The Elmer A. Sperry Award 1986

for advancing the art of transportation

The Elmer A. Sperry Medal

The Elmer A. Sperry Award

The Elmer A. Sperry Award shall be given in recognition of a distinguished engineering contribution which, through application, proved in actual service, has advanced the art of transportation whether by land, sea or air.

In the words of Edmondo Quattrocchi, the sculptor of the Elmer A. Sperry Medal:

"This Sperry medal symbolizes the struggle of man's mind against the forces of nature. The horse represents the primitive state of uncontrolled power. This, as suggested by the clouds and celestial fragments, is essentially the same in all the elements. The Gyroscope, superimposed on these, represents the bringing of this power under control for man's purposes."

Presentation of

The Elmer A. Sperry Award for 1986

to

George W. Jeffs
Dr. William R. Lucas
Dr. George E. Mueller
George F. Page
Robert F. Thompson
John F. Yardley

by

The Board of Award under the sponsorship of

The American Society of Mechanical Engineers
Institute of Electrical and Electronics Engineers
Society of Automotive Engineers
The Society of Naval Architects and Marine Engineers
American Institute of Aeronautics and Astronautics

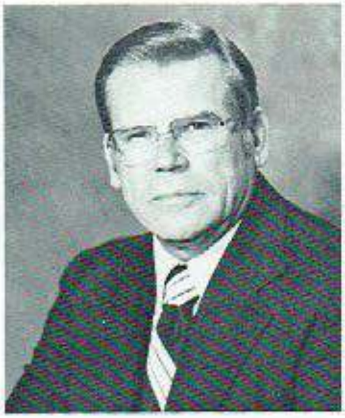
At the 94th Annual Meeting
American Institute of Aeronautics and Astronautics

Thursday, May 1, 1986
Hyatt Regency Crystal City—Washington, DC

George W. Jeffs is currently President, North American Space Operations; Corporate Vice President, Rockwell International. Mr. Jeffs began his career with Rockwell International in 1947. In 1976, Mr. Jeffs was appointed a corporate officer of Rockwell International, accountable for directing the corporation's space transportation system, space operations satellite systems and propulsion divisions.

Dr. William R. Lucas is the Director of the National Aeronautics and Space Administration's George C. Marshall Space Flight Center, Huntsville, Ala. He became Director in 1974, after having served three years as Deputy Director. In 1980, President Carter conferred on Dr. Lucas the new rank of Distinguished Executive in recognition of sustained extraordinary accomplishment in the career Federal Service.

Dr. George E. Mueller recently retired as Chairman of the Board and President of System Development Corporation in Santa Monica, California (1972-1983). From 1963 to 1970 he was Associate Administrator for Manned Space Flight at NASA, Washington, D.C. During that period the Marshall Space Flight Center, Manned Spacecraft Center, and the John F. Kennedy Space Center reported to him, along with the Apollo, Gemini, Apollo Applications, and the Advanced Manned Missions Offices.



George F. Page retired from NASA in 1984 as Deputy Director of John F. Kennedy Space Center after 21 years with NASA in Operation Management positions, including: Manager of Apollo Spacecraft Operations Division, Director of Expendable Launch Vehicle Operations, and Director of Shuttle Operations for the first four shuttle missions. Mr. Page is currently with Lockheed Space Operations Company as Director of Space Shuttle Test Operations at Vandenberg Air Force Base, California.

Robert F. Thompson is currently Vice President and General Manager—Space Station Programs, McDonnell Douglas Astronautics Company. Prior to joining McDonnell Douglas in 1982, Mr. Thompson served 35 years with NASA. His position from 1970-1981 was Program Manager—Space Shuttle Program, Lyndon B. Johnson Space Center, Houston, Texas.

John F. Yardley is currently President, McDonnell Douglas Astronautics Company. In 1974 he left his position with McDonnell Douglas Astronautics Company to become NASA Associate Administrator for Manned Space Flight. In 1978 he became Associate Administrator for the Space Transportation System, where he served until after the successful launch of STS-1 in April, 1981.

