WILLIAM EDWIN GORDON was born in Patterson, New Jersey, on January 8, 1918. His father, James William Gordon, was born in England in 1878 and immigrated to the United States around 1905; his mother, Mary Scott Williamson, was born in Patterson in 1883 to parents who had emigrated from Scotland. James Gordon worked as a sales representative for the Waterman pen company, whose office was in New York City, and his territory included areas in nearby New Jersey.

Bill attended public schools in Totowa Borough and then enrolled at Montclair (NJ) State Teachers College, where he obtained a BA in mathematics (1939) and an MS in educational administration (1942), and taught in junior high schools in the northern NJ towns of Mendham and Oradell. At Montclair State, he met Elva Freile, who had grown up in nearby Teaneck. They were sweethearts throughout college and married in June 1941.

Adapted with permission from Biographical Memoirs of the National Academy of Sciences (available online at www.nasonline.org/memoirs), where his tribute includes more technical detail. The authors thank Kenneth Bowles, Dale Corson (NAS/NAE), Donald Farley, Nancy Ward, Paul Cloutier, and the Woodson Research Center of the Fondren Library at Rice.
Bill enlisted in the Army Air Corps in 1942 and was assigned to study meteorology at New York University, from which he earned a second MS in 1946. He ended his service as a captain in the Air Corps in Austin, Texas, where he and his family stayed so he could continue to work on radio wave propagation. In 1948 they moved to Ithaca, NY, as Bill pursued studies in electrical engineering (EE) at Cornell University. The Gordon family grew to include two children, Larry and Nancy.

After studying with Edwin Hamlin and Henry Booker (NAS), Bill received his PhD degree in 1953 and became an associate professor in Cornell’s School of Electrical Engineering. In 1959 he was appointed professor, and in 1965 he was named the Walter R. Read Professor of Engineering.

In his early years Bill was de facto the leader of the tropospheric research program, and part of a lively group of EE students and professors who met in a weekly seminar on radio wave propagation. In a seminar in April 1958 he presented his ideas for what became the Arecibo radar—the first public presentation of the concept of a large ionospheric scatter radar.

That summer Bill assembled a group to study the radar, and in December they published a report with design parameters and a brief discussion of experiments and observations that the 1000-ft radar could support.¹ The report also discussed sinkholes in karst regions that might serve as a natural bowl to support a large reflector.

Gordon led the design team in 1958, and also promoted the dish in Washington. The Advanced Research Projects Agency (ARPA) had just been formed, and its mission included support of studies of the ionosphere. In late 1959 ARPA provided funds for an engineering study of the radar and, in June 1960, funds for construction. Excavation at the site in Puerto Rico, 12 miles south of Arecibo, started in September.

Bill moved with his family to Arecibo to manage the construction. A few other families joined the Gordons, and the

group became and remained very close. The development effort at the site was intense, but balanced by swimming and shell collecting at nearby undeveloped beaches, along with trips around Puerto Rico and to other Caribbean islands.

The radar was dedicated in November 1963 as the Arecibo Ionospheric Observatory, and Bill became its first director and leader of the ionospheric research group. Within five years he had invented, promoted, and overseen the design and construction of the world’s largest scientific radar and radio astronomy system. He later said these were the best five years of his life.

The Arecibo Observatory has always been regarded as an engineering marvel. In 2003 it was designated both a Milestone in Electrical Engineering and Computing by the IEEE and a Historic Mechanical Engineering Landmark by ASME. In 2008 it was listed on the National Register of Historic Places by the National Park Service.

In 1965, having exceeded Cornell’s extended leave for faculty, he reluctantly moved back to Ithaca. Just one year later he was recruited by Rice University president Kenneth Pitzer to serve as dean of science and engineering and professor of space science. Pitzer had a vision for Rice that included its development as a major research university of international stature, with strength in the arts and humanities as well as science and engineering, and with excellent graduate as well as undergraduate programs. Bill was intrigued by the chance to be part of Rice’s transformation, and the move eliminated the strains of dealing with Arecibo management issues at Cornell.

He had no way of knowing how challenging his new task would turn out to be, and how quickly he would be tested in his new job. The ambitious research vision for Rice was not shared by all of the university’s board of trustees, many of whom were concerned that Rice would lose its focus on quality undergraduate education by diverting resources to graduate study and research. When Pitzer left to accept the presidency of Stanford University, the board appointed an executive committee to run the university while a search was conducted to find the new president. Bill was named chair of
that committee and essentially functioned as interim president. A faculty committee was formed to consider candidates and make recommendations to the board. Unfortunately, the board chose and named a new president without consulting the faculty committee, resulting in a major faculty protest. Bill, having been at Rice only a short while, found himself in a very difficult position but never wavered in his judgment that the board had indeed acted improperly. In March 1969 the board dissolved the executive committee and appointed an acting president. Bill was appointed vice president (one of four) and remained dean of engineering and science. In the view of Rice faculty who were there at the time, Bill’s determination to follow through on Pitzer’s vision was a turning point for the university. After a second presidential search, this time with faculty involvement, the board announced that chemist Norman Hackerman (NAS) would be Rice’s fourth president.

Bill continued as dean of science and engineering, and then dean of natural sciences (now the Wiess School of Natural Sciences) after engineering was split off as its own school. In 1980 President Hackerman named Bill as provost and vice president, a position he held until his retirement in 1986.

During his two decades of service in the administration, Bill was a major force in Rice’s rise to a leading national research university. As dean and provost he used his legendary powers of gentle persuasion, and financial incentives where appropriate, to increase the faculty ranks of women and members of other underrepresented groups, especially in science and engineering. He enhanced interdisciplinary research, insisted on fair and balanced evaluation of faculty for promotion and tenure, ensured that faculty in non–science and engineering fields were appropriately recognized for their scholarship and other creative endeavors, strengthened the undergraduate curriculum and teaching (he felt communication skills should receive greater emphasis across the curriculum), and eased Rice through the transition from expensive mainframe computers to personal computers.

He also stressed the importance of science and engineering majors studying the arts, humanities, and social sciences
to better understand the proper role of technology in society. And in an effort to encourage dialogue across the intellectual boundaries of the campus and foster a true community of scholars, he created the Provost’s Lecture Series and encouraged faculty to discuss their research and scholarly activity with those in other fields as well as the broader Rice community. To this end, he established the Rice faculty organization Scientia, brainchild of mathematics professor Salomon Bochner (NAS), to broaden the conversation across traditional intellectual cultures. Now called the Scientia Institute, it remains a vital organization.

Besides his very effective administrative skills, Bill’s productive scientific and technical career spanned different fields over the decades, starting with his focus on radio wave propagation (1942–57). At the University of Texas in Austin, he investigated anomalous radio propagation due to vertical stratification, or ducting, and tropospheric radio wave propagation. He developed the idea that atmospheric “blobs,” or turbulence, with corresponding fluctuations in the refractive index of air were responsible for some of the peculiar radar echoes that he saw. He remained interested in turbulence and its effect on radio wave propagation throughout his career.

Bill’s PhD thesis was on atmospheric turbulence and the resulting scatter propagation of radio waves. This work was restricted to the troposphere, the part of the atmosphere below about 10 km, where water vapor is important and the maximum range for scatter communications is about 700 km. Longer-range propagation was due to scattering in the stratosphere, the dry region above about 10 km, but few direct measurements of the dielectric constant in the stratosphere existed. Theoretical reasoning was used to estimate the fluctuations and the scattered power, and successfully explained scatter propagation from the troposphere, to distances of about 1000 km at frequencies from 100 to a few thousand MHz.

Scatter propagation via the ionosphere was also of interest. Scattering on field-aligned irregularities in electron density was important for a number of phenomena, including echoes from the aurora, and for radio wave propagation to 2000 km. The ionospheric region responsible for these effects was from about 70 to 300 km above the Earth. Gordon considered the possibility of getting sufficient scatter from higher levels, but concluded that the signals would be too weak to allow long-range communication. At that point apparently he had the idea to stop thinking in terms of eddies or irregularities established by turbulence, and to think instead of scattering from the individual electrons acting incoherently. He calculated the strength of the forward-scattered signal to be expected with this mechanism, and found that the signal would be much too weak for communications. But then he took the crucial step of estimating the signal to be expected if the antenna were directed vertically, rather than horizontally, as in applications to over-the-horizon communications. The signal was still weak but strong enough to detect with sufficient averaging, and this could give the electron density in the scattering region.

