The Elmer A. Sperry Award
1998

FOR ADVANCING THE ART OF TRANSPORTATION

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, 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 1998

to

BRADFORD W. PARKINSON

for leading the concept development and early implementation of the Global Positioning System (GPS) as a breakthrough technology for the precise navigation and position determination of transportation vehicles

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
Society of Naval Architects and Marine Engineers
American Institute of Aeronautics and Astronautics
American Society of Civil Engineers

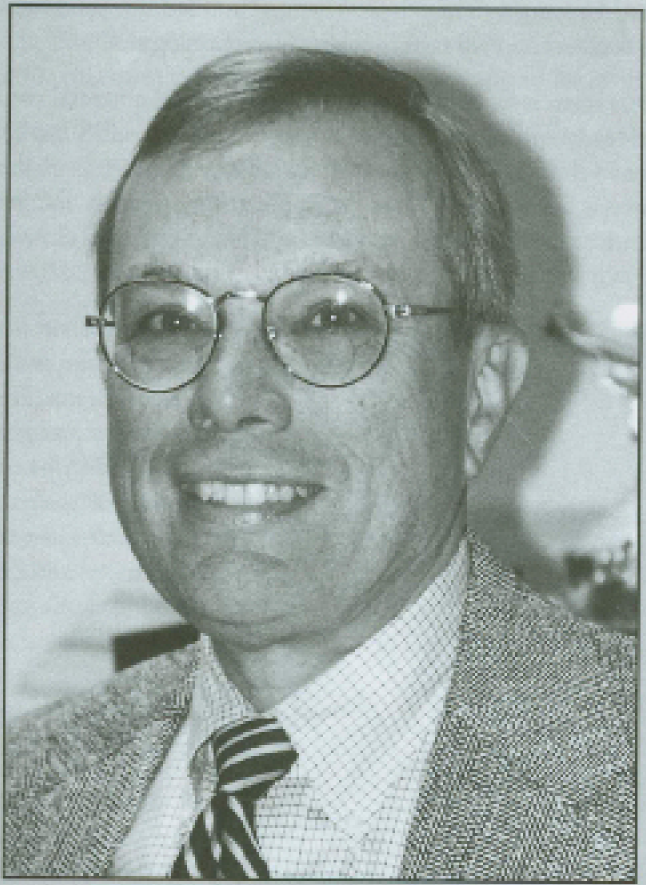
at the
Honors Ceremony of the
Institute of Electrical and Electronics Engineers
The Banqueting House, Whitehall Palace
June 12, 1999 — London, England

Bradford W. Parkinson

In 1972 Dr. Bradford Parkinson (Colonel, United States Air Force) was named team leader of a Joint Program Office for the Department of Defense (DOD) to direct the integration of emerging satellite technology concepts leading to the implementation of what has evolved as the Global Positioning System, later named NAVSTAR GPS. He then directed the GPS development program for its six critical initial years, including the development of satellites, ground control station and user equipment. He was the launch commander on the first launches. Dr. Parkinson's education, industry and military background ideally equipped him to lead this breakthrough in transportation technology.

Dr. Parkinson graduated from the US Naval Academy (BS 1957), the Massachusetts Institute of Technology (MS 1961) and Stanford University (PhD 1966). He was a distinguished graduate of the US Naval War College and was head of the Department of Astronautics and Computer Science at the US Air Force Academy. From 1966 to 1968 he was an academic instructor for the USAF Test Pilot School at Edwards Air Force Base. From 1972 to 1978 he led concept development and directed the NAVSTAR GPS Joint Program Office at the Air Force Space and Missile Organization.

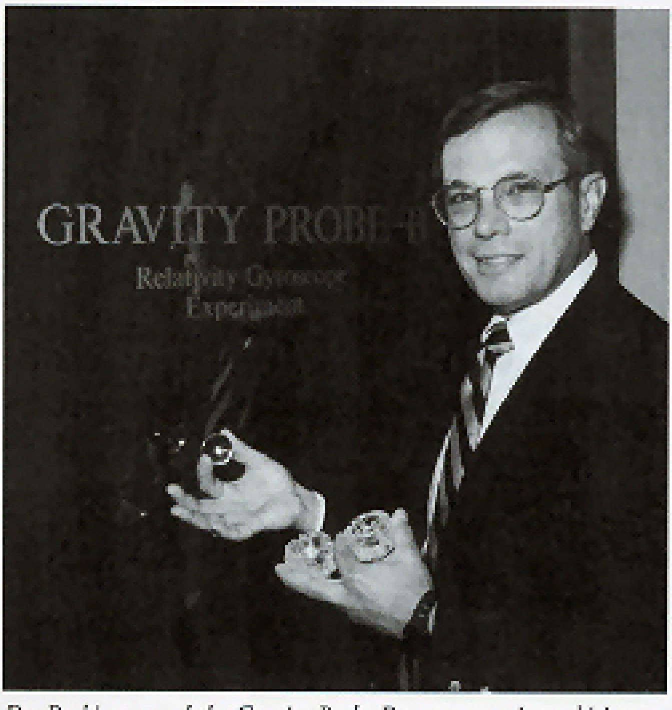
Colonel Parkinson, seen here with an F-104, served as an academic instructor at the USAF Test Pilot School at Edwards Air Force Base in California.