The Beginning

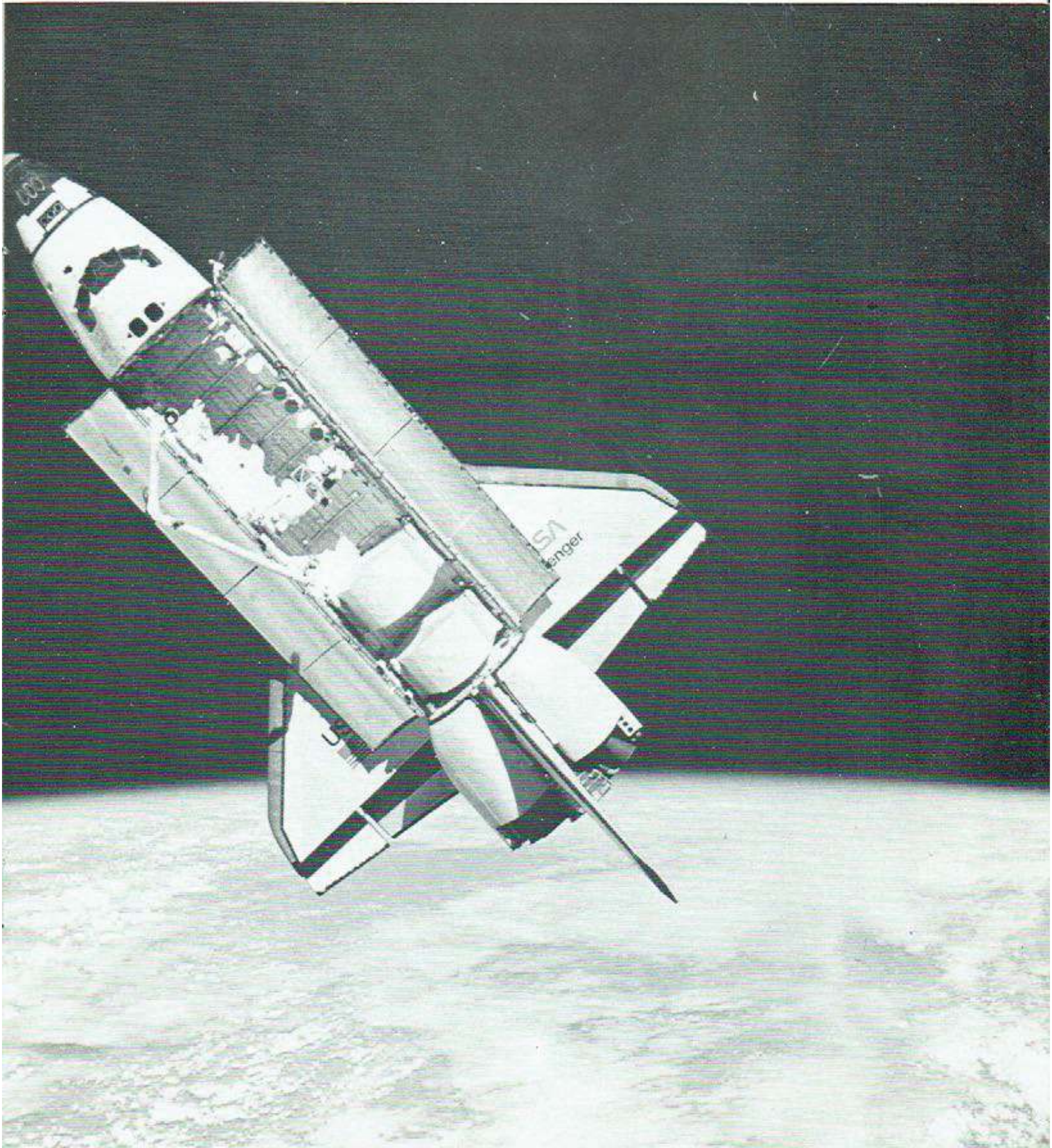
Several years before Neil Armstrong took the first "giant step for mankind" on the moon, the success of the Apollo program had space planners working hard. It was clear that less expensive, more routine access to space was essential to sustaining ongoing effort and to almost any future plans. The NASA Office of Manned Space Flight, under the direction of George Mueller, focused attention on a reusable system, both to reduce cost through reuse and to save on the expense of completely ground testing systems that would be used just once.

