Prof. BRADFORD PARKINSON

DOKTOR HONORIS CAUSA
UNIWERSYTETU MORSKIEGO W GDYNI

DOCTOR HONORIS CAUSA
OF GDYNIA MARITIME UNIVERSITY

Prof. Bradford PARKINSON

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TOTEM

Uniwersytet Morski w Gdyni dziękuje prof. Bradfordowi Parkinsonowi oraz „GPS World" za udostępnienie artykułu „The Origins of GPS" i zgodę na przedruk w okolicznościowej publikacji z okazji nadania tytułu doktora honoris causa Profesorowi Parkinsonowi.

Gdynia Maritime University would like to thank Professor Bradford Parkinson and *GPS World* for providing the article "The Origins of GPS" and granting permission for its reprint in this publication.

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Prof. BRADFORD PARKINSON

DOKTOR HONORIS CAUSA UNIWERSYTETU MORSKIEGO W GDYNI

DOCTOR HONORIS CAUSA OF GDYNIA MARITIME UNIVERSITY

GDYNIA 2024

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SPIS TREŚCI

FOREWORD BY THE PRESIDENT OF GMU, PROFESSOR ADAM WEINTRIT, PhD, DSc, FRIN, FNI, MASTER MARINER

Ladies and Gentlemen,

Few of our contemporaries have had such a tremendous impact on the development of almost every area of knowledge and technology to whom we are so indebted as Bradford Parkinson, an engineer and a Professor at Stanford University—the Father of GPS. Almost a year ago, precisely at the time of the 50th anniversary of the launch of NAVSTAR, the Global Positioning System, on my initiative, Gdynia Maritime University began the procedure for the conferral of the honorary title of Doctor *honoris causa* on Professor Parkinson. On 16 November 2023, the Senate of Gdynia Maritime University passed a resolution on the conferral of the honorary title of Doctor *honoris causa* on Professor Bradford Parkinson in recognition of his revolutionary contribution to the development of technology and all modes of transportation, as well as the creation of the foundations for epochal change in the functioning of the world in the 20th and 21st centuries through leading the team responsible for the development of the first global satellite navigation system.

Under the GMU Statutes, this honorary title is awarded to persons of merit in the development of science and learning, culture, or the social life of the University. Inaugurated into this highly regarded narrow circle of honorary doctors on the momentous occasion of the 50th anniversary of the launch of the Global Positioning System, which fully revolutionized air, marine, and land navigation, and of which he was the main architect as the Head of the United States Air Force's (USAF) NAVSTAR GPS Joint Program Office, is Professor Bradford Parkinson.

The satellite navigation system, known formally as NAVSTAR, the Global Positioning System, was launched in 1973. Today, billions of people around the world rely on the enormous engineering infrastructure that is GPS, which covers the entire planet and reaches into space. This celestial network is used to improve marine and aviation safety; in the location of shipwrecks and rescue of ships in danger at sea; transport services (road, rail, air, and inland and marine waterways); construction; geodesy; cartography; tourism; recreation; farming; food production; banking; and science. GPS, which has revolutionized navigation and the precision of time measurement, has also become an essential tool for ordinary smartphone users, allowing them to determine their exact location on the planet. Thanks to the ability of the satellite system to accurately pinpoint the location of receivers and a well-designed map, we can reach our destination without even knowing the route.

Nominations for the award of the honorary title of Doctor *honoris causa* must be supported by three external university senates, and so I sought the approval of Warsaw University of Technology, the Polish Naval Academy, and the Polish Air Force University. The Rectors of these academic institutions, Professor Krzysztof Zaremba, Rector-Commander Rear Admiral Professor Tomasz Szubrycht, and Rector-Commander Brig. Gen. Krzysztof Cur, accepted my proposal without hesitation, and positively petitioned their respective Senates to support the nomination.

In addition to the support of three academic institutions, the procedure also requires the positive opinions of three independent professors. These were provided by Professor Jarosław Bosy of Wrocław University of Environmental and Life Sciences, Professor Stanisław Oszczak of the Polish Air Force University, and Professor Zbigniew Burciu of Gdynia Maritime University.

I had the honor and pleasure of informing Professor Bradford Parkinson of the decision of the Senate of Gdynia Maritime University to confer on him the honorary title of Doctor *honoris causa* on 21 November 2023. In response, he wrote that it was “wonderful news and a great honor” that he was to receive an honorary title from our University as he himself is a graduate of the American Naval Academy, which has much in common with our, as he described it, “very capable educational institution.” This was the impression left upon him by the album for the centenary of Gdynia Maritime University, a copy of which he received from Professor Krzysztof Czaplewski, who often attends professional meetings with Professor Parkinson in the USA, therefore supporting the exchange of technical knowledge and the strengthening of ties between our countries.

The list of institutions which, during the 1990s and the first decade of the 21st century, benefited from the knowledge and competencies of Professor Parkinson, is impressive. Professor Parkinson has been honored with several dozen awards and distinctions, including an Honorary Fellow of AIAA; a Life Fellow of IEEE; the AIAA Goddard Astronautics Award; the NASA Distinguished Public Service Medal; the Lloyd V. Berkner Award of the American Astronautic Society; the Charles Stark Draper Prize; the Gold Medal of the Royal Institute of Navigation; the Gold Medal of the American Association of Mechanical Engineers (ASME); and the Queen Elizabeth Prize for Engineering. In the year 2000, he was made an honorary doctor of the University of Calgary. However, to my knowledge, the Professor has yet to be given this honor by a European University.

Esteemed Professor, it is indeed a great honor and privilege that you have accepted this distinction from Gdynia Maritime University. The circumstances of the award of the title are also exceptional. On the diploma which you will receive are two signatures, that of the Promoter of the procedure for the conferral of the honorary title of Doctor *honoris causa* and that of the President of the University. Professor Krzysztof Czaplewski is the chair of the International Association of Institutes of Navigation (IAIN), and I have the honor of chairing the International Association of Maritime Universities (IAMU). As it happens, never before have two staff members from the same faculty of the same university held such prominent roles in our international community and professional environment.

Distinguished Honorary Doctor of Gdynia Maritime University, please accept my most sincere and heartfelt congratulations and deepest respect on behalf of our entire academic community.

Professor Adam Weintrit, PhD, DSc, FRIN, FNI, Master Mariner
President of Gdynia Maritime University

I'VE BEEN A REVOLUTIONIST FOR 50 YEARS WITH THIS STEALTHY REVOLUTION. AND GPS IS, INDEED, A STEALTHY REVOLUTION. AND WE'VE CONTINUED TO CALL IT A STEALTHY REVOLUTION. BUT OUR REVOLUTION CONTINUES.

BRADFORD PARKINSON

Photo: iStock

LAUDATION ON THE OCCASION OF THE CONFERRAL OF A DOCTORATE HONORIS CAUSA BY GDYNIA MARITIME UNIVERSITY ON PROFESSOR BRADFORD PARKINSON

PROFESSOR KRZYSZTOF CZAPLEWSKI, DSc(Eng)
GDYNIA MARITIME UNIVERSITY

Your Magnificence,
Esteemed Senate,
Distinguished Professor,
Ladies and Gentlemen,

I have been given the honor and privilege by the Senate of Gdynia Maritime University to act as the promoter in the procedure for the conferral of the honorary title of Doctor *honoris causa* on an extraordinary person, known around the world as the Father of GPS – Professor Bradford Parkinson.

The honorary title of Doctor *honoris causa* is the highest academic honor awarded to the most outstanding individuals, particularly those who have contributed exceptionally to the development of science, culture, and the economy, and whose work has strongly impacted the modern world. The honorary title is given to those who enjoy undisputed authority and unquestionable moral standing. Honorary Doctors are persons who have the potential to change the world around them. Without a shadow of a doubt, one of these exceptional individuals is Professor Bradford Parkinson, a man whose work has had a notable impact on the everyday life of humanity. Just as the spread of steam engines changed the face of the earth in the 19th century, similarly in the second half of the 20th century, the proliferation of computer technology and the launch of satellite systems changed our lives forever. Without satellite systems, our use of computer technology in today's age of information would be incomplete. Without the personal involvement of Professor Parkinson, modern transportation would not be what it is today. There would be no electronic banking or popular VOD services. Each and every one of us benefits, consciously or unconsciously, from the effects of the work of the Professor and those with whom he has cooperated.

Bradford Parkinson was born on February 16, 1935. He attended Breck Middle School in Golden Valley, Minnesota. In 1957, he graduated with a distinction from the U.S. Naval Academy in Annapolis with a Bachelor of Science Degree in Engineering. His particular engineering interests were noted by one of his professors who recommended he consider being commissioned in the U.S. Air Force (USAF). At the beginning of his USAF career, he completed training in electronics maintenance and oversaw large ground radar installations in Washington State. The Air Force provided the future professor the opportunity to attend Massachusetts Institute of Technology, where he studied Controls Engineering, Inertial Guidance, Astronautics and Electrical Engineering. Upon graduation, he received a Master of Science in Aeronautics and Astronautics. As a USAF officer, he was assigned to work at the Central Inertial Guidance Test Facility at Holloman Air Force Base in Alamogordo, New Mexico, in the role of Chief Analyst for the evaluation of the Air Force's inertial guidance systems.

In 1964, he began a Ph.D. at Stanford University, graduating in 1966 with a degree in Aeronautics and Astronautics.

Bradford Parkinson's career in the USAF and beyond is extremely impressive. He served as an academic instructor at the USAF Test Pilot School from 1966 until 1968 and was chief of the Simulation Division. He was also the chief academic instructor to a class of Astronauts. Many of his students went on to work at NASA and flew on the Space Shuttle.

After his time at the Test Pilot School, he was assigned to the Air Force Academy Department of Astronautics and Computer Science, where he worked as a professor and held the role of Deputy Head. He was also involved in the development of a brand-new version of the AC-130 gunship. Later, he deployed to South East Asia during the Vietnam War, where he flew 26 combat missions, for which he was awarded several military honors. Combat experience allowed him to refine the weapons control system.

Photo: USAF

Bradford Parkinson at a U.S. Air Force range.

Following his return from deployment, he rejoined the Air Force Academy as the Head of the Department of Astronautics and Computer Science.

In 1973, he was assigned to Project 621B – a code name for a program for the development of a new satellite navigation system. Through his keen dedication, he built a new team of experts, which he headed from 1973 until 1978. The team devised the concept for a satellite navigation system which is available for use 24 hours a day, 365 days a year, developed the system's architecture, and led to its launch. Colonel Parkinson was personally responsible for gaining clearance for the development of the system from USAF command and in the U.S. Senate. He also worked on resolving research questions in relation to:

- modification of the CDMA radio signal;
- adaption of the orbit of satellites to reduce the number of satellites at optimal altitude;
- the implementation of atomic clocks into satellite equipment.

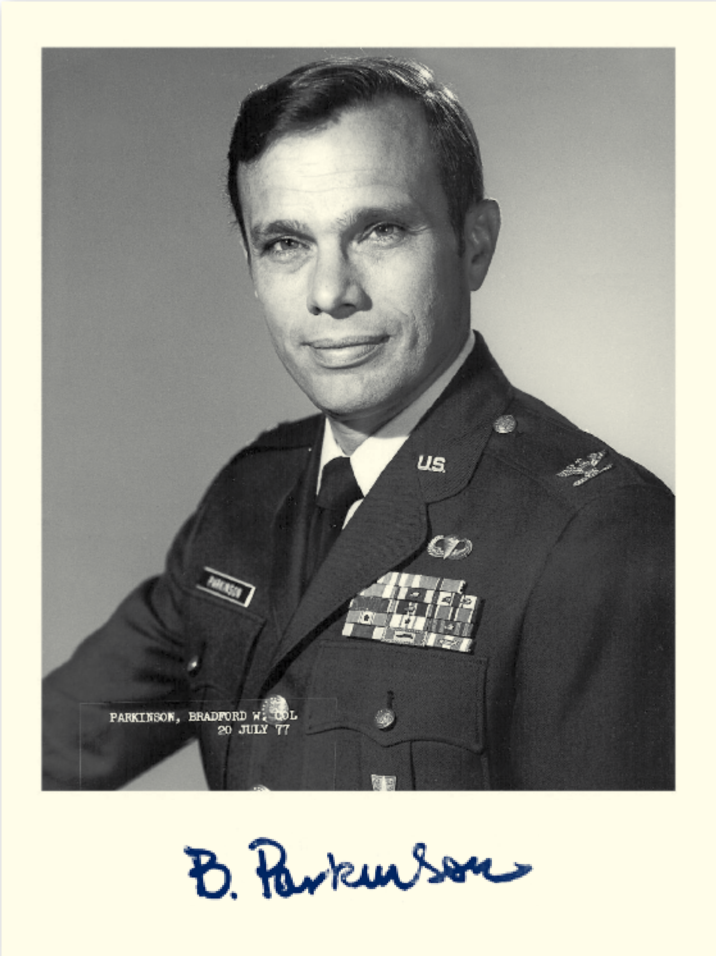


Photo: USAF

Colonel Bradford Parkinson, 20 July 1977

In 1978, after 26 years in the military, he retired from the U.S. Air Force at the rank of full colonel.

However, work on the development of GPS continued. In 1979, he worked as a mechanical engineering professor at Colorado State University and later took up the role of Deputy President of the Space System Group at Rockwell International, where he was involved in strategic planning and the development of advanced space systems. During the years 1980-1984, he was the vice president and CEO of the Boston-based software company Intermetrics, which was responsible for the creation of the HAL/S programming language used on the NASA Space Shuttle program. In 1984, he accepted an appointment as a Research Professor at Stanford University where he went on to assume Stanford's "Edward C. Wells" Chair of Aeronautics and Astronautics, teaching Astrodynamics and Control Theory. In 1999, he became the CEO of Trimble Navigation.
He was also the co-principal investigator and program manager on the NASA/Stanford University joint endeavour Gravity Probe B, which was the first ever direct mechanical test of Einstein's General Relativity. The results were announced and published between 2007 and 2015.

Bradford Parkinson has served on many corporate and governmental boards. For many years, he has been one of the co-chairs of the National Executive Committee for Space-Based Positioning, Navigation and Timing Advisory Board – one of three organisations that oversee the Global Positioning System. In addition, he prepares independent opinions for the U.S. government in relation to its areas of responsibility.

We are honoured to have here with us today a remarkable person who dedicated his entire career to the development of humanity. Unquestionably, one of the most important achievements of Professor Parkinson is the launch of GPS. Another extremely important achievement, however, is the creation of the theoretical foundations and the development of the Wide Area Augmentation System (WASS), mainly used in air transport. The U.S. GPS Satellite Support System increases the accuracy of the determination of the horizontal position by a GPS receiver to 2-3 meters. GPS receivers, assisted by the WAAS system, use corrections when calculating their positions to improve the accuracy of determined positions. The Professor is also the author of other innovations in using satellite systems, such as the blind landing of Boeing 737 aircraft using GPS alone, or the complete automatic control of agricultural tractors using GPS on an uneven field with an accuracy of two inches.

The innovation of Bradford Parkinson's work was confirmed by seven patents obtained during the years 1996-2004.

Photo: Gregg Segal

HRH The Prince of Wales presents the 2019 QE Prize to Prof. Bradford Parkinson.

Photo: https://scpnt.stanford.edu/news/four-pnt-pioneers-awarded-2019-queen-elizabeth-prize-engineering

Professor Parkinson has received many awards and distinctions for his scientific and professional activity. One of the most important awards granted to today's esteemed Honorary Doctor is the Queen Elizabeth Award. This prestigious honor was given to the entire team responsible for the architecture and development of GPS by the Prince of Wales (now King Charles III) in 2019. A year earlier he received the IEEE Medal of Honor.

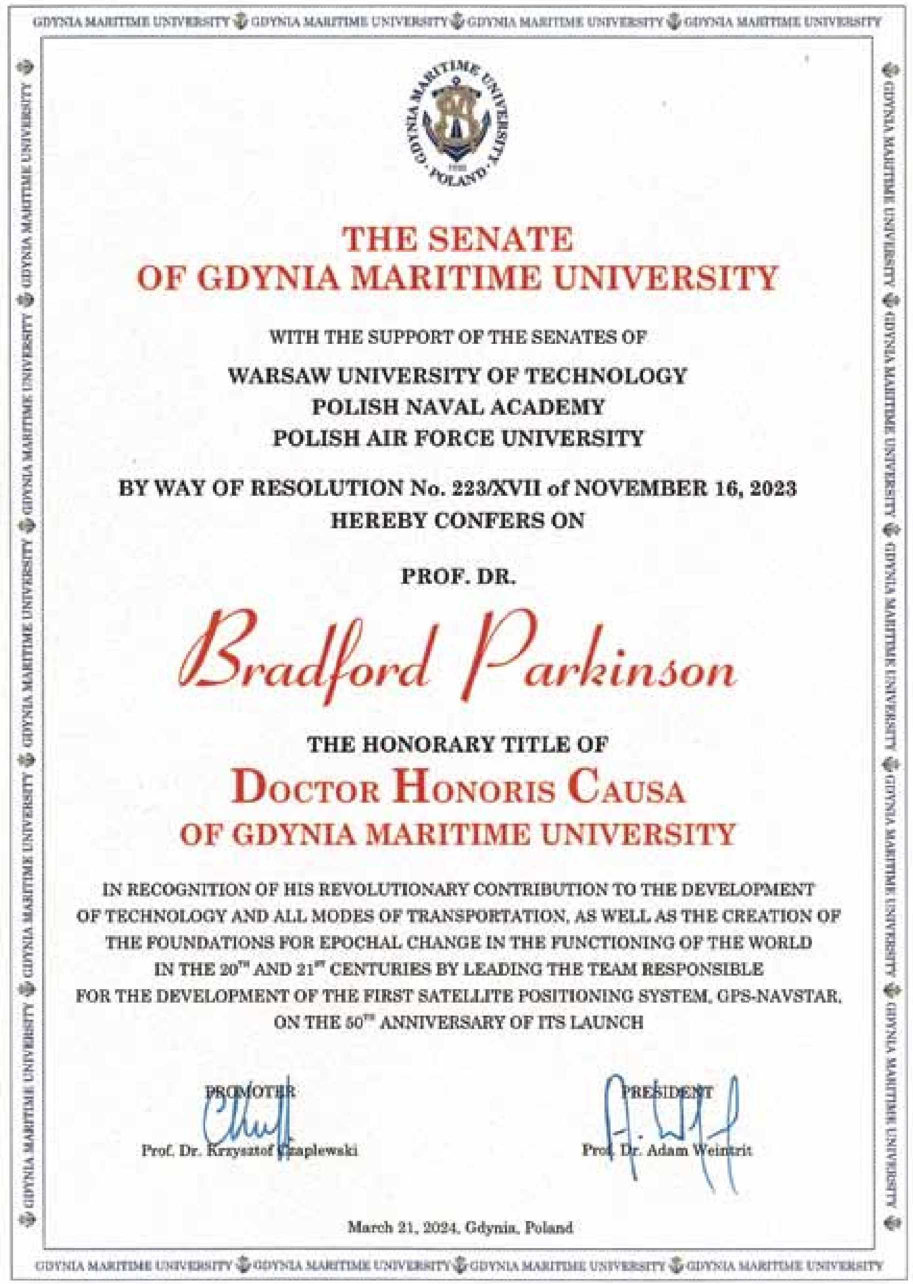
In the dedication written in a copy of his book "Global Positioning System: Theory and Applications" gifted to me by the Professor, he wrote, "Pioneers are always on top". Professor Bradford Parkinson is the pioneer who will always be on top and will always be in our memory – his name etched in the marble of our University's commemorative tablet of honorary doctors.

Professor Krzysztof Czaplewski
Maritime Institute
Gdynia Maritime University

HONORS & AWARDS

- Queen Elizabeth Prize for Engineering (2019)
- Medal of Honor, IEEE (2018)
- Honorary Fellow, AIAA (2017)
- Marconi Award, The Marconi Society (2016)
- Hall of Fame, Engineer's Club of Dayton (2015)
- Honorary Fellow, Royal Institute of Navigation (2014)
- Engineering Hero, Stanford University (2012)
- Necho Award, International Association of Institutes of Navigation (2012)
- The Rheim Technology Prize, Eduard Rheim Institute, Munich (2012)
- Distinguished Graduate, US Naval Academy (2011)
- Pioneer's Award, US Space Command (2009)
- Lloyd Berkner Award, American Astronautical Society (2008)
- Silicon Valley Hall of Fame, Silicon Valley Engineering Council (2007)
- Goddard Astronautics Award, AIAA (2006)
- ASME Gold Medal Award, American Society of Mechanical Engineers (2004)
- Fellow, IEEE (2004)
- Member, National Inventors Hall of Fame (2004)
- Charles Stark Draper Prize, NAE (2003)
- Discover Innovation Award for Communications, Discover Magazine (2002)
- Simon Ramo Award, IEEE (2002)
- Distinguished Public Service Medal, NASA (2001)
- Fellow, The Institute of Navigation (ION) (1999)
- Hall of FAME, NASA (1998)
- Sperry Award, IEEE (1998)
- Magellanic Premium Award, American Philosophical Society (1997)
- Member, International Academy of Astronautics (IAA) (1997)
- Von Karman Lectureship, AIAA (1996)
- Edward C Wells Professor of Aeronautics & Astronautics, Stanford University (1995)
- GPS Hall of Fame Award, NAVSTAR Joint Program Office (1995)
- Pioneer Award, AESS/IEEE (1994)
- Public Service Medal, NASA (1994)
- Johannes Kepler Award, ION (1991)
- Fellow, The Royal Institute of Navigation (1990)
- Fellow, American Institute of Aeronautics & Astronautics (AIAA) (1990)
- Member, National Academy of Engineers (NAE) (1990)
- Burka Award, ION (1987)
- Kirschner Award, IEEE (1986)
- Thurlow Award, ION (1986)
- Engineer of the Year for Silicon Valley, AIAA (1985)
- Gold Medal Award, Royal Inst. of Navigation (1983)
- Legion of Merit, US Air Force (1978)
- Defense Department Superior Performance Award, NAVSTAR (GPS) GPO (1977)
- Bronze Star, US Air Force (1970)
- Presidential Unit Citation, Dept. Of Defense (1970)
- Air Medals (2), US Air Force (1969)
- Member, Sigma Xi (1961)
- Member, Tau Beta Pi (MIT Chapter) (1961)

https://profiles.stanford.edu/bradford-parkinson



GDYNIA MARITIME UNIVERSITY

THE SENATE
OF GDYNIA MARITIME UNIVERSITY

WITH THE SUPPORT OF THE SENATES OF

WARSAW UNIVERSITY OF TECHNOLOGY
POLISH NAVAL ACADEMY
POLISH AIR FORCE UNIVERSITY

BY WAY OF RESOLUTION No. 223/XVII of NOVEMBER 16, 2023
HEREBY CONFERS ON

PROF. DR.

Bradford Parkinson

THE HONORARY TITLE OF
DOCTOR HONORIS CAUSA
OF GDYNIA MARITIME UNIVERSITY

IN RECOGNITION OF HIS REVOLUTIONARY CONTRIBUTION TO THE DEVELOPMENT OF TECHNOLOGY AND ALL MODES OF TRANSPORTATION, AS WELL AS THE CREATION OF THE FOUNDATIONS FOR EPOCHAL CHANGE IN THE FUNCTIONING OF THE WORLD IN THE 20TH AND 21ST CENTURIES BY LEADING THE TEAM RESPONSIBLE FOR THE DEVELOPMENT OF THE FIRST SATELLITE POSITIONING SYSTEM, GPS-NAVSTAR, ON THE 50TH ANNIVERSARY OF ITS LAUNCH

PROMOTER
Prof. Dr. Krzysztof Czaplewski

PRESIDENT
Prof. Dr. Adam Weintrit

March 21, 2024, Gdynia, Poland

NOS SENATUS
UNIVERSITATIS MARITIMAE GDINENSIS

CUM FAVORE SENATUUM

POLYTECHNICAE VARSOVIENSIS
ACADEMIAE CLASSIS MILITARIS GDINENSIS
ACADEMIAE AERONAUTICAE MILITARIS DEBLINENSIS

CONTULIMUS

EX DECRETO AMPLISSIMI SENATUS
223/XVII die XVI mensis Novembris anno MMXXIII facto

PROFESSORI DOCTORI

Bradfordio Parkinson

HONORABILEM NOMEN

DOCTORIS HONORIS CAUSA
UNIVERSITATIS MARITIMAE GDINENSIS

PROPTER IMMENSAM CONTRIBUTIONEM IN PROGRESSUM SCIENTIARUM TECHNICARUM ET HORUM OMNIUM QUAE AD VECTURAM PERTINENT ATQUE IN CREATIONEM FUNDAMENTORUM GRAVISSIMARUM IN MUNDO SOCIETATISQUE MUTATIONUM SAECULIS XX ET XXI PER REGIMEN IN COETU QUI CREAVIT PRIMUM SYSTEMA COLLOCANDI GLOBALE QUI SATELLITES ARTIFICIOSOS UTITUR CUI LINGUA ANGLICA NOMEN EST GPS-NAVSTAR PATRINO SYSTEMATIS LINGUA ANGLICA GPS VOCATI, ANNO QUINQUAGESIMO AB EIUS INAUGURATIONE

PROMOTOR RITE CONSTITUTUS
Prof. Christophorus Czaplewski

H.T. RECTOR MAGNIFICUS
Prof. Adamus Weintrit

datum Civitate Gdinensi, die XXI mensis Martii anno MMXXIV

SENAT
UNIWERSYTETU MORSKIEGO W GDYNI

PRZY POPARCIU SENATÓW

POLITECHNIKI WARSZAWSKIEJ
AKADEMII MARYNARKI WOJENNEJ W GDYNI
LOTNICZEJ AKADEMII WOJSKOWEJ W DĘBLINIE

NADAJE

UCHWAŁĄ SENATU Nr 223/XVII z dnia 16 listopada 2023 r.

PROFESOROWI DOKTOROWI

Bradfordowi Parkinsonowi

ZASZCZYTNY TYTUŁ

DOKTORA HONORIS CAUSA
UNIWERSYTETU MORSKIEGO W GDYNI

W UZNANIU REWOLUCYJNEGO WKŁADU W ROZWÓJ TECHNIKI ORAZ WSZYSTKICH GAŁĘZI TRANSPORTU JAK RÓWNIEŻ W STWORZENIE PODSTAW DO EPOKOWEJ ZMIANY FUNKCJONOWANIA ŚWIATA I SPOŁECZEŃSTW W XX I XXI WIEKU POPRZEZ KIEROWANIE ZESPOŁEM ODPOWIEDZIALNYM ZA UTWORZENIE PIERWSZEGO SATELITARNEGO SYSTEMU POZYCYJNEGO GPS-NAVSTAR OJCU CHRZESTNEMU SYSTEMU GPS, W 50-TĄ ROCZNICĘ JEGO URUCHOMIENIA

PROMOTOR
Prof. dr hab. inż. Krzysztof Czaplewski

REKTOR
Prof. dr hab. inż. kpt. ż.w. Adam Weintrit

Gdynia, 21 marca 2024 r.

RESOLUTION NO. 223/XVII

OF THE SENATE OF GDYNIA MARITIME UNIVERSITY

of 16 November 2023

regarding the conferral of the honorary title of Doctor *honoris causa* on Professor Bradford Parkinson by Gdynia Maritime University

Under article 28, item 1, point 9 of the Higher Education and Science Act of 20 July 2018 (Journal of Laws of 2022, item 574, with later amendments) and statute 14.1.8 of the Statutes of Gdynia Maritime University, the Senate of Gdynia Maritime University adopts the following Resolution:

§ 1

In recognition of his revolutionary contribution to the development of technology and all modes of transportation, as well as the creation of the foundations for epochal change in the functioning of the world in the 20th and 21st centuries through leading the team responsible for the development of NAVSTAR, the Global Positioning System, Gdynia Maritime University confers on Professor Bradford Parkinson, the godfather of GPS, a doctorate *honoris causa* on the occasion of the 50th anniversary of its launch.

§ 2

The Resolution is valid from the date of adoption.

Chair of the Senate

Professor Adam Weintrit, Ph.D, D.Sc.
Master Mariner

RESOLUTION NO. 23/2023

OF THE SENATE OF THE POLISH NAVAL ACADEMY

of the Heroes of Westerplatte

of 29 June 2023

regarding: the provision of an opinion on the conferral of the honorary title of Doctor *honoris causa* on Professor Bradford Parkinson by Gdynia Maritime University

In response to the request of the Chair of the Senate, President of Gdynia Maritime University, Professor Adam Weintrit, of 29 May 2023, the Senate of the Polish Naval Academy of the Heroes and Westerplatte, by way of an open ballot, declares that:

§ 1

The Senate of the Polish Naval Academy of the Heroes of Westerplatte hereby expresses a favourable opinion on the conferral of the honorary title of Doctor *honoris causa* on Professor Bradford Parkinson by the Senate of Gdynia Maritime University.

§ 2

The Resolution is valid from the date of adoption.

RECTOR AND COMMANDER
THE POLISH NAVAL ACADEMY
CHAIR OF THE SENATE

Rear Admiral Prof. Tomasz SZUBRYCHT, D.Sc

RESOLUTION No. 28/2023

OF THE SENATE OF THE POLISH AIRFORCE UNIVERSITY

of 20 June 2023

Regarding the provision of an opinion on the conferral of the honorary title of Doctor *honoris causa* on Professor Bradford Parkinson by Gdynia Maritime University

On the request of the President of Gdynia Maritime University, Professor Adam Weintrit, of 29 May 2023, in connection with the initiation of the proceedings for the conferral of the honorary title of Doctor *honoris causa* on Professor Bradford Parkinson of Stanford University by Gdynia Maritime University, based on article 28, item 1, point 9 of the Higher Education and Science Act of 20 July 2018 (Journal of Laws of 2023, item 742, with later amendments) and having examined the scientific activity and the merits of the candidate for the highest academic honour, the following Resolution is hereby adopted:

§ 1

The Senate of the Polish Air Force University expresses a positive opinion on the conferral of the honorary title of Doctor h*onoris causa* on Prof. Bradford Parkinson of Stanford University by Gdynia Maritime University.

§ 2

The Resolution is valid from the date of adoption.

LOTNICZA AKADEMIA WOJSKOWA
m.p.

CHAIR OF THE SENATE
RECTOR-COMMANDER

Brig. Gen. Pilot Krzysztof CUR

Entitled to vote: 20
Votes cast in open ballot: 20
- votes for 20
- votes against 0
- abstentions 0

Drawn up in duplicate:
Copy No. 1 – ad acta
Copy No. 2 - President of Gdynia Maritime University, Prof. Adam Weintrit

Resolution No. 401/L/2023

of the Senate of Warsaw University of Technology

of 20 September 2023

Regarding support for the motion to confer a doctorate *honoris causa* on Professor Bradford Parkinson by Gdynia Maritime University

Under § 42, item 2, point 3 of the Statutes of Warsaw University of Technology, in response to the request received from Gdynia Maritime University, the following Resolution is hereby adopted:

§ 1

Following consideration of the scientific contributions of Professor Bradford Parkinson, the Senate of the Warsaw University of Technology supports the motion for the conferral of a doctorate *honoris causa* on Professor Bradford Parkinson by Gdynia Maritime University.

§ 2

The Resolution is valid from the date of adoption.

Senate Secretary	Rector
Anna Stoczkiewicz, M.Sc	Prof. Krzysztof Zaremba, D.Sc (Eng.)

Professor Jarosław Bosy, D.Sc (Eng.)
Wrocław University of Environmental
and Life Sciences

Uniwersytet
Przyrodniczy
we Wrocławiu

OPINION
On the conferral of the honorary title of Doctor *honoris causa* on Professor Bradford Parkinson by Gdynia Maritime University.

Professor Bradford Parkinson is a retired Stanford University professor and an outstanding specialist in aviation and astronautics. He was the chief architect of the Global Positioning System, NAVSTAR GPS, which he developed during his time as the director of the United States Air Force (USAF) GPS Program Office.

Professor Bradford Parkinson was born on 16 February 1935 in Madison, Wisconsin, and grew up in Minneapolis, Minnesota, where he graduated from Breck School in 1952. He joined the U.S. Air Force in 1957 after graduating with a Bachelor of General Engineering from the U.S. Naval Academy. In 1961, he completed a master's degree in aeronautics and astronautics at Massachusetts Institute of Technology (MIT), and five years later, a doctorate at Stanford University. After carrying out battle missions in Southeast Asia and serving as an academic instructor at the USAF Test Pilot School, he was promoted to the rank of colonel and headed the Faculty of Astronautics and Information Technology at the USAF Academy.

In 1972, Colonel Parkinson joined the Space and Missile Systems Organization (SAMSO). For a short time, he served as the chief engineer for Advanced Ballistic Re-Entry Systems (ABRES). In November 1972, shortly after being transferred to the 621B navigation satellite program, he became the program's manager, overseeing what would during the next year become the program for the development of the Global Positioning System (GPS).

As the head of the first program office, he played a leading role in the creation of various space systems for PNT - Positioning, Navigation and Timing - for the U.S. Navy and the U.S. Army. At this time, he was also the principal advisor for GPS at the Department of Defense. He headed the GPS program until his retirement in 1978, commanding the launch of the prototype Block 1 GPS satellite.

His activities included the development of satellites, terrestrial systems, and user equipment, as well as extensive testing systems to validate system accuracy and other system quality parameters. The Department of Defense awarded Colonel Parkinson the Superior Performance Award for his performance as the best program director in the USAF in 1977.

I consider these achievements to be groundbreaking, for they brought us into the new era of the Global Earth Observation System, where the determination of positions on the ground, water, and in the air is based on a uniform system of navigational satellites.

The second extremely important chapter of Bradford Parkinson's life began after his military retirement and involves his activity in science and business. In 1978, he began work at Colorado State University, where as a professor of mechanical engineering he conducted research and lectured on courses on the automatic control of objects. During the years 1979-1980, he was the vice president of Rockwell International, and during the years 1980-1984, the vice president and general director of Intermetrics, a company dedicated to software and engineering. He returned to academic work in 1984 as a lecturer at Stanford University. In 1995, he became a professor of aeronautics and astronautics.

Professor Parkinson directed research projects that carried out pioneering and groundbreaking work on landing commercial aircraft using GPS alone, the creation of a prototype (for the Federal Aviation Administration) of the Wide Area Augmentation System (WAAS) — a surface-navigation and positioning system, the prototype of a precision system for the control of an agricultural tractor using GPS, and more.

As a professor at Stanford University, he played leading roles as head, deputy head, and main researcher of the NASA Gravity Probe-B program, using orbiting gyroscopes to test the general theory of Einstein's relativity.

This extremely important phase of the professor's life resulted in many scientific publications, and above all, in the development of applications using GPS in various functions, as well as research on Earth's gravitational field. The activity of Professor Parkinson in the business sector has allowed for the practical application of many of these solutions, which has contributed to the spread of the use of GPS in support of many areas of the economy. He held the role of CEO/ President of Trimble Navigation, a world leader in the development of applications based on GPS, and later, GNSS.

In 2001, he gained the status of professor emeritus at Stanford University and continued to lead teams conducting research projects connected with the development of GPS.

During the 1990s and the first decade of the 21st century, the list of institutions that benefited from the knowledge and competencies of Professor Parkinson is impressive. He chaired the NASA Advisory Council, was a member of the Presidential Commission for Aviation Safety, chaired the Supervisory Board of the Aerospace Corporation and the NASA Jet Propulsion Laboratory Advisory Council, held various positions at the National Academy of Engineering, and was a member of the National Research Council's Precision Time and Interval S&T Study

Committee. In 2009, he continued to work in the Independent Global Positioning System Validation Team (GPS IRT), developing recommendations for GPS for Air Force Command.

Professor Bradford Parkinson has been a mentor for many scientists and engineers. His experience and the position he has gained in the international community have led to the dynamic development of satellite navigation systems and their practical use. He is the author of more than 100 scientific papers on GPS and Gravity Probe-B. Particularly important was his role as co-editor of a fundamental book entitled "Global Positioning System: Theory and Applications", published as a two-volume work by the American Institute of Aeronautics and Astronautics (AIAA) in 1996. The book is a timeless publication from which thousands of researchers and users of GPS have drawn knowledge and continue, and will continue, to learn in the future.

Professor Parkinson has been honored with several dozen awards and distinctions, including the AIAA Goddard Astronautics Award; the Lloyd V. Berkner Award of the American Astronautic Society; the Gold Medal of the Royal Institute of Navigation; the NASA Distinguished Public Service Medal; the Gold Medal of the American Association of Mechanical Engineers (ASME), and the prestigious Charles Stark Draper Award, which, alongside Professor Parkinson was in 2003, also awarded to Dr. Ivan Getting. He is a member of the NASA Hall of Fame and the National Inventors Hall of Fame.

Final Considerations

Professor Bradford Parkinson is the author of pioneering and ground-breaking research, with brilliant success in implementing its results into practical applications, demonstrating how scientific knowledge can positively affect economic and social reality. His contribution to the creation and development of GPS has opened up new perspectives for generations of researchers and engineers and brought progress to the lives of millions of people around the world.

Considering the outstanding scientific and implementation achievements of Professor Bradford Parkinson, his overwhelming involvement in the activities of scientific, economic, and public institutions, and his notable impact on the functioning of many scientific and business bodies around the world, I strongly support Gdynia Maritime University's proposal to confer on the Professor the honorary title of Doctor *honoris causa*.

Professor Jarosław Bosy, D.Sc (Eng.)
Wrocław University of Environmental and Life Sciences

Professor Zbigniew Burciu, D.Sc (Eng.), Master Mariner
Gdynia Maritime University
Faculty of Navigation
Department of Ship Operations

Opinion on the conferral of the honorary title of Doctor *honoris causa* on Professor Bradford Parkinson by Gdynia Maritime University

The opportunity to write a review of the achievements of Professor Bradford Parkinson as part of the procedure for making him an honorary doctor of Gdynia Maritime University is a great privilege, and yet also a great challenge, as Professor Bradford Parkinson has had an enormous impact on the development of transport safety science. His work on the development of satellite positioning systems distinguishes him among scientists influencing the development of world maritime transport.

At the time of the launch of the first Sputnik artificial satellite in 1957, opinions within the global aviation and military communities suggested that the use of satellites for the positioning of objects was achievable. The first experiments using such technology were carried out by the U.S. Navy, which in 1960 launched satellites under the code name Transit.
Maritime accidents have always led to changes in maritime transport safety. These have included the safety of navigation and the construction, equipment, and operation of vessels.
The first regulations were introduced in British law in the 19th century, such as the Regulation for the Prevention of Collisions at Sea from 1863 or the introduction in 1890 to the Merchant Shipping Act of the obligation for freeboard markings on the hulls of ships. The first international maritime organization was founded in 1865 as the International Telegraph Union and Lighthouse Organization at Cape Spartel[1]. Organized actions aimed at reducing the risk of loss of life at sea date from the time of the sinking of the Titanic.
Due to the increasingly international nature of shipping, in which ship crews, operators, charterers, classification societies, insurers and other parties involved in maritime trade were no longer associated with a ship's colors, there arose the need to establish an international maritime organization which would introduce a common legal framework for maritime transport safety. This is how the International Maritime Organization (IMO) was established, which primarily aims to create the conditions for the implementation of the highest possible standards for maritime safety throughout the world.

In contrast to the main objective of the IMO, namely, legislative action that has an indirect impact on the improvement of safety, Professor Bradford Parkinson's work has had a direct impact on maritime transport safety. His professional career has not been dedicated to the standardization of regulations in maritime transport, but to technical sciences, in particular satellite navigation

[1] See Iwona Galewska, The importance of multilateral treaties in the history of Europe, Krakowskie Studia Małopolskie 2013, No. 18

systems, in which his achievements have been exceptional, and his contribution to general safety at sea invaluable as the main architect of the Global Positioning System.

As a U.S. Air Force Colonel, Professor Bradford Parkinson was the leader in the creation of the Global Positioning System, a navigation tool that is still being developed today. It can be concluded that his achievements, used by systems in more than a billion GPS receivers, have revolutionized the way maritime and road transport operates.

Positions determined using satellite systems allow for the very accurate location of disasters at sea. The accuracy of the position determined by GPS, calculated in centimeters, reduces the time of arrival at the site of a disaster, influences the determination of the size of the search area, and therefore reduces the duration of search and rescue operations. This increases the likelihood of survivors being saved on rafts and in the water.

As Professor Parkinson said of himself in January 2020, “I've been a revolutionist for 47 years with this stealthy revolution. And GPS is, indeed, a stealthy revolution. [...] And we've continued to call it a stealthy revolution. [...] But our revolution continues.”
We can say with utmost certainty that Professor Bradford Parkinson revolutionized the world in relation to the positioning/location of objects, including threats and danger of loss of life at sea.

Bradford Parkinson was born on 16th February 1935, in the state of Wisconsin. He graduated from the Naval Academy and then served in the U.S. Navy and the U.S. Air Force. He completed a Master's Degree in Aeronautics and Astronautical Engineering at Massachusetts Institute of Technology. He was the deputy director of the Department of Astronautics and Information Technology at the U.S. Air Force Academy. During the years 1973-1978, he headed the program for the development of NAVSTAR GPS, as well as the Gravity Probe B program. In 1978, he led preparations for the launch of the prototype GPS satellite.

During his 26-year military career, he served 21 years in the Air Force, from 1957 until 1978, and five years in the Navy. Before his retirement, he reached the rank of Colonel. After leaving the U.S. Air Force in 1978, he became a professor of mechanical engineering at Colorado State University in Fort Collins and was the vice president of the company Space Systems, part of Rockwell International Group (later absorbed by Boeing), where he worked on strategic planning and the development of advanced — top secret — space systems.

From 1980 until 1984, he was the vice president and CEO of the Boston-based software company Intermetrics, which is responsible for the creation of the HAL/S programming language used on the NASA Space Shuttle program.

During the years 1984-1999, he was a professor and the head of the Department of Aeronautics and Astronautics at Stanford University. In 1999, he became the CEO of Trimble Navigation, and since 2001, he has held the status of professor emeritus at Stanford University. Since 2004, he has been the first vice-president of the National Executive Committee for Space-Based Positioning, Navigation and Timing (PNT).

Professor Bradford Parkinson is the author of seven patents. After 13 years, he resigned from the post of Chairman of the Advisory Council of the Jet Propulsion Laboratory (JPL), one of the NASA research centers, after having served much longer than the ordinary two-year term of office. He still serves as the co-chair of the Advisory Board of the National Executive Committee for Space-Based PNT.

For the effects of his extensive research activity, including the creation of the Global Positioning System, Professor Bradford Parkinson has received many prestigious awards and distinctions from private organizations, the army, and government bodies, including the Charles Stark Draper Award, the National Inventors Hall of Fame and the IEEE Medal of Honor. NASA awarded him both the Public Service Medal in 1994 and the Distinguished Public Service Medal in 2001. In 2016, he was awarded the Marconi Award. The British Institute of Navigation awarded him a Gold Medal in 1983. He was recognized as an outstanding graduate of the U.S. Naval Academy in 2011 and a Hero of Stanford University School of Engineering in 2012.

In 2019, he was awarded the Queen Elizabeth Prize in Engineering, along with three others involved in the creation of GPS: James Spilker, Hugo Freuhauf and Richard Schwartz. Professor Bradford Parkinson is an honorary member of the Royal Institute of Navigation and the American Institute of Aeronautics and Astronautics. He is also a member of the American Association of Astronautics and the American Institute of Navigation.

Professor Bradford Parkinson's professional, scientific, research and development achievements are outstanding and inspire respect not only in the scientific community associated with the use of GPS technology. His achievements are used around the world in many sectors of industry, the economy, and transport, including maritime transport. These are achievements that positively impact wider issues of safety.

The Professor's superior professional and scientific activity merits praise. He gives lectures for students and is active outside of science within international organizations and many committees. He is a role model for students, the academic community and business.
The abovementioned scientific contributions, achievements and merits are worthy of the utmost credit, and I therefore strongly support the motion to confer on Professor Bradford Parkinson the honorary title of Doctor *honoris causa* – his acceptance of this honor will be a notable distinction for the academic community of our University

Professor Zbigniew Burciu, D.Sc (Eng.), Master Mariner
Gdynia Maritime University

Professor Stanisław Oszczak, D.Sc (Eng.)
Polish Air Force University

Opinion on the scientific output, achievements and merits of Professor Bradford Parkinson – candidate for the conferral of the honorary title of Doctor *honoris causa* by Gdynia Maritime University

It is my great honor and privilege to present Professor Bradford Parkinson as the creator of the Global Positioning System (GPS), an outstanding scholar, the creator of the technological revolution in positioning and satellite navigation, and in particular, a man of great kindness. He is an example of how much can be achieved with hard work, initiative, systematic courageous action, consideration for colleagues and students, and by focusing not only on our own success but on supporting the development of others. These character traits, together with extraordinary diligence and a willingness to devote time to others, are the source of the Professor's scientific renown.

The life, work and achievements of such an outstanding person as Professor Parkinson are very abundant and cannot be subjected to detailed analysis. I will therefore focus on the facts that I believe to be relevant to the process of the award of the honorary title of Doctor *honoris causa* .

Professor Bradford Parkinson was born on 16 February 1935 in Madison, Wisconsin. During his studies at the Naval Academy, he specialized in navigation and served in the U.S. Navy and the U.S. Air Force. As an academic instructor, and later the Head of the Faculty of Simulation at the USAF Test Pilot School, he gained five years of experience in inertial guidance and navigation systems. As an Officer in the U.S. Air Force, he was awarded a Master's Degree in Aeronautics and Astronautical Engineering from Massachusetts Institute of Technology (MIT) and worked with Draper Lab as an analyst on terrestrial and space navigation systems. During the years 1970-1971, he held the role of deputy director of the Department of Astronautics and Information Technology at the U.S. Air Force Academy. From 1973 until 1978, he was the head of the 621B program for the development of NAVSTAR, the Global Positioning System, and later a lecturer at Colorado State University, and Vice President of Rockwell International (later, Boeing Inc.). In 1984, he became a Professor and Head of the Department of Aeronautics and Astronautics at Stanford University. In 1999, he became the CEO of Trimble Navigation, and in 2001, Stanford University made him professor emeritus. In 2004, he was named as the first vice-president of the National Executive Committee for Space-Based Positioning, Navigation and Timing.

In November 1972, as a Colonel in the U.S Air Force, Professor Bradford Parkinson, often referred to as the "Father of GPS", was given the role of program manager of a large team developing NAVSTAR GPS, for which he was the main architect, advocate and programmer. His principal achievement is the synthesis of three previous programs and concepts: the Orbit Determination System for the first Transit satellite navigation system, the atomic clocks technology developed at the Naval Research Laboratory, and the digital satellite signal structure created by the Air Force. Following several improvements in these three services, a uniform concept for the construction and operation of a second-generation satellite navigation system was developed. The project, which provided for the use of 24 satellites with high orbits lasting 12 hours, was approved in 1973 and was scheduled to be completed by 1978.

In keeping with this concept, the PNT – Positioning, Navigation and Timing satelite system currently has a constellation of 31 satellites and the following excellent characteristics which are available to every user:

- a global system operating at every latitude;
- available 24 hours a day, 365 days a year;
- positioning and navigation of an object is possible in all weather conditions;
- ground reference points and navigation aids are required to determine the position of an object and for navigation;
- the only condition is to ensure the visibility of the sky with a constellation of four satellites.

The bold universal concept of the Global Positioning System is a true world revolution in geodesy, air, maritime, and land navigation, the control of automatic objects, and more recently, in Artificial Intelligence (AI) systems. Several billion users benefit from the system.

In Poland, the first static GPS satellite measurements, in collaboration with scientific centers from Western Europe and the USA, were carried out between 1989 and 1992 at the reference points of the so-called "EUREF-POL zero satellite network" to link the core national geodetic network to the Western European coordinate system. Thanks to satellite measurements, Poland joined a united Europe long before joining the European Union (2004). During the years 1990-1991, despite an embargo on the purchase of such equipment at the time, several scientific centers in Poland purchased high-end two-frequency surveyors manufactured by Trimble and Ashtech, thanks to the approval of the U.S. Department of State.

The geodetic and navigational survey of observation techniques — static measurements, pseudo-cinematics, and differential techniques of DGPS — was initiated, test measurements were carried out, GPS technology was included in the syllabuses of degree programs, and the training of users and the implementation of the system in practice began. DGPS techniques were implemented by the Maritime Offices to create a system of reference stations for the

Southern Baltic Navigation Shield, while maritime universities successfully applied this systems to maritime navigation, hydrography and port navigation services. The Polish Air Force University researched real-time satellite navigation, the design of flight plans, and procedures for the take-off and landing of aircraft during air traffic control.

Land navigation methods were successfully developed, including the creation of mobile mapping digital technology and commercial products distributed to thousands of road navigation users. A network of precision GNSS reference stations (ASG-EUPOS and several commercial networks) was established within the country, allowing for the location of points to be determined with centimeter-level precision as well as the precise navigation of unmanned aircraft (UAV). Precise multisystem GNSS receivers and sophisticated mathematical methods for the development of satellite observations allow the coordinates of points to be obtained to an accuracy of within millimeters. Satellite techniques were used in the testing of horizontal and vertical deformities of the earth's crust. Examples of this are the determination of places of land subsidence in the Old Town in Gdansk, as well as the study of the deformation of the land in the mining areas of Polish mining company *KGHM Polska Miedź* and in the mining areas in Silesia.

Several satellite projects carried out in the Tri-City area also warrant attention. In 2000, a pilot network of DGPS reference stations was established in Gdynia, Sopot and Gdansk for the purpose of positioning and navigation of urban transport, city services, and locating events at the Centre for Crisis Management. Gdynia Maritime University produces specialists in satellite positioning and navigation methods and carries out many research and implementation projects concerning modern GNSS techniques in maritime navigation, hydrography, rail navigation, and public transport.

In summary, GPS and other GNSS satellite systems currently have many millions of users in Poland, all thanks to the work of Professor Bradford Parkinson, the highly successful implementation of his concept and the provision of access to GPS on a world scale.

Professor Bradford Parkinson is also worthy of a great deal of credit for organizing and coordinating many large scientific research initiatives that have stimulated the integration of scientific communities and numerous navigational practical activities. The Professor's enormous scientific, technological, organizational, and educational achievements have met with a great deal of recognition in world-class prestigious awards, honors, distinctions, and decorations. Among the many important awards and distinctions that Professor Parkinson has been honored with are the Queen Elizabeth Price for Engineering (2019); the IEEE Medal of Honor (2018); the Marconi Award (2016); the Honorary Fellowship of the Royal Institute of Navigation (2014); an NSS Space Pioneer Award (2009); the AIAA Goddard Astronautics Award (2006); the NAE Charles Stark Draper Prize for Engineering (2003); the NASA Distinguished Public Service Medal (2001); the Fellowship of The Institute of Navigation (1999); induction into the NASA Hall of Fame (1998); the NAVSTAR Joint Program Office's GPS Hall of Fame Award, (1995); the Johannes Kepler Award (1991); the Royal Institute of Navigation Gold Medal Award (1983); and the U.S. Air Force Legion of Merit (1978).

Professor Parkinson is the author and co-author of many scientific publications and books, of which 84 are published in world-renowned scientific journals. As a professor who has worked at several universities, he also has extensive teaching experience.

The effects of the Professor's work in all areas are a source of respect and admiration. A person of knowledge, passion, and exceptional talent, he is also a courageous man, who dares to dream into the future and to work consequently to put these dreams into practice.

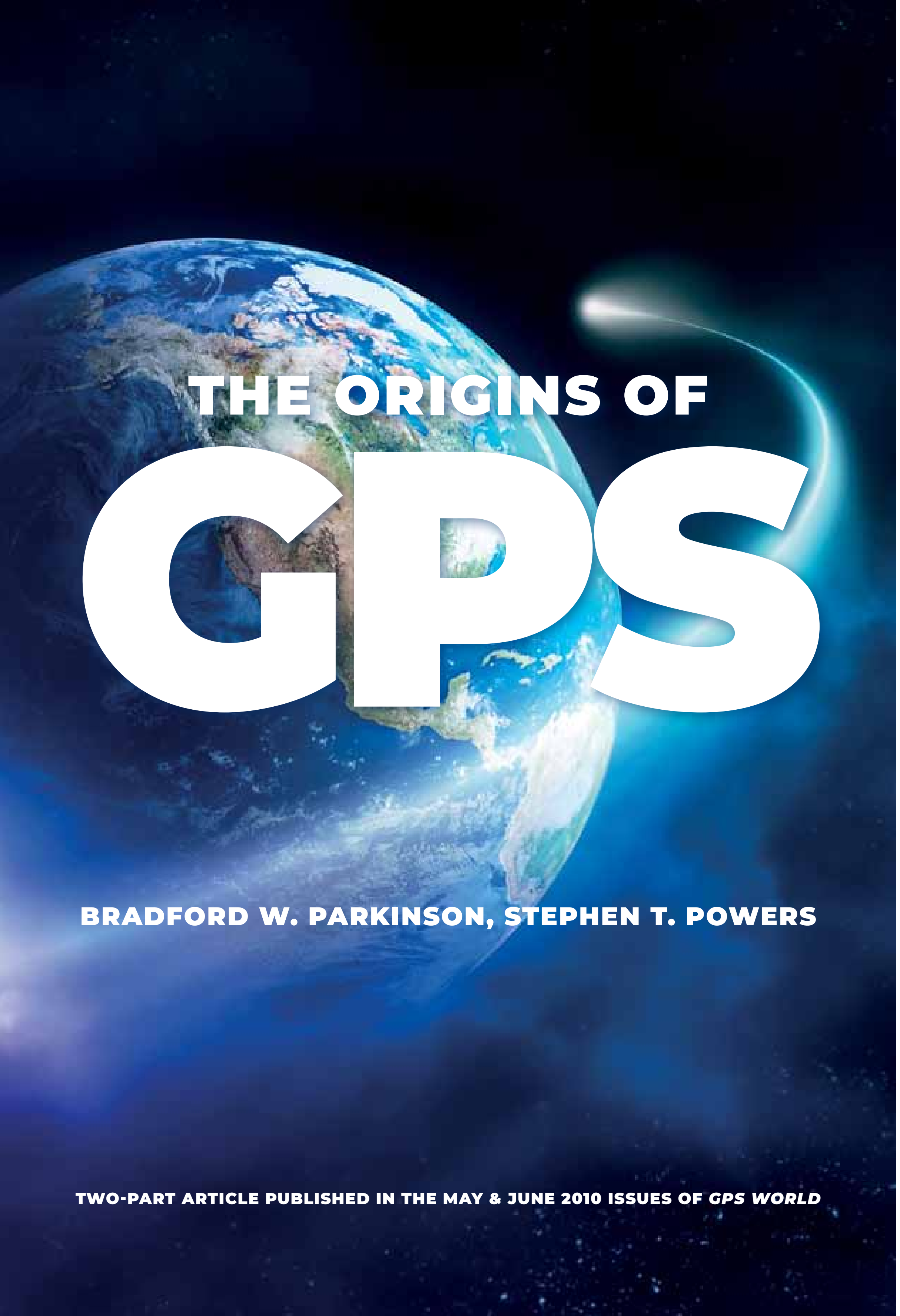
Professor Bradford Parkinson is fully deserving of the conferral of the prestigious honorary title of Doctor *honoris causa* on him by Gdynia Maritime University — a renowned University, whose mission closely resembles in nature the work carried out with outstanding success by the Professor.

As a man of great culture and humanitarianism, with a broad view of the world and scientific issues, an outstanding intellect, and an engaging manner, Professor Parkinson is a role model for academic staff, the academic community, pupils, and students. In every contact with the Professor, his tolerance and earnestness regarding the beliefs and opinions of others is noticeable. His extraordinary professional and scientific work, which he has successfully combined with his world-famous organizational and teaching activity promoting an innovative approach to satellite navigation and measurement techniques, and the spread of this knowledge and the education of personnel around the world, must be singled out for praise.

I strongly support the motion for the conferral of an honorary doctorate on Professor Bradford Parkinson and call for the Senate of Gdynia Maritime University to adopt a resolution on the matter.

Olsztyn, 28 August 2023

Professor Stanisław Oszczak, D.Sc (Eng.)
Polish Air Force University



THE ORIGINS OF GPS

BRADFORD W. PARKINSON, STEPHEN T. POWERS

TWO-PART ARTICLE PUBLISHED IN THE MAY & JUNE 2010 ISSUES OF *GPS WORLD*

CONTENT

THE PIONEERS WHO LAUNCHED THE SYSTEM

With Gaylord Green, Hugo Fruehauf, Brock Strom, Steve Gilbert, Walt Melton, Bill Huston, Ed Martin, James Spilker, Fran Natali, Joe Strada, Burt Glazer, Dick Schwartz, Len Jacobson, AJ Van Dierendonck, and others.

The original system study, the key innovations, and the forgotten heroes of the world's first — and still greatest — global navigation satellite system. True history, told by the people who made it. Part one of a two-part special feature.

The stealth utility: over the past 30 years, a new entity has steadily and stealthily crept into the fabric of worldwide society, creating capabilities and dependencies that did not exist before. This utility is known as the Global Positioning System, or GPS. With more than a billion GPS receivers in use, this stunning achievement has truly revolutionized the way the world functions in the 21st century. Virtually every cell-phone system relies on GPS for timing. Almost every ship and aircraft carries multiple GPS receivers to provide positioning information. Other applications span military targeting, transportation, object tracking, and resource identification. Today, the loss of GPS signals would have catastrophic consequences.

How did GPS come into being? What technologies were essential to its success? Who developed those technologies? Recently a number of GPS histories have appeared that are very inaccurate on these subjects. Our purpose in writing this account is to set the record straight, and in so doing to give credit to many of the original developers of GPS whose contributions have somehow been forgotten. Throughout this article you will find their names highlighted. Space does not permit us to name the many other individuals who deserve enormous credit for the subsequent refinement and invention of new GPS applications.

Figure 1 gives a summary view of the history of U.S. satellite-based navigation, particularly GPS. Details of the Russian GLONASS and the European Galileo systems are not included as they arrived later, and generally mimicked the GPS development albeit with their own, locally developed detailed designs

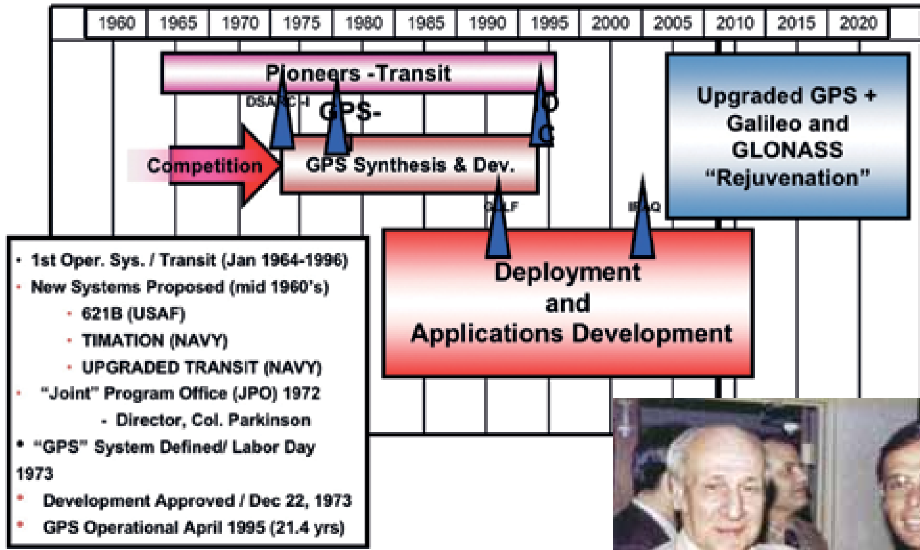


Figure 1. The eras of satellite navigation.

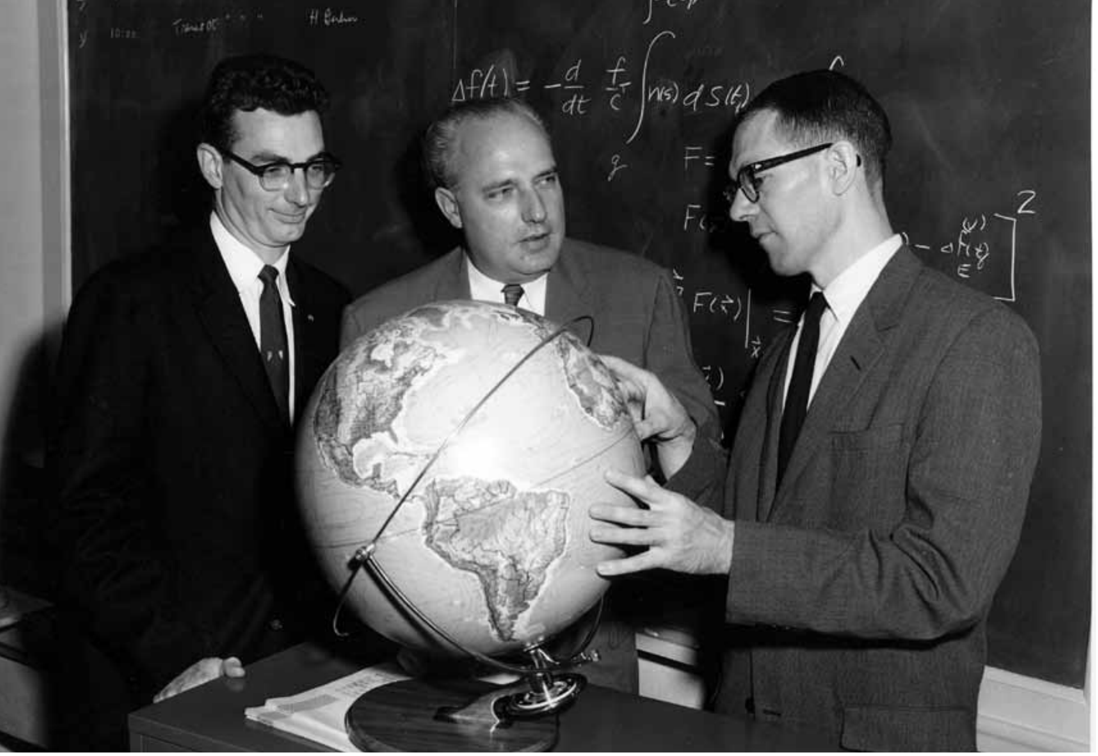
Dr. Richard Kershner, who led the development of Transit. On his left, young Col. Bradford Parkinson, who led the development of GPS.

This history focuses on the period up to about 1980, when GPS was approved for full-scale development. Between that time and the date that GPS was declared fully operational, April 27, 1995, many additional contributions were made. The system withstood several early attempts by the Air Force to cancel it entirely. Fortunately, those attempts did not succeed, and the Air Force now fully embraces GPS as an essential part of virtually every weapon system in the inventory.

We call this a tribute to the almost-forgotten people whose intellectual labor and skill initially developed GPS. As we unveil this story, we will point out the original — and critical — system study, the 1966 Woodford/Nakamura Report, that became the essential blueprint for GPS. Many people are unaware of this study since, in its original form, it was classified U.S. Department of Defense (DoD) Secret. It was not declassified until August 1979, more than a year after the first launch of a GPS operational satellite in February 1978.

We also intend to describe and justify the key innovation that enabled the system. This keystone technology is the GPS code-division multiple-access (CDMA) signal. While CDMA was necessary for GPS success, it was by no means sufficient.

We will also define and describe the five major original challenges that had to be met to achieve the success that GPS now enjoys; that will come in the second installment of this history, to appear in next month's issue.



Mathematician Bill Guier (l) and physicist George Weiffenbach (r), told APL Research Center director Frank T. McClure (c), about their success using Doppler tracking for satellites. "McClure's brain started going into fast forward," remembered John Dassoulas. "Knowing the navigational challenges the U.S. Navy faced, McClure said, 'Well, if you can find out where the satellite is, you ought to be able to turn that problem upside down and find out where you are.' "

GPS PREDECESSORS: TRANSIT

On October 4, 1957, the entire world was amazed by the launch of Russia's Sputnik satellite. The American public greeted this event with both apprehension and curiosity. Both the Army and Navy had been quietly working on satellite projects for some years. In an attempt to catch up, the United States had a spectacular failed launch when the Naval Research Laboratory's (NRL's) TV-3 crashed on December 6, 1957. On January 31, 1958, the United States Army launched a grapefruit-sized satellite, Explorer 1. The NRL then achieved success with the launch of TV-4, renamed Vanguard-1, on March 27, 1958.

In 1958, the Applied Physics Laboratory (APL) of Johns Hopkins University employed an extremely competent team of engineers and scientists. Two of those scientists, **Drs. William Guier** and **George Weiffenbach**, began to study the orbits of the new Sputnik satellites. The satellites were broadcasting a continuous tone signal. Their velocity relative to the ground created a Doppler shift of that signal that was unique. After some innovative work, Guier and Weiffenbach discovered they could determine the Sputnik's orbit with a single pass of the vehicle.

At that point **Frank McClure** of APL made a very creative suggestion: Why not turn the problem upside down? Using a known satellite position, a navigator could determine his location anywhere in the world after receiving and processing the satellite signal for 15 minutes. His insight became the basis for the Navy's Transit satellite program, also known as the Navy Navigation Satellite System (Figure 2).

This pioneering system was developed under the leadership of **Dr. Dick Kershner,** head of the Space Department of APL. Transit's main purpose was to provide position updates to the United States submarine ballistic-missile force then under development. These submarines were a major deterrent during the Cold War. Transit was first tested in 1960, and by 1964 the system was fully operational. Under Kershner, APL rapidly mastered the art of building long-life satellites. In fact, two of the vehicles continued operation for more than 20 years.

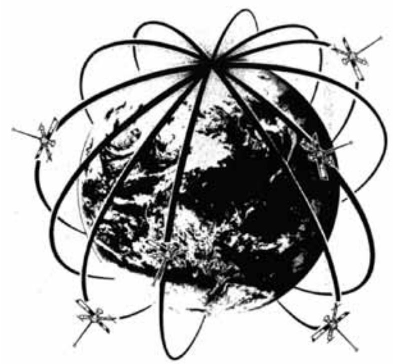


Figure 2. The Transit birdcage of operational orbits.

Transit was a relatively small satellite that initially used solar power and gravity-gradient stabilization (Figure 3). It provided a position fix every few hours; fixes took 10 to 16 minutes of exposure of the submarine's antenna on the surface. It achieved 25-meter accuracy, but only in two dimensions. Further, if the user was moving, accurate velocity measurement was critical: a 1-knot error would produce a 0.2-nautical mile position error.

All Navy ships could use the system, and in 1967 Transit was offered to the civilian community by Vice President Hubert Humphrey. Magnavox became the principal developer of civil user sets with **Tom Stansell** as an early expert in the technology.

Contributions to GPS. The Transit program developed a technique essential for GPS: the use of two frequencies to calibrate the time delay of the radio signal induced by the ionosphere. This dual-frequency technique was incorporated into GPS to attain the highest positioning accuracy. In addition, Transit also pioneered the accurate prediction of satellite orbits, another essential GPS technology. Orbit prediction will be highlighted later, as one of the five fundamental challenges that faced GPS system designers.

In 1974, Transit made a further contribution to GPS development that we discuss in that approximate timeframe.

Figure 3. A Transit satellite showing the gravity-gradient boom that kept the antennas pointing at the earth.

PROGRAM 621B

As early as 1962, **Dr. Ivan Getting**, president of the Aerospace Corporation, saw the need for a new satellite-based navigation system. He envisioned a more accurate positioning system that would be available in three dimensions, 24 hours a day, seven days a week. He had direct access to the highest levels of the Pentagon and was a tireless advocate for his vision.

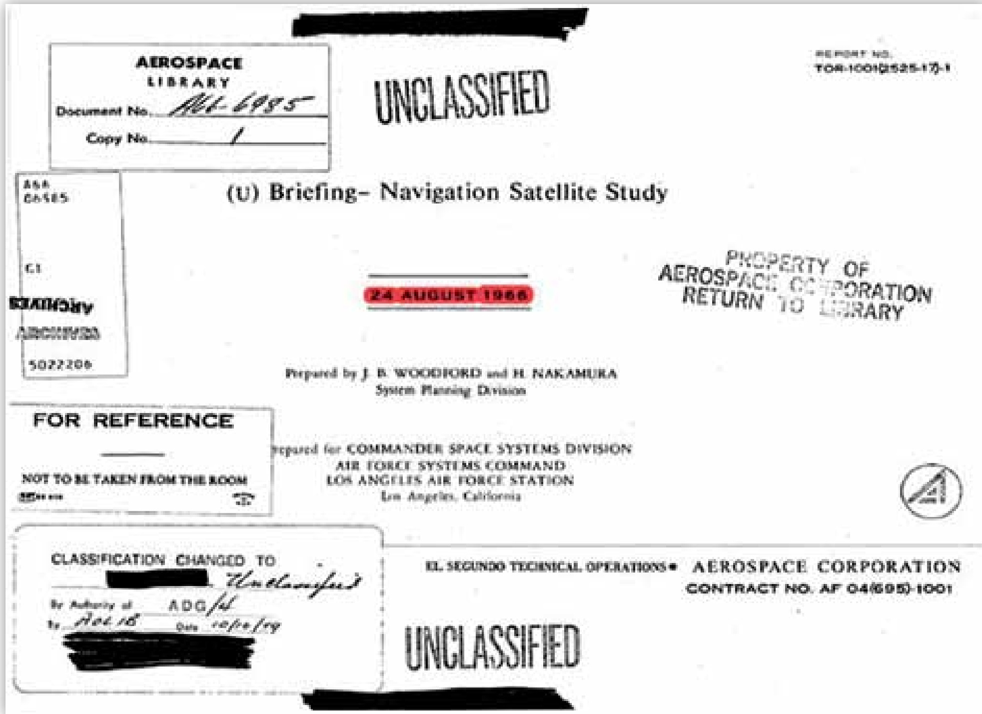
Getting's energy and foresight in the early 1960s were essential to gaining Air Force support to study system alternatives. As a result, the Air Force formed a new satellite navigation program that was later named 621B. Getting's efforts were recognized in 2002 when he shared the Charles Stark Draper Prize of the National Academy of Engineering with Bradford Parkinson.

By 1962, engineers at Aerospace, under Air Force sponsorship, were heavily immersed in studying the system aspects of a new navigational satellite system. From 1964 to 1966, Aerospace carried out an extensive, formal system study whose principal authors were **James Woodford** and **Hideyoshi Nakamura**, both highly regarded space-systems engineers.

Their work was summarized at a DoD secret briefing in August 1966. As a result of the classification, it was unavailable to anyone outside the project until 13 years later, in 1979, when it was finally declassified (figure 4).

The Woodford/Nakamura Report was a complete system study that examined these issues:

- capabilities and limitations of then-current DoD navigation systems;
- tactical applications and utility of improved positioning accuracy;
- comprehensive analysis of alternative system configurations and techniques for positioning, using satellites.



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System Planning Division

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Figure 4. Front page of the seminal GPS system study performed from 1964 to 1966 by USAF 621B Program. Originally classified secret, it was not declassified until after the initial GPS satellite had been launched. This was the essential foundation to the GPS System design.

The report concluded with a set of recommendations for advanced technology development for navigation satellite programs.

The detailed analysis of possible passive navigation techniques was extremely important. It pointed out that the most capable passive-ranging design, called triple delta rho, would eliminate the need for an extremely stable clock in the user equipment and would provide three-dimensional positioning. (In this article we use clock, oscillator, and frequency standard interchangeably. The timing community makes some distinctions among these words, but for purposes of this history the distinctions are not particularly important.) This later was selected as the fundamental GPS system concept of ranging to four satellites simultaneously.

Key conclusions of the 1966 study advocated:

- passive ranging from the satellites (the issue was which ranging signal to use)
- atomic clocks in space, and a technology program to develop space hardened atomic clocks
- further system studies as well as experimental demonstrations.

Since the full survey of alternative system configurations was extremely important in selecting an optimum system configuration, we reproduce the summary in figure 5. Note that the “Computation Performed by User” is split into two columns. Focus on the columns of the one-way passive ranging techniques with the red outline. Inside, there are two “user boxes,” one with A and one with X. The A shows the user needs an atomic clock. The X shows the user needs only a crystal clock. The option later selected for GPS is designated as G. This technique is the 3Δρ (triple delta rho, or four satellites) that eliminated the need for the user atomic clock, and provided three-dimensional positioning (really four-dimensional since it also captured time).

In October 1970, more than four years after the completion of this study, Roger Easton of NRL applied for a patent on the two-satellite, ρ-ρ technique (option N) that required an atomic clock for the user and was only two-dimensional. The patent (U.S. 3,789,409) was granted in 1974, a year after the three-dimensional design of the GPS system had already been defined in the Lonely Halls Pentagon meeting to be described later.

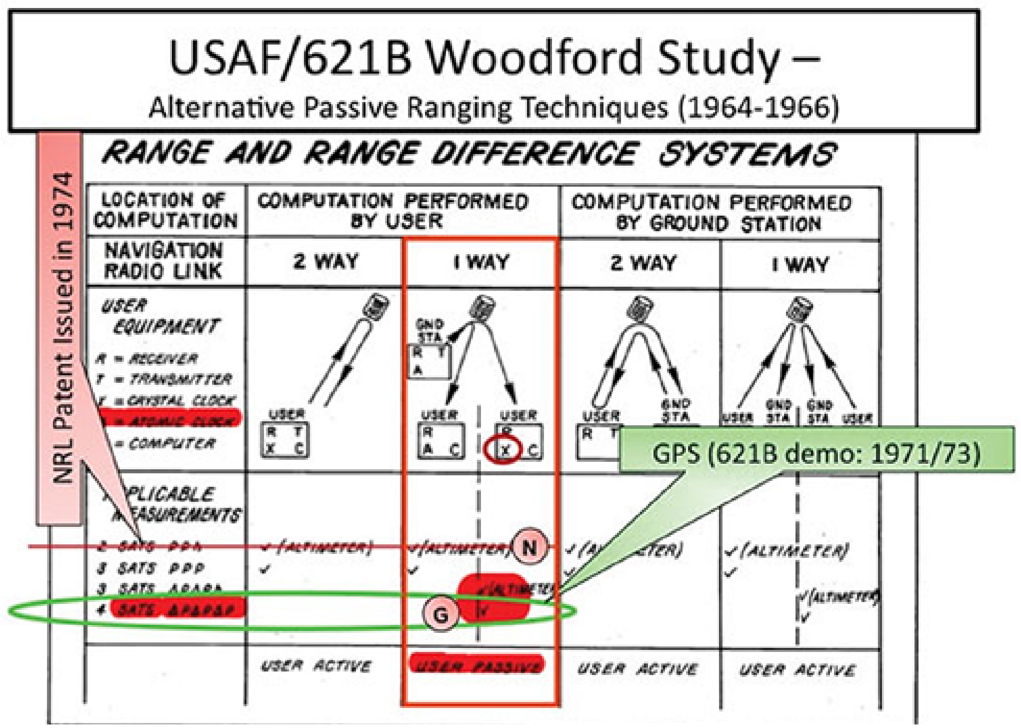
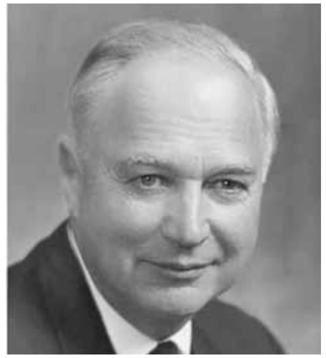


Figure 5. Summary of the alternative satellite-based navigation techniques from the 1964–66 USAF/621B study. The most capable option, circled in green, became the basis for the White Sands prototyping and testing, and then evolved into GPS. NRL applied for a patent on the less capable technique (red line) four years after the Woodford/Nakamura Study was completed



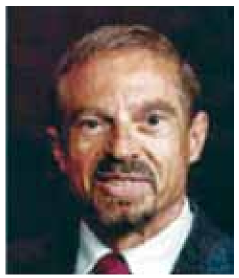
Dr. IVAN GETTING, believed to be the earliest significant proponent for a new navigation system by 1962. He provided important support for GPS at the highest level of government.

HIDEYOSHI NAKAMURA, one of the authors of the key report on competing satellite navigation systems that identified the strengths of 621B for thee-dimensional positioning.

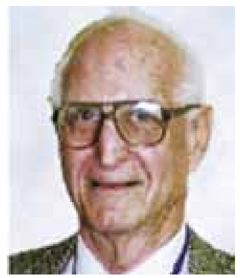
JAMES WOODFORD, co-author of the report that advocated passive ranging, atomic clocks in space, and experimental demonstrations to prove the validity of nascent GPS concepts.

More 621B Studies. From 1966 to 1972, program 621B continued with trade-off studies including: signal modulation, user data processing techniques, orbital configuration, orbital prediction, receiver accuracy, error analysis, system cost, and comprehensive estimates of the tactical mission benefits. More than 90 reports completed by USAF/Aerospace during this period remain available in the Aerospace Corporation library.

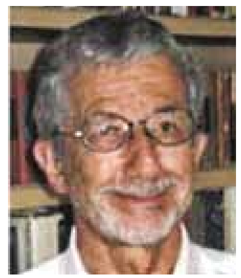
PRN or CDMA Signal Structure. Of these studies, the most important were those aimed at selecting the best passive ranging technique for the navigation signal. By 1967, it appeared that the best technique was a variation of a new communications modulation known as CDMA. Pioneering this signal were several outstanding scientists, **Dr. Fran Natali** and **Dr. Jim Spilker** (both of Philco-Ford), and **Dr. Charlie Cahn** (of Magnavox).



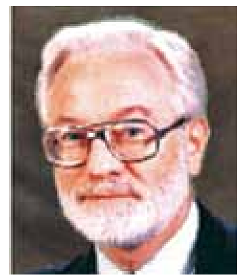
JIM SPILKER, one of the creative geniuses who helped develop the GPS signal structure. See his article on binary coded symbols on page 8 of this issue.



CHARLES CAHN, an important contricutor to GPS signal design. He advocated a C/A code length of 2047 chips, while Spilker wanted 511; Parkinson split the difference.



ROBERT GOLD invented the technique that selected orthogonal modulation codes. This allows more than 50 satellites to broadcast on the same frequency



TOM STANSELL was a member of the Magnavox team that developed civil Transit receivers. He later became an advocate for GPS.

This signal has many names. In addition to CDMA, it is sometimes called spread spectrum, since the energy of the signal was spread over a wide range of radio frequencies. It is also sometimes called PRN or pseudorandom noise because the encoded (and repeated) sequence appears to be random transitions of +1 and -1.

The name code-division is used because each satellite is assigned its own coded signal. Each was a binary (digital) sequence selected to be uncorrelated with other signals and also uncorrelated with time shifts of the signal itself. The expected, powerful advantage of this technique was that all satellites would broadcast on exactly the same frequency. It would clearly lend itself to digital signal processing. Furthermore, and very important, any time-shifts induced by the receiver for the various satellite signals would be effectively eliminated.

However, several significant questions concerning CDMA still needed resolution. These included:

- Could such a signal be easily acquired in the face of time uncertainty and Doppler shifts?
- Was there a technique to encrypt the military signal so that unauthorized users could not gain access?
- How would the codes be easily selected to avoid a false lock and also allow additional satellites to be added without interfering with existing satellite signals?
- Would the anticipated complexity of the receiver drive costs to unacceptable levels?
- Was the signal resistant to accidental or deliberate interference?
- Could this signal accommodate communication capability for satellite location, satellite clock correction, and other parameters?

Fortunately, in 1967 a technique for selecting orthogonal codes was invented by an accomplished applied mathematician, **Dr. Robert Gold** of the Magnavox Corp. Naturally these are now known as the Gold codes. His solution resolved the third CDMA issue stated above.

White Sands Tests. To address the remaining issues, the 621B program developed two prototype versions of CDMA navigation receivers (Magnavox and Hazeltine) for testing at the White Sands Missile Range (WSMR). For these initial 1971 tests, 621B arranged four transmitters in a configuration known as the inverted range. (Interestingly, the more capable receiver was the MX-450 that was only on loan from Magnavox.) These transmitters broadcast CDMA signals from locations that were similar to a satellite configuration except that they were broadcast from the ground. For the simulation of satellite geometry, a balloon-based transmitter was also included for the aircraft-landing tests. **Al Gillogly** of Aerospace spent many hours installing and troubleshooting the test configuration.

Al Gillogly, Aerospace engineer (left), setting up the critical tests of prototype GPS receivers at WSMR in 1970.

By 1972, program 621B had successfully proven the effectiveness and accuracy of the CDMA signal by demonstrating that such a configuration would achieve 5-meter, 3-dimensional navigation accuracy. Much credit for the painstaking analysis of these results should go to **Bill Fees** of Aerospace who wrote the final detailed test report. These test results answered most of the remaining issues regarding the CDMA signal.

The tests also confirmed the power of the modulated signal by showing that all satellite signals could, indeed, be received simultaneously on the same frequency. These tests also corroborated the expectation that ranging to four satellites eliminated the need for a highly precise user atomic clock, while still supporting full, three-dimensional navigation. This became an extremely important feature of GPS. If each user had required an atomic-clock class frequency-standard, no inexpensive user equipment could have been produced within the technology horizon visible at that time. This is still true today.

All this evidence supported CDMA as the passive ranging signal of choice and was available to the Air Force's 621B team when the system configuration was selected at the September 1973 Pentagon meeting that will be discussed later.

621B Demo, Operational Differences. From the time of the 1966 Woodford/Nakamura study on, the Air Force and Aerospace advocated the use of atomic clocks in the operational satellites with the modulation also originating in the satellites. There were two significant risks to placing atomic clocks in the satellites: First, the technology readiness risk: no hardened atomic clocks had yet been designed and flown; and second, the political/budgeting risk associated with gaining approval for a development/demonstration program for the full capability. The Air Force developed a plan to reduce both risks.

In late 1968, the Air Force's NavSat program in the Plans Office (XR) at the Space and Missile Systems Organization (SAMSO) was redesignated as 621B. All of the various proposals that went forward from SAMSO to Headquarters came henceforth from the 621B office in XR. This included a proposal in early 1972 to deploy a four-satellite demonstration system. This proposal addressed both risks. It would reduce the technology readiness risk in the clocks by launching simple L-band transponders. At the same time, it would save substantial money, thereby reducing the political/budgeting risk.

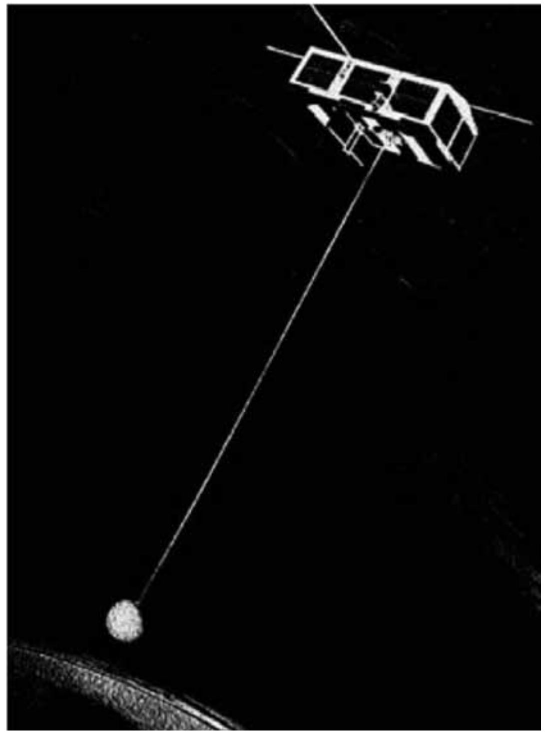
In many circles, this proposal was erroneously thought of as 621B because it came from that office, but in fact, the operational concept for 621B never contemplated or advocated using transponders in the final operational system. Transponders had been rejected for the operational system because they could be easily jammed from the ground. Such a jamming signal would overpower the transponder and steal all of the transmitted energy away from the transponded navigational signal. This enemy jamming would shut down the entire system, clearly an unacceptable risk.

Proposed Initial Constellation. To demonstrate four-satellite, passive ranging capability, 621B had studied a number of orbital configurations, including geo-synchronous and lower inclined orbits. The program proposed to place a constellation of three or four synchronous satellites in orbits over the United States. This array would allow extended periods of four-satellite testing without committing to a full global employment. If this demonstration were successful, the next step would have been to add three more longitudinal sectors, each with its own array. Again, the principal redeeming feature of this approach was that there was some hope of it being funded. The Air Force in the Pentagon placed enormous pressure on the 621B program to come up with the absolutely cheapest way to demonstrate the four-satellite approach.

Figure 6. The Japanese QZSS has a similar constellation to an early proposal for GPS under 621

This proposed constellation design was a reasonable compromise, given the boundary conditions of a four-satellite demonstration and absolutely minimal cost. It is interesting that the Japanese, with a requirement to supplement GPS with satellite signals to improve coverage in urban areas (where there are high shading angles), have designed a very similar constellation. The Japanese configuration is intended to improve coverage restricted to their longitudinal sector of the globe. The new system is called Quasi-Zenith Satellite System (QZSS), and the Japanese appear to be well on the way to fielding it.

TIMATION AND NRL



Timation 1, developed by NRL, was a miniaturized, innovative design.
The quartz clock was less stable than expected, apparently due to temperature and cosmic-ray effects

In 1964, the U.S. Navy initiated a second satellite program, named Timation, under the direction of **Roger L. Easton**, Sr., a long-time member of the NRL staff. The NRL's Timation project was aimed at exploring techniques for passive ranging to satellites, as well as time transfer between various timing centers around the world. This project ran parallel to, and was in competition with, the Air Force Program. It subsequently developed a number of experimental satellites, the first of which was called Timation 1. This small satellite, weighing 85 pounds and producing 6 watts of power, was launched on May 27, 1967.

The key feature of Timation 1 was that it included a very stable quartz clock. The fundamental ranging technique was to synchronize a clock at the user's location with the clock on the satellite and use a passive-ranging signal structure called side-tone ranging. By 1968, NRL demonstrated single-satellite position fixes, accurate to about 0.3 nautical miles, that required about 15 minutes of data collection (Global Positioning System, Volume 1, chapter "Navigation Technology Program," R.L. Easton, p.16). NRL engineers encountered two significant problems during their testing: solar radiation caused shifts in the clock's frequency, and ionospheric group delay created ranging errors.

The NRL launched a second satellite, Timation 2, into a 500-mile orbit on September 30, 1969. To calibrate ionospheric group delay, the satellite broadcast on two frequencies very similar to the technique pioneered by the Transit program. Its quartz oscillator was expected to be somewhat more stable, about one part in 1011. Again, a large frequency shift was observed in the clocks that was finally traced to a solar proton storm. NRL was able to demonstrate ranging accuracies of approximately 200 feet to a fixed location.

Timation NTS-1 carried two slightly modified commercial rubidium clocks. Unfortunately, attitude-stabilization problems induced temperature variations that masked any quantitative performance evalulation. The atomic clocks were not useful as prototypes for GPS.

Timation NTS-1. The last satellite in the original Timation series was launched in July 1974. By that time the Timation program had been placed under the GPS Joint Program Office in Los Angeles, reporting through the Navy Deputy, **Cdr. Bill Huston**, to the Program Director Col. Bradford Parkinson. The JPO had renamed the satellite as Navigation Technology Satellite (NTS-1). The gross weight had been increased to 650 pounds with a power requirement of 125 watts. This satellite, developed by **Pete Wilhelm** of NRL, was placed at an orbital altitude of 7,500 nautical miles.

The NTS satellites were strictly technology-testing satellites. For many reasons, they had no role in the development of the operational satellites by the JPO and Rockwell. The latter were operational satellites and were called NDS, for Navigation Development Satellites. They were the only ones used in the operational testing during phase I of GPS.

NTS-1 included two small, lightweight rubidium oscillators as clocks. A German commercial company called Efratom had independently developed these models. Amazing at the time, they only consumed about 13 watts of power and weighed some four pounds each. Further Efratom involvement will be pointed out later. While NRL made some electronic modifications, the modified clocks were not in any sense able to withstand the radiation of the GPS orbits. The NTS-1 clocks were certainly not prototypes for the Rockwell clocks that were developed directly for the JPO and flown on the first block of GPS satellites.

NRL tests showed that the modified rubidium clocks had an unacceptable level of sensitivity to temperature variations. **Al Bartholemew** of the NRL later wrote that "the lack of attitude stabilization system on NTS-1 resulted in large temperature variations which ultimately masked any quantitative evaluation of rubidium standard performance." (Global Positioning System, volume 1, chapter "Satellite Frequency Standards," C.A. Bartholomew, p. 25.) This apparently occurred because the satellite used a two-axis gravity gradient stabilization system that does not function well at these altitudes. The Navigation Development Satellites (NDS), later developed by the JPO, avoided this by developing a new, full three-axis, attitude-control system. NTS-1 carried other space technology demonstrations including highly efficient solar cells.

Later, NRL developed a second (and last) satellite (NTS-II) for the GPS Program Office, after the Pentagon had approved the project in December 1973. The vehicle included two modified cesium beam oscillators developed by Frequency and Time Systems Inc. (FTS) of Danvers Massachusetts. The key atomic clock developer was the engineer and creative entrepreneur **Robert Kern**. This clock showed great initial promise but it was not yet a space prototype in terms of radiation hardening and parts life. In addition, the JPO provided a Rockwell-developed navigation payload for NTS-II that the JPO had developed for the operational GPS satellites. This would allow the NRL satellite to broadcast the GPS CDMA signal.

BOB KERN, who founded FTS and Kernco. Superb engineer and creative entrepreneur. He designed and built the first operational space-borne Cesium clock that was verified on the fifth GPS vehicle.

BILL FEES wrote the final test report detailing 621B's effectiveness and accuracy with a CDMA signal.

Lt. Gen. KEN SCHULTZ appointed Col. Brad Parkinson as 621B Program Director (later GPS). His strong support, particularly in recruiting talent for the JPO, was essential in creating the competence and skills of the GPS Program

NTS-II was launched on June 23, 1977, from Vandenberg Air Force Base. Originally it was hoped that NTS-II would be a part of the initial GPS test constellation. It could then have supplemented the satellites being developed by Rockwell, providing another passive ranging signal for the user equipment tests at Yuma Proving Ground. Unfortunately, the NRL ranging transmitter in NTS-II failed prior to the launch of the first JPO NDS satellites, rendering the NRL satellite unusable for the Yuma Proving Ground testing. "Of the two experimental cesium standards carried on NTS-II," Ron Beard of NRL wrote, "one experienced a power supply failure after a period of satisfactory operation." It is known that the other cesium clock continued to operate for over a year, but quantitative drift rates on orbit were never available. As a result of these failures, the cesium clock tests were inconclusive. (Proceedings of the IEEE 43rd Annual Symposium on Frequency Control, 1989, R.L. Beard, p. 276.) Only tests with the first four JPO/Rockwell satellites were available to support the full-scale development approval on June 5, 1979.

For the next step, NRL defined a radiation-hardening program and contracted with FTS to develop a hardened cesium clock. This new clock was flown on the fourth operational GPS satellite (NDS 4, launched December 10, 1978). Unfortunately, the clock suffered a premature failure of the power supply after only 12 hours of operation. FTS soon found the root cause and fixed the design. Beginning with NDS 5, the on-board cesium clocks performed well and were equal or better in stability to the Rockwell rubidium oscillators.

COMPETITION, LONELY HALLS

By 1972, a few Pentagon authorities had recognized that a new satellite-based navigation system would be a valuable asset with multiple military applications. Literally hundreds of positioning and navigation systems in use by the DoD were expensive to maintain and upgrade. Obviously, a single replacement system offered significant cost savings. Unfortunately, the two competing concepts from 621B and NRL apparently confused the decision-makers. Discussions grew very acrimonious at times. As a result of this inter-service competition and a reluctance to commit the necessary monies, the Pentagon put off making any decision.

In November of 1972, Col. Bradford Parkinson was the director of engineering for the Advanced Ballistic ReEntry Systems Program (ABRES) at SAMSO. **Brig. Gen. Bill Dunn**, who led the advance planning group (XR), identified Parkinson as a potential candidate to head the floundering 621B program. At Dunn's behest, **Lt. Gen. Kenneth Schultz**, commander of SAMSO, asked Parkinson if he would like to be assigned to the 621B program. Parkinson had a very relevant background in navigation, guidance, and control that included a Ph.D. from Stanford in astronautical engineering. He had been chair of the Astronautics Department at the U.S. Air Force Academy, spent three years as a guidance analyst at the Central Inertial Guidance Test Facility, and was operationally oriented with 26 combat missions in AC-130 gunships.

The background was a match, but Parkinson expressed an unwillingness to volunteer for the assignment if he were not assured that he would be the program director. Schultz said he could not yet make that promise. However, immediately after Parkinson left his office, the general reassigned him to the 621B program and effectively made him the director.

Beginning in December, immediately after he assumed control of 621B, Parkinson instituted a series of 7 a.m. educational meetings. At these gatherings, the program staff reexamined every aspect of the proposed 621B program, including alternatives. This educational process was a key to having everyone in the Program Office completely understand the technical issues they faced.

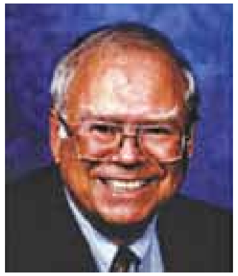
During this period Gen. Schultz supported the program in every way that he could. In particular, Parkinson was allowed to recruit Air Force officers whose background and experience were aligned with the needs of the fledgling program. All had advanced engineering degrees from the very best universities in the country including MIT, Michigan, and Stanford. In addition, virtually every officer had experience in developing real hardware or in testing inertial guidance systems. The first officer Parkinson brought aboard was **Air Force Major Gaylord Green**, who had worked for him on ABRES. Green's creativity, focused on satellites and orbits, had an extremely important impact on the success of GPS.

The result of Parkinson's hunting license was a cadre of about 25 of the best and brightest people that the Air Force had to offer.

In addition there was a small, carefully-selected group of Aerospace technical support personnel (led by **Walt Melton** from 1970 to 1972). This fine group of Aerospace engineers and scientists was experienced in an all technical aspects of space navigation programs and particularly skilled at issues relating to signal modulation, satellite position prediction, and building long-life satellites. Many of their names will be highlighted in Part Two of this story. The Aerospace contingent continued to enjoy the strong support of the president of the Aerospace Corporation, Ivan Getting.

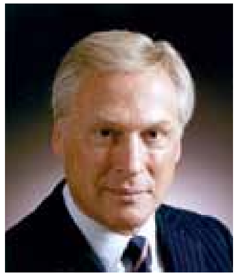
Replacing Melton early in Phase One was **Ed Lassiter**, who had extensive space-flight experience and was a mainstay of the early GPS development.

MAJOR GAYLORD GREEN. His innovations included design of the modified orbits that ensured daily test time at the instrumented Yurna range.



WALT MELTON, early leader of the Aerospace Program, a creative engineer who later led a group at General Dynamics that developed the GPS Ground Control System.

ED LASSITER was the Aerospace program manager under Brad Parkinson for the latter stages of Phase 1. A skilled engineer with much flight experience, he was especially skilled at early identification and solution to program risks.



Dr. MALCOLM CURRIE. As the number 3 man in the Pentagon, his support was essential to overcoming resistance from the Air Force.

During early spring of 1973, the director of Defense Research and Engineering (DDR&E), **Dr. Malcolm Currie**, formerly of Hughes Aircraft, who had just been appointed to the number three position in the DoD, found himself flying between Washington, D.C. and Los Angeles on most weekends. His secondary purpose was to oversee the relocation of his family, but he needed an official reason to travel to Los Angeles. So, each Friday afternoon he would visit SAMSO in Los Angeles for a presentation. After a few weeks, his host Gen. Schultz ran out of subjects to present, and instead invited Currie to spend an afternoon with his new program director, Col. Parkinson.

Schultz's invitation led to an astonishing meeting, because a newly-promoted colonel does not usually have the opportunity to confer with the number three person in the DoD over an uninterrupted three- or four-hour period. This informal meeting was held in private, in a very small cubicle within the JPO offices. With a Ph.D. in physics, Currie was a very quick study, so the interaction was lively and deep, delving into every aspect of the 621B proposal. After that meeting, Currie became a good friend to and a sponsor of the new satellite-based navigation program. He later played a critical role in ensuring DoD support, particularly in light of the Air Force's attempts to cancel the infant program.

DSARC 1. On August 17, 1973, Parkinson was invited to the Defense Systems Acquisition Review Council meeting to make a presentation on 621B. The meeting's purpose was to determine whether to proceed with the concept demonstration program. It was held at the Pentagon, and attended by senior officers of all services, with Mal Currie presiding. At the meeting's conclusion, the Council voted against approving the 612B program. Currie immediately invited Parkinson into his private office to tell him he wanted a new system proposal developed that would incorporate the best features of all the technical alternatives. He emphasized the need for a joint program involving all services.

Lonely Halls Meeting. Parkinson immediately called a meeting in the Pentagon over Labor Day weekend, September 1973. Over that weekend, the world's largest office building appeared to be a series of poorly-lit, uninhabited tunnels because everyone was away on vacation. The light at end of those tunnels, both figuratively and literally, came from a small conference room on the top floor, seating about a dozen attendees, all Air Force officers except for three Aerospace Corporation engineers. The purpose of the meeting was to define modifications to the 621B proposal that would meet Currie's directive. Parkinson wanted the isolation to ensure unfettered creativity in defining the new proposal. Leading to this, the Analytical Sciences Corporation (TASC) under the guidance of Gaylord Green had completed a new systems study, a review and update of the earlier systems study directed by Jim Woodford and Hideyoshi Nakamura for project 621B in 1964–66.

After much deliberation, over that weekend the JPO defined the GPS with ten facets:

- The fundamental 621B concept of simultaneous passive ranging to four satellites would be the underlying principle of the new system proposal, ensuring that user equipment would not require a synchronized atomic clock.
- The signal structure would be the 621B CDMA modulation. It would include both a clear, acquisition modulation (C/A) and a precision military modulation (P/Y). The C/A modulation was to be freely available to civil users throughout the world.

- There would be two GPS broadcast frequencies in the L band, using the same dual-frequency technique that Transit had employed to correct for ionospheric group delay, as well as providing redundancy.
- Based on the progress that NRL had made in satellite clocks, the program committed to space-hardened atomic clocks on the first operational/demonstration GPS satellites (called Navigation Development Satellites, or NDS). At the Lonely Halls meeting, Parkinson concluded that the NRL technology was relatively low-risk, obviating the need to use the ground-relay, experimental demonstration scheme that 621B had previously proposed. It later turned out that the clock development was not as mature as it appeared, but the JPO backup clock development by Rockwell was available in time for the first launch.
- The orbits for the satellites were to be inclined at 62º and not geosynchronous. Green proposed 11-hour, 58-minute (sidereal synchronous) orbits that gave about two hours of testing over the same United States test area each day. NRL had advocated similar 8- or 12-hour inclined orbits. Because of the need for an extensive testing program on an instrumented range, exact 8- or 12-hour orbits would have been unsatisfactory, because they would continuously shift relative to the Earth. While these orbits resembled those advocated by NRL, Green's modification was critical to the success of the testing program.
- Orbit prediction would be handled with modifications to the Transit-developed orbit-prediction programs called Celeste.
- The initial test constellation would include four operational satellites, competitively procured, one of which would be a refurbished qualification model. They would be launched on refurbished Atlas-F rockets, which minimized cost, but also limited the number of solar panels that could be carried because of weight.
- A family of user equipment prototypes would be procured competitively. This equipment would span all normal military uses, and also include a low-cost set that would prototype civilian use. Where affordable, competitive contracts would be let. Particular attention would be devoted to user equipment integration with inertial navigation units and demonstration of anti-jam capabilities.
- The master control station and its backup would be on U.S. soil, but monitor stations would be placed around the world.
- The testing would be principally performed at the Army's Yuma test range with accuracy measured from a tri-lateration laser configuration. Using three laser ranging devices at the same time would ensure that all test vehicles could be measured to about a meter of positioning error. It was expected (and later proven) that this technique could even calibrate Air Force or Navy fighter aircraft flying close to Mach 1. Testing would make use of the inverted range concept, with satellites replacing each range transmitter as each newly launched GPS satellite became operational on orbit.

Dual Use. One aspect should be strongly pointed out. Contrary to some versions of GPS history, from the very beginning, GPS was configured to be a dual-use system. Civilian users were to be given free access to the signal specification and were expected to use the so-called clear acquisition signal for navigation and other purposes. In fact, Parkinson highlighted civilian use when he testified before Congress on the proposed new system.

GPS Approval. That Labor Day weekend of September 1973 had been a very busy three days. With help from the Air Staff Program Element Monitor (PEM) **Lt. Col. Paul Martin**, the Lonely Halls gathering developed a seven-page Decision Coordinating Paper (DCP) and a presentation of the new concept. Over the next two-and-a-half months there was a flurry of activity as Parkinson made presentations and defended the concept before all those who could block the proposal in the Pentagon. This effort was culminated with the approval to proceed on December 14, 1973. There were no significant modifications to the proposal that had been developed during the Lonely Halls meeting in the Pentagon.

During the whole Phase I development, Parkinson resolved to avoid any conflict with the other original competitors to build a satellite-based navigation system. He deliberately ignored dubious claims of invention and statements regarding the origins of GPS technology. Until quite recently, he has overlooked these false claims by those who did not directly participate in determining the GPS architecture and did not participate in the specific GPS design and deployment. He felt the real purpose was to build the system, not to fight over credit.

Recently an article appeared that implied that the GPS design was essentially the same as Timation. ("In what ways did GPS improve on Timation?" Easton: "I can't think of any ways in which GPS improved on Timation. Essentially, they are the same system." Interview in High Frontier magazine.)

Aware that this incorrect statement denigrated the people who had first analyzed, advocated, and demonstrated the fundamental concept, as well as built the system, Parkinson resolved to correct the record, and highlight the names of those who deserve credit. This is a major purpose of this article. This article has been reviewed and approved for veracity by virtually all the key figures (still alive) who actually designed, built, and tested GPS.

GPS Phase I program approval meant that the real work could begin. The conclusion of a two-part history, told by the people who made it.

By January 1974, the GPS program at the Joint Program Office (JPO) was well underway. With only about 30 officers, the workload was enormous. Fortunately, the Aerospace cadre of about 25 also made extraordinary contributions. In a flurry of activity, the team developed requests for proposals, made top-level specifications, and published initial interface control documents. The work of converting viewgraphs into real hardware, as many know, is an exacting and sometimes painful process.

Of course there were many challenges, but five of them, principally engineering, stand out as particularly daunting. These were:

- Defining the specific details of the GPS CDMA signal structure;
- Developing space-hardened, long-life, atomic clocks;
- Achieving rapid and accurate satellite orbit prediction;
- Ensuring and demonstrating spacecraft longevity approaching ten years;
- Developing a full family of GPS user equipment.

We discuss each challenge in detail, including the names of those most instrumental in meeting them. The first appearances of their names are **highlighted**, although if they appeared in Part One of this story (May 2010 issue), their names are not highlighted.

Early GPS manpack worn by JPO Army deputy Lt. Col. Paul Weber. This photo graced the cover of the first-ever GPS brochure.

CHALLENGE 1.

Defining the specific details of the GPS CDMA signal structure (coherence, acquisition, spreading, communication protocol, structure, error correction, message structure, and so on).

The selection of the GPS signal structure was broadly confirmed with the tests that were run by program 621B at the White Sands Missile Range with the help of **Joe Clifford**, **Bill Fees**, and **Larry Hagerman**, all from the Aerospace Corporation.

While the fundamental decision to select CDMA had been made during the Lonely Halls meeting, a vast number of details had yet to be worked out. Fortunately, there were many earlier studies of the signal. Dr. Jim Spilker (then of Philco Ford), who had also written the major reference book on digital communications, authored one of the studies. Dr. Charles Cahn, Nat Natali, **Burt Glazer**, **Ed Martin**, and Dr. Robert Gold of Magnavox all made significant contributions. One of the most important details was the decision that the carrier, code, and data of the GPS signal would all be phase-coherent (Figure 1). As discussed later, this decision enabled much of the precision that we now see in advanced GPS receivers.

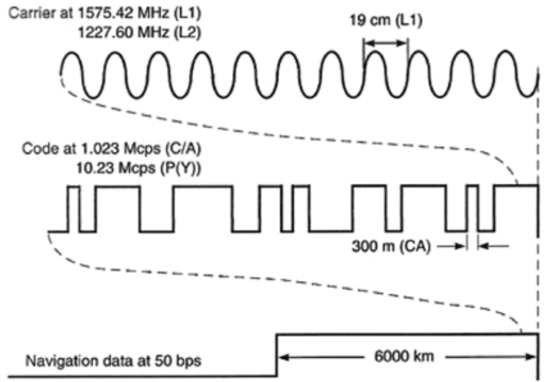


Figure 1. GPS signals were designed to be all aligned as transmitted, that is, coherent. (Courtesy Misra and Enge, Global Positioning System).

The exact Gold codes family had to be selected from the original family, since Dr. Gold's technique did not include the natural Doppler shifts. The data message was integrated into both the civil (C/A) and military (P/Y) signals through inversion of their codes every 20 milliseconds.

To work out the details of the data message, the JPO had a strong team including **Major Mel Birnbaum**, **Col. Brock Strom**, and **Capt. Bob Rennard**. Outside contractors making major contributions included Dr. Fran Natali, **Dr. A. J. Van Dierendonck**, and others. Van Dierendonck played a particularly effective role in helping define "GPS time." This sounds rather mundane, but had some very interesting complexity. Jim Spilker recommended the 1023-bit message length to avoid a correlation problem associated with Doppler shifts (this recommendation was incorrectly attributed in the last issue).

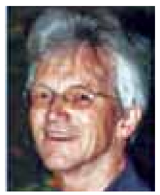
The data stream came down at 50 bits per second. Through this tiny pipe of information, all the precision of GPS had to pass. It included the space-vehicle orbit-position information (ephemerides), system time, space-vehicle clock-prediction data, transmitter status information, and C/A signal handover time to the P/Y code. Also as a part of the message, ionospheric-propagation delay models were incorporated for the single-frequency user. Further, to aid rapid acquisition of new satellites just rising over the horizon, the ephemerides of all other satellites in the full constellation had to be included. Each digital word had to be defined in terms of scaling, bias offset, and precision in terms of the number of bits transmitted.

About 95 percent of the GPS message has endured with no changes needed at all. In a few cases, because the newer user equipment is more accurate, greater precision is desirable. It is a great tribute to the brilliant engineers and scientists who designed the signal structure in 1975 that it has endured for 35 years with so little need for modification.

Some of the JPO Heroes at a "dining-in," a recognition dinner. From left, Major **MEL BIRNBAUM** (made many important contributions. He was famous for marathon code reviews that could last 18 hours straight. He hated to miss schedules!); Col. **DON HENDERSON** (later Maj. Gen.) second Air Force deputy; Major **RALPH TOURINO** (later Maj. Gen.), Program Control; Lt. Col. **KEN JUVETTE**, Director of Procurement; and LCdr. **JOE STRADA,** a key leader in the extensive test program.

A.J. VAN DIERENDONCK helped define "GPS Time."

ED MARTIN, one of the key systems engineers at Magnavox.



ERNST JECHART (left) and **GERHARD HUEBNER**, developers of the commercial rubidium clock. They later teamed with Rockwell to develop the first successful GPS clock, the only working clock on the first four GPS vehicles.

HUGO FRUEHAUF, chief engineer for the design and development of the first GPS satellites. His oversight was essential to produce the first GPS atomic clocks.

RON BEARD of NRL, a staunch supporter of GPS over many years.

CHALLENGE 2.

Developing space-hardened, long-life, atomic clocks (qualified for the upper Van Allen Belt, with 4- to 5-year lifetime requirement for individual clocks)

In 1966, both the Air Force and the Navy recognized that developing a precise, stable time-base for generating the one-way (passive) navigation ranging signal in the satellite was essential. Cesium atomic clocks had been invented, demonstrated, and offered for commercial sale by the middle of the 1950s, before the Space Age. The major commercial issues with these clocks were that they tended to be bulky, power-hungry, and not hardened against space radiation. To address that problem, rubidium atomic clocks, noteworthy for their small size and low power requirements, were developed. Still, the issues of mechanical and radiation hardening as well as temperature sensitivity had to be resolved before they could be used in space.

The 621B/Woodford/Nakamura study of 1964/66 called for atomic clocks in the satellites in at least seven places. The study advocated a technology program to space-harden existing clock technology. Unfortunately, the Air Force chose not to pursue a space atomic-clock technology program.

However, the Naval Research Laboratory (NRL) did institute a program in 1964. It pursued the technology for stable clocks with a series of satellites that have already been discussed. The first Timation satellite, launched in May 1967, carried a quartz clock. Not surprisingly, the frequency varied substantially with satellite temperature. The second Timation satellite also contained a quartz clock as well as a temperature controller and showed improved operation, but the results still fell short of those necessary for a GPS satellite. The third satellite in the series had not been launched before the Pentagon approved GPS development in December 1973. In any case, Timation III was designed to carry two slightly upgraded, off-the-shelf commercial rubidium clocks.

Qualification Model of the first GPS atomic clock, built by Rockwell International working directly with Efratom, a small German company.

Based on the progress that NRL had made, during the Lonely Halls meeting the JPO decided to commit to atomic clocks in the first operational GPS satellites. This third Timation satellite was renamed NTS-I and came under the newly formed Joint Program Office for GPS. The satellite was launched on July 14, 1974, as a part of the GPS program. However, the ineffective attitude-stabilization system caused varying sun angles and hence, significantly varying temperatures, masking any careful evaluation of the rubidium performance.

The GPS space-based rubidium atomic clock technology was derived from a unit produced by Efratom, a small company initially based in Germany. The geniuses behind this creative device were **Ernst Jechart** and **Gerhard Huebner.**

By the summer of 1974, a satellite contractor, Rockwell International (RI), had been selected to build the GPS operational satellites. Included in the program direction by the JPO was a separate development of rubidium clocks for the satellites as an alternative to the NRL cesium clock effort, in case the NRL effort faltered. **Hugo Fruehauf** of Rockwell had independently discovered and contacted Efratom, the company that NRL was working with, although his interaction was totally independent of that of the NRL. In addition, Fruehauf's relationship with Efratom was simplified because of his fluency in German, since Jechart did not speak English, and Efratom had just established an office in Southern California near the Rockwell developers. Figure 2, a page from the original Rockwell proposal, shows the excellent ground test data at both 1000 seconds and at 24 hours.

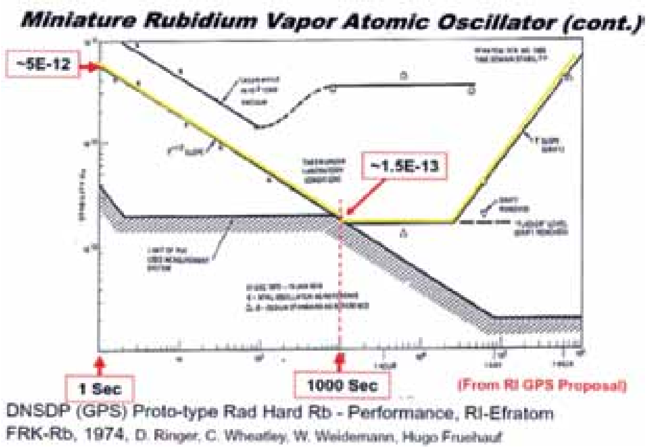


Figure 2. Test results for the Rockwell proposed GPS space-hardened prototype atomic (rubidium) clock, based on the Efratom commercial clocks.

On realizing that the small Efratom company would be incapable of producing a radiation-hardened, space-qualified rubidium oscillator, RI's GPS satellite program manager Richard Schwartz created a teaming relationship with them, which included his chief engineer, Hugo Fruehauf, plus Dale Ringer, Dr. Chuck Wheatley of Rockwell's Autonetics Division, and Efratom's Werner Weidemann. With heroic efforts, this team built a space-qualified clock in time for the first GPS launch in February 1978.

Meanwhile, the NRL-sponsored development of a cesium clock by FTS ran somewhat behind schedule. Their cesium clock was not available for the first three GPS satellite launches. The first NRL hardened clock was included on the fourth GPS satellite; unfortunately that unit failed after 12 hours of operation because of a power-supply problem. As a result, the only operating clocks on the first four GPS satellites were those developed by the Joint Program Office through its contractor Rockwell International. The decision to proceed to full-scale development for GPS, called DSARC 2, was made before any NRL-developed clocks had become operational.

That said, the NRL-sponsored FTS cesium clocks were available for later satellites, and performed extremely well. Later Block II GPS satellites carried two rubidium-frequency standards made by Rockwell and two cesium-frequency standards (primary source, Frequency and Time Systems; secondary sources, Kernco and Frequency Electronics Inc., on selected vehicles). Figure 3 summarizes the early clock program.

Program / (Service)	Dates	# of Sats / Nav Method	Nav Dim	Clocks	Ops Status
NNSS (Transit); (Navy-JHU/APL)	1964 to ~1990	(7) Doppler Signals	2D	(1) Quartz Oscillator	Was fully operational
Timation I & II; (Navy-NRL)	1967 and 1969	(2) Side-tone Ranging	2D	(1) Quartz Oscillator	Experimental. Very sensitive to thermal variations and Proton bombardment.
Navigation Technology Satellite-1 (NTS-1) (Navy- NRL)	Launch July 1974	(1) Hazeltine 621B Transm., No Data; + (2) Ranging Tones	2D	(2) Efratom Com'l Rb's, modified by NRL to perform in space, +(1) Quartz	Experimental: (1) Rb operated for more than one year– no quantitative data; (1) Rb failed early
NTS-2; (Navy-NRL); USAF/JPO provided Nav. Payload	Launch July 1977	(1) Rockwell-ITT PRN Nav. Pkg. provided by USAF-JPO; + (2) Side-Tone Ranging Signals	2D	(2) Proto space qualified FTS Cs + (2) Quartz Osc's	Good initial performance from Cesiums. Although intended to be part of the initial (4) Satellite Nav testing, NTS-2 failed before GPS nav testing began.
GPS Operational Prototypes, awarded to Rockwell in 1974 by USAF-JPO.	Devel'mt 1973-75; Rockwell Block-I launches began Feb. 1978	(4) / ITT PRN Nav. Pkg's. each satellite	3D	(3) RI-Efratom Rb's on the 1st (3) DNS Sats; 4th Sat & up, (3) RI-Efratom Rb's + (1) 2nd gen. FTS Cs**. 1st Cs on NDS 4 failed after 12 hrs, but fixed for NDS-5	GPS Constellation of (4) Rockwell Block-I GPS Satellites for the initial Navigation Test Program. Only Rockwell Rb clocks available for testing at YUMA for GPS.

Figure 3. Earliest satellite-clock technology developments, culminating in the last row: four Rockwell satellites with Rockwell-developed rubidium clocks.

In spite of NRL's development difficulties, GPS users owe a debt to the lab for its pursuit of this technology. Clearly GPS would not have performed so well without space-hardened atomic clocks. It was the apparent NRL progress that strengthened the argument. The support of Ron Beard of NRL in this joint effort has been invaluable to the program over many years. More than 450 atomic frequency standards have now flown in space. By far the greatest user has been GPS.

CHALLENGE 3.

Achieving rapid and accurate satellite orbit prediction, to within a few meters of user ranging error (URE) after 90,000 miles of travel.

Since the GPS system architecture had upload stations only on U.S. soil, the satellites were out of sight for many hours, making accurate prediction of their orbits essential. To achieve the expected positioning accuracy, the orbit prediction had to contribute less than a few meters of ranging error after 90,000 miles of travel. Achieving this standard was a major challenge in the early days of GPS. Such a prediction must account for the complications of Earth pole wander, Earth tides, general and special relativity, the noon turn maneuver of the satellite, solar and Earth radiation, and the reference station's location. Figure 4 gives an example of the problems of polar wander. With roughly a 400-day period, this effect had an amplitude of many tens of feet. While this wander has to be included in the GPS orbit-prediction model, fortunately GPS is the major technique to measure it.

Another, usually unrecognized feature is that the monitor stations only use the GPS signal for ranging. In other words, they are passive, rather than using the usual technique of that era, two-way ranging. The reference receivers were of a special design, developed by Jim Spilker's company, STI. They successfully received the first signal from the Rockwell/ITT satellite (NDS-1) on March 5, 1978, after its launch on February 22, 1978.

Fortunately, the Transit program had pioneered precise orbit prediction and had taken these effects into account. Its Astro/Celeste program, developed by **Bob Hill** and **Dick Anderle** at the Naval Surface Weapons Center in Dahlgren, Virginia, batch-processed the measurements taken by the reference stations. Unfortunately, this processing would take too long to provide the most up-to-date predictions.

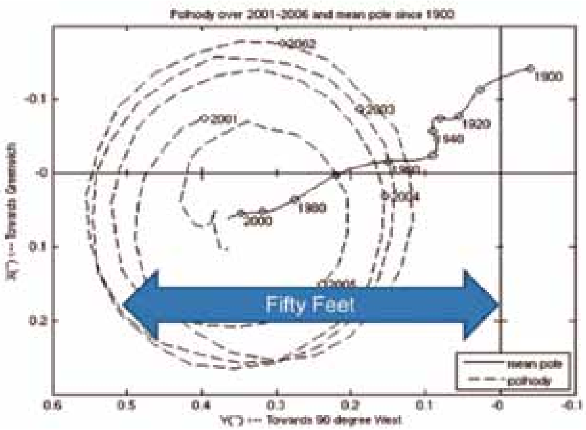


Figure 4. Motion of the Earth's spin axis must be included in the measurement parameters for GPS satellite location. The broadcast ephemeris is adjusted to include this effect, so the user need not make further adjustments. (Courtesy of International Earth Rotation and Reference Service).

A new scheme was devised that included partial derivatives of prediction relative to reference-station measurements. A.J. Van Dierendonck applied his knowledge of filters to help lead development of these calculations, which allowed a modified (linearized) Kalman filter to be used for near-real-time optimal prediction. Bill Fees of Aerospace, Walt Melton of General Dynamics, and **Sherm Francisco** of IBM, among others, implemented these techniques. The initial master control and upload stations were located at Vandenberg Air Force Base, since moved to Schriever Air Force Station; a backup master control station has been re-established at Vandenberg.

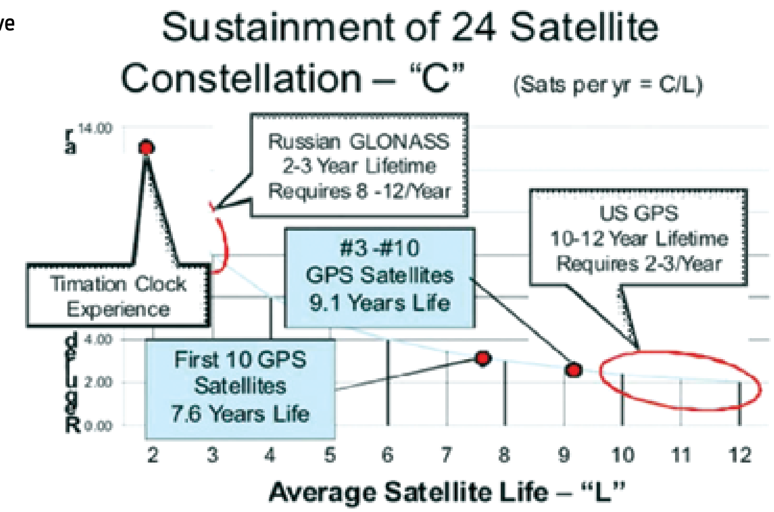
CHALLENGE 4.

Ensuring and demonstrating spacecraft longevity approaching 10 years (the issue was GPS affordability).

The issue was simply that sustaining a constellation of 24 satellites would be prohibitively expensive if the satellites did not have long lives. Again, the Air Force/621B study by Woodford and Nakamura in 1966 focused on the problem: "The most specific change in satellite technology is the increase of mean time before failure (MTBF). MTBFs on the order of 3 to 5 years can now be considered feasible."

The problem is easily illustrated in Figure 5. The light blue line shows the trade-off between average satellite lifetime, L, and the required number of satellites per year for a 24-satellite constellation. GLONASS, the Russian system competing with GPS, has the experience shown in the upper white box. With satellite lifetimes averaging two to three years (or less), GLONASS has a corresponding requirement for eight to 12 satellite launches per year. Only a very wealthy country can sustain such a launch program.

Figure 5. The imperative for long satellite lifetimes.



The red oblong illustrates the U.S. GPS experience, which requires only two to three launches per year. Also shown is the initial experience of GPS during Phase I. The first 10 GPS satellites reached an average age of 7.6 years, with #3 and #10 exceeding 9 years. This is an enormous credit to Rockwell International and in particular the program manager Richard Schwartz. He had excellent system engineering support from **Andy Codik**. The JPO satellite division was intially led by Major Gaylord Green and later by **Maj. Doug Smith**, with help from **Capt. Jack Henry**.

Three factors are key to long-lived satellites:

- Designs with carefully selected redundancy (for example, clocks, power amplifiers);
- Enforcing a rigorous part-selection program including the de-rating of parts (must be class S. or equivalent);
- Testing as you fly and insisting on a detailed analysis of all failures.

Figure 5 also illustrates why the Timation clocks could not be used as prototypes for the GPS program. In general, their maximum lifetimes were approximately one year. Clearly their designs needed greater maturation.

The demonstrated lifetimes were essential to passing the next milestone, DSARC II, which allowed GPS to proceed to full-scale development.

CHALLENGE 5.

Developing a full family of GPS user equipment that capitalized on the digital signal (leading to inexpensive digital implementation) and spanned most fundamental military uses, as well as demonstrating civilian cost feasibility.

The last, but certainly equally difficult of these five engineering challenges, was the development of nine different types of GPS user equipment. Recognize that a major part of the challenge was to stuff the real-time digital software processing into the relatively primitive digital computers of that era. Table 1 summarizes the development of user equipment:

All of the sets performed well within specification. They were characterized, however, by large size and heavy power demands. Magnavox, under the technical direction of **Vito Calbi**, produced the largest variety of user equipment. It was a subcontractor to General Dynamics, who reported directly to the JPO. At Aerospace, **Frank Butterfield** was a gifted contributor, particularly skilled at practical antenna design.

User Equipment Set	Description	Manufacturer
X Unaided	Four-channel, high-performance, military	Magnavox
X Aided	Four-channel, inertially-aided, military	Magnavox
Y Unaided	Single-channel, sequential, military	Magnavox
Y Aided	Single-channel, sequential, inertially-aided, military	Magnavox
HDUE-High Dynamic	Five-channel, high-performance, military	Texas Instruments
MVUE-Manpack Vehicular	Single-channel manpack/ground vehicle military	Texas Instruments
GDM-Generalized Development Model	Five-channel, high anti-jam military	Collins Radio Group of Rockwell International
MP-Manpack	Single-channel manpack/ground vehicle military included concept for determining azimuth	Magnavox
Z (ARN 132)	Single-channel, low-cost civil prototype	Magnavox

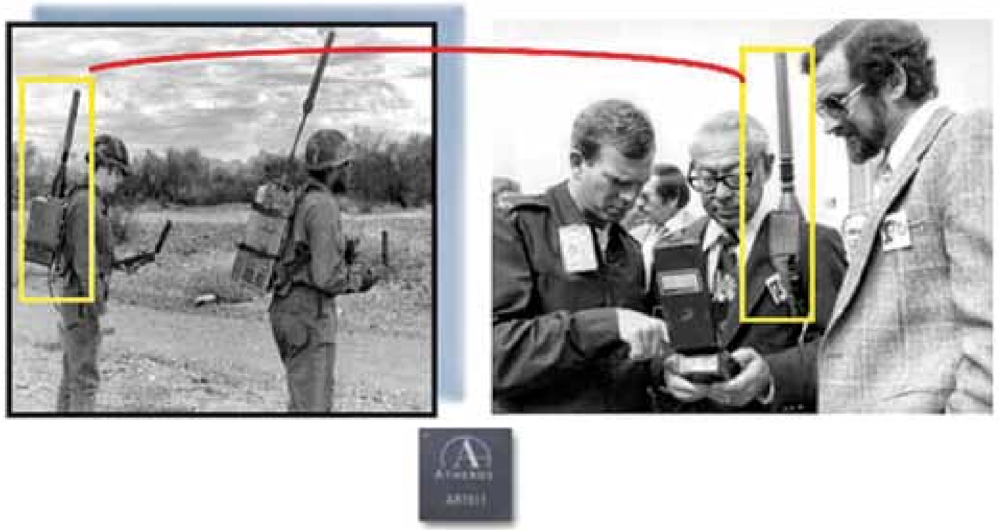
▲ **TABLE 1** User equipment.

The Rockwell Collins Generalized Development Receiver (GDM). This advanced receiver achieved more than 100 dB of anti-jam in actual flight tests.

The Generalized Development Model (GDM) reciever, developed by Rockwell Collins Group, was the largest of the sets, created for a specific purpose: to demonstrate the ultimate jam resistance for GPS user equipment. It attained performance better than 100 dB jamming-to-signals ratio (J./S) in actual flight test. The GDM receiver achieved this by integration with inertial components, directional antennas, and shading with the aircraft body. Such a receiver can fly directly over a 1 kW jammer at 4,000 feet and not be affected. The original GDM program manager at the USAF Avionics Lab was **Maj. Roger Brandt**

The single-channel manpacks were large and clumsy, but they operated very well. The payoff created by the CDMA signal is illustrated with the 12-channel, single-chip modern implementation, shown in the bottom picture. This contemporary chip's accuracy is much better than any of the equipment produced during Phase I.

Developing test environment and analysis setup was almost as challenging as the user equipment. Lt. Col. Val Denninger, Maj. Darwin Abbey, and Lt. Cdr. Joe Strada led this very successful effort. While most testing took place at Yuma Proving Ground, test sites were also located in San Diego and elsewhere.



1978 single-channel (sequential) Manpacks, two types by Magnavox and Texas instruments. Batteries alone weighed much more than current military handsets. Righthand photo, the second JPO deputy, Col. Don Henderson (left), and Aerospace program manager Ed Lassiter (right). Bottom, a modern 12-channel (parallel) Atheros chip receiver with more capability.

The CDMA (spread-spectrum or PRN) modulation used for passive ranging is clearly the most fundamental innovation of GPS. This signal enabled four-dimensional positioning for the user without requiring an atomic clock in the user equipment. The Russian GLONASS (the other, partially-operational global navigation satellite system) also used spread-spectrum passive ranging, but resorted to a frequency-separation scheme (FDMA, frequency-division multiple-access) that has proven inferior in actual use.

The innovative design of this CDMA signal has enabled all of today's precision applications for GPS. It is currently common for inexpensive GPS receivers to simultaneously receive signals from more than 10 satellites, yet all of these signals are being broadcast on exactly the same frequency. In fact, the number of signals that can be received is virtually unlimited using the spread-spectrum CDMA approach. Using a routine processing algorithm, the user, receiving more than four signals, has an instantaneous position that is more accurate than that using four satellites alone. This robustness includes a technique to ensure integrity of the GPS solution. The method, called receiver-autonomous integrity monitoring (RAIM), isolates a rogue satellite that is not operating properly, to ensure integrity of the GPS solution.

Another technique, called carrier tracking, is enabled with the coherence of the code and the carrier broadcast in this signal. When coupled with some form of differential GPS operation, the result is relative positioning accuracy that is unprecedented — frequently better than a millimeter. For example, surveyors can now routinely resolve three-dimensional position to this accuracy. Even common user equipment can make use of the coherence of the signal. The receiver accomplishes this by employing the so-called Hatch/Eschenbach filter that uses the reconstructed carrier signal to smooth the code-transition measurement that greatly decreases the noise of the raw code measurement.

GOOD OL' Country Boys. "I was making very frequent trips to D.C. and elsewhere. Accompanying me I usually had the excellent support of Captain Fergus Henderson (who was studying to be a lawyer, and had a master's from MIT), and Major Harry Hughes (USMA, 1959). Occasionally my AF Deputy, Steve Gilbert, would also help me. When we got on the airplane to go home, we would somehow end up humming `Country roads, take me home´ as a sort of lament and blues song. As a result, `Country roads´ became the Program's song. Steve Gilbert was a very accomplished banjo player. I was a struggling banjo player. We would sing the song in two-part harmony, as here at a dining-in, and everyone pretended to like it. On one memorable trip, Steve broke out his banjo in the air and we had a whole section of a DC-10 involved in a sing-along."

The processing gain in the GPS CDMA signal has been enhanced by deep integration with inertial navigation components. This has enabled the demonstrations of very high interference rejection by such receivers. **Dale Klein** and **Ed Copps** of Intermetrics Corp. were major contributors to the integration of GPS with inertial measurement units for the Magnavox high-performance military receivers.

Side-Tone Ranging. The competing side-tone ranging signal structure offered by NRL in the 1970 Easton patent had a fundamental flaw. If the signals were broadcast at the same frequency, they would interfere with each other. On the other hand, if they were broadcast on different frequencies, the user equipment would require a separate analog front end and tracking loops for each signal. In addition, each channel would have its own time-delay bias that would probably vary with temperature of the user equipment. A study by Magnavox also noted that the side-tone ranging signal could be easily spoofed; it was not clear how to encrypt such a signal. The final problem was that the signal was fundamentally an analog type and would have not been able to take advantage of modern digital signal processing. As a result, the receivers would be more complex and expensive.

The Air Force 621B/Aerospace and Magnavox studied the CDMA signal structure extensively after the 621B Woodford/Nakamura study was completed in 1966. Bob Gold of Magnavox had, in 1967, invented the technique to select acquisition codes that were mathematically guaranteed to not look alike (were uncorrelated). Early in the program, the JPO hired Dr. Jim Spilker, a recognized worldwide authority on digital signal processing, to contribute to this effort. Another worldwide expert, Charlie Cahn of Magnavox, was also a major contributor to the signal design. As mentioned previously, the details of the signal required the efforts of many people.

By 1969, the CDMA signal was being used in many communication applications. Adapting this signal for navigation raised the questions that were posed in an earlier section. It is hard to believe today the issues surrounding its use had to be addressed in 1970. It is to the great credit of Program 621B that it built the receivers and ran the series of tests at White Sands Missile Range that had earlier resolved all the major issues surrounding the signal structure. This irrefutable evidence allowed the JPO team to confidently choose this signal during the Lonely Halls meeting in September 1973. Great credit must go to Bill Fees who worked tirelessly to complete the analysis that demonstrated 5-meter accuracy in those White Sands tests.

CDMA-ENABLED APPLICATIONS

The distinction between the Timation side-tone ranging and the 621B CDMA signal is critical to understanding the origins of GPS. The Air Force CDMA signal was different in essential and fundamental ways from the Easton side-tone ranging modulation. Three examples of precise three-dimensional applications, not achievable with side-tone ranging, illustrate the subsequent success of the 621B digital CDMA signal.

Aircraft Blind Landing. In 1992, the Federal Aviation Administration (FAA) sponsored Stanford's development and demonstration of the first Category III (blind landing) system in a commercial aircraft; the effort was led by **Clark Cohen** and developed by a group of Stanford students under the supervision of Brad Parkinson. The only sensor for both position and attitude was GPS. The carrier-tracking receiver was a derivative of a Trimble receiver; it relied on the CDMA signal structure for both accuracy and integrity. (See Figure 6.)

- **The Expected in 1974: Aircraft Navigation**
- **The Surprise 1992: Hands-Off to Touchdown!**

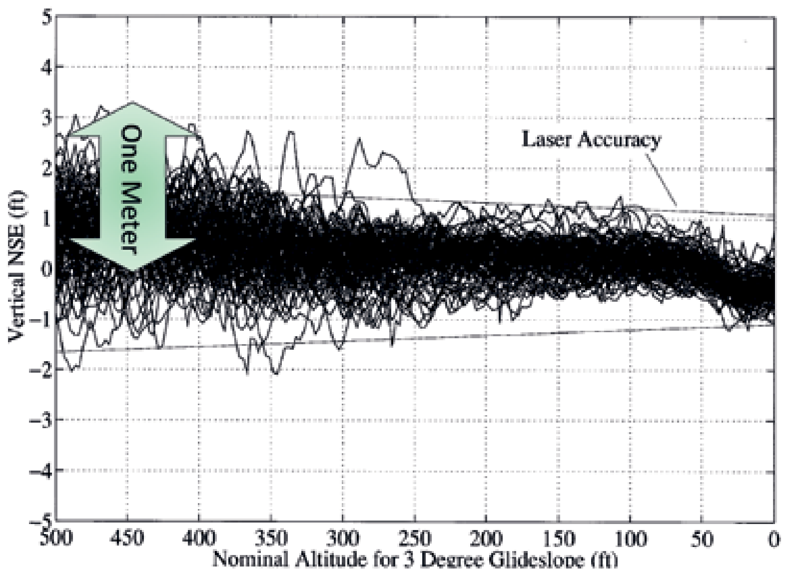
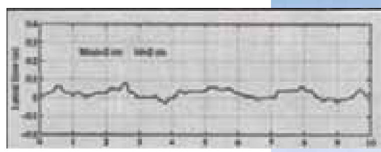


Figure 6. Results of first blind landing tests using GPS alone, 110 landings with a commercial Boeing 737.

Robotic Farm Tractor. Using similar technology, a different group of Stanford students in the same lab demonstrated the first precision GPS-controlled robotic farm tracker. Again, the capability was enabled by the GPS CDMA signal. The John Deere Company sponsored this effort, which has now expanded into a worldwide market of more than $400 million per year.

- **The Expected in 1974: Land Navigation**
- **The Surprise 1996: Automatic Steering to an inch**
  3 Axis attitude to 1.0 degrees



Robotic farm tractor developed at Stanford with support from John Deere company.
Student leader Mike O'Connor and colleague Tom BeLl shown. Tracking test at 5 meters/ second, with worst error around 3 inches!
Now a $400M/year market.

Earth Crustal Monitoring. A third example of the power of the CDMA signal is precise survey, focused on Earth movement and crustal tracking (Figure 7). The original GPS surveying receivers were pioneered by Phil Ward at Texas Instruments and Charlie Trimble at Trimble Navigation, among others.

- **The Expected in 1974: Survey to 1 Meter**
- **The Surprise: Survey to 1 milimeter – measuring velocity to 1 milimeter per year**

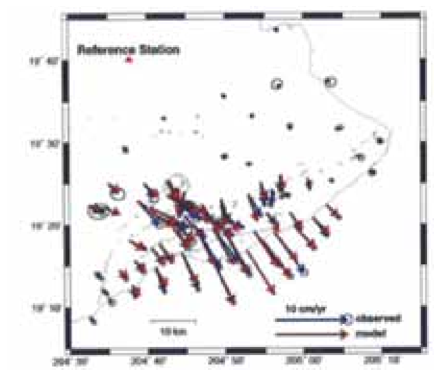


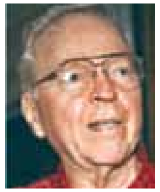
Figure 7. Continuous observation of earth crustal motion with a precision of better than a millimeter: distributed slip on Kilauea volcano, Hawaii

Summary. Many technologies came together to make GPS operational, none more revolutionary than the signal structure demonstrated by 621B at White Sands, and selected by Parkinson during the Lonely Halls meeting. Virtually all high-precision uses of GPS depend on the characteristics of this signal.

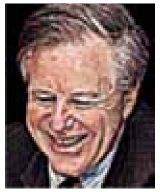
DICK SCHWARTZ, GPS satellite development manager and VP at Rockwell International. His skill ensured the success of the first GPS constellation of 4 RI satellites.

MAJOR WALT LARKIN, one of the keys to satellite long life. Larkin, Irv Rezepnik of Aerospace, and the Rockwell GPS spacecraft developers insisted on rigorous selection and testing of all spacecraft components.

SHERM FRANCISCO of IBM did key work in orbit prediction.



PHIL WARD developed the TI-140, an early commercial high-precision receiver.



CHARLIE TRIMBLE produced early surveying receivers.

LT. COL. (LATER COL.) STEVE GILBERT fought the successful battle in the Pentagon that allowed GPS to survive threatened funding cuts in the early 1980s

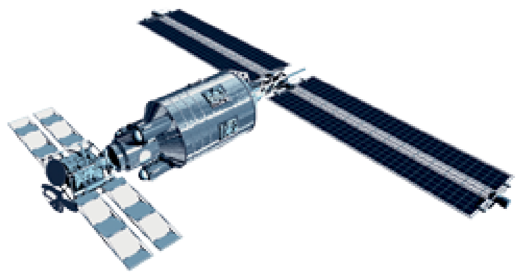


Photo: Shutterstock

MORE ON GPS ORIGINS

The fundamental basis for the GPS design was clearly the Woodford/Nakamura and subsequent studies undertaken by 621B, not the system outlined by NRL in the Easton patent. More than 500 million current users have overwhelmingly confirmed the value of the selected technique using a minimum of four-satellite passive ranges and the CDMA signal. If each GPS user had to employ an atomic clock, the price of most GPS receivers would be prohibitive. The value of a four-dimensional solution for users has also been irrefutable. Had GPS followed the blueprint of the NRL patent, it is reasonable to say that almost all system uses, military as well as civilian, would have been fatally compromised. Further, had the Easton side-tone ranging signal been selected, broadcasting 30 satellites on the same frequency, as GPS does today, it would have created an undecipherable electromagnetic jumble.

Summarizing Easton's Patent. We earlier mentioned the NRL/Easton patent for the Timation design. It is important to summarize that invention and its relationship to the actual GPS design. A few people have written that Roger Easton "invented" GPS. As stated, Easton did have a competing concept that he had developed at NRL. In October 1970, four years after the completion of the secret, seminal system study by Woodford and Nakamura, Easton applied for a patent, "Navigation System Using Satellites and Passive Ranging Techniques," that was granted on January 29, 1974 (U.S. 3,789,409). A careful reading of the patent, available on the web, reveals the following:

- The technique described by Easton clearly calls for a synchronized "extremely stable oscillator" at the user station. Elsewhere he states: "would typically be controlled by an atomic clock." This less-capable method of navigating was examined in the Woodford/Nakamura study, four years before Easton's patent application, and is definitely not the technique chosen by GPS.
- The patent advocates the use of a passive ranging technique, whose description occupies most of the patent, with multiple frequency tones, not the CDMA technique of GPS that had already been studied by 621B. Before the patent was issued, 621B had already built prototype GPS CDMA receivers, flown them at the White Sands range, and demonstrated three-dimensional accuracies of about 5 meters. The Easton passive-ranging technique, commonly called side-tone ranging (STR), had been included in a 621B analysis of alternatives. STR was rejected because of poor resistance to interference or spoofing, and the inability to broadcast all satellites at the same frequency without destructive self-interference.
- Both the description and the accompanying diagram in the patent clearly refer to two-dimensional navigation, using lines of position. To extend this to three or four dimensions was not mentioned. Such extension would probably only be possible if the satellites all broadcast on different frequencies, which would have made extremely high-precision positioning (as attained by the actual GPS design) infeasible.

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Thus, it is correct to state that the Easton patent did not, in any way, represent the actual GPS design in at least these three fundamental aspects.

Further Transit Contribution. In 1974, after the first phase of GPS had been approved, the Transit program requested funds to upgrade the Transit signal structure to the same passive ranging technique (CDMA) being planned for GPS. The program's purpose was to use Transit signals to track Trident missile testing launches in broad ocean areas. Air Force Col. Bradford Parkinson (director of the GPS Program), Dr. James Spilker (Stanford Telecommunications Inc.), and **Jack Klobuchar** (Air Force Cambridge Research Laboratory) responded with a technique for substituting GPS signals, with a translated frequency relayed to the ground to track those missile tests.

After three Pentagon briefings on the proposed alternative technique, **Dr. Bob Cooper** of the DoD concluded that the GPS signal would be used. Included was a decision to add two more satellites to the Phase I development of GPS to accommodate the Trident launch window. As a result, $66 million was transferred from the Navy to the USAF GPS program. The benefit to the fledgling GPS program was enormous. This greatly expanded the test time for GPS, and also reduced the risk, since no spare satellites had been approved for the program. While the Trident program was somewhat unhappy with the loss of funds and control, it immediately unleashed the creativity of Johns Hopkins University Applied Physics Laboratory and successfully met the Trident missile test tracking requirements.

GPS JPO INNOVATIONS

GPS was the first DoD program directed to be managed as a Joint Service Development Program. This new approach, conceived by Dr. Currie, led the GPS program to be designated a JPO or Joint Program Office. As a result, there were deputy program managers assigned from the Navy (Cdr. Bill Huston), Army (**Lt. Col. Paul Weber**), Marine Corps (**Lt. Col. Jack Barry**), and Defense Mapping Agency (**Paul Frey**), as well as the customary Air Force deputy (initially **Lt. Col. Steve Gilbert**, later **Lt. Col. Don Henderson**). Rather than use these well-qualified people from other services simply as liaisons, they were each assigned specific programmatic responsibilities.

At the first major program review at Andrews Air Force Base, Parkinson called the convening general's attention to the fact that he was leading a joint program, and with the general's indulgence he had invited his deputies from the other services to attend. Since attendance by other services at Air Force program reviews was unheard of, this drew a gasp from the roughly 200 Air Force officers attending. The JPO approach truly broke new ground in intra-service cooperation.

At the JPO. Frank Butterfield of Aerospace, Col. Parkinson, and Cdr. Bill Huston, deputy JPO director from the U.S. Navy, in the early 1970s. A model of a Phase I GPS satellite stands on the table between the latter two.

Parkinson had entreated the Federal Aviation Administration to also send a deputy. The public response by the FAA deputy administrator for development was: “We don’t want GPS, we don’t need GPS, and if it is ever deployed, we will never use it.” Throughout this period, Glen Gilbert (sometimes called “the father of air traffic control”) was a strong and early advocate for FAA use of GPS. It took many years for the FAA to accept his views. Obviously times change; the current relationship between the FAA and the GPS Program Office is excellent, fostered by Col. Dave Madden and his FAA counterpart Leo Eldredge.

JPO as Prime Contractor. The JPO cadre served as the prime or integrating activity for the whole program. Gen. Schultz almost fired Parkinson when he proposed this. The general had expected him to hire a separate commercial integrating contractor. After Parkinson explained that the major interfaces between the three segments — satellite, ground control, and user equipment — were the signals, Gen. Schultz acceded to the plan. This pioneering aspect was critical because it ensured that all aspects of the system would be under the direct purview and control of the JPO.

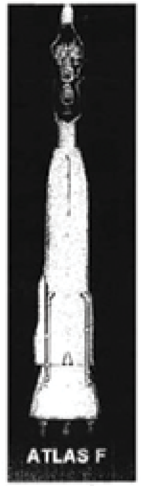
Award and Incentive Fees. The use of innovative procurement awards for the contractors was very new in DoD in 1974. Beginning with the satellite contract, the JPO made extensive use of new forms of positive rewards for the contractor, including incentives for on-orbit performance. Gaylord Green pioneered this activity with skills developed as a project officer in the Advanced Ballistic ReEntry Systems Program (ABRES) program office. Incentives were applied to virtually all the other contracts as well, and seemed to have a very positive effect.

Normally the Space and Missile Systems Organization (SAMSO) procurement office, which was independent of the JPO, would have been reluctant to approve such radical new ideas. Fortunately, Parkinson carpooled with another colonel who was head of SAMSO procurement and a breath of fresh air. This attitude was exemplified by a sign at eye level as you left the procurement director’s office: “Nothing would be done at all if a man waited until he could do it so well that no one could find fault with it.” (It turns out this came from remarks by Cardinal John Henry Newman.) With that attitude, the SAMSO office approved almost all of the JPO’s “wild” procurement innovations. Many of these innovations are now routine.

Changes. The Air Force provided a high-level spec for the satellite that defined the signal structure, the power on the ground, the frequencies, the orbit, and the amount of weight the booster could put into that orbit at apogee. The JPO left it up to the contractor to design a satellite that could meet those requirements. The key point is the JPO never changed the requirements, which kept GPS on course with minimum cost increases for the devlopment.

Refurbished Atlas F Booster. Today, up to half the cost of a satellite on-orbit is the cost of the booster to place it there. While the costs were perhaps not proportionally so large in 1977, they still could consume large pieces of a program’s budget. Luckily, the United States had mothballed much of its liquid-fuel ballistic missile force during that period. The JPO chose to use refurbished Atlas Fs as boosters, saving many millions of dollars. Some have suggested this idea originated with NRL. While NRL may have also been using them, both Parkinson and Green came from the ABRES program where refurbished Atlas Fs were already employed. Thus, the decision made in the Lonely Halls meeting was based on knowledge the JPO already had, which included additional steps the ABRES had taken to improve the reliability of the booster. (See Figure 8).

Figure 8. Refurbished Atlas-F booster characteristics. Col. Parkinson and Maj. Green brought this concept from previous use on the USAF ABRES program.



Refurbished Atlas F ICBM	
Configuration	**Weight (lb)**
Atlas F at Lift -off	270,934
Navstar Payload at Booster Separation	1636
Payload at final orbit	982

A Motto. Emblazoned on a prominent wall in the JPO was a sign that read:

“The mission of this Program Office is to

- Drop 5 bombs in the same hole
- and build a cheap set that navigates
- and don’t you forget it!”

By distilling the JPO mission into one succinct motto, the program intended to provide a guide for all its actions. If a decision fundamentally helped achieve that mission, it was probably the right one.

The Political Battlefield. Political battles in the Pentagon are often brutal and unforgiving. The fundamental reason is that the budget is always viewed as a zero-sum game. One program's money comes at another program's expense. GPS was a system that sprang from the space development community ("the Space Weenies") and had virtually no champions from the operational components. Unlike current DoD satellite programs, there were no explicit formal requirements for the new system and hence little official status. Parkinson spent many trips to the operating forces to explain the value of precision weapon delivery. Between skepticism and deafness, GPS survival was always extremely uncertain. The Air Force generally opposed its deployment, even after the extensive tests of 1978–80 had clearly demonstrated that GPS was, by far, the best blind-bombing system ever conceived.

Fortunately, there were some key supporters of GPS who overcame that resistance. They were affectionately called the **GPS Mafia**. The most important member of this unchartered group was Malcolm Currie, whose efforts were discussed earlier. His powerful number-three position at the Pentagon gave him the authority to force funding decisions on the uniformed military. At least one general officer was extremely upset with Parkinson over his relationship with Dr. Currie, and gave him a public tongue-lashing over the issue during a chance encounter in a Pentagon corridor. **Dr. Johnny Foster,** whom Mal Currie replaced, was another early supporter of the program.

USAF Col. Steve Gilbert, the original deputy program manager for GPS in Los Angeles, was a tireless, heroic contributor. Later on he played a critical role, fighting the battles within the Pentagon as the Air Force Program Element Monitor (PEM). His next position was as the GPS representative in the Office of the Secretary of Defense. While there, Steve fought back repeated challenges that would have canceled GPS in the early 1980s. Without his efforts, GPS almost certainly would never have happened.

Other members of the GPS Mafia were Lt. Col. Paul Martin (the original GPS Program Element Monitor), **Brig. Gen. Hank Stelling** (RDS in Pentagon), and **Cols. Brent Brentnall** and **Emmitt DeAvies** (DDR&E representatives).

The users of GPS owe all of these supporters a real vote of thanks. As the Duke of Wellington said about the battle of Waterloo, "It was a near-run thing."

Fortunately, GPS supporters prevailed, and the two Iraq wars have made all branches of the military believers in the value of the system, although they sometimes regard it as magic. A combat Army colonel in Iraq was reportedly asked what he thought of satellite systems to help him fight. His response:

"I don't need any (expletive) space systems. My GPS and my Iridium comm give us everything we need."

GPS really is a stealth utility.

THOUGHTS ON THE FUTURE

There are now many additional or improved satellite systems on the horizon. American GPS has heretofore only offered a single, clear navigation signal for civil users. That is rapidly changing. Two more frequencies and a number of additional signals will be available from the next two generations of U.S. satellites. Other countries are also working hard to follow the GPS lead. Figure 9 depicts some of these new systems.

Figure 9. Upgrades of GPS (only current operational civil signal; next generation, four new civil signals at two new frequencies), GLONASS (next generation, four new civil signals at two new frequencies) and new international navigation satellite systems (Galileo, four new civil signals to appear at two new frequencies; finally, Compass) are on the near horizon. The plethora of signals will enable improved accuracy and integrity. This will lead to new applications.

An international common navigation signal called L1C has been accepted and almost completely defined. It will broadcast on the same 1575 MHz frequency as the current GPS civil signal. It will be of the same type (CDMA) as the original GPS signal, although it will have significant enhancements to increase precision and accuracy. If the engineering is done properly, this signal should be interchangeable for all GNSS systems that support civilian use. The positioning, navigation, and timing (PNT) community will benefit enormously by having all of these signals available. Again, the key enabling decision was the CDMA signal structure defined by 621B and tested at White Sands.

We will mention one CDMA-enabled application with a large market potential. This is the use of multiple GNSSs (up to 50 satellites) in automobiles for lane guidance and car separation. During times of low visibility, freeways are notorious for multi-vehicle collisions. We believe the technology will be in hand to greatly reduce these tragedies. The new application would involve cooperative navigation with cars in the vicinity all tied together in a communication grid. GPS-measured velocity is almost a forgotten aspect of the system, yet it can be accurate to much better than 0.1 meters per second. If two cars in the vicinity of each other can know both relative position and relative velocity, collision probabilities can be easily assessed and avoidance actions quickly and automatically recommended.

This is just a glimpse of the future. We believe many other new or improved applications will be enabled by future deployments.

SUMMARY

Just as a building is not invented, GPS was not the product of any single invention. GPS as a system was an innovation enabled by many antecedent technologies and concepts. Some were brand new in application, or had to be adapted to their role in GPS, for example the CDMA signal technique. In making those system selections, the final design was the product of the entire JPO team, whose roots went back to many of the greatest institutional sources of innovation in the country.

The two most critical foundations were:

- The comprehensive study done by Jim Woodford and Hideyoshi Nakamura for USAF/621B in 1964/66, exploring virtually all alternative ranging techniques from satellites, both active and passive, and calling for atomic clocks in the satellites. In particular, the four-dimensional 621B concept of using "four in view" was analyzed and became the bedrock of the GPS design, ensuring that the user could make do with a simple crystal clock.
- The selection and demonstration of the CDMA passive ranging signal by 621B at White Sands. These tests confirmed four-satellite, single-frequency operation and proved that such operation obviates the need for an atomic clock in each GPS user set.

Photo: Shutterstock

These directly led to the systems architecture decisions made in the Lonely Halls meeting. Also essential were finding workable solutions to the five critical challenges:

- Defining the specific details of the GPS CDMA signal structure
- Developing space-hardened, long-life, atomic clocks
- Achieving rapid and accurate satellite orbit prediction
- Ensuring and demonstrating spacecraft longevity
- Developing a full family of GPS user equipment.

In tracing the origins, the first navigation satellite program, the Transit program of APL, should be singled out. Working under contract to the Navy's Nuclear Submarine Program, APL pioneered the dual-frequency technique to calibrate ionospheric delay errors as well as the painstaking development of an accurate orbit-prediction program. Both early efforts were essential to the ultimate success of GPS.

Also important was NRL's push to harden frequency standards for use in satellites. While the JPO rejected Easton's navigation technique, NRL's apparent clock progress, by 1973, convinced the decisionmakers at the Lonely Halls meeting to commit to including atomic clocks in the first prototype, Rockwell-built GPS satellites. While it is ironic that no clock with NRL heritage was operational on the first four GPS satellites, the NRL's persistence finally paid off with the introduction of its cesium beam clocks on an equal footing with the Efratom/Rockwell-designed rubidium clocks later, during GPS Phase II.

Throughout this article, many of the contributors to the early definition, development, and testing of GPS have been named. Certainly many others have also been inadvertently left out. In closing we would like to sincerely thank the scores of engineers who assembled the first-of-a-kind demonstration system.

As a stealth utility, one pervasive accolade is that GPS is now taken for granted. People throughout the world now expect to know exactly where they are and what time it is.

Reprinted courtesy of Bradford Parkinson

PRZEDMOWA REKTORA UNIWERSYTETU MORSKIEGO W GDYNI PROF. DR. HAB. INŻ. KPT. Ż.W. ADAMA WEINTRITA

Szanowni Państwo,

niewiele jest osób nam współczesnych, którym zawdzięczamy tak wiele, którzy wywarli gigantyczny wpływ na rozwój niemal każdej dziedziny wiedzy i techniki. Niewątpliwie należy do nich prof. Bradford Parkinson z kalifornijskiego Uniwersytetu Stanforda – „Father of GPS". Niemal rok temu, dokładnie w 50. rocznicę uruchomienia programu systemu satelitarnego GPS, z mojej inicjatywy rozpoczęliśmy na Uniwersytecie Morskim w Gdyni procedurę przyznania Profesorowi godności doktora honoris causa. 16 listopada 2023 roku Senat UMG przyjął uchwałę w sprawie nadania prof. Bradfordowi Parkinsonowi tytułu doktora honoris causa Uniwersytetu Morskiego w Gdyni „w uznaniu rewolucyjnego wkładu w rozwój techniki oraz wszystkich form transportu, jak również stworzenie podstaw do epokowej zmiany funkcjonowania świata i społeczeństw XX i XXI wieku poprzez kierowanie zespołem odpowiedzialnym za utworzenie pierwszego satelitarnego systemu pozycyjnego GPS-NAVSTAR (Global Positioning System – NAVigation Signal Timing and Ranging)".

Zgodnie ze Statutem UMG ten zaszczytny tytuł przyznawany jest osobom szczególnie zasłużonym dla rozwoju nauki, kultury lub życia społecznego. Dziś do tego szacownego i wąskiego grona dołącza wielki wizjoner prof. Bradford Parkinson. A okazja ku temu jest szczególna: 50. rocznica zapoczątkowania wspólnego cywilno-wojskowego programu technicznego Globalnego Systemu Pozycjonowania GPS-NAVSTAR, który całkowicie zrewolucjonizował nawigację lotniczą, morską i lądową, a którego prof. Bradford Parkinson był głównym architektem jako dyrektor Biura Programowego systemu GPS Sił Powietrznych Stanów Zjednoczonych (USAF).

Satelitarny system pozycyjny, formalnie znany jako Globalny System Pozycjonowania NAVSTAR, został zapoczątkowany w 1973 r.

Miliardy ludzi na całym świecie polegają dziś na ogromnej infrastrukturze inżynieryjnej, która objęła całą naszą planetę i sięga w przestrzeń kosmiczną, znajdując zastosowanie w podnoszeniu bezpieczeństwa morskiego, lotniczego, lokalizowaniu i ratowaniu rozbitków i statków znajdujących się w niebezpieczeństwie, w usługach transportowych (drogowych, kolejowych, lotniczych, śródlądowych i morskich), budownictwie, geodezji, kartografii, turystyce, rekreacji, rolnictwie, produkcji żywności, bankowości i nauce. GPS, który zmienił nawigację i precyzję pomiaru czasu, stał się niezbędny także dla zwykłych posiadaczy smartfonów, umożliwiając im dokładne określenie lokalizacji i miejsca na Ziemi. Dzięki precyzyjnej lokalizacji odbiornika i dobrze zaprojektowanej mapie nawet kompletnie nie znając trasy, możemy pewnie dotrzeć do celu naszej podróży.

Ponieważ wniosek o nadanie tytułu doktora honoris causa musiał uzyskać poparcie trzech Senatów uczelni zewnętrznych, przeprowadziłem rozmowy z Politechniką Warszawską, Akademią Marynarki Wojennej im. Bohaterów Westerplatte oraz Lotniczą Akademią Wojskową. Rektorzy tych uczelni: prof. dr hab. inż. Krzysztof Zaremba, rektor-komendant kadm. prof. dr hab. Tomasz Szubrycht i rektor-komendant gen. bryg. pil. dr inż. Krzysztof Cur bez wahania przyjęli moją propozycję i przekonali Senaty kierowanych przez siebie uczelni, by poparły nasz wniosek.

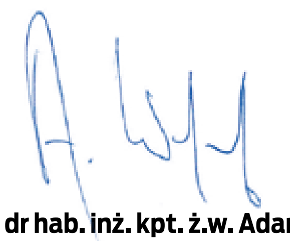
Oprócz poparcia trzech uczelni konieczne były również pozytywne opinie trzech niezależnych profesorów. Zadeklarowali się je przygotować: prof. dr hab. Jarosław Bosy z Uniwersytetu Przyrodniczego we Wrocławiu, prof. dr hab. inż. Stanisław Oszczak z Lotniczej Akademii Wojskowej w Dęblinie i prof. dr hab. inż. kpt. ż.w. Zbigniew Burciu z Uniwersytetu Morskiego w Gdyni.

O nadaniu tytułu doktora honoris causa Uniwersytetu Morskiego w Gdyni z wielką przyjemnością i radością poinformowałem Profesora Parkinsona 21 listopada 2023 roku. W odpowiedzi napisał, że jest to dla niego wspaniała wiadomość i przyjęcie godności doktora honoris causa naszej uczelni będzie dla niego zaszczytem, sam bowiem jest absolwentem amerykańskiej Akademii Marynarki Wojennej, która ma przecież wiele wspólnego z naszą, jak to określił, „bardzo zdolną instytucją edukacyjną”. Ukazał Mu to podarowany album, wydany z okazji stulecia Uniwersytetu Morskiego, który otrzymał od prof. Krzysztofa Czaplewskiego, często uczestniczącego w spotkaniach zawodowych w USA, co pomaga w wymianie technicznej i wzmacnianiu więzi między naszymi krajami.

Lista instytucji, które w latach 90. ubiegłego stulecia i w pierwszej dekadzie XXI w. korzystały z wiedzy i kompetencji prof. Parkinsona, jest imponująca. Profesor uhonorowany został kilkudziesięcioma nagrodami i wyróżnieniami, w tym: Honorary Fellow of AIAA, Life Fellow of IEEE, AIAA Goddard Astronautics Award, NASA Distinguished Public Service Medal, Nagrodą Lloyda V. Berknera, Draper Prize nadaną przez National Academy of Engineering, uważaną powszechnie za „Engineering Nobel Prize”, a także Złotym Medalem Królewskiego Instytutu Nawigacji, Złotym Medalem Amerykańskiego Stowarzyszenia Inżynierów Mechaników (ASME) oraz w 2019 roku Queen Elizabeth Prize for Engineering. W 2000 roku został uhonorowany godnością doktora honoris causa Uniwersytetu w Calgary. Natomiast nigdy dotąd nie został uhonorowany godnością doktora honoris causa w Europie. Przynajmniej nic mi o tym nie wiadomo, by któraś z europejskich uczelni wyprzedziła nas z taką inicjatywą.

A sposobność jest naprawdę wyjątkowa. Na dyplomie, który za chwilę otrzyma prof. Parkinson, widnieją dwa podpisy: promotora przewodu i rektora uczelni. Tak się składa, iż w chwili obecnej promotor przewodu prof. Krzysztof Czaplewski jest przewodniczącym Międzynarodowego Stowarzyszenia Instytutów Nawigacji IAIN (International Association of Institutes of Navigation), natomiast ja mam honor przewodniczyć Międzynarodowemu Stowarzyszeniu Uczelni Morskich IAMU (International Association of Maritime Universities) – nigdy dotąd nie miało miejsca, aby dwóch pracowników z jednego Wydziału tej samej uczelni piastowało równocześnie tak wysokie funkcje w naszym międzynarodowym środowisku i świecie zawodowym.

Szanowny Panie Profesorze, Dostojny Doktorze Honoris Causa Uniwersytetu Morskiego w Gdyni, składam Panu w imieniu całej naszej społeczności akademickiej najszczersze i najserdeczniejsze gratulacje oraz wyrazy głębokiego szacunku. Jest to dla nas ogromny zaszczyt, że przyjął Pan tę godność właśnie od nas.



Prof. dr hab. inż. kpt. ż.w. Adam Weintrit
rektor Uniwersytetu Morskiego w Gdyni

ZOSTAŁEM REWOLUCJONISTĄ PRZED 50 LATY, WYWOŁUJĄC TĘ UKRYTĄ REWOLUCJĘ. I NADAL NIM JESTEM, BO GPS JEST UKRYTĄ REWOLUCJĄ, KTÓRA WCIĄŻ TRWA.

BRADFORD PARKINSON

Fot. iStock

LAUDACJA PROF. DR. HAB. INŻ. KRZYSZTOFA CZAPLEWSKIEGO (UNIWERSYTET MORSKI W GDYNI) Z OKAZJI NADANIA TYTUŁU DOKTORA HONORIS CAUSA UNIWERSYTETU MORSKIEGO W GDYNI PROFESOROWI BRADFORDOWI PARKINSONOWI

Wasza Magnificencjo,
Wysoki Senacie,
Dostojny Panie Profesorze,
Szanowni Państwo!

Z woli Senatu Uniwersytetu Morskiego w Gdyni przypadł mi wielki zaszczyt i honor pełnić rolę promotora w postępowaniu o nadanie tytułu doktora honoris causa Uniwersytetu Morskiego w Gdyni nietuzinkowej osobie, znanej na całym świecie jako „the Father of GPS" – Panu Profesorowi Bradfordowi Parkinsonowi.

Tytuł doktora honoris causa jest najwyższą godnością akademicką, nadawaną najwybitniejszym postaciom, szczególnie zasłużonym dla rozwoju nauki, kultury, gospodarki, których działalność miała silny wpływ na aktywności człowieka we współczesnym świecie. Tę godność otrzymują osoby cieszące się niekwestionowanym autorytetem i postawą moralną. Doktorzy honoris causa mają siłę sprawczą zmieniającą otaczający ich świat. Bez wątpienia do takich osób należy Pan Profesor Bradford Parkinson, którego efekty pracy mają wpływ na codzienne życie ludzkości. Tak jak era maszyny parowej zmieniła oblicze świata, tak w drugiej połowie XX wieku rozpowszechnienie techniki obliczeniowej i uruchomienie systemów satelitarnych na zawsze zmieniły nasze życie. Żyjemy bez wątpienia w erze informacyjnej, ale bez systemów satelitarnych konsumpcja zdobyczy informatyki byłaby niepełna. Bez osobistego zaangażowania Pana Profesora nie mógłby funkcjonować współczesny transport we wszystkich jego odmianach, nie byłoby bankowości elektronicznej czy też tak popularnych serwisów VOD. Każdy z nas, świadomie czy też nieświadomie, wykorzystuje efekty pracy Pana Profesora i osób, z którymi współpracował.

Prof. Bradford Parkinson urodził się 16 lutego 1935 roku. Swoją edukację rozpoczął w szkole średniej w Breck School w Golden Valley w stanie Minnesota. W 1957 roku ukończył z wyróżnieniem US Naval Academy w Annapolis. Wówczas uzyskał tytuł Bachelor of Science in Engineering. Jego zainteresowanie inżynierią sterowania zostało dostrzeżone przez grono profesorskie i zaproponowano Mu służbę w Siłach Powietrznych Stanów Zjednoczonych (USAF). Przeszedł szkolenie w zakresie konserwacji elektroniki i nadzorował duże naziemne instalacje radarowe w stanie Waszyngton, następnie USAF umożliwiły przyszłemu profesorowi odbycie studiów magisterskich w Massachusetts Institute of Technology, gdzie studiował inżynierię sterowania, naprowadzanie bezwładnościowe, astronautykę i elektronikę. Po ukończeniu studiów uzyskał dyplom magistra w dziedzinie aeronautyki i astronautyki. Jako oficer USAF został przydzielony do pracy w Centralnym Ośrodku Testów Naprowadzania Inercyjnego w Alamogordo w stanie Nowy Meksyk, gdzie jako główny analityk zajmował się systemami naprowadzania bezwładnościowego USAF.

W 1964 roku rozpoczął studia doktoranckie na Stanford University, które ukończył w 1966 roku, uzyskując doktorat w dziedzinie aeronautyki i astronautyki.

Jego kariera zawodowa jako oficera USAF oraz późniejsza jest imponująca. W latach 1966-1968 służył jako instruktor akademicki w Szkole Pilotów Testowych USAF. Był szefem Wydziału Symulacji, jak również głównym instruktorem w klasie astronautów. Większość Jego studentów w następnych latach rozpoczęła służbę w NASA i wchodziła w skład załóg promów kosmicznych.

Po zakończeniu służby w Szkole Pilotów Testowych został przeniesiony do Akademii Sił Powietrznych USA, gdzie jako profesor pełnił służbę na stanowisku zastępcy kierownika Katedry Astronautyki i Informatyki. Równolegle ze służbą w uczelni brał udział w opracowaniu nowej wersji śmigłowca bojowego AC-130, kierując budową innowacyjnego, cyfrowego systemu kierowania ogniem. Po zakończeniu prac uczestniczył w 26 misjach bojowych w Azji Południowo-Wschodniej, za udział w których został uhonorowany wieloma odznaczeniami wojskowymi. Ponadto uzyskane doświadczenia podczas działań bojowych pozwoliły na udoskonalenie systemów kierowania ogniem.

Fot. USAF

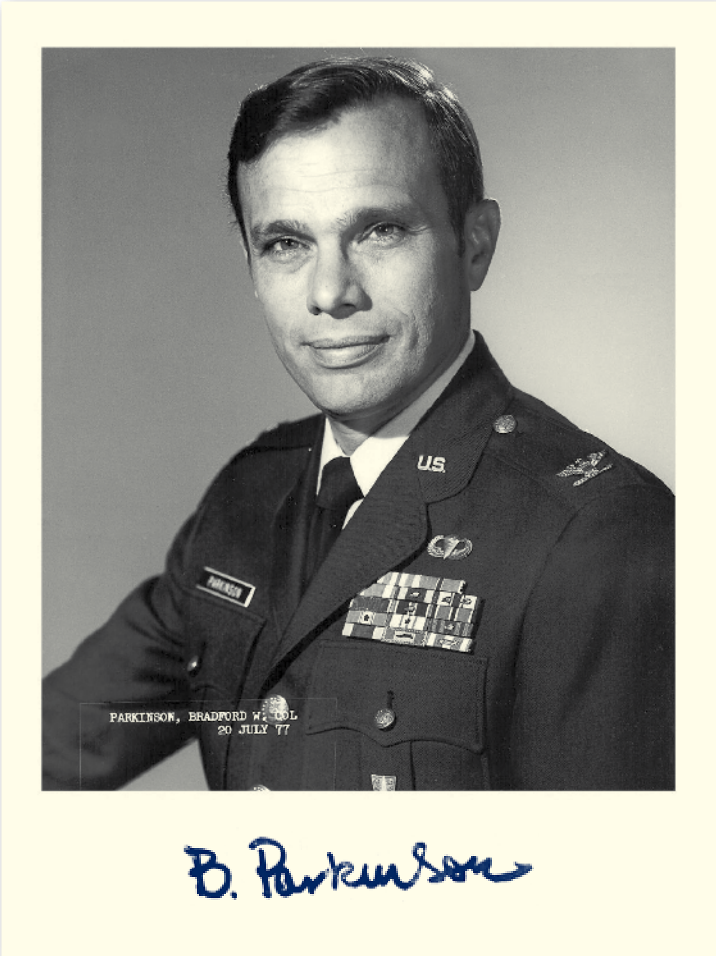
Bradford Parkinson w bazie wojskowej Sił Powietrznych Stanów Zjednoczonych (USAF)

Po zakończeniu służby w Azji Południowo-Wschodniej powrócił do Akademii Wojsk Lotniczych na stanowisko kierownika Katedry Astronautyki i Informatyki.

W 1973 roku rozpoczął prace przy Programie 621B. Pod tym kryptonimem funkcjonował program budowy systemu satelitarnego. Z ogromnym zaangażowaniem zbudował nowy zespół, który stworzył koncepcję systemu satelitarnego dostępnego 24 godziny na dobę przez 365 dni w roku. Kierował tym zespołem w latach 1973-1978.
Zespół stworzył architekturę systemu i doprowadził do jego uruchomienia, a pułkownik Parkinson osobiście był odpowiedziany za uzyskanie zgody, zarówno w Senacie USA, jak i w Dowództwie Sił Powietrznych USA, na jego budowę. Ponadto rozwiązywał problemy badawcze z zakresu:

- modyfikacji sygnału radiowego CDMA,
- dostosowania orbit satelitów w celu zmniejszenia ich liczby na optymalnej wysokości,
- wprowadzenia zegarów atomowych do wyposażenia satelitów.

Fot. USAF



Pułkownik Bradford Parkinson, 20 lipca 1977 r.

W 1978 roku zakończył, w stopniu pułkownika, służbę wojskową, która trwała 26 lat.

Zakończenie służby wojskowej nie przerwało prac nad rozwojem systemu GPS. W 1979 roku pracował jako profesor inżynierii mechanicznej na Colorado State University, a następnie przyjął stanowisko wiceprezesa Space System Group w Rockwell International, gdzie zajmował się planowaniem strategicznym i opracowaniem zaawansowanych systemów kosmicznych. W latach 1980-1984 był wiceprezesem i dyrektorem generalnym w firmie Intermetrics, odpowiedzialnej za stworzenie języka programowania HAL/S, używanego na promach kosmicznych. W 1984 roku objął stanowisko profesora na Stanford University, gdzie objął Katedrę Aeronautyki i Astronautyki im. Edwarda C. Wellsa. Wykładał astrodynamikę i teorię sterowania. W 1999 roku pełnił funkcję dyrektora zarządzającego w firmie Trimble Navigation.

Był jednym z głównych badaczy i kierownikiem programu Gravity Probe B, realizowanego wspólnie przez NASA i Stanford University, którego celem było pierwsze w historii testowanie ogólnej teorii względności Einsteina. Wyniki tych badań zostały opublikowane w latach 2007-2015.

Prof. Bradford Parkinson zasiadał w wielu radach korporacyjnych i rządowych. Od wielu lat jest współprzewodniczącym National Space-Based Positioning Navigation and Timing Advisory Board of GPS, jednego z trzech organów zarządzających systemem GPS, który kreuje kierunki rozwoju systemu GPS, zarządza programami badawczymi i finansowaniem badań. Ponadto przygotowuje niezależne opinie dla Rządu Stanów Zjednoczonych z zakresu swojej odpowiedzialności.

Jak już wspomniałem, gościmy dzisiaj osobę nietuzinkową, która – można śmiało stwierdzić – całe swoje zawodowe życie poświęciła rozwojowi ludzkości. Do najważniejszych osiągnięć Pana Profesora bezwzględnie należy zaliczyć uruchomienie systemu GPS, ale również stworzenie podstaw teoretycznych i budowę systemu Wide Area Augmentation System (WAAS) który jest wykorzystywany przede wszystkim w transporcie lotniczym. Amerykański Satelitarny System Wspomagania GPS zwiększa dokładność wyznaczania pozycji poziomej przez odbiornik GPS do dwóch-trzech metrów. Odbiorniki GPS, wspomagane systemem WAAS, wykorzystują poprawki podczas obliczania swoich pozycji, aby poprawić dokładność wyznaczeń. Pan Profesor jest również autorem innych innowacji z zakresu wykorzystania systemów satelitarnych, np. lądowanie Boeinga 737 „na ślepo" z wykorzystaniem tylko systemu GPS czy też w pełni automatyczna kontrola GPS ciągników rolniczych na nierównym polu z dokładnością do dwóch cali.

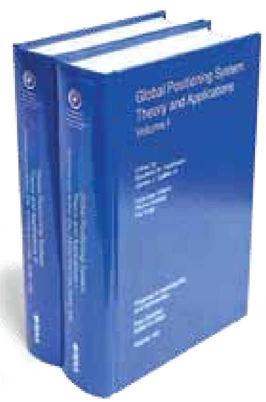
Efekty Jego prac, ich innowacyjność, zostały potwierdzone w latach 1996-2004 uzyskaniem siedmiu patentów.


Fot. Gregg Segal


Fot. https://scpnt.stanford.edu/news/four-pnt-pioneers-awarded-2019-queen-elizabeth-prize-engineering

Bradford Parkinson przyjmuje Nagrodę Królowej Elżbiety z rąk księcia Walii Karola (obecnie króla Karola III), 19 grudnia 2019 roku

Za swoją działalność naukową i zawodową był wielokrotnie nagradzany i wyróżniany. Jedną z najważniejszych nagród, którą dostał bohater dzisiejszej uroczystości, jest Nagroda Królowej Elżbiety dla całego zespołu odpowiedzialnego za architekturę i budowę systemu GPS, wręczona w 2019 roku przez księcia Walii Karola (obecnego króla Karola III). Rok wcześniej otrzymał Medal Honoru IEEE.



W dedykacji, którą napisał mi Pan Profesor w swojej książce pod tytułem „Global Positioning System: Theory and Applications", oprócz wielu miłych słów znalazło się stwierdzenie: „Pioneers are always on top". To Pan Profesor Parkinson jest tym pionierem, który zawsze będzie na topie i zawsze będzie w naszej pamięci. A dowodem tego jest umieszczenie Jego nazwiska na pamiątkowej TABLICY DOKTORÓW HONORIS CAUSA naszej uczelni.

Prof. dr hab. inż. Krzysztof Czaplewski
Uniwersytet Morski w Gdyni

NAGRODY I WYRÓŻNIENIA

- Queen Elizabeth Prize for Engineering (2019)
- Medal of Honor, IEEE (2018)
- Honorary Fellow, AIAA (2017)
- Marconi Award, The Marconi Society (2016)
- Hall of Fame, Engineer's Club of Dayton (2015)
- Honorary Fellow, Royal Institute of Navigation (2014)
- Engineering Hero, Stanford University (2012)
- Necho Award, International Association of Institutes of Navigation (2012)
- The Rheim Technology Prize, Eduard Rheim Institute, Munich (2012)
- Distinguished Graduate, US Naval Academy (2011)
- Pioneer's Award, US Space Command (2009)
- Lloyd Berkner Award, American Astronautical Society (2008)
- Silicon Valley Hall of Fame, Silicon Valley Engineering Council (2007)
- Goddard Astronautics Award, AIAA (2006)
- ASME Gold Medal Award, American Society of Mechanical Engineers (2004)
- Fellow, IEEE (2004)
- Member, National Inventors Hall of Fame (2004)
- Charles Stark Draper Prize, NAE (2003)
- Discover Innovation Award for Communications, Discover Magazine (2002)
- Simon Ramo Award, IEEE (2002)
- Distinguished Public Service Medal, NASA (2001)
- Fellow, The Institute of Navigation (ION) (1999)
- Hall of FAME, NASA (1998)
- Sperry Award, IEEE (1998)
- Magellanic Premium Award, American Philosophical Society (1997)
- Member, International Academy of Astronautics (IAA) (1997)
- Von Karman Lectureship, AIAA (1996)
- Edward C Wells Professor of Aeronautics & Astronautics, Stanford University (1995)
- GPS Hall of Fame Award, NAVSTAR Joint Program Office (1995)
- Pioneer Award, AESS/IEEE (1994)
- Public Service Medal, NASA (1994)
- Johannes Kepler Award, ION (1991)
- Fellow, The Royal Institute of Navigation (1990)
- Fellow, American Institute of Aeronautics & Astronautics (AIAA) (1990)
- Member, National Academy of Engineers (NAE) (1990)
- Burka Award, ION (1987)
- Kirschner Award, IEEE (1986)
- Thurlow Award, ION (1986)
- Engineer of the Year for Silicon Valley, AIAA (1985)
- Gold Medal Award, Royal Inst. of Navigation (1983)
- Legion of Merit, US Air Force (1978)
- Defense Department Superior Performance Award, NAVSTAR (GPS) GPO (1977)
- Bronze Star, US Air Force (1970)
- Presidential Unit Citation, Dept. Of Defense (1970)
- Air Medals (2), US Air Force (1969)
- Member, Sigma Xi (1961)
- Member, Tau Beta Pi (MIT Chapter) (1961)

https://profiles.stanford.edu/bradford-parkinson

UNIWERSYTET MORSKI W GDYNI

SENAT
UNIWERSYTETU MORSKIEGO W GDYNI

PRZY POPARCIU SENATÓW

POLITECHNIKI WARSZAWSKIEJ
AKADEMII MARYNARKI WOJENNEJ W GDYNI
LOTNICZEJ AKADEMII WOJSKOWEJ W DĘBLINIE

NADAJE
UCHWAŁĄ SENATU Nr 223/XVII z dnia 16 listopada 2023 r.

PROFESOROWI DOKTOROWI

Bradfordowi Parkinsonowi

ZASZCZYTNY TYTUŁ
DOKTORA HONORIS CAUSA
UNIWERSYTETU MORSKIEGO W GDYNI

W UZNANIU REWOLUCYJNEGO WKŁADU W ROZWÓJ TECHNIKI ORAZ WSZYSTKICH GAŁĘZI TRANSPORTU JAK RÓWNIEŻ W STWORZENIE PODSTAW DO EPOKOWEJ ZMIANY FUNKCJONOWANIA ŚWIATA I SPOŁECZEŃSTW W XX I XXI WIEKU POPRZEZ KIEROWANIE ZESPOŁEM ODPOWIEDZIALNYM ZA UTWORZENIE PIERWSZEGO SATELITARNEGO SYSTEMU POZYCYJNEGO GPS-NAVSTAR OJCU CHRZESTNEMU SYSTEMU GPS, W 50-TĄ ROCZNICĘ JEGO URUCHOMIENIA

PROMOTOR
Prof. dr hab. inż. Krzysztof Czaplewski

REKTOR
Prof. dr hab. inż. kpt. ż.w. Adam Weintrit

Gdynia, 21 marca 2024 r.

GDYNIA MARITIME UNIVERSITY · GDYNIA MARITIME UNIVERSITY · GDYNIA MARITIME UNIVERSITY · GDYNIA MARITIME UNIVERSITY

THE SENATE OF GDYNIA MARITIME UNIVERSITY

WITH THE SUPPORT OF THE SENATES OF

WARSAW UNIVERSITY OF TECHNOLOGY
POLISH NAVAL ACADEMY
POLISH AIR FORCE UNIVERSITY

BY WAY OF RESOLUTION No. 223/XVII of NOVEMBER 16, 2023
HEREBY CONFERS ON

PROF. DR.

Bradford Parkinson

THE HONORARY TITLE OF

DOCTOR HONORIS CAUSA
OF GDYNIA MARITIME UNIVERSITY

IN RECOGNITION OF HIS REVOLUTIONARY CONTRIBUTION TO THE DEVELOPMENT OF TECHNOLOGY AND ALL MODES OF TRANSPORTATION, AS WELL AS THE CREATION OF THE FOUNDATIONS FOR EPOCHAL CHANGE IN THE FUNCTIONING OF THE WORLD IN THE 20TH AND 21ST CENTURIES BY LEADING THE TEAM RESPONSIBLE FOR THE DEVELOPMENT OF THE FIRST SATELLITE POSITIONING SYSTEM, GPS-NAVSTAR, ON THE 50TH ANNIVERSARY OF ITS LAUNCH

PROMOTER	PRESIDENT
Prof. Dr. Krzysztof Czaplewski	Prof. Dr. Adam Weintrit

March 21, 2024, Gdynia, Poland

UNIWERSYTET MORSKI W GDYNI · UNIWERSYTET MORSKI W GDYNI · UNIWERSYTET MORSKI W GDYNI · UNIWERSYTET MORSKI W GDYNI

NOS SENATUS UNIVERSITATIS MARITIMAE GDINENSIS

CUM FAVORE SENATUUM

POLYTECHNICAE VARSOVIENSIS
ACADEMIAE CLASSIS MILITARIS GDINENSIS
ACADEMIAE AERONAUTICAE MILITARIS DEBLINENSIS

CONTULIMUS
EX DECRETO AMPLISSIMI SENATUS
223/XVII die XVI mensis Novembris anno MMXXIII facto

PROFESSORI DOCTORI

Bradfordio Parkinson

HONORABILEM NOMEN

DOCTORIS HONORIS CAUSA
UNIVERSITATIS MARITIMAE GDINENSIS

PROPTER IMMENSAM CONTRIBUTIONEM IN PROGRESSUM SCIENTIARUM TECHNICARUM ET HORUM OMNIUM QUAE AD VECTURAM PERTINENT ATQUE IN CREATIONEM FUNDAMENTORUM GRAVISSIMARUM IN MUNDO SOCIETATISQUE MUTATIONUM SAECULIS XX ET XXI PER REGIMEN IN COETU QUI CREAVIT PRIMUM SYSTEMA COLLOCANDI GLOBALE QUI SATELLITES ARTIFICIOSOS UTITUR CUI LINGUA ANGLICA NOMEN EST GPS-NAVSTAR PATRINO SYSTEMATIS LINGUA ANGLICA GPS VOCATI, ANNO QUINQUAGESIMO AB EIUS INAUGURATIONE

PROMOTOR RITE CONSTITUTUS	H.T. RECTOR MAGNIFICUS
Prof. Christophorus Czaplewski	Prof. Adamus Weintrit

datum Civitate Gdinensi, die XXI mensis Martii anno MMXXIV

UCHWAŁA NR 223/XVII

SENATU UNIWERSYTETU MORSKIEGO W GDYNI

z dnia 16 listopada 2023 r.

w sprawie nadania prof. Bradfordowi Parkinsonowi tytułu doktora honoris causa Uniwersytetu Morskiego w Gdyni

Na podstawie art. 28 ust. 1 pkt 9 ustawy z dnia 20 lipca 2018 r. – Prawo o szkolnictwie wyższym i nauce (Dz. U. z 2022 r. poz. 574, z późn. zm.) oraz § 14 ust. 1 pkt 8 Statutu Uniwersytetu Morskiego w Gdyni Senat uchwala, co następuje:

§ 1

Senat Uniwersytetu Morskiego w Gdyni, w uznaniu rewolucyjnego wkładu w rozwój techniki oraz wszystkich form transportu jak również stworzenie podstaw do epokowej zmiany funkcjonowania świata i społeczeństw w XX i XXI wieku poprzez kierowanie zespołem odpowiedzialnym za utworzenie pierwszego satelitarnego systemu pozycyjnego GPS-NAVSTAR (*Global Positioning System - NAVigation Signal Timing And Ranging*), nadaje tytuł honorowy doktora honoris causa prof. dr. Bradfordowi Parkinsonowi, ojcu chrzestnemu systemu GPS, w 50-tą rocznicę jego uruchomienia.

§ 2

Uchwała wchodzi w życie z dniem podjęcia.

Przewodniczący Senatu

prof. dr hab. inż. kpt. ż.w. Adam Weintrit

UCHWAŁA NR 23/2023

SENATU AKADEMII MARYNARKI WOJENNEJ

im. Bohaterów Westerplatte

z dnia 29 czerwca 2023 roku

w sprawie: wyrażenia opinii dotyczącej nadania Panu prof. Bradfordowi Parkinsonowi tytułu doktora honoris causa Uniwersytetu Morskiego w Gdyni

Senat Akademii Marynarki Wojennej im. Bohaterów Westerplatte, na wniosek Przewodniczącego Senatu – Rektora Uniwersytetu Morskiego w Gdyni – prof. dr. hab. inż. kpt. ż. w. Adama WEINTRITA z dnia 29 maja 2023 r. w głosowaniu jawnym stwierdza, że:

§ 1

Senat Akademii Marynarki Wojennej im. Bohaterów Westerplatte pozytywnie opiniuje nadanie Panu prof. Bradfordowi Parkinsonowi tytułu doktora honoris causa Uniwersytetu Morskiego w Gdyni przez Senat Uniwersytetu Morskiego w Gdyni.

§ 2

Uchwała wchodzi w życie z dniem podjęcia.

AKADEMIA MARYNARKI WOJENNEJ IM. BOHATERÓW WESTERPLATTE

REKTOR-KOMENDANT
AKADEMII MARYNARKI WOJENNEJ
PRZEWODNICZĄCY SENATU

kontradmirał prof. dr hab. Tomasz SZUBRYCHT

Uzgodniono pod względem formalno-prawnym

Egz. Nr 2

UCHWAŁA Nr 28/2023
SENATU LOTNICZEJ AKADEMII WOJSKOWEJ
z dnia 20 czerwca 2023 r.

w sprawie wyrażenia opinii dotyczącej nadania prof. Bradfordowi Parkinsonowi tytułu doktora honoris causa Uniwersytetu Morskiego w Gdyni

Na wniosek Rektora Uniwersytetu Morskiego w Gdyni prof. dr. hab. inż. kapitana żeglugi wielkiej Adama WEINTRITA z dnia 29 maja 2023 r. w związku z wszczęciem postępowania o nadanie prof. Bradfordowi Parkinsonowi z Stanford University tytułu doktora honoris causa Uniwersytetu Morskiego w Gdyni na podstawie art. 28 ust. 1 pkt. 9 ustawy z dnia 20 lipca 2018 r. Prawo o szkolnictwie wyższym i nauce (Dz. U. 2023 r. poz. 742, ze zm.) oraz po zapoznaniu się z charakterystyką działalności i zasług kandydata na najwyższą godność akademicką uchwala się, co następuje:

§ 1

Senat Lotniczej Akademii Wojskowej wyraża pozytywną opinię w sprawie nadania przez Senat Uniwersytetu Morskiego w Gdyni prof. Bradfordowi Parkinsonowi z Stanford University tytułu doktora honoris causa Uniwersytetu Morskiego w Gdyni.

§ 2

Uchwała wchodzi w życie z dniem podjęcia.

LOTNICZA AKADEMIA WOJSKOWA
m.p.

PRZEWODNICZĄCY SENATU
REKTOR – KOMENDANT

gen. bryg. pil. dr inż. Krzysztof CUR

Uprawnionych do głosowania: - 20
Głosowało w głosowaniu jawnym: - 20
- głosów „za" - 20
- głosów „przeciw" - 0
- „wstrzymało się od głosu" - 0

Wykonano w 2 egz.:
Egz. Nr 1 – aa
Egz. Nr 2 – Rektor Uniwersytetu Morskiego w Gdyni prof. dr hab. inż. kpt. ż. w. Adam WEINTRIT
Wyk. Luiza Bretsznajder, