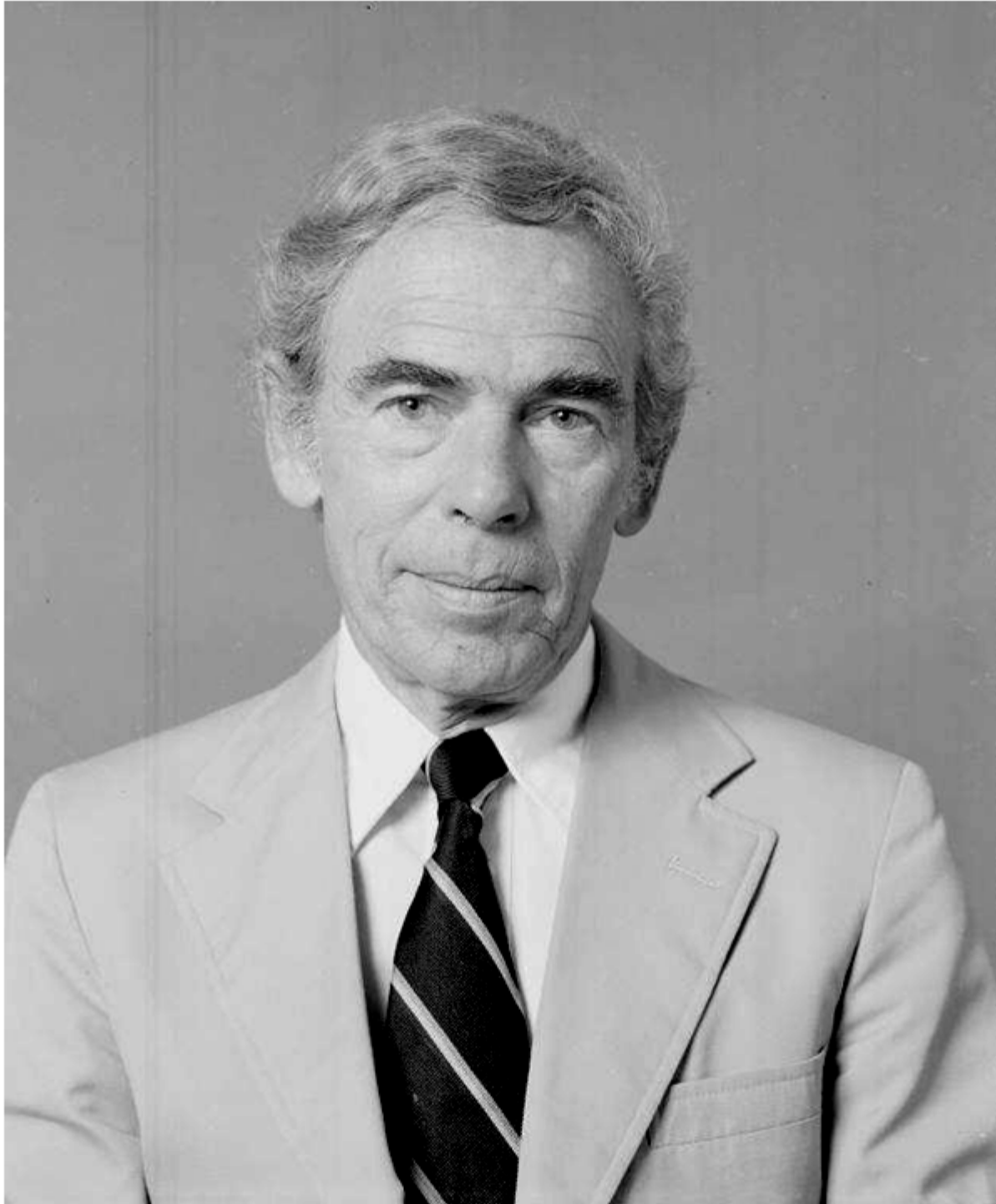


# Edward Allan Frieman Biography

Dennis Monday



Edward Allan Frieman was born January 19, 1926, in New York City, the son of Joseph and Belle Davidson Frieman. He entered Columbia University on the U.S. Navy V-12 program and received a B.S. in electronics in 1946. He received a M.S. degree in 1948 and a Ph.D. in 1951 in physics from the Polytechnic Institute of Brooklyn. His doctoral dissertation was entitled, *The Proton-Proton Reaction and Energy Production in the Sun*. His advisor was Professor Lloyd Motz. Frieman married Ruth Rodman on June 19, 1949; they had four children. After her death, he married Joy Fields on September 17, 1967.

Frieman was trained by the navy as a hard hat diver in the Hudson River. He was commissioned an ensign and assigned to Joint Task Force One in 1946 and participated in the atomic bomb tests at Bikini Atoll. He later said that observing the tests made a deep impression upon him. Frieman continued in the Naval Reserve after his discharge from active duty and returned to New York to complete his graduate education.

Frieman went to Princeton University in 1952 to work on Project Matterhorn. He worked with John A. Wheeler in the nuclear weapons program. Lyman Spitzer Jr., chairman of the Princeton Astronomy Department, started Project Matterhorn with research funds from the U.S. Atomic Energy Commission to work on fusion research. The project was classified. Frieman was a research associate on the project 1952-1953. After the nuclear weapons program was completed, Spitzer asked him to head the theoretical division in 1954, a position he held for ten years.

Frieman met a number of prominent physicists during his Princeton years including Enrico Fermi, John von Neumann, J. Robert Oppenheimer, and Edward Teller. Frieman first visited the Los Alamos National Laboratory in connection with his Project Matterhorn work, and there he met Kenneth W. Watson, Keith A. Brueckner, Marvin L. Goldberger, Francis E. Low, and Geoffrey F. Chew. Frieman also got to know Hans A. Bethe, whom he had met as a graduate student, during this time. Frieman met Albert Einstein and attended his seminars at Palmer Laboratory at Princeton.

Frieman has acknowledged the influence of Wheeler and Spitzer on his life as a physicist. Frieman later commented that he learned how to bring physical insight into research and how to make the right approximation at the right time from Spitzer. Spitzer asked Frieman to remain at Princeton in 1961 when the Plasma Physics Laboratory was established under Spitzer's direction. Frieman joined the Princeton faculty that year as Professor of Astrophysical Science and had several students. One of these was Charles F. Kennel. Frieman served as Associate Director of the Plasma Physics Laboratory 1964-1979. While at Princeton, Frieman met Admiral Bobby Ray Inman who introduced him to the world of submarines, military strategy, and naval tactics. Frieman served as a member of the Princeton Plasma Physics Laboratory Advisory Committee 1987-1990.

Frieman developed a reputation as a leader in plasma physics and fusion theory. His early work developing the Energy Principle for ideal plasma stability allowed him and his colleagues to explore the complex ramifications of macroscopic equilibrium and stability of Spitzer's stellarator concept, profoundly affecting fusion research. Frieman unified the field of plasma kinetic equations by use of multiple time-scale analysis, synthesizing the collisionless Vlasov equation, hard collision Boltzmann, grazing Fokker-Planck, and nondominant Balescu-Lenard equations into a single kinetic framework. Frieman and Paul H. Rutherford contributed basic formulations to the theory of drift waves that opened this area of research to wider investigation. Frieman became active in a number of scientific organizations during his Princeton years and began working as a consultant for government and industry. He served as a consultant for Los Alamos Scientific Laboratory in 1952. He was a consultant for the University of California Radiation Laboratory 1954-1957. He was a member of the board of directors of the Aeronautical Research Association of Princeton. In 1959, he became a consultant for General Atomic Corporation and United Aircraft. His life-long association with the National Aeronautics and Space Administration (NASA) began in 1959 when he served as a member of its Research Advisory Committee.

In 1958, John A. Wheeler and two other Princeton professors proposed the establishment of a body of scientists who could advise the government on highly technical matters connected with national security. The proposal was approved by the President's science advisor James R. Killian and JASON was established with ARPA funding in 1960. Frieman became a member of JASON in 1960. Frieman and other JASON members had high-level security clearances and discussed technical problems including nuclear weapons issues. During the 1970s JASON met in La Jolla, California, annually for summer study and Frieman got to know the community and enlarge his acquaintance among West Coast scientists.

Frieman was a member of JASON from 1960 to 1979, when he entered government service, and again from 1981 to the present. During his years at JASON, Frieman worked mainly on technical problems of interest to the U.S. Navy. He chaired JASON 1976-1978. During these years, he set up finance and program committees. In 1960, Frieman became a consultant for the Department of Defense. In 1961, he became a member of the Weapons Systems Evaluation Group (Watson Committee). He was a senior research fellow of the National Science Foundation in 1964. He served on the Board of Trustees of Jersey City State College 1968-1975. He was a member of the Board of Editors of the American Physical Society, serving as an editor of *Physics of Fluids* 1964-1966, and the *Physical Review* 1966-1967. In 1977 he was a consultant to the Energy Research and Development Administration (ERDA) Office of Laser Fusion, and in 1978 he joined the Naval Research Advisory Committee.

Frieman left Princeton in 1979 to accept a position at the Department of Energy (DOE) as Director of the Office of Energy Research and Assistant Secretary at the invitation of President Jimmy Carter's administration. This position had been previously held by several scientists with backgrounds in fusion research. Frieman succeeded John M. Deutch who was promoted to Assistant Secretary in DOE. Frieman had met Deutch in the 1960's, but they became closely acquainted during their years at DOE, and their paths often crossed in later years. Deutch mentored Frieman in government service. Frieman was initially interviewed by DOE Secretary James R. Schlesinger, but his appointment was significantly delayed when Schlesinger left DOE and was succeeded by Charles W. Duncan Jr., who supported the selection of Frieman for the post. Senator William H. Bradley oversaw Frieman's confirmation by the Senate on December 11, 1979, and it was during this process that Frieman first met Senator Albert Gore Jr. Frieman had complex responsibilities at DOE. All DOE laboratories except the weapons labs reported to him. He was responsible for establishing a consistent national energy plan, getting it through Congress with funding by the Office of Management and Budget. During Frieman's years at the department the basic research budget was increased under both the Carter and Reagan administrations. The country was in the midst of an energy crisis, and Frieman restructured the fusion program and worked on energy technology. During his years at DOE, Frieman participated in a number of public discussions of controversial scientific issues including synthetic fuels, disposal of nuclear waste, and DOE funding of atmospheric carbon dioxide research. It was during this period that Frieman became familiar with the climate change issue that had far reaching implications for energy policy.

Frieman developed a wide circle of acquaintances in Washington. His assistants at DOE included Marvin Moss, who later followed him to Scripps Institution of Oceanography, and Gregory H. Canavan. Canavan was a White House Fellow who had been educated at the Air Force Academy and at the University of California, Davis. He had been an Air Force colonel before entering government service. Canavan directed the DOE Office of Inertial Fusion. Canavan became Plasma Physics Group Leader at the Los Alamos National Laboratory in 1981 and later worked on analyses for the Strategic Defense Initiatives Organization. Canavan and Moss often worked with Frieman in later years.

Frieman got to know Frank Press, Science Advisor to President Carter and Director of the Office of Science and Technology Policy (OSTP) in the White House. He interacted frequently with George A. Keyworth, who was then at Los Alamos National Laboratory. John M. Deutch introduced Frieman to H. William Menard, Director of the U.S. Geological Survey and many other scientists working in key positions in Washington. Frieman and Richard C. Atkinson, Director of the National Science Foundation, worked together often during this period. Frieman's contacts in science policy circles in Washington increased his effectiveness at DOE. He counted many of the men he worked with during these years as personal friends. He had an opportunity to observe and participate in the process of setting national priorities in science. He gained knowledge in government administration and funding for science, and saw how science controversies played out in public and in Washington.

One of the problems Frieman encountered at DOE concerned the measurement of atmospheric carbon dioxide that was central to the discussion of global climate change. In 1978, DOE absorbed the Energy Research and Development Agency (ERDA) that had previously been part of the Atomic Energy Commission. ERDA was

one of the sponsors of Charles David Keeling's research at the Scripps Institution of Oceanography, University of California, San Diego. Keeling had long measured atmospheric carbon dioxide and demonstrated its steady increase during two decades. While the effects of this increase were debated, no scientist questioned Keeling's data. There was great uncertainty within the government as to whether Keeling's research should be funded by the National Science Foundation, the Department of Energy, or the National Oceanic and Atmospheric Administration (NOAA). This uncertainty was threatening the continuation of Keeling's research. Scripps director William A. Nierenberg appealed to Frieman, who insured Keeling's continued funding by DOE and made the department the government's lead agency in carbon dioxide research.

The energy implications, environmental effects, and societal consequences of an increase in atmospheric carbon dioxide were very important topics discussed in scientific circles during Frieman's years in Washington. It was during this period that he became involved with scientific and public policy committees interested in monitoring climate on a global scale and making environmental policy.

While the position of Director of Energy Research, Department of Energy was designed to be a scientific rather than political appointment, Frieman was forced out when the Reagan administration replaced Carter. Frieman decided not to return to Princeton and resigned from the Princeton faculty on June 30, 1981 in order to move west.

Frieman accepted a position as Executive Vice President and Group Manager for Science Applications International Corporation (SAIC) in La Jolla, California. SAIC is a high technology research and development firm founded in 1969 by John R. Beyster of General Atomic as an employee-owned corporation. Its headquarters are in La Jolla, but it maintains many facilities at various locations across the United States, and in the 1990s it established several international divisions.

During the early years, SAIC employees worked on projects under government contract that concerned nuclear power and nuclear weapons effects studies. Much of this work was classified. During the 1980s, when Frieman joined the corporation, SAIC specialized in applying scientific engineering, computer, and systems technology to highly complex problems, primarily in the area of national defense and in management services, energy, and environmental problems. SAIC managed the Defense Science Board summer study program, and JASON summer studies were held at SAIC. In 1990 SAIC had an annual revenue approaching one billion dollars and a staff of eleven thousand. Its work was expanded to include research in national security, energy, the environment, health, and high technology.

While most of its work continued to be research and development, SAIC staff also designed and manufactured some hardware, such as signal processors. Their work on the MX missile for the Air Force and other contractors addressed problems related to carbon-carbon components and other manufacturing challenges concerned in the production of missile nozzles. SAIC is known for developing complex systems for the government. For instance, its Composite Health Care System (CHCS) was a fully integrated clinical system designed to support patient visits at U.S. military medical facilities worldwide. The corporation also had an active acquisitions program and took over a number of industrial firms and laboratories.

At the time Frieman joined SAIC, it was organized into ten major research operating groups, headed by vice presidents, and three separate divisions, headed by presidents. Frieman headed the SAIC National Security Studies and Systems Group (NSSSG). NSSSG included projects concerned with national security policy, nuclear force posture and technology, TNF targeting, Soviet studies and intelligence support, and technology transfer, assessment, and policy. Frieman was a member of the SAIC Technical Advisory Panel. He was elected to the SAIC Board of Directors in 1987 and served on the board until 1996.

Frieman's general responsibilities at SAIC included developing new business opportunities especially in research of interest to the U.S. Navy and intelligence community. He oversaw the work of the NSSSG, participated in strategic planning for the corporation, and worked on corporate acquisitions and recruiting.