After much study, a space shuttle in the now familiar, twin booster, expendable fuel tank launch configuration was agreed upon and the stage set for one of the most ambitious engineering achievements of our time. President Richard Nixon made the announcement: "The United States shall proceed at once with the development of an entirely new type of space transportation system designed to help transform the space frontier of the 1970s into familiar territory, easily accessible for human endeavor in the 1980s and 90s."

This commitment could not have been made without a solid foundation of theory, development experience and effective, proven management relationships. Our Sperry Award recipients are living examples of the cooperation that typified the program. All were veterans of previous programs of great complexity. The extraordinary challenge of this program, combining launch, orbit and reentry into a single vehicle system, from sea level to earth orbit, from Mach 26 to touchdown, was met with teamwork of the highest order. There was simply no other way.

When President Nixon made his announcement, George Jeffs was Vice President and Program Manager, Apollo Crew Module Systems, Rockwell International; William Lucas was Deputy Director, Marshall Space Flight Center, NASA; George Mueller, formerly Associate Administrator for Manned Space Flight, NASA Headquarters, was in private industry; George Page was Chief, Spacecraft Operations, Kennedy Space Center, NASA; Robert Thompson was Manager, Space Shuttle Program, Johnson Space Center, NASA; and John Yardley was Vice President and General Manager, Space Shuttle Program, McDonnell Douglas Astronautics Company.

Competition among industry contractors was keen, but eventually Rockwell International was chosen prime contractor for design and development of the Space Shuttle orbiter system. Other respondents were Grumman Aerospace Co., Lockheed Missiles and Space Co., and McDonnell Douglas Astronautics Co. Subsequently, Martin Marietta was selected to develop the large external fuel tank and Morton Thiokol's Wasatch Division was given the task of developing the Space Shuttle solid rocket boosters.



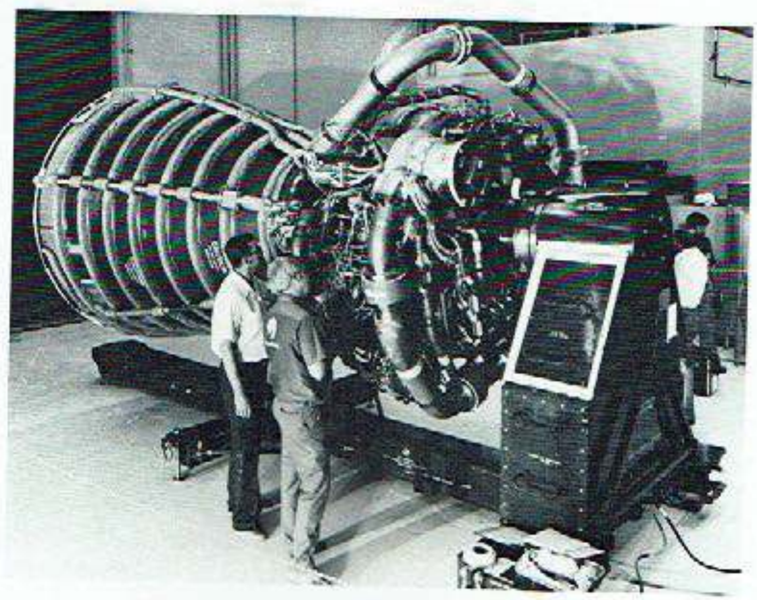
Technical Challenges

Launch, orbit and recovery phases each posed a range of problems from the relatively routine to seemingly farfetched "what ifs?" that abound in most pioneering efforts. The following examples illustrate both the technical complexity of the Space Transportation System and the unique set of conditions that existed for virtually every component.

Main Engines: For the Shuttle to be practical, a very powerful engine with a small frontal area was needed. Otherwise, the Shuttle's payload capability would be severely compromised. A new type of closed cycle, high pressure, computer controlled engine design was selected. This engine would be subjected to higher operating temperatures and stresses than any before, and yet, if it were to be reusable, it would have to endure them repeatedly.

Although a substantial amount of money was spent for a "component" test facility, it proved of little use. Because of the closed cycle and the resultant interaction between pumps, combustion chambers, etc., it was decided that the only realistic way to test was to use the engine itself as the test facility. John Yardley recalled,

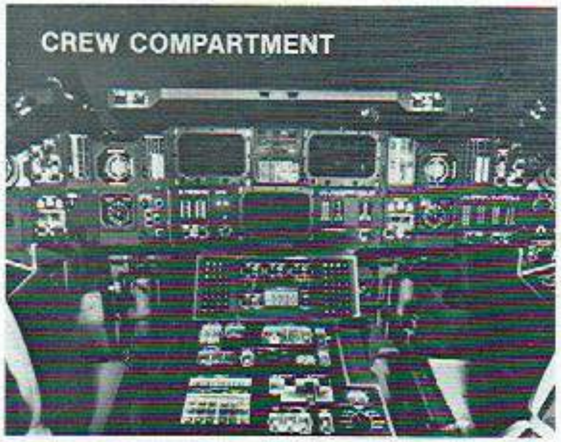
> To prove that the engine was indeed reliable, when operated within a certain set of groundrules, we established a qualification sequence which required several separate engines to make 10 consecutive safe flights. Any failure required the whole program to start over. Many said it couldn't be done. The program was run with strict configuration control using inspections and preventive maintenance as planned between flights, and the results were perfect. This series of tests gave the designers, the astronauts, and the management the confidence to fly the engine. Seventy-five flawless engine flights have now occurred without any main engine failures.

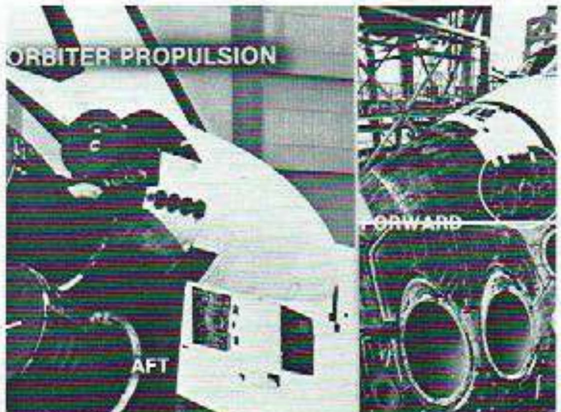


Crew Compartment: The crew compartment had to be, at the same time, a control cabin, living quarters, an on-orbit laboratory, a gym and a cafeteria. It had to protect crew and computers from multiple-g to zero-g and through outside temperatures from near absolute zero to several thousand degrees. Such a multitude of human engineering problems had never been solved before in one compartment. The results have been spectacular. As many as seven astronauts are able to work efficiently in relative harmony in a totally confined and confining chamber.

The main link to the mission control computers is through the three television-like screens, which display everything the crew needs to know. During reentry, for instance, the screens display where the vehicle will be in projected 20-second intervals. To add to crew effectiveness, the information is projected on the pilot's window so the pilot can see flight information while looking through the forward window.

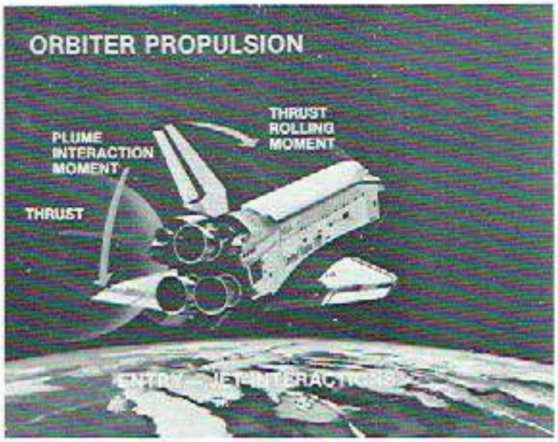
In addition to allowing the crew to see out, the windows are a critical structural element. A careful balance of pressure must be maintained across the outer pane. Because pressure shock waves attach very close to the center panes under certain flight conditions and because they are subject to buffet, the windows are one of the critical load points on the vehicle.