This was the birth of incoherent scatter radar, an area in which Bill was particularly active in 1958–65. His first estimate of the signal to be expected from the incoherent scattering of radio waves on electrons in the ionosphere was made early in 1958. He worked out the required properties of a radar that could measure the density and temperature of the electrons in the ionosphere to a height of 1000 km. Using readily available components at a frequency of a few hundred MHz, the antenna would need a diameter of about 1000 ft (305 m). The main assumption was that the electrons scattered the incoming radiation according to the Thomson formula, and the elementary scattered waves added independently to form the total echo. The density was obtained from the strength of the echo and the temperature from the width of the spectrum of the echo, as each elementary echo contained a frequency (Doppler) shift according to the vertical component of the electron’s velocity.
Bill published an article in late 1958\textsuperscript{3} that described the radar and its capabilities. His ideas were largely confirmed by Kenneth L. Bowles, who showed that Gordon’s calculation gave roughly the correct back-scattered power—but that the width of the spectrum was narrower than expected, allowing for a much greater range of experimentation.

The radar of the Arecibo Ionospheric Observatory was designed to measure density and temperature up to 1000 km, and for three decades (1966–97) Bill and his students exploited the system in ionosphere experiments. They verified the theoretical calculations showing that for a certain range of the ratio of the radio frequency wavelength to the Debye length (the “screening distance” around a charged particle), the echo was concentrated in a narrow “ion line” controlled by the ion mass and not the electron mass. This meant that in this range the system was two orders of magnitude more sensitive than had originally been thought, and this opened up many avenues of research into the ionospheric plasma.

An upward radio wave in the ionosphere, at a frequency below the critical (penetration) frequency, will be partially absorbed near the level where the wave frequency equals the local plasma frequency. If the wave is strong enough, substantial heating can occur, and parametric instabilities will induce large fluctuations in the densities of both ions and electrons. To study these effects a 100 kW transmitter at 5.6 MHz was added to the Arecibo system in 1967. Larger and more versatile transmitters were later added, and in 1980 a new heating facility consisting of a powerful transmitter and an array of log-periodic antennas was built at Islote, Puerto Rico, 4 miles northeast of the observatory. The high-frequency wave (3–30 MHz) heats the plasma, while the 430 MHz radar is used as a probe to study the heated region. With students and collaborators, Gordon conducted heating experiments using this equipment and published papers spanning the years 1971 to 1991.

In addition to his research, teaching, publishing, and administrative leadership, throughout his career Bill consulted with industry, served as an advisor to federal agencies and national and international scientific organizations, and in other ways served the professional community and public. His many professional service activities included work with the International Union of Radio Science (URSI; international vice president, honorary president), Institute of Radio Engineers (chair, Professional Group on Antennas and Propagation), Upper Atmosphere Research Corporation (chair, 1971–72, 1973–78), University Corporation for Atmospheric Research (chair, board of trustees, 1979–81), Cornell University Board of Trustees, and more than 60 advisory and review committees for the National Science Foundation (NSF), Stanford Research Institute, US Information Agency, National Academy of Sciences (NAS), National Academy of Engineering (NAE), and National Research Council (NRC).


In recognition of his engineering and scientific accomplishments, and for his numerous public services, Bill was elected to and received awards from many organizations. He was elected to the NAS in 1968 and served as foreign secretary (1986–90), and elected to the NAE in 1975. He was a foreign associate of the Engineering Academy of Japan and a fellow of the American Academy of Arts and Sciences, American Association for the Advancement of Science, American Geophysical Union, and Institute of Electrical and Electronics Engineers.

He received URSI’s Balthazar van der Pol Gold Medal (1966) for “Development of the incoherent scatter technique
for ionospheric studies,” the American Meteorological Society Medal (1969), the NAS Arctowski Medal (1984) “For his pioneering development of theory and instrumentation for radar backscatter studies, which opened a broad field of research in the high altitude ionosphere,” a Medal Commemorating 100 Years of International Geophysics from the USSR Academy of Sciences (1985) for distinguished contributions in international geophysical programs, and the Centennial Medal of the University of Sofia (1988).

Bill thought about science beyond the boundaries of his own work. In a lecture to Rice alumni in 1977 he discussed scientific creativity. Creativity, he said, usually results from a confluence of factors:

- the problem is available and the time is right;
- youthful spirit, a mix of logic and emotion;
- preparation, hard work, insight, intuition;
- combination of approaches;
- realization that thinking is a lonely, individual process, but colleagues are essential;
- joy of discovery; and
- beauty of the product.

He explained the role of technology to the Society of Rice University Women in 1984:

Technology is an art, an art of converting in a systematic way the work of scientists and engineers into products and processes that materially enrich civilization. The scientist’s goal is knowledge, the engineer’s goal is design, i.e., applying knowledge in a useful practical way, the technologists are the artists who efficiently and economically produce, in the needed quantities, the products or processes.

Bill was one of the most highly principled people any of us are ever likely to meet. His honesty and integrity were legendary on matters large and small. And he was in all things a gentleman. After a trip with a group of Rice alums to observe and talk about Halley’s Comet, he received a letter penned by
a member of the group with the heading “Tribute to Professor William Gordon from the Travel Group.” The letter said it all:

We could scarcely ask for a better companion, or a more qualified teacher. From my short experience here I am confident Bill is the kind of teacher Shakespeare had in mind when he wrote in *Henry VIII*: ‘He was a scholar and a good one; exceeding wise, fair-spoken, and persuading...(and) to those that sought him, sweet as summer.

Bill was also well known and highly respected in federal policy circles, largely through his service on many advisory committees and as NAS foreign secretary. He had opportunities to hold high-level positions with the federal government but his heart was in academia. In a 1993 letter to NSF director Ed Knapp, who had expressed interest in recruiting Bill to an important position at the foundation, Bill wrote:

Were you to offer and I to accept a position...for a few years, I would find myself then ready to retire from academic life but having lost my already tenuous grip on an active career as a scientist.... In contrast if I continue as professor and administrator, I don’t lose my grip on a continuing career as an experimentalist and I find myself with something to retire to, not something to retire from.

Bill was a model civic scientist, not only because of his many services to the science and engineering community and federal agencies but also by virtue of his public outreach and speaking to community organizations, churches, and schools. In addition to talking about his passion—space and atmospheric physics, and Arecibo in particular—he addressed pressing national concerns such as energy and climate change.

In the 1970s he began to alert fellow scholars and especially business and community leaders to the potential impacts of climate change, warning that while the threat was long term, it was time to start paying attention. As the years passed with little policy progress Bill became convinced that the problem of global warming and climate change was becoming urgent. In a lecture to the Rice faculty in November 1986, he asked,
The world we live in, will it survive? Are we abusing it in ways that may not be reversible?... Man’s economic and technical activity, even providing his food, fuel, and housing, contributes to significant global changes. The enemy is us.

Bill liked to raise tropical plants he discovered in Puerto Rico and sail his boat Dulcinea on Galveston Bay. The family spent many summers at their lakeside cottage on Cape Cod, where they enjoyed sailing and the visits of friends and relatives.

Elva died in February 2002. In 2003 Bill married Mary Elizabeth (Liz) Bolgiano and moved to Ithaca, where she had lived for over 50 years. Bill and Elva had been friends with Liz and her husband, Ralph, who had been on the engineering faculty at Cornell and was now also deceased. Liz was a wonderful partner for Bill in their adventures and travels, until his passing February 16, 2010, at age 92.

Liz died in 2015. Bill is survived by his son Larry (Christine) and daughter Nancy Ward (George), four grandchildren (two of whom attended Rice: Amanda Gordon graduated in 1998 and George Ward in 2001), and three great-grandsons.