BRADFORD W. PARKINSON

After retiring from the military in 1978, Dr. Parkinson joined Colorado State University as a Professor of Mechanical Engineering, where he conducted research and taught courses in automatic controls. From 1979 to 1980 he served as a Group Vice President at Rockwell International, then moved to Intermetrics, Inc., where he was Vice President and General Manager. After leaving that assignment in 1984 he was appointed the Edward C. Wells Professor of Aeronautics and Astronautics at Stanford University. There he has created and led the Stanford University GPS research program that focused on civil uses for the new technology.

Dr. Parkinson's research team is funded by FAA, NASA, and commercial companies. His group is recognized as world leaders in pioneering numerous innovative GPS applications including the dynamic control of vehicles, the development and demonstration of the Wide Area Differential GPS concept for air traffic control, applications suitable for the blind landing of aircraft, robotic control of land vehicles, and use of GPS to perform closed-loop control of satellites in orbit.



Dr. Parkinson and the Gravity Probe B team are using orbiting gyroscopes in an effort to test Einstein's General Theory of Relativity.

Dr. Parkinson is also breaking new scientific ground in two other related directions. First, he is the technical leader and program manager of the NASA-funded Gravity Probe B program, a test effort to validate Einstein's General Theory of Relativity using orbiting gyroscopes. Second, he is managing the development of advanced technology for that mission, including precision metrology, control of spacecraft, and estimation of atmospheric effects.

THE ACHIEVEMENT

It is unlikely that any engineering achievement nominated for the Sperry Award has so totally embraced the Award's criterion of "advancing the art of transportation whether by land, sea, or air" than has the NAVSTAR Global Positioning System, or GPS. The applications of this brilliant new technology have extended to every object that resides on, or moves over, the surface of the earth or in its extraterrestrial space. By providing precise information on both position and time, GPS enables the derivative benefits of knowing velocity and acceleration, opening up the additional potential for precision control and navigation for all modes of transportation.

In its early applications, GPS used its array of satellites to allow military ships, aircraft, and ground vehicles to determine their locations anywhere in the world. The benefits for commercial use were also quickly recognized so that provisions for a reduced accuracy signal were made available. The system has now progressed to the point where GPS for commercial uses has demonstrated accuracy better than any other systems previously developed for the navigation and control of all transportation systems.[1]

The power of GPS has just begun to permeate the facets of our daily life. While we may today acknowledge that this sophisticated technology is routinely providing navigation services for commercial airlines, trucking networks, railroads and ships at sea, we will soon be recognizing, and utilizing, the practical benefits it can bring to each of us in many different forms. From the hand-held emergency transmitter no larger than a package of cigarettes that can silently guide the police to your assistance when a personal threat is imminent, to the weekend boater who wants to "tag" that prime fishing spot for a subsequent visit, or to the motorist who can now avoid the frustrations of confusing road signs and unfamiliar bearings to reach his destination, GPS has arrived with a wealth of applications that will bring new comforts and convenience to our lives.

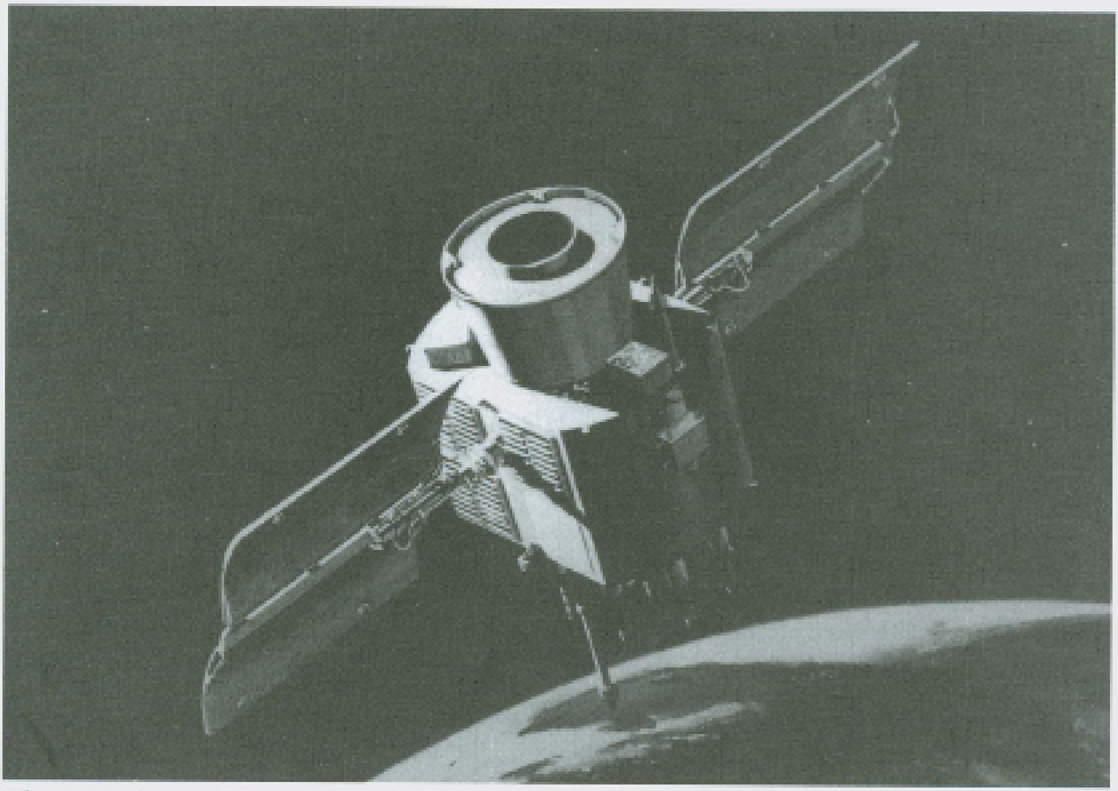
The development of GPS did not emerge out of the laboratory of a solitary inventor in the manner of an Edison, Sperry, or Tesla, but was the amalgamation of concepts evolving from leading edge experiments with satellites, precision clocks, and new understandings of orbital mechanics. Separate efforts by the U.S. Air Force, Navy, private industry, and academia all provided significant breakthroughs in contributing important aspects of the ultimate system, but it took a combined team, utilizing the creativity, vision, and resources of each participating agency, to synthesize the best attributes of each. It was Bradford Parkinson's focused leadership that brought these often-divergent scientists and strategists to the table and delivered the essence of a practical and growth-oriented satellite positioning system that is universally known as the Global Positioning System.