Frieman represented and promoted SAIC nationally in the area of high technology. His responsibilities also included spotting trends in national research and development.

Frieman was active in public service after moving to the West Coast. He was elected to membership in the National Academy of Sciences in 1981 and served on a number of high level committees. In 1981, he was appointed a consultant to the Office of Science and Technology Policy (OSTP). George A. Keyworth II was Science Advisor to President Ronald Reagan 1981-1985. Frieman, a democrat, was surprised when Keyworth asked him to chair the newly formed White House Science Council. After some discussion, Frieman was appointed vice chair of the council on February 8, 1982.

OSTP was created by Congress to provide scientific advice to the executive branch of government. Its chief function was to coordinate federal science and technology policy. The Science Advisor to the President served as OSTP director. Keyworth created the White House Science Council to advise him on scientific issues of concern to the nation. The council had fifteen members. They met approximately six times annually. Frieman already knew many members of the council including Paul E. Gray of MIT, Edward Teller, and Hewlett-Packard co-founder David Packard. In the course of his work on the council, Frieman worked closely with Keyworth, his successor, William R. Graham, and with David Packard and Frank Press. John M. Deutch joined the council a few years later.

The highest priorities in science policy during Keyworth's years in the White House were national defense and efforts to strengthen the basis for U.S. economic growth. The council was briefed on a broad range of scientific issues such as AIDS, air traffic safety, climate change, technology transfer, military technology, and the war in the Falklands. Council panels met to address specific issues and policies. Frieman chaired the White House Science Council (WHSC) Special Nuclear Material Panel and the Military Technology Panel in 1982. Frieman was on the White House Science Council when the Strategic Defense Initiative (SDI) began and SDI programs proliferated in government, industry, and universities. Before leaving the council at the beginning of the Bush administration in 1989, Frieman participated in a council discussion of the nature of the science advisor's job and made recommendations to strengthen OSTP.

Frieman served on the Vice President's Science Advisory Board 1992-1993. The board was created and charged by Vice President J. Danforth Quayle to view the national space policies in the context of the end of the Cold War. This was the first reappraisal of fundamental principles of U.S. activities in space since Sputnik in 1957.

Frieman was appointed by the U.S. State Department to serve on the Board of Directors of the U.S.-Israel Binational Science Foundation 1980-1981 and again 1988-1995. The board oversaw the work of the foundation that funded grants in cooperative scientific research, supported science education, funded workshops, and provided opportunities for postdoctoral research. Frieman worked to improve the organization and management of the foundation.

Frieman was active on many groups within the National Academy of Sciences, notably the Committee on International Security and Arms Control (1985-1987), the Ocean Studies Board (1987-1993), and the Panel on the Government Role in Civilian Technology (1990-1993). Frieman chaired the Board on Global Change of the Commission on Geosciences, Environment, and Resources (1993-1994). Frieman and board staffer John Perry worked to restructure the Board on Global Change to interface more effectively with the Committee on Environment and National Resources of the National Science and Technology Council at the White House. Their successful effort led to the creation of the National Academy of Sciences Board on Sustainable Development, which Frieman chaired 1995-1999. Frieman served as a member of the Commission on Physical Sciences, Mathematics, and Resources (CPSMR) 1982-1985 and was a member of the Commission's Naval Studies Board during that period. In 1999 Frieman was appointed co-chair of the French Académie des Sciences.

Frieman served on the Panel on Science, Technology and National Security of the President's Council of Advisors on Science and Technology (PCAST) 1991-1992. The panel was asked to evaluate selected issues in

science and technology policy needs arising from national security. Frieman also served on the PCAST Panel on Megaprojects in the Sciences. The panel advised on national and international issues related to planning, financing, and organization of large-scale projects in the sciences. Such projects included the Earth Observing System (EOS), high energy research, the European Center for Nuclear Research (CERN), and the International Thermonuclear Experimental Reactor (ITER).