Reaction Control System: Once the Shuttle reaches orbital speed and the main engines are shut down, position, relative to the earth and sun, is changed with the reaction control system. Without this highly reliable and redundant system, the versatility and on-orbit value of the Shuttle would be practically nil. This system of small reaction jets had to be designed for low noise level and g-forces (to avoid waking the astronauts during rest periods) and to help control the Shuttle during reentry.

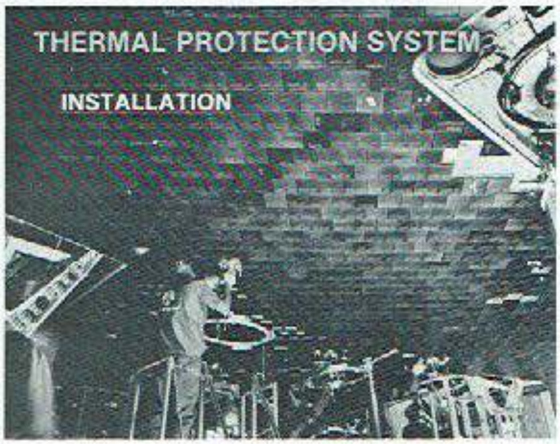
The Shuttle comes in from space almost like a pancake to help it slow down and to spread the heat across the protective tiles. The vertical tail is relatively ineffective and the aft Reaction Control System must then be used for Shuttle directional control. When the jets fire, the plume interacts with the air flow over the wings, reducing the lift on that side of the Shuttle. The interaction counter-balances the rolling moment induced because the yaw thrusters are positioned above the center of gravity. This mode is used down to about 45,000 feet, slightly above where commercial airliners fly.



Reentry Thermal Protection: The challenge was to design a reentry-heat shield that could do its own job of protection, survive launch and orbit, contribute to the aerodynamics of approach and landing, and yet be reusable! Elegantly simple in concept but extremely complex in application; there are more than 20,000 thermal protection tiles on the Shuttle, each weighing about three-quarters of a pound. Every tile is different; almost every one has a different part number. A different set of design loads and a detailed structural analysis is required for each.

The tile material, silica fiber, is one of the world's best insulators but it is very brittle and easily damaged if not protected. These properties make installation a work of art as well as a work of engineering.

First, a protective coating is applied to the aluminum skin of the Shuttle. Next, a thin, felt-like pad is attached to isolate the brittle tiles from the flexing and vibrations of the Shuttle skin. Finally, the tiles themselves are individually glued in place. A black, protective, emittance coating covers the outside surface. To test the bonding, special rigs had to be built to test each tile to a pull test of about ten pounds per square inch. Both design and installation were fully proven during the first few missions. Despite some minor redesign, the basic concept met all operational requirements.



The Approach and Landing Test Program: Simulating actual mission conditions without actually flying the Shuttle was a perplexing problem. In earlier flight test programs, unproven vehicles were tucked under the wing of a large airplane and flown as captives of the mother craft. A novel variation of this concept was necessary for the Shuttle.

Eight "captive" flights were flown in which the orbiter was mounted atop a specially modified Boeing 747 aircraft. These captive flights were followed by five free flights in which the shuttle, *Enterprise*, was released from the carrier aircraft and maneuvered to a landing.

The descent of the Shuttle was slowed by a special aerodynamic tail cone that made it handle more like a normal airplane. The last two free flights were made without the tailcone which greatly increased the glide slope in full simulation of an actual reentry and landing. The need to use full scale, expensive test articles created a great deal of apprehension among those responsible for mission success. The recollection of George Jeffs reflected the thoughts of many members of the industry/NASA team:

> The first of the free-flight tests made me hold my breath as that 747 climbed to 25,000 feet with the orbiter: I kept thinking, "Is there anything we've forgotten: Is there any way this can go wrong?"