[1]*As noted in the list of Sperry Awards at the back of this booklet, previous contributions to navigation were honored in 1960, 1970 and 1988.*

WHAT IS NAVSTAR GPS?

Basic Description

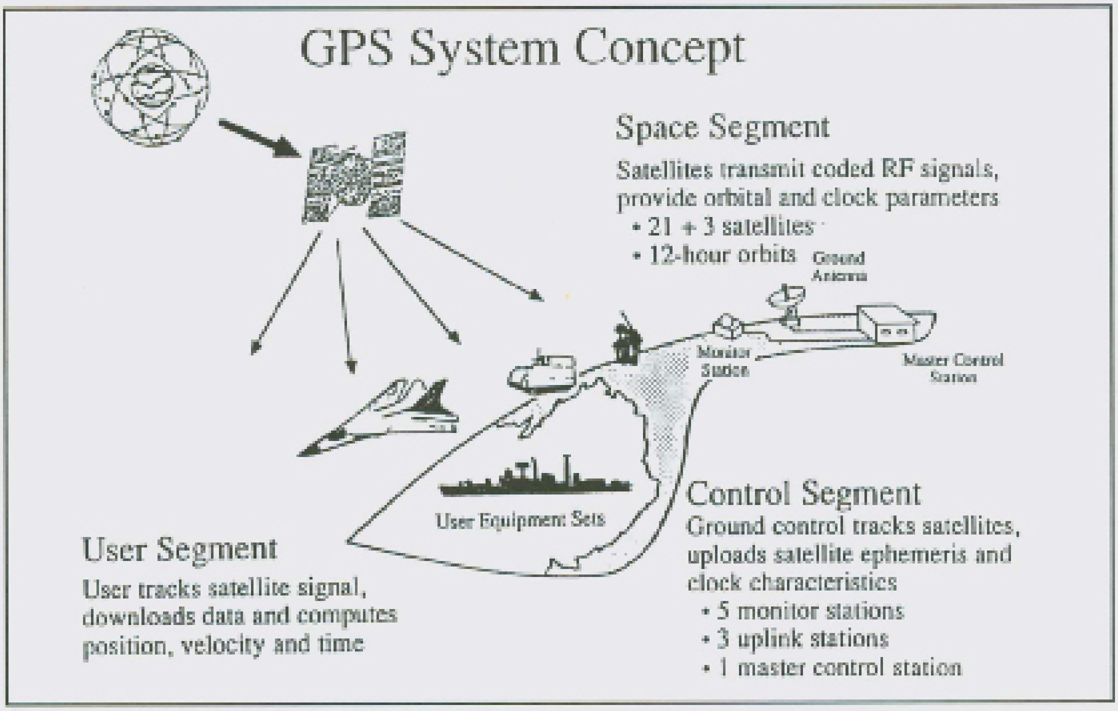
GPS is a satellite-based navigation system that provides precise three-dimensional position information, including time-based derivatives of velocity and acceleration, at any point on the earth or in its atmosphere. It comprises three distinct Segments:



This is one of 24 satellites in the Space Segment of the Global Positioning System.

The *Space Segment*, consisting of 24 satellites, guaranteeing that at least four are visible to a GPS receiver at any given time. The satellites are arranged in a constellation of six orbital planes, approximately spaced at 55 degrees inclination, with four satellites per plane. The satellites orbit at an altitude of 10,898 nautical miles and have a design life of 7.5 years. A minimum of twenty-one of the satellites are in use at any one time, while three others are designated "active spares." Currently 27 are operational.

The *Control Segment*, consisting of a master control station and five ground monitoring stations (receiver-transmitters and antennas) at locations around the world. These five stations are equipped with precise time standards and continually track the visible satellites while monitoring their broadcast signals. The tracking information thus obtained is sent to the master control station located in Colorado that computes the satellite orbits and clock corrections for each of them. Three of the five ground stations have an uplink capability which is used to send updated orbit information and clock correction data to the satellites.