Frieman's work on the Superconducting Super Collider (SSC) was a particularly high profile assignment. In January 1987, President Ronald Reagan decided to support the construction in the United States of the world's largest particle accelerator, the SSC, which was estimated to cost four and one-half billion dollars. The Department of Energy developed a site selection plan, and the National Academy of Sciences was asked to assist by evaluating the suitability of proposed sites. DOE wanted the site selection process to be aboveboard. Frieman was appointed to chair the academy's Superconducting Super Collider Site Selection Committee.

The SSC Committee was to evaluate the proposed sites and narrow the list. In January 1988, the committee submitted a list of the eight best-qualified sites, which then was sent to the DOE. The SSC attracted controversy because its proposed cost seemed high to a nation trying to control its budget deficit. While the work of the SSC Committee was a success, the effort to build the SSC failed, and Frieman concluded that its failure was caused by politics rather than science. This experience deepened his interest in the interplay of science and politics and awakened concern about the difficulty of prioritizing fundamental science projects in the United States. Frieman agreed with Frank Press that scientists needed to bear more of the responsibility for prioritizing science projects and making difficult choices among them.

During the 1980s Frieman's background in military matters, physics, technology, naval warfare, and science education and industry in the United States made him one of a small number of scientists who had an overview of government activity in science. He observed the rapid changes that occurred with the end of the Cold War, which he characterized as a paradigm shift. He watched science policy move from a focus on basic research to a focus on science that addressed societal needs. The technological and economic as well as intellectual benefits of science were discussed in Washington. Departments developed mission oriented scientific programs. Frieman's speeches during this period expressed his view that the relationship among scientists, politicians, and citizens had changed fundamentally, and scientists needed to build new arguments in support of scientific programs. He also felt that the once separate worlds of defense/intelligence and science should converge.

Frieman served on the Board of Trustees of the Associated Universities, Inc. 1981-1982. He served on the editorial board of the *Journal of Defense Research* until 1986. Frieman was a member of the Defense Science Board (DSB) 1984-1987, and continued on the board as senior consultant 1988-1990, and as a member of several DSB committees. The Defense Science Board was established in 1956 as a senior advisory board for the Department of Defense (DOD) on high-level problems of national security. It directly advised the Joint Chiefs of Staff and senior DOD administrators. During Frieman's service on the DSB, the board considered problems including the technology base in the United States; terrorism; military manpower; management issues, such as managing large defense contracts; tactics including space technology; strategic issues, such as developments in nuclear submarines; and surveillance issues. Frieman chaired the DSB Task Force on Special Operations, which was charged in 1984 to review and evaluate the requirements, research and development, acquisitions and programs for command and control of special and counter-terrorist operations. In 1984, Frieman served on the Science and Technology Advisory Panel to the Central Intelligence Agency. He was also a member of the Advisory Group on SDI to the Institute for Defense Analyses.

Frieman joined the faculty of UCSD as Adjunct Professor in the Department of Physics on July 14, 1981, just as he arrived at SAIC. SAIC Chief Executive Officer John R. Beyster had a close relationship with UCSD and encouraged Frieman to take an interest in university affairs. Frieman already knew the key figures at UCSD including Chancellor Richard C. Atkinson, who had formerly headed the National Science Foundation and later became President of the University of California. Frieman accepted Atkinson's invitation to serve for a two-year term on the UCSD Board of Overseers in 1983.

During this period, Frieman served on a number of advisory boards and committees connected with the University of California. Frieman served on the Advisory Board of the Institute for Theoretical Physics at the University of California, Santa Barbara 1986-1989. He served as a founding member of the California Council on Science and Technology 1990-1992. The council was created by the California Legislature. Its membership was composed of scientists, and it responded to requests by the governor and legislature for advice on science and technology. The council had a reporting relationship to the president of the University of California. During the years Frieman served on the council the members considered issues such as waste management, environment, and technology.