Bringing It Together

Most of the design and development challenges were met but the Space Shuttle was still not a system. The program had, in reality, only completed phase one. The Shuttle had to be mated to the solid boosters and the large external fuel tank and then checked out on the launch pad. The first Shuttle, the *Enterprise*, was used as a practice vehicle to check the procedures as well as the pad facilities. It was not intended to actually fly into orbit.

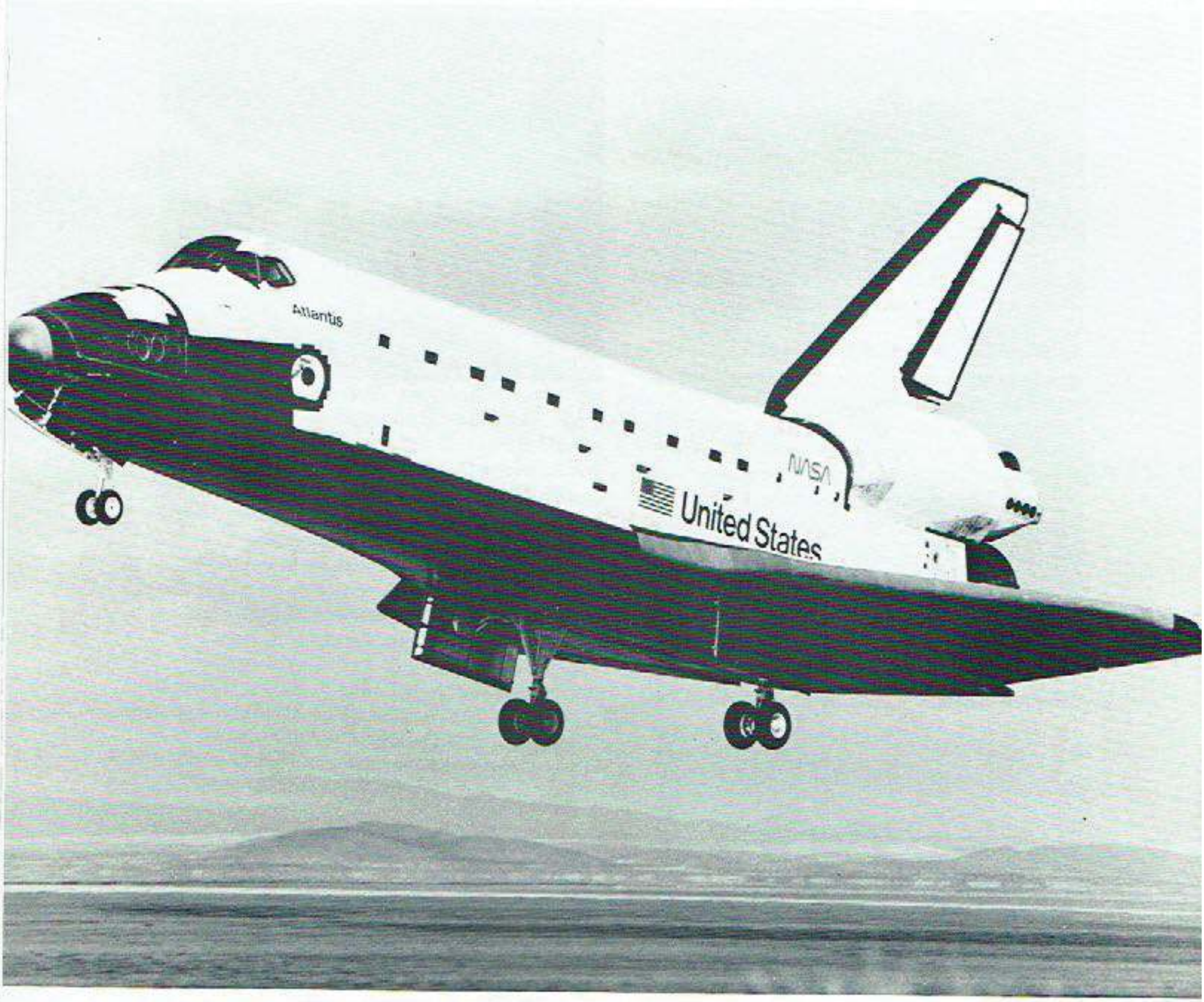
The second Shuttle, the *Columbia*, arrived at Kennedy Space Center in March 1979 to begin preparation for the first flight into space.

The first flight of *Columbia* occurred on April 12, 1981 and was a demonstrable success. The orbiter returned two days later in completely reusable condition. The system had actually proved itself!

Shuttle Operations

The Sperry Award goes to improvements ...demonstrated in actual service.

In the next four years, the Shuttle deployed 24 commercial satellites, carried out 16 major scientific or engineering missions, two dedicated and one partial defense-related mission, retrieved two wayward satellites and returned them to Earth for refurbishment, and repaired a scientific satellite and another commercial satellite in orbit. Shuttle astronauts have also been on eight different space walks to observe, repair, retrieve, construct or otherwise prove that humans can and do perform useful and important work in space.


Atlantis
NASA
United States

In spite of our best efforts, humankind is continually reminded that pioneering work and achievements involve great risk. The tragic failure of *Challenger* in January 1986 after so many successes is difficult to accept. But accept it we must, for the dream is alive and the Space Transportation System will continue.

The Sperry Board of Award joins the award recipients in dedicating this award to the memory of the seven astronauts who perished in mankind's reach for the stars.

Previous Elmer A. Sperry Awards

1955 to *William Francis Gibbs* and his Associates for development of the S.S. United States.

1956 to *Donald W. Douglas* and his Associates for the DC series of air transport planes.

1957 to *Harold L. Hamilton, Richard M. Dilworth* and *Eugene W. Kettering* and Citation to their Associates for the diesel-electric locomotive.

1958 to *Ferdinand Porsche* (in memoriam) and *Heinz Nordhoff* and Citation to their Associates for development of the Volkswagen automobile.

1959 to *Sir Geoffrey De Havilland, Major Frank B. Halford* (in memoriam) and *Charles C. Walker* and Citation to their Associates for the first jet-powered aircraft and engines.

1960 to *Frederick Darcy Braddon* and Citation to the Engineering Department of the Marine Division, *Sperry Gyroscope Company,* for the three-axis gyroscopic navigational reference.

1961 to *Robert Gilmore Letourneau* and Citation to the Research and Development Division, *Firestone Tire and Rubber Company,* for high speed, large capacity, earth moving equipment and giant size tires.

1962 to *Lloyd J. Hibbard* for application of the ignitron rectifier to railroad motive power.

1963 to *Earl A. Thompson* and Citation to his Associates for design and development of the first notably successful automobile transmission.

1964 to *Igor Sikorsky* and *Michael E. Gluhaneff* and Citation to the Engineering Department of the Sikorsky Aircraft Division, *United Aircraft Corporation,* for the invention and development of the high-lift helicopter leading to the Skycrane.

1965 to *Maynard L. Pennell, Richard L. Rouzie, John E. Steiner, William H. Cook* and *Richard L. Loesch, Jr.* and Citation to the Commercial Airplane Division, *The Boeing Company,* for the concept, design, development, production and practical application of the family of jet transports exemplified by the 707, 720, and 727.

1966 to *Hideo Shima, Matsutaro Fujii* and *Shigenari Oishi* and Citation to the *Japanese National Railways* for the design, development and construction of the New Tokaido Line with its many important advances in railroad transportation.

1967 to *Edward R. Dye* (in memoriam), *Hugh DeHaven* and *Robert A. Wolf* and Citation to the research engineers of *Cornell Aeronautical Laboratory* and the staff of the Crash Injury Research projects of the *Cornell University Medical College.*

1968 to *Christopher S. Cockerell* and *Richard Stanton-Jones* and Citation to the men and women of the *British Hovercraft Corporation* for the design, construction and application of a family of commercially used Hovercraft.

1969 to *Douglas C. MacMillan, M. Neilsen* and *Edward L. Teale, Jr.* and Citations to Wilbert C. Gumprich and the organizations of *George G. Sharp, Inc., Babcock and Wilcox Company,* and the *New York Shipbuilding Corporation,* for the design and construction of the N.S. Savannah, the first nuclear ship with reactor, to be operated for commercial purposes.

1970 to *Charles Stark Draper* and Citations to the personnel of the *MIT Instrumentation Laboratories,* Delco Electronics Division, *General Motors Corporation,* and Aero Products Division, *Litton Systems,* for the successful application of inertial guidance systems to commercial air navigation.

1971 to *Sedgwick N. Wight* (in memoriam), and *George W. Baughman* and Citations to William D. Hailes, Lloyd V. Lewis, Clarance S. Snavely, Herbert A. Wallace, and the employees of *General Railway Signal Company*, and the Signal & Communications Division, *Westinghouse Air Brake Company*, for development of Centralized Traffic Control on railways.

1972 to *Leonard S. Hobbs* and *Perry W. Pratt* and the dedicated engineers of the Pratt & Whitney Aircraft Division of *United Aircraft Corporation* for the design and development of the JT-3 turbo jet engine.

1975 to *Jerome L. Goldman, Frank A. Nemec* and *James J. Henry* and Citations to the naval architects and marine engineers of *Friede and Goldman, Inc.* and *Alfred W. Schwendtner* for revolutionizing marine cargo transport through the design and development of barge carrying general cargo vessels.

1977 to *Clifford L. Eastburg* and *Harley J. Urbach* and Citations to the Railroad Engineering Department of *The Timken Company* for the development, subsequent improvement, manufacture and application of tapered roller bearings for railroad and industrial uses.

1978 to *Robert Puiseux* and Citations to the employees of the *Manufacture Francais des Pneumatiques Michelin* for the design, development and application of the radial tire.

1979 to *Leslie J. Clark* for his contributions to the conceptualization and initial development of the sea transport of liquefied natural gas.

1980 to *William M. Allen, Malcolm T. Stamper, Joseph F. Sutter* and *Everette L. Webb* and Citations to the employees of *Boeing Commercial Airplane Company* for their leadership in the development, successful introduction and acceptance of wide-body jet aircraft for commercial service.

1981 to *Edward J. Wasp* for his contributions toward the development and application of long distance pipeline slurry transport of coal and other finely divided solid materials.

1982 to *Jorg Brenneisen, Ehrhard Futterlieb, Joachim Korber, Edmund Muller, G. Reiner Nill, Manfred Schulz, Herbert Stemmler* and *Werner Teich* for their contributions to the development and application of solid state adjustable frequency induction motor transmission to diesel and electric motor locomotives in heavy freight and passenger service.

1983 to *Sir George Edwards, OM, CBE, FRS; General Henri Ziegler, CBE, CVO, LM, CG; Sir Stanley Hooker, CBE, FRS;* (in memoriam); *Sir Archibald Russell, CBE, FRS* and *M. Andre Turcat, Ld'H, GG;* commemorating their outstanding international contributions to the successful introduction and subsequent safe service of commercial supersonic aircraft exemplified by the Concorde.

1984 to *Frederick Aronowitz, Joseph E. Killpatrick, Warren M. Macek* and *Theodore J. Podgorski* for the conception of the principles and development of a ring laser gyroscopic system incorporated in a new series of commercial jet liners and other vehicles.

1985 to *Richard K. Quinn, Carlton E. Tripp,* and *George H. Plude* for the inclusion of numerous innovative design concepts and an unusual method of construction of the first 1,000-foot self-unloading Great Lakes vessel, the M/V STEWART J. CORT, which revolutionized the economics of Great Lakes transportation.

The 1985 Elmer A. Sperry Board of Award

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