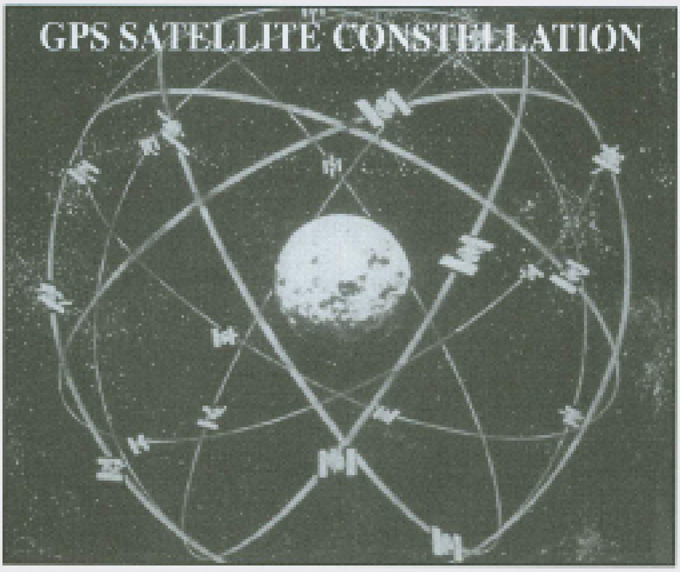


The total Global Positioning System is comprised of a Space Segment, Control Segment, and User Segment.

The *User Segment*, now consisting of several million GPS receivers with antennas mounted on the object to be tracked. Each receiver uses the satellite signals to calculate a navigation "solution," or position, and can also determine velocity and acceleration. Time is also measured to better than a microsecond. Depending on the user, the GPS may be coupled with other systems or sensors to provide increased situational awareness.

The Operational Concept

A GPS receiver, wherever it is situated, has the ability to determine its range to each of at least four satellites by measuring the time required for a transmitted signal from each satellite to reach it. This requires a highly precise measurement of this very small incremental time, since a one nanosecond (one-billionth of a second) time difference is equivalent to approximately 11.8 inches (30 cm.) of range error. This dictates that the clock of a receiver and the clock contained in each satellite being measured are closely synchronized, so that the delay in time due to the ranging transit time can be used to calculate accurate distances. These pairs of clocks, however, are *not* precisely synchronized, but compensation is made using a "clock bias" determined from a geometrical solution involving the fourth satellite.



Four satellites orbit in six planes to provide precise position information.

If the distance to one satellite is known, then the receiver would be located somewhere on the surface of a sphere with the satellite located at the center. The radius of the sphere would be equal to the range. To narrow down the possibilities of the receiver location, the distance to a second satellite is calculated. This locates the receiver at some point on the circle where the spheres from the two satellites intersect. It is helpful to visualize two soap bubbles that are joined together. Their intersection will be a circular plane, along the edge of which the receiver would be located. As additional satellite ranges are determined, the intersecting spheres (soap bubbles) further narrow down the possibilities of a receiver location, the exact determination of which requires that its distance from a minimum of three satellites (at exactly the same instant) be known. The fourth satellite range is used to determine the timing bias for the satellites, required to generate the geometric solutions for all four spheres to intersect at a single point.

The GPS user can receive satellite signals from any visible satellite. Because of the positioning of the satellite "constellation," any GPS receiver typically can track 8 to 11 signals, although only four GPS satellites are needed to fix the receiver position.

THE DEVELOPMENT OF NAVSTAR GPS

1957 – 1972: Precursors

The ultimate development and deployment of GPS as a successful operating navigation and position-fixing system evolved out of a succession of separate military-funded programs exploiting early satellite technology. The first explorations came on the heels of the Sputnik launch in October 1957, which set in motion several activities to discover the attributes of a transmitting satellite, and more importantly, the exact nature of its orbit. The radio signals radiated by Sputnik provided Doppler shift data which could be used to fix the path of its orbit. With a geometric fix point (orbit) established, using that "known" to determine the position of a radio receiver seemed an obvious next step.

Transit - The Navy was first on the scene, sponsoring the Johns Hopkins Applied Physics Lab to launch a satellite known as Transit in 1960. This system was developed to help submarines navigate, but it was two-dimensional in nature and sensitive to the velocity of the user. In addition, multiple satellites in view would destructively jam the navigational capability. However, the new technologies developed for Transit, particularly relating to the analysis of the earth's gravity field and ionospheric refraction correction techniques, were valuable contributions for what lay ahead.

TIMATION - By 1972, another Navy satellite system was expanding the technology by orbiting very precise clocks. Known as TIMATION, this satellite system was used to provide time and time transfer between various points on the earth, and could also provide navigation information. The breakthrough concept with TIMATION was that no Doppler measurement was required, but the user could directly and quickly measure range using "side tone ranging." This was known as passive ranging, and required accurate spaceborne clocks that could be regularly updated by a master clock on the ground to synchronize the multiple satellites needed for worldwide coverage. The TIMATION system was launched in May 1967, and the program gradually matured to a point in 1974 when the satellite was re-designated as the Navigation Technology Satellite (NTS) as part of the DOD joint development of GPS.

Project 621B - Transit and TIMATION were essential foundations for GPS. The third forerunner was a U.S. Air Force program known as 621B, directed by an office in the Advanced Plans group at its Space and Missile Organization (SAMSO). By 1972, this program had demonstrated the operation of a new type of ranging transmission based on a coded signal, basically a repeated digital sequence of ones and zeroes. This signal, through "processing gain" was superior to all predecessors because it was so jam resistant. Program 621B was the immediate predecessor to the activity that eventually developed the Global Positioning System, and it marked Dr. (now Colonel) Parkinson's initial involvement as a key management figure in directing space-based navigation concepts as part of a project that was focused on actual hardware development. In fact, it was Dr. Parkinson's timely "rescue" of this program from possible cancellation by the Department of Defense that earmarked him for increasing responsibility in future development efforts.

