

LAUREATES

Dr Bradford Parkinson

Born in Wisconsin, USA, on 16 February 1935, Bradford Parkinson is often called the 'father of GPS'. He gained a BS in engineering from the US Naval Academy (1957) and immediately joined the US Air Force where he helped develop a modernised AC-130 Spectre Gunship and flew more than 170 combat hours. Parkinson was also an instructor at the US Air Force Test Pilot School and led USAF's Department of Astronautics and Computer Science. During his time at USAF he gained an MS in aeronautics from MIT (1961) and a PhD from Stanford University (1966) in guidance control navigation. In 1972 he was asked to revive US Air Force programme, 621B, and create a global navigation system (GPS) with satellites. He became the first Director of the NAVSTAR GPS Joint Program Office in 1973, which led to the development of the GPS spacecraft, Master Control Station, and eight types of user equipment.

After retiring from USAF in 1978, he taught mechanical engineering at Colorado State University for a year and became Vice President of the Space Systems Group at Rockwell International, Inc., where he helped develop the Space Shuttle. He spent six years in industry before becoming a professor of Aeronautics and Astronautics at Stanford University (1984).

He developed GPS applications such as the first automatic landing of a commercial aircraft and the first fully automatic control of farm tractors on a field to an accuracy of two inches (5 cms). Parkinson was the programme manager (and continues as the associate programme manager and co-principal investigator) for NASA's Gravity Probe-B mission. His numerous awards include the Draper Prize of the National Academy of Engineering (2003), the Marconi Award (2016) and the IEEE Medal of Honour (2018).

Professor James Spilker

James Spilker gained a degree, Masters and PhD in electrical engineering from Stanford University (1955-58). He joined the Lockheed Research Labs and during the 1960s wrote a number of papers on signal timing technology. These made the precision tracking of satellites, which is necessary for GPS, possible. He then worked for Ford Aerospace where he designed and implemented the payload for the world's first military satellite communications system. Bradford Parkinson asked him to join him at Stanford in the 1970s, where Spilker contributed to the original GPS architecture and designed the GPS civil signal (L1 c/A code).

In 1973 Spilker co-founded Stanford Telecommunications, which was selected by Parkinson to recommend the GPS signal structure for CDMA (code division multiple access). This was accepted by the US Air Force and became the civilian signal that is now used by 4 billion receivers. Spilker's delay lock loop process for tracking CDMA signals was the key component that enabled the system and is essential to GPS accuracy. His team also developed and built the receiver that processed the first GPS satellite systems and operated a special on-orbit GPS satellite receiver that demodulates millions of signal bits to verify operation in the radiation belts.

Between 2001-05 he was a professor and consultant in engineering at Stanford University. In 2005, he co-founded the Stanford University Center for Position, Navigation and Time, and became the co-founder and executive chairman of AOSense Corporation in 2006. He was a lead designer in developing the L5 civilian signal, first launched in 2011. This provides higher accuracy and is more resistant to interference from space weather. He co-invented the split spectrum mode (binary offset carrier or BOC) that allows civilian and military signals to use separate areas of the spectrum. He also developed adaptive vector tracking for simultaneously tracking ranging signals from multiple satellites. This system maintains accuracy and has an improved performance against interference.

Vector tracking will be critical to handling GPS satellite navigation expansion in the future. Spilker won the AIAA Sommerfield Book Award for *Global Positioning System: Theory and Applications* (1996), considered the standard reference for GPS. His recognitions include the Kepler Award (1999) and the IEEE Thomas Edison Medal (2015).

Richard Schwartz

Dick Schwartz graduated in engineering from The Cooper Union for the Advancement of Science and Art in New York and has an MBA from Pepperdine University. He joined Rockwell in 1957 and led many of its most successful space and satellite programs, including the first flights of GPS and the NASA Space Shuttle. He was Rockwell's GPS Satellite Program Manager and commissioned his chief engineer, Hugo Fruehauf, to work with Efratom engineers to produce a satellite design that could withstand intense radiation. It also had antennas that ensured uniform power. He became President of the Rocketdyne Division of Rockwell International in 1983 and was also President of Hercules Aerospace and Executive Vice President of the Hercules Corporation (1990 onwards). He was Chief Executive Officer and later Chairman of ATK (1995-2000), which builds precision weaponry for the US Government, and has been a Director of Frequency Electronics since 2004.

Hugo Fruehauf

Hugo Fruehauf gained his degree in electronic engineering technology from DeVry University, Illinois. From 1960-65 he was Field Operations Test Engineer at Martin-Marietta and Convair Astronautics covering Atlas-Agena launches and Titan-I ICBM testing at Vandenberg Air Force Base; and for test launches of the TM-76B Cruise Missile at Cape Canaveral. He joined Rockwell International in

1965 as electrical systems manager for the Saturn-V, 2nd stage launch vehicle at the Mississippi Test Facility (now the Stennis Space Center).

He was Rockwell's Chief Engineer and Systems Manager for the design and development of the GPS Satellite (1973-78). He was also Chief Engineer for the design and development of NASA's TDRS (Tracking and Data Relay Satellite) and helped develop the first fully radiation hardened rubidium vapour atomic clock alongside Schwartz.

Fruehauf joined the German company Ball-Efratom and served as President and CTO until 1995. Here he worked to invent the first miniature rubidium vapour atomic oscillator, which met GPS' accuracy requirements and became the 'clock of choice' for GPS satellites. He was Group Vice President and CTO at Defense Group, Alliant Techsystems (1995-97) and, between 1998-2007, was VP/CTO at FEI and President/CEO/CTO at FEI-Zyfer, Zyfer and Odetics Telecom.

He gained an MBA in global business and management from Pepperdine University - Graziadio School of Business and Management (2005-07) and set up the Hugo Fruehauf Company in 2008 and is currently a consultant. He is also an adjunct professor at the Pepperdine University Graduate School (2008 onwards).