Frieman served on many high-level University of California systemwide and UCSD committees concerned with science in the university and its research policies. Many of his assignments involved the three national laboratories operated by the University of California for the federal government: Lawrence Berkeley Laboratory, Lawrence Livermore National Laboratory, and Los Alamos National Laboratory. Frieman was also a member of the Task Force on Research and Technology Transfer of the University of California Transition Team, which smoothed the transition between the terms of David P. Gardner and Jack W. Peltason as university presidents.

Frieman served on the UC Council on Research 1992-1996. The council advised the UC Senior Vice President, Academic Affairs, on research policy and planning. The council membership included senior university administrators and directors of major programs and laboratories. It was responsible for advice on the establishment of special committees on critical research issues, spotting national and state trends in research policy, and promoting communication.

Frieman served on the UC President's Council on National Laboratories 1992-1995. This council was established by UC President David P. Gardner to assist in the university's efforts to assume a broader and more active role in the management of the three laboratories. Frieman served on the council's Technology Transfer Panel. The council reviewed the management system of the laboratories, especially performance evaluation procedures for scientists, and undertook a rigorous scientific assessment of the laboratories. Frieman's panel specifically addressed technology transfer in the national laboratories and the relationship of the laboratories to industry.

Frieman was named a member of the UC Defense Conversion Working Group in 1993. This group was established by the UC Office of the President to assist the university in its efforts to compete for Technology Reinvestment Project (TRP) funds. TRP was a federal program that provided funds to stimulate commercialization of dual-use technologies. Frieman was appointed to a number of groups that discussed research opportunities. He served on the UCSD Federal Research Advisory Group 1992-1996 to identify and evaluate federal research policy and project initiatives. He participated in planning for a UCSD proposal to host the engineering phase of the ITER Program, an international fusion research program proposed in 1985 by President Reagan.

Frieman had many connections at UCSD's Scripps Institution of Oceanography. He had known UCSD founder Roger R. Revelle since 1964, when he turned down Revelle's offer of a position on the UCSD faculty. Both men taught courses in marine policy at UCSD during the early 1980s. Revelle was a former director of UCSD's Scripps Institution of Oceanography. Frieman knew Scripps director physicist William A. Nierenberg, and Frieman was a long time friend of physical oceanographer Walter H. Munk. Nierenberg, Frieman, and Munk were all members of JASON. Frieman knew Scripps geologist H. William Menard from their years in Washington. Frieman's old Princeton colleague Kenneth W. Watson was also in La Jolla as director of the Scripps Marine Physical Laboratory.

When Nierenberg retired as Scripps Director, Walter H. Munk was appointed the head of the search committee. The search committee recommended Frieman for the job with strong support from Atkinson. From July 1, 1986 until his retirement on August 31, 1996, Frieman served as the eighth director of the Scripps Institution of

Oceanography, Vice Chancellor-Marine Research, UCSD and Dean of the Scripps Institution of Oceanography. His faculty appointment was Professor of Oceanography. During Frieman's tenure, Scripps was recognized by the National Research Council as the leading oceanographic institution in the United States. In 1986 Scripps had an annual budget of over sixty million dollars, more than half of which was research grants funded by the National Science Foundation (NSF) and the Office of Naval Research (ONR). It operated a fleet of six research vessels and platforms. While the institution was primarily known for research in oceanography, it also trained graduate students with funds provided mostly by the State of California.

Frieman accepted the position of director for a period of five years, but Chancellor Atkinson requested that he continue in the position in 1993, when the university experienced a fiscal crisis. Frieman's years as director were turbulent ones, encompassing the national defense buildup and SDI during the Reagan administration, followed by the collapse of the Soviet Union. These years also included the economic challenges of inflation followed by a serious recession, which impacted the budget of the State of California and its university. These events led to significant changes in national goals, especially in the area of defense and scientific research. The federal government wanted university scientific research to support national goals and improve national economic competitiveness.

The organizations that had long supported research at Scripps examined their scientific programs and made changes. ONR reexamined its mission and funded more research in littoral seas and less deep-water oceanography. Under Frieman's leadership, Scripps turned its attention toward environmental research. Frieman encouraged Scripps investigators to adopt an entrepreneurial attitude and reach out to federal agencies beyond ONR and NSF. During his directorship, many faculty and research staff members who had joined the institution at mid-century retired. Other faculty and staff opted for early retirement when the university offered incentives to reduce staff, but even with these efforts, departmental budgets were slashed in the deepest months of the recession.

Frieman initiated strategic planning and made critical new appointments focused on a new vision of the mission of the institution. He established a new research unit in atmospheric science. He strengthened Scripps programs in global climate change and positioned the institution as an honest broker of information on the controversial scientific issues of the day, including climate change and global warming. Frieman tried to expand Scripps work in satellite oceanography and space science. During his directorship, he built a new aquarium and pier. He championed funding for a new research vessel, R/V Roger Revelle. He led Scripps to create a new academic program in earth sciences leading to a bachelor's degree.

Frieman served on a number of important UCSD boards and committees. Frieman was elected a member of the Board of Trustees of the UCSD Foundation in 1987 and served on it for many years. The foundation was established to foster, encourage, and promote UCSD and to solicit, collect, acquire, manage, and invest gifts of money and property donated to UCSD. Frieman was a member of UCSD CONNECT 1987-1992. CONNECT is a UCSD/private sector local program that tries to link high-tech entrepreneurs to management skills and resources they need to succeed. Frieman was also a member from 1992 to 1995 of San Diego Dialogue, a town and gown organization chaired by William L. McGill to discuss and shape San Diego's development.

Frieman became even more active in public service during his years at Scripps. In 1991, he chaired the NASA Earth Observing System (EOS) Engineering Review Committee. EOS was a NASA program and the centerpiece of the U.S. Global Change Research Program. It was a key component in NASA's Mission to Planet Earth program. As such, it was of great interest to Frieman but also of central interest to Scripps because its scientists had participated in the earliest studies of atmospheric carbon dioxide.

The information EOS was designed to collect addressed fundamental scientific issues in climate change and global warming. In 1991 EOS was criticized for being too expensive, too late to influence policy on global change, subject to single point failure, and too narrowly structured. Some scientists suggested that Brilliant Eyes, CLIMSAT, and other programs offered better approaches to data collection than EOS. The Engineering



Review Committee had to study the entire EOS system and make recommendations that addressed the criticism. The committee had a stellar membership including D. James Baker, formerly President of the Joint Oceanographic Institutions, Inc. (JOI), and Gregory H. Canavan.

The EOS Engineering Review Committee was asked to do an external engineering review of the EOS platform configuration and launch sequence. It was to analyze the budget, review technical and scientific alternatives within the program to ensure that the program would meet its scientific objectives, achieve data collection focused on global change issues, minimize annual funding requirements and technical risks, and be adaptable to changing requirements. The committee completed its report in September 1991, and Frieman testified about it before the Senate Committee on Commerce, Science, and Transportation on September 26, where he again met Senator Albert Gore Jr.

The committee recommended a complete reconfiguration of EOS-A and EOS-B into a set of smaller satellites and recommended that the program be focused more on climate change than general global change issues. NASA adopted its recommendations, and in 1992 the Committee addressed EOS funding difficulties in Congress, laying out technical alternatives to overcome the worst effects of delays. The committee continued to be active well into 1995 reviewing changes in the EOS program and trying to assist NASA in keeping the program up to high standards despite continued delays and budgetary problems.

Frieman was elected a fellow of the American Association for the Advancement of Science in 1994. He retired from the Scripps Institution of Oceanography, UCSD in 1996 and returned to his office at SAIC.

