Bruce R. Lundeen

BRUCE T. LUNDIN

1919–2006

Elected in 1976

"For leadership in aeronautical propulsion research and launch vehicle development."

BY ROBERT S. ARRIGHI
SUBMITTED BY THE NAE HOME SECRETARY

BRUCE T. LUNDIN played a crucial role in establishing the framework for the National Aeronautics and Space Administration (NASA) in 1958 and was an integral figure for nearly 35 years at the Cleveland laboratory that is now the NASA Glenn Research Center. He was an exceptional researcher and manager who pioneered significant areas in modern aeronautical propulsion, complex space programs, and new methods of energy conversion and conservation. He died on January 24, 2006, at the age of 86.

Bruce's efforts in developing thrust augmentation techniques such as the afterburner and in testing full-scale engines in altitude-simulating facilities led to industrywide advances. In the late 1950s he developed a document that spurred the National Advisory Committee on Aeronautics (NACA) to assume a primary role in the new field of space flight. Throughout the 1960s he spearheaded the center's development work, which included launch vehicles such as Centaur and Agena. After a brief transfer to NASA headquarters, he was named director of the NASA Lewis Research Center in 1969 (it later became the NASA Glenn Research Center). He guided Lewis through the most difficult period in its history by delving into energy-efficient engines, the development of alternative energy resources, and environmental monitoring

before retiring in 1977. His integrity, doggedness, and well-reasoned managerial style resulted in a number of major aerospace and energy accomplishments.

Bruce was born on December 28, 1919, and raised in Alameda, California. He earned his bachelor's degree in mechanical engineering in 1942 at the University of California, Berkeley, specializing in heat transfer. He then took a position in San Francisco with Standard Oil of California, where he participated in the design of power plants, water treatment plants, and pumping stations for oil refineries. At the time, the NACA was building a staff for its new Aircraft Engine Research Laboratory (AERL) in Cleveland. When a former professor recommended Bruce, the AERL offered him a mechanical engineering position. Engineering jobs in California were scarce at the time, and he accepted what he believed would be a temporary job and moved to the Midwest.

Bruce's initial AERL work involved the cooling and heat transfer of an Allison V-1710 piston engine for the P-39 fighter. He was responsible for determining the cooling characteristics of the multicylinder, liquid-cooled engine on a dynamometer test stand. But he was soon thrown into the secret new field of jet propulsion, and received a deferment from the World War II draft because of his ongoing research in this field. By the time the AERL restructured itself in October 1945 to concentrate on the turbojet and supersonic flight, 24-year-old Bruce had accumulated enough experience to be named head of the Engine Research Division's new Jet Propulsion Research Section.

Bruce and his roughly 15 research engineers tested a series of full-scale turbojet and ramjet engines. A major problem with early turbojets was the need to increase speed during takeoffs. The group's work between 1943 and 1946 yielded new thrust augmentation concepts such as the afterburner and variable-area nozzle, which remain basic elements of many modern jet aircraft. The afterburner had been proposed elsewhere, but Bruce's team was the first to create an operational version, with a variable-area nozzle whose size would increase or decrease at various stages during flight.

Bruce believed strongly that researchers learn by operating engines in large flight-simulating facilities, not by sitting at a desk. To facilitate these efforts he advocated the construction of the Four Burner Area (1947) and Propulsion Systems Laboratory (1952); the latter was the nation's most powerful facility with this capability. The altitude chambers at these facilities, whose design was more efficient than wind tunnels, could test actual engines in simulated flight conditions and became a standard tool for engine research.

Bruce received a brief promotion in August 1949 to become chief of the thermodynamics branch, with responsibility for about 30 engineers who analyzed engine cycles, propulsion systems, and basic thermodynamics in turbojets and ramjets. Just months later, he was named assistant chief of the Engine Research Division, and in 1952, at age 33, he was promoted to chief. In these positions he continued to oversee full-scale engine testing in simulated flight conditions. The research analyzed automatic control systems, exhaust systems, and complete propulsion systems. Exhaust nozzles, ejectors, directional controls, radiant heat transfer, and ramjets were all studied during these years. These investigations contributed significantly to the performance and reliability of modern commercial and military aircraft. One key development by the group in the 1950s was the reverse thruster, directing the jet engine's exhaust forward to quickly slow the aircraft when landing.

During this period Bruce was also responsible for establishing requirements for future aircraft and ramjet engines. He advocated the expansion of the AERL's research to spacecraft propulsion, seeing it as an extension of the NACA's aeronautical propulsion efforts. The Cleveland lab had done small-scale fuels studies for rocket engines since 1945, flight-tested ramjets for missile applications in the late 1940s and 1950s, and added a test stand for firing large rocket engines in 1955. Although others at the lab were also interested in space, Bruce was among the most outspoken.

In 1957, Bruce participated in the Research Planning Council with other NACA veterans to develop and coordinate

the lab's research goals and test facilities. The group members felt that the need for aircraft propulsion work was diminishing and should be replaced with additional space programs. Bruce famously recalled "that about half the staff was afraid of getting sucked into space and no longer protected to do their research in a quiet manner, and the other half of us, we were afraid of being left out of this new frontier." He felt passionately that the NACA should not only participate but coordinate all space-related research.

The launch of Sputnik in October 1957 resulted in widespread calls for the establishment of a national space program. One Sunday afternoon in December 1957, Bruce drafted "Some Remarks on a Future Policy and Course of Action for the NACA," outlining the formation of a new space agency based on the NACA structure. This seminal document advocated a broad range of space research to be coordinated by the NACA, warned against concentrating on any single project, and called for the establishment of a new laboratory dedicated to space. Updated by Associate Director Abe Silverstein and renamed "Lewis Laboratory Opinion of a Future Policy and Course of Action for the NACA," the report was presented to headquarters and served as the basic template for NASA.

With the establishment of NASA and the transfer of Abe Silverstein to headquarters in 1958, Bruce was named associate director, responsible for directing and planning research for the entire lab, which had been renamed the NASA Lewis Research Center. The Center expanded its space propulsion and power research during Bruce's tenure, with the development of electric, solar, and nuclear power–generating systems for spacecraft and high-energy chemical, electric, and nuclear propulsion systems.

Shortly after President Kennedy's April 1961 pledge to send Americans to the Moon within the decade, studies were undertaken to analyze various orbital rendezvous and direct ascent approaches to reach the Moon. Bruce led a team that was given one week to assess different Saturn boosters and consider the Earth orbit, lunar orbit, and combination of Earth and lunar orbit methods of rendezvous. The group, known as

the Lundin Committee, pressed NASA to continue to consider all options and emphasized the need to concentrate on launch vehicles and rendezvous options during Apollo's early stages. The committee felt that the rendezvous option would accelerate the Apollo program, permit the use of different size boosters, and save the money earmarked for the massive Saturn V boosters. The committee unsuccessfully lobbied for the use of a low-altitude Earth-orbit rendezvous using two or three smaller Saturn vehicles. A later, more detailed study supported the Lundin Committee findings, but the direct ascent method was eventually selected because it was deemed less complicated.

During this period Bruce was also asked to lead a group to investigate sites for the Manned Space Flight Center. NASA Administrator T. Keith Glennan originally restricted the search to sites near existing NASA centers, then narrowed it further to the NASA Langley or NASA Ames Research Centers. After discussing the matter with 20 aerospace officials in Washington, the group recommended a site near Ames. NASA initially agreed with Bruce's suggestion, but pressure from Congressional leaders resulted in the consideration of numerous other sites. Continued efforts by Vice President Lyndon Johnson, including a large donation of land, resulted in the selection of Houston.

Abe Silverstein returned to Cleveland as the director of NASA Lewis in November 1961. At the time there was some internal controversy at Lewis about the Center's overinvolvement in developmental work. Bruce, a strong advocate for its involvement in program management, suggested segregation of the research and development work. Lewis was restructured, with Bruce serving as associate director of development. The development staff, which increased from 200 to 800 in just three years, moved into the new Development Engineering Building located outside the main campus.

Bruce was responsible for hiring, negotiating contracts with industry, and managing multimillion-dollar budgets while continuing his oversight of electric propulsion, chemical propulsion, nuclear power generation, and nuclear rocket

systems. By 1962, he had established a centralized office to support four major chemical rocket programs: the M-1 engine for the Nova rocket, the J-2 and F-1 engines for Saturn, and the RL-10 engine for Centaur. The development group's work expanded with the addition of the Centaur program in 1962, the Agena rocket program in 1963, and the 260-inch-diameter solid rocket and supersonic transport programs in 1964.

The uniquely designed Centaur second-stage rocket, the first spacecraft to run on liquid hydrogen, was Lewis's most important contribution to the national space program. It was designed to transport Surveyor spacecraft to the Moon in order to explore possible landing sites for the Apollo missions. The NASA Marshall Space Flight Center was originally responsible for the Centaur program. After the explosion of the first launch attempt in May 1962, Marshall sought to cancel the program. Instead, NASA headquarters asked Abe Silverstein and Bruce Lundin to assume management and transferred the program to Lewis, where Bruce and Abe oversaw an extensive multiyear test and evaluation effort for the rocket. Centaur not only successfully completed the Surveyor missions but has carried over 100 satellites and interplanetary probes to date. Lewis's 35-year management of the Centaur program is one of its greatest achievements.

In May 1968 Bruce was transferred to NASA headquarters to serve as deputy associate administrator and then acting associate administrator for the Office of Advanced Research and Technology. After only eight months, he returned to Cleveland as the director of NASA Lewis after the retirement of Abe Silverstein. Nearing the end of a long career, Bruce did not discover a comfortable summit as director but rather a long season of turmoil.

Lewis had refocused its efforts in aeronautics in the late 1960s. Significant gains had been made in areas such as noise reduction, supersonic nozzles and compressors, and more efficient engines. The Apollo Program was winding down, however, and Lewis had virtually no direct participation in the development of the space shuttle. Budgets for nonshuttle programs were slashed. The Lewis staff was reduced by 700 by

1971, and the nation's nuclear rocket program was cancelled in late 1972, resulting in the closure of Lewis's subsidiary, Plum Brook Station. On January 6, 1973, Bruce personally informed the staff that the station was to be closed almost immediately. That year, another 800-plus employees left through dismissal or retirement. Bruce implemented a job placement program and prided himself on the fact that every separated employee found other employment.

Further tears were beginning to show in the fabric that held Lewis together. The Center's core management team, who had worked, raised families, and socialized together for more than 30 years, began retiring in the 1970s. In addition, Bruce was mandated by headquarters to begin using contractor labor for many of Lewis's technical and support positions. This led to increased internal tensions and shattered Lewis's cohesiveness at a time of already low spirits. In an effort to boost morale and generate staff support for Lewis's goals, Bruce instituted the Lewis Awareness Program in 1974, featuring talks by him, ceremonies, film specials, and newspaper articles to recognize Lewis's accomplishments, programs, and staff.

Bruce sought new areas of research for Lewis and increased research on energy-efficient engines and noise reduction for the airline industry. He was convinced that the staff's long history of energy conversion work for space applications could be applied to new methods of clean and renewable energy. In the midst of the oil embargo, Lewis undertook a wide range of alternative energy programs. One of the most successful was a wind energy program in partnership with what is today the Department of Energy; it set a precedent for what has become an entire wind turbine industry. Lewis also developed solar-powered electric systems for remote areas and towns, batteries for electric automobiles, and the efficient Stirling automotive engine. In these ways Bruce successfully molded Lewis into a leading energy-conversion laboratory.

Lewis also began a number of environmental monitoring programs. Bruce reached agreements with the city of Cleveland to assist with pollution testing; aircraft were used to collect air samples and to map shipping channels on the frozen Great

Lakes; and the Brayton engine was developed to reduce automobile emissions.

Lewis's greatest achievements during Bruce's tenure were in the Launch Vehicles Division. The group was responsible for not only maintaining and updating the Centaur rocket but also integrating the payload with the Atlas and Titan boosters. More than 30 high-profile missions were launched during Bruce's term, including Pioneer 10, the first spacecraft to explore the outer solar system; Mariners 6 and 7, which mapped Mars; Mariner 10, which orbited Venus and Mercury; and the Viking spacecraft, which placed two rovers on the Mars surface.

Overall, however, the Lewis Center continued to struggle under a somewhat strained relationship with NASA headquarters, difficulty convincing the energy industry to use renewable resources, and requirements to continually reduce its workforce and operating budget. There were even rumors that Lewis would be transferred from NASA to the Department of Energy. Despite the difficult circumstances, Bruce was able to maintain Lewis's preeminence in aircraft engine research, launch vehicles, and power generation.

Bruce retired in 1977 after 35 years of federal service. His achievements were recognized throughout his career, beginning in 1953 when he received the Cleveland Technical Society Council's Technical Award. He went on to receive NASA's Medal for Outstanding Leadership in 1965, Public Service Award in March 1971, and in October of that year NASA's highest award, the Distinguished Service Medal. In 1966 he was selected to deliver the Jennings Scholar Lecture, in 1975 he was awarded an honorary doctor of engineering degree by the University of Toledo, and in 1976 he was elected to the National Academy of Engineering and also presented with the National Space Club's Astronautics Engineer Award.

Bruce chaired the NASA Investigation Board for the Skylab mission in 1973 and the NASA Seasat Failure Review Board in 1978. He also served as staff director and consultant to the chairman of the President's Commission on the Accident at Three Mile Island in 1979 and participated in the Wakefield

Overview Commission. He was a member of the US Air Force Scientific Advisory Board and of the NASA Aerospace Safety Advisory Panel. In 1980 he cochaired the Atlas-Centaur Review Board, which strongly recommended continued use of Centaur despite the availability of the new space shuttle vehicles.

He was a fellow of the American Institute of Aeronautics and Astronautics, American Astronautical Society, and Royal Aeronautical Society, and a member of Tau Beta Pi, Sigma Xi, and the American Society for Public Administration. He wrote over 40 technical papers, including the chapter on ramjet engines in the Princeton series on High-Speed Aerodynamics and Jet Propulsion and an influential postwar report that summarizes the NACA's afterburner development.

In addition to this service, Bruce was a frequent spokesman for NASA in the community and was also active in various civic, religious, and educational organizations, such as the Federal Executive Board, the Combined Federal Campaign, the Southwest Community Hospital of Berea, Ohio, and the Boy Scouts of America, from which he received the Order of Merit. He sponsored Explorer Scout Posts in electronics and aerospace for top science students and opened the NASA Explorer Posts to a wider community. He also served as the district chairman of the southwest suburbs and led its sustaining membership enrollment drive for several years. He was named chairman of the Cleveland Executive Board.

Bruce had a long, distinguished career as an engineer, manager, and director of major programs. His efforts provided a firm foundation for subsequent achievements in aeronautics, space, and energy. He continually demonstrated outstanding leadership in planning research, organizing resources for effective and timely execution, and inspiring extraordinary efforts from his staff to solve complex problems.

He was a personable and very human man who enjoyed nature and woodworking when not engaged in his aerospace work. He built much of his family's furniture, toys, and accessories. In his house overlooking a wooded ravine just outside Lewis's rear entrance he maintained an extensive library on a variety of topics.

Bruce is survived by his widow Jean, daughters Dianne and Nancy, son Robert, three grandchildren, and two great-grandchildren.