1972-1973: Concept Synthesis: The Joint Program Office for GPS

In the early 1970s, the concept of having the various military services working together in order to increase efficiency and reduce inter-service bickering was applied to the evolution of satellite technology programs. The resulting Joint Program Office (JPO) was created in 1972 at the Space and Missile Organization, with the Air Force designated as the lead service. It was the first formal example of this cooperative management. Dr. Parkinson was named as the first Program Director, supported by deputy program managers from the Army, Navy, Marine Corps, Defense Mapping Agency, Coast Guard, Air Logistics Command, and NATO. Also assisting the effort was a small cadre of engineers from The Aerospace Corporation. Dr. Parkinson's assignment was to develop the concept of a global positioning system as a joint program and to gain approval of the Department of Defense to proceed with full-scale demonstration and development.

Dr. Parkinson (center) served as the first Program Director of the Joint Program Office for GPS at the Space and Missile Organization.

At the outset, Brad Parkinson emphasized to his team the original guidelines voiced by the DOD in forming the Joint Program Office for the advancement of navigation and position-fixing technology through GPS. The directive, although today appearing somewhat oblique and tongue-in-cheek, stated that the military's primary purposes in developing GPS were two-fold, i.e., to:

- Facilitate precision weapon delivery, and
- Provide a capability which would help reverse the proliferation of navigation systems in the industry (at this point in time, the "industry" was 100% military-oriented).

When, in mid-1973, the program was originally brought before the Defense System Acquisition and Review Council (DSARC) for approval, it was packaged as a 621B system. This presentation failed its review because it did not adequately represent the views and requirements of all the services. A crucial "back to the drawing board" effort of the Joint Program Office took place over Labor Day weekend of 1973, where Dr. Parkinson directed the development of a new design that removed the "Air Force only" connotation and involved all contending parties in the conception process. Soon after that, in December 1973, DSARC approval was granted. The project to develop GPS was underway.

1973-1978: The Concept Becomes Reality

What the DSARC approved in December 1973 was a Phase I program for Dr. Parkinson and his team to validate the total system concept for GPS. A major stumbling block that they faced was a classic bureaucratic "catch 22":

- How could the development of user equipment be approved when there was no guarantee it would work with the satellites?
- How could the satellites be launched without insuring they would work with the land-based equipment?

On the surface, it appeared that the means to validate the concept was at an impasse. The development of satellites was a long and costly process, made even more critical by a funding constraint that approved only four satellites, one of which was a refurbished qualification model.

As part of the Labor Day effort, a solution to this conundrum was found. In order to minimize the exposure to a massive program setback that any launch or operational failure would have presented, it was decided to initially test the concept not in space, but *on the ground*. In 1976, on the desert floor near Yuma, Arizona, a system of solar-powered GPS transmitters was deployed in a pattern that approximated the position of the GPS satellites when arrayed in their spaceborne "constellation." Because the transmitters were fixed relative to each other, they were called *pseudolites* (from pseudo-satellites).

The satellite transmitters were synchronized to each other, followed by verification that the user equipment could work with them prior to launch. As each of the four satellites were launched, pseudolites were successively dropped from the test system until all four of the satellites were in orbit and the equipment was completely debugged. It was then, in 1977, that the operational claims for GPS that had originally been made to "sell" the DSARC were able to graduate from concept to demonstrated effectiveness.

This approach satisfied the doubters, and helped to sustain and give direction to the five long years of satellite and user hardware technology development that lay ahead of the team. It gave credence and strength to the construction phase by removing many of the elements of risk associated with untested concepts. By the end of the "hands on" hardware phase in 1978 when the first Navigation Development Satellites were launched, the main components of user equipment had been validated quantitatively and qualitatively. Additional testing then followed, testing the hardware on equipment ranging from F-16 fighter aircraft, helicopters, submarines, and "man-pack" equipment carried during deployment by soldiers into various types of terrain. Literally hundreds of tests were conducted at U.S. military test facilities around the country.

PROLIFERATING APPLICATIONS FOR CIVILIAN TRANSPORTATION

Transforming GPS from Military to Civil Use

These experiments quickly confirmed what had long been recognized: that GPS would serve many more civilian uses than those for the U.S. military. Furthermore, adapting GPS to these new roles was not difficult. Of the three segments of the GPS system described above, the two most complex – the satellites and the ground stations – continued to be funded and controlled by the Department of Defense. What had to be adapted to a widening variety of new applications was the user-hardware segment, basically the receivers. This transformation was relatively simple since numerous civilian companies had developed and were producing user hardware for the military. They were now eager to serve the far larger market for civil user hardware.

Following some additional refinements that would serve to protect the accuracy and integrity of the military system should an enemy attempt to use GPS technology against us, the path rapidly cleared for propagation of GPS into the civil sector.

GPS and Civil Transportation

Prominent among the early civilian uses for GPS were those for an exploding range of transportation applications, where it far surpassed the performance of previously state-of-the-art systems.

The utilization of GPS in advancing the art of transportation has been growing at a rate that is increasing geometrically. There is currently no transportation system under development that does not include, as an integral consideration of its design, the potential for incorporating some aspect of GPS. This could be in the familiar application of navigation or position-fixing to enable safe and unencumbered transit from point-to-point, or the more recent derivation of the technology which will permit accurate *attitude control* for maneuvering in space, or close to the ground, as in an approach and landing to an airport.

