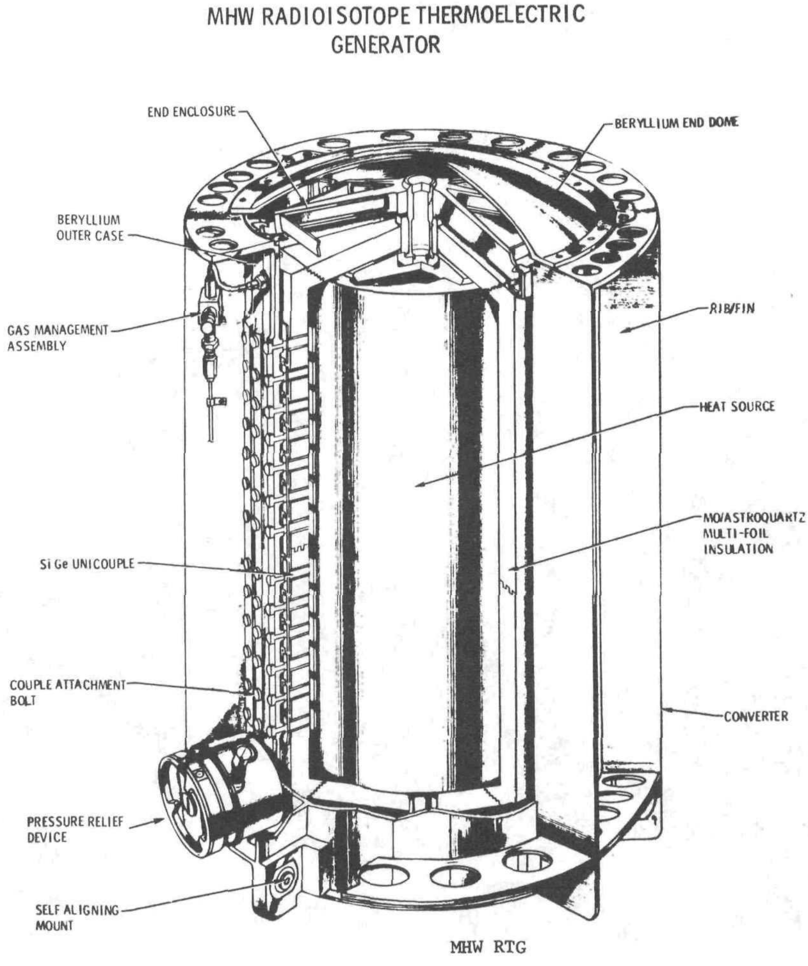
6

On the Apollo 12 mission (launched 14 November 1969) Alan Bean removes the heat source from its carrying cask in the LEM prior to inserting it into the SNAP-27 sitting at his feet on the surface of the Moon. Beginning with Apollo 12, SNAP-27s powered scientific experiments left behind on the lunar surface by Apollo astronauts; the experiments were finally shut down after many years although the RTG power was still meeting operational requirements. (Source: NASA Archives.)



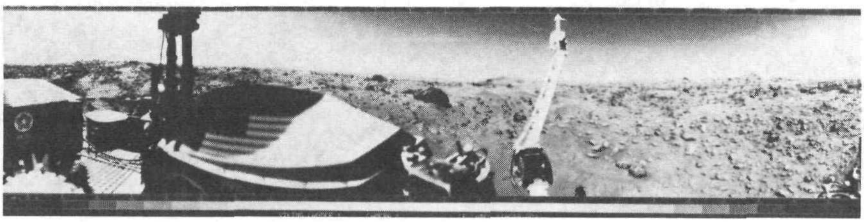
7

Dr. John A. Simpson (left) and Dr. James A. Van Allen, principal investigators involved with NASA's Pioneer 11 mission to Jupiter (using SNAP-19s for power), discuss preliminary estimates of Jupiter's intense radiation belts received at NASA's Ames Research Center at Moffett Field, California. Pioneer 11 entered and survived the region of Jupiter's most severe radiation on 2 December 1974. (Source: NASA Ames Research Center Archives.)



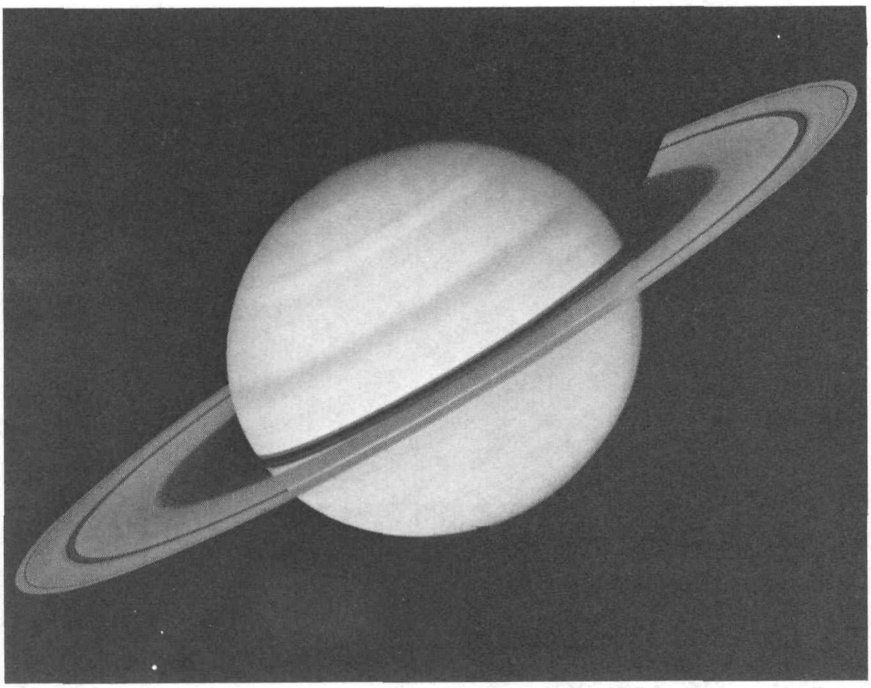
8

Cutaway illustration of essential features of the MHW RTG, the most advanced RTG used to date on space missions. The MHW is designed to meet power requirements in the multi-hundred watt range and was used on the LES 8/9 satellite missions of the Department of Defense and on NASA's Voyager missions to the outer planets. (Source: Department of Energy.)



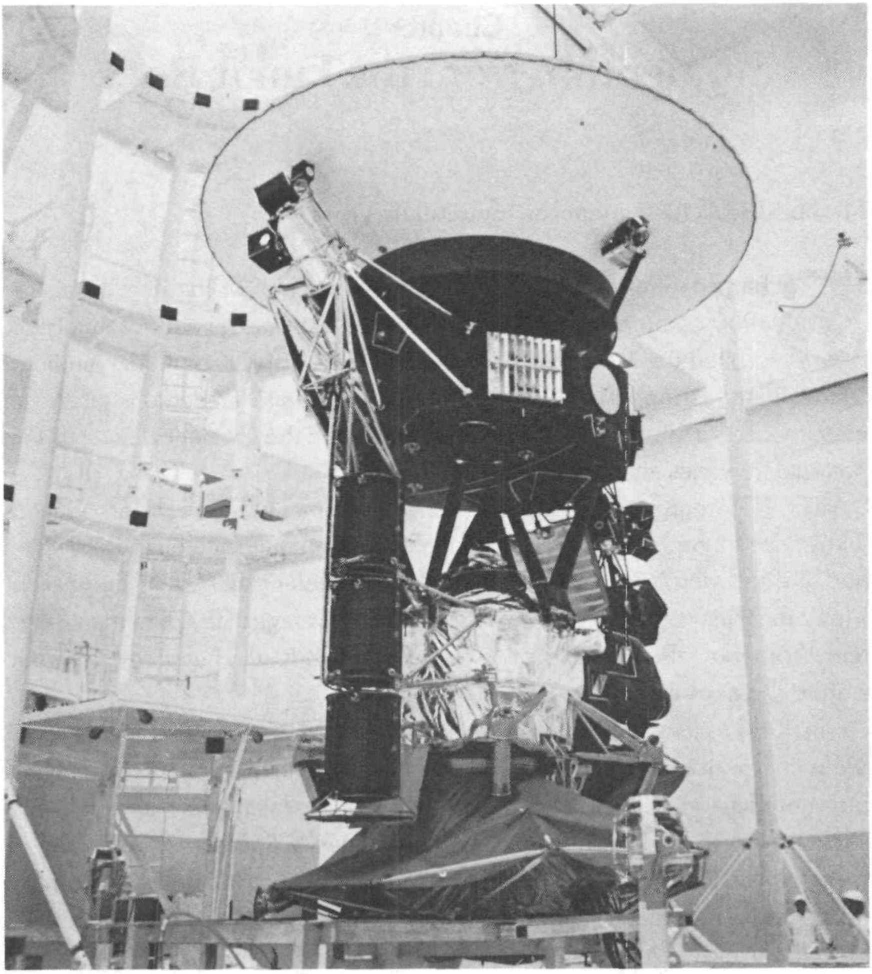
9

Sand dunes and rocks on the surface of Mars, photographed by Viking 1's camera on 23 July 1976. The American flags that can be seen are located on the two RTG wind screens, specially designed to protect the SNAP-19 RTGs from dust storms on the surface of Mars. (Source: NASA Archives.)



10

Saturn and its rings photographed from a distance of 11 million miles by NASA's Voyager 1 (powered by MHW RTGs) on 30 October 1980. Such spectacular views of distant space phenomena are made possible by RTG power which can operate regardless of the distance of a spacecraft from the sun. (Source: NASA Jet Propulsion Laboratory Public Information Office.)



11

The Voyager spacecraft awaiting encapsulation in the Spacecraft Assembly and Encapsulation Center at the Kennedy Space Center. The extendable boom on the left bears three MHW RTGs (stacked black cylinders), while the boom on the right carries science instruments shrouded in black thermal blankets. After launch, booms are extended to their full lengths and the RTGs providing electrical power are kept as far away as possible from the instruments they power. (Source: NASA Jet Propulsion Laboratory Public Information Office.)