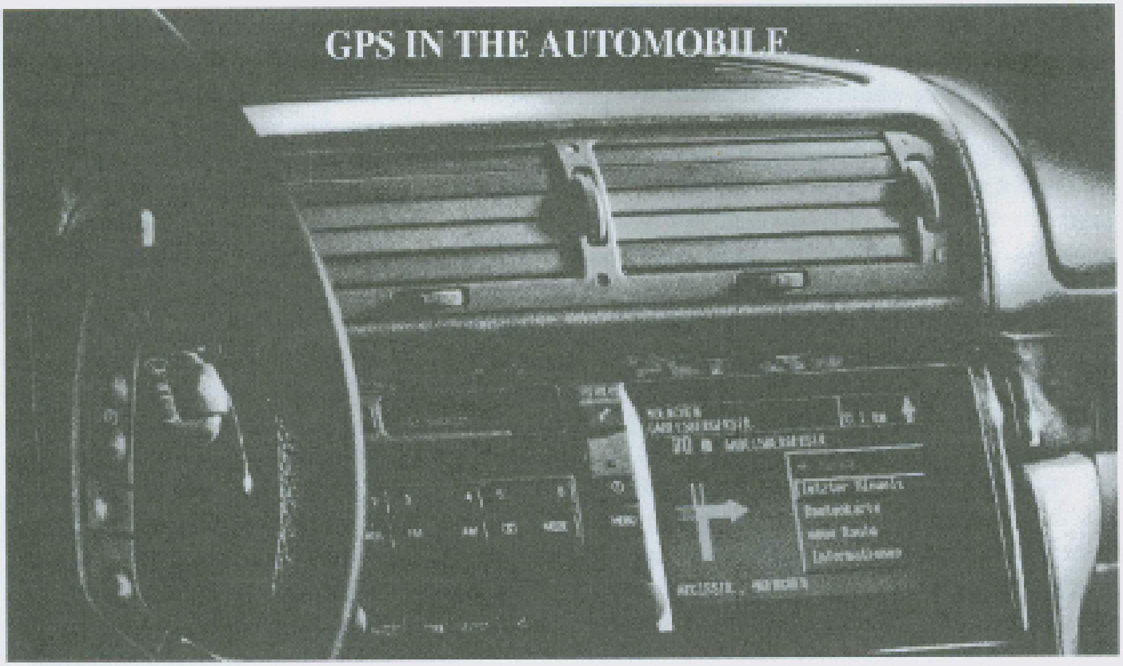
Some Specific Applications

In his opening remarks as the 1996 AIAA Von Karman Distinguished Lecturer, Dr. Parkinson referred to GPS as the "ninth utility,"[2] noting that the ability to "know where you are within the width of a street has spawned a host of new technologies, new uses, and new industries." It is widely acknowledged that the breakthrough utilization of GPS in the civil sector came when it made possible the knowledge of precise position of *vehicles in transit*; previous methods had to rely on position reporting via radio or telephone, or calculations based on last known headings, and (assumed) constant speed profiles. GPS eliminated all of the doubt and inaccuracy of such reports and vector plotting, and could do so despite the "imperfections" (varying speed, delays, changing routes, etc.) along the way. Several early, new and prospective examples include:

Land

- The original utilization of GPS for navigation on land in the non-military sector began with applications involving the need to precisely track the movements of high value or hazardous material over national highways. One early application was to monitor shipments of nuclear waste material to dump sites, with GPS receivers mounted on lead vehicles of the convoys.
- As recently as two years ago, GPS units were being manufactured at a rate of 60,000 per month, with almost half of them going into Japanese automobiles. In the United States, design innovation using GPS to determine the position of automobiles for assistance in case of breakdown are available from upper-end luxury category manufacturers, but this feature will soon extend to all models in the near future.

[2] *The other "eight utilities" are generally acknowledged to be electricity, gas, telephone, TV, water, sewer, garbage collection, and radio.*



GPS, currently available in luxury models, will soon be available in all new automobiles.

- Industrial applications involving the movement of machinery are also becoming widespread. In one instance, GPS is being used to track and coordinate the movements of large, parallel overhead cranes which are used to move lumber. The resolution of position and velocity is precise enough to prevent adjacent cranes from interfering with each other.
- New high speed train systems, such as the TGV in Europe, are equipped with GPS systems as a backup monitoring system to assure human controllers that the trains are maintaining desired speeds and separations. With a fixed track system, the predicted navigation course of a trainset is never an issue, but with the potential for block signaling failures and loss of data, a look-down satellite fix is a reassuring redundant safety enhancement.
- The construction of new automobile roadways, bridges, and rail systems to support land transportation has been made easier through the use of GPS by surveying crews during the pre-construction phase of these major projects. Without relying on line-of-sight theodolites with their optical distortions and difficult logistics, survey crews are now unencumbered with no more than a backpack containing the GPS receiver and antenna, to accomplish their tasks. In fact, surveying was the first market for GPS, since early satellite deployment only allowed periodic opportunities of viewing at any point on the earth.

Air

- With a special variant of GPS involving the use of a fixed receiver on the ground in conjunction with satellites (Differential GPS, or DGPS), accuracies of *2 to 4 centimeters* on a landing centerline have been demonstrated. Major FAA-sponsored contractors are working to establish GPS-based landing feasibility, and in 1994 Stanford University, under Dr. Parkinson, and United Airlines demonstrated a full Category III autoland capability with a Boeing 737 aircraft. The FAA's greatest concern with landing aids, that of *system integrity*, is being consistently demonstrated to a convincing degree. It is now possible to approach, and precisely land, on the most remote dirt landing strip in the middle of Kansas, without the usual heavy investment in instrument landing hardware at the site. In fact, nothing more is required than knowing the geographical coordinates of the intended touchdown spot!

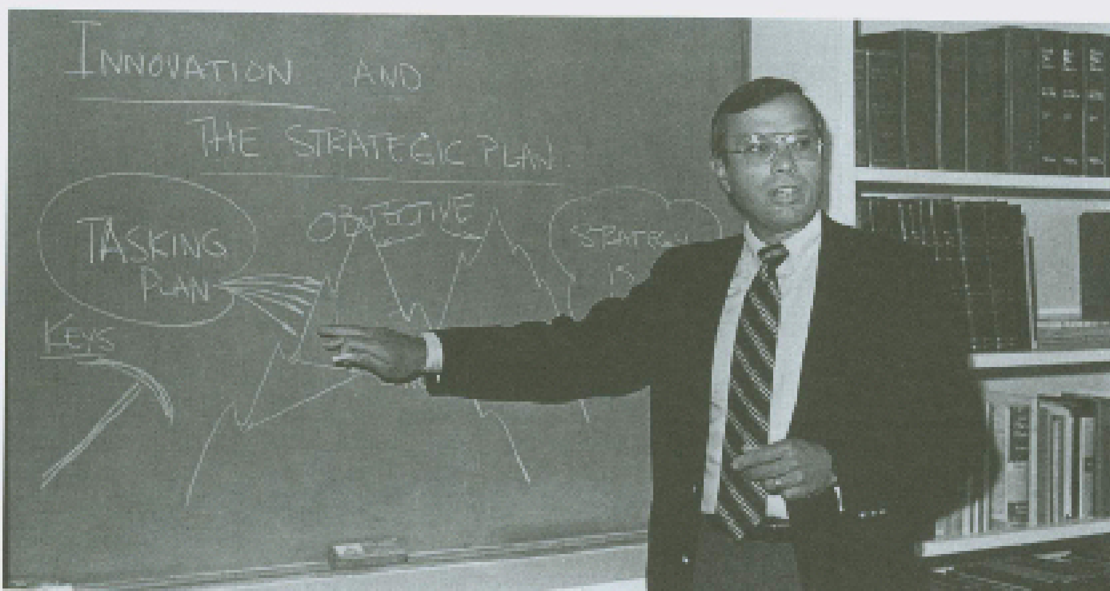
Using the variant known as Differential GPS, an airplane can land with precision even when there is no instrument landing equipment at the site.

- An extension to the DGPS application is Wide-Area Differential GPS (WADGPS) which will increase the operating area of DGPS for all aircraft with benefits of collision avoidance capabilities in congested air traffic areas. The FAA has already embarked on a program with the attributes of DGPS in the U.S., calling it WAAS, or Wide Area Augmentation System.
- All major avionics manufacturers are providing basic GPS navigation hardware for aircraft, and the system is basic to many new aircraft development programs such as the Boeing 777 and the Airbus A3XX. Currently used as a back-up to inertial systems, it will soon become the primary source of navigation for both domestic and oceanic enroute operations.
- For general aviation applications, all-purpose navigation receivers can be purchased at a fraction of inertial systems (some less than $500), with simple installation, no required calibration, and with a highly reliable output giving the pilot accurate track over the ground, speed, and time to destination.
- In a recent experiment in vehicle control applications, a variation of DGPS used multiple receiver antennas on an airplane to dynamically measure vehicle attitude to demonstrated accuracies of 0.1 degree. The potential that this breakthrough represents compared to onboard inertial reference systems, with their stringent calibration requirements and drift problems, is already encouraging further development.

Sea

- Applications for GPS on waterborne craft have been growing at a rate where virtually every modern marine vessel afloat today, whether in commercial or pleasure use, benefits from a GPS installation. In instances where the installation of marine surveillance radar systems has been cost prohibitive for smaller operators, the affordable GPS has become the navigation and collision avoidance resource of choice. Maritime navigation safety has been measurably enhanced as a result.
- In a recent survey of ancient Chinese junks and prows in Hong Kong's Aberdeen Harbor, the editor of a prominent avionics trade magazine was amazed to find the majority of these craft carrying portable GPS receivers. They were being used to locate prime fishing locations for subsequent visits, as well as a means to navigate the difficult convolutions of the Hong Kong harbors and shoreline!

- In yet another application to maritime operations, the tracking of oil spills is being accomplished using buoys equipped with GPS and a radio system to notify an Oil Spill Response Team of their location. The buoys are designed to drift with the spill, with the alerting systems making ships aware of the oil spill location for avoidance purposes, plus keeping the spill undisturbed for subsequent cleanup operations.
- Maritime navigation, particularly in confined waterways, is being enhanced with follow-on refinements to GPS. The U.S. Coast Guard has now completed its coverage of all major waterways, including the Great Lakes and the Mississippi River, with a specialized version of DGPS for more precise steering information that can be used by river traffic.
- Another application that has major significance in shipping lanes near the Arctic Circle is the ability to track the position and migration of large ice floes and icebergs. The larger floes can be at sea for years, are impractical to destroy, and pose a major threat as collision potential to maritime vessels. They are being equipped with GPS and monitored around the clock, forming the basis for alerts when in the vicinity of sea lanes. Some of these floes are no higher than the surface of the ocean and are impossible to detect with ship-borne surveillance radar.



At Stanford University, Professor Parkinson continues to lead innovative research into broader applications of GPS technology.

As a Stanford University Professor, Dr. Parkinson has continued his research on GPS advanced applications and techniques. Under FAA and commercial sponsorship a plethora of new applications have been demonstrated by his team. Noteworthy is the development of a fully robotic John Deere farm tractor. This has shown "hands off" tracking of computer-stored "rows" to an accuracy of 1 to 2 inches. This application alone may lead to productivity enhancements that fully justify the U.S. government's investment in GPS.

California Farmer *magazine cover shows Dr. Parkinson and students with an automated tractor.*

As we have seen from this diverse list, recent system refinements to GPS have considerably broadened its applications to transportation and enhanced the accuracy and usability of the concept. However, the basic technology approach for GPS that developed out of the complexity of competing concepts that were synthesized by Dr. Parkinson over that Labor Day weekend in 1973 have not changed. Rather, they provided a solid base from which new applications have continued to emerge over the subsequent twenty-five years.

In presenting Dr. Parkinson the Elmer A. Sperry Award, the Board is giving recognition to the fact that, in the transportation sector, GPS has become a dominant design consideration for enhancing safety and operational effectiveness regardless of the size, shape, speed, or operating environment of the vehicle.

Elmer A. Sperry, 1860-1930

After graduating from the Cortland, N.Y. Normal School in 1880, Sperry had an association with Professor Anthony at Cornell, where he helped wire its first generator. From that experience he conceived his initial invention, an improved electrical generator and arc light. He then opened an electric company in Chicago and continued on to invent major improvements in electric mining equipment, locomotives, streetcars and an electric automobile. He developed gyroscopic stabilizers for ships and aircraft, a successful marine gyro-compass and gyro-controlled steering and fire control systems used on Allied warships during World War I. Sperry also developed an aircraft searchlight and the world's first guided missile. His gyroscopic work resulted in the automatic pilot in 1930. The Elmer A. Sperry Award was established in 1955 to encourage progress in transportation engineering.

The Elmer A. Sperry Award

To commemorate the life and achievements of Elmer Ambrose Sperry, whose genius and perseverance contributed so much to so many types of transportation, the Elmer A. Sperry Award was established by his daughter, Helen (Mrs. Robert Brooke Lea), and his son, Elmer A. Sperry, Jr., in January 1955, the year marking the 25th anniversary of their father's death. Additional gifts from interested individuals and corporations also contribute to the work of the Board.

Elmer Sperry's inventions and his activities in many fields of engineering have benefited tremendously all forms of transportation. Land transportation has profited by his pioneer work with the storage battery, his development of one of the first electric automobiles (on which he introduced 4-wheel brakes and self-centering steering), his electric trolley car of improved design (features of its drive and electric braking system are still in use), and his rail flaw detector (which has added an important factor of safety to modern railroading). Sea transportation has been measurably advanced by his gyrocompass (which has freed man from the uncertainties of the magnetic compass) and by such navigational aids as the course recorder and automatic steering for ships. Air transportation is indebted to him for the airplane gyro-pilot and the other air navigational instruments he and his son, Lawrence, together developed.

The donors of the Elmer A. Sperry Award have stated that its purpose is to encourage progress in the engineering of transportation. Initially, the donors specified that the Award recipient should be chosen by a Board of Award representing the four engineering societies in which Elmer A. Sperry was most active:

American Society of Mechanical Engineers
(of which he was the 48th President);
American Institute of Electrical Engineers
(of which he was a founder member);
Society of Automotive Engineers; and
Society of Naval Architects and Marine Engineers.

In 1960, the participating societies were augmented by the addition of the Institute of Aerospace Sciences. In 1962, upon merging with the Institute of Radio Engineers, the American Institute of Electrical Engineers became known as the Institute of Electrical and Electronics Engineers; and in 1963, the Institute of Aerospace Sciences, upon merger with the American Rocket Society, became the American Institute of Aeronautics and Astronautics. In 1990, the

American Society of Civil Engineers became the sixth society to become a member of the Elmer A. Sperry Board of Award.

Important discoveries and engineering advances are often the work of a group, and the donors have further specified that the Elmer A. Sperry Award honor the distinguished contributions of groups as well as individuals.

Since they are confident that future contributions will pave the way for changes in the art of transportation equal at least to those already achieved, the donors have requested that the Board from time to time review past awards. This will enable the Board in the future to be cognizant of new areas of achievement and to invite participation, if it seems desirable, of additional engineering groups representative of new aspects or modes of transportation.

THE SPERRY SECRETARIAT

The donors have placed the Elmer A. Sperry Award fund in the custody of the American Society of Mechanical Engineers. This organization is empowered to administer the fund, which has been placed in an interest bearing account whose earnings are used to cover the expenses of the board. A Secretariat is administered by the ASME, which has generously donated the time of its staff to assist the Sperry Board in its work.

The Elmer A. Sperry Board of Award welcomes suggestions from the transportation industry and the engineering profession for candidates for consideration for this Award.

PREVIOUS ELMER A. SPERRY AWARDS

1955 To *William Francis Gibbs* and his Associates for design 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 developing the diesel-electric locomotive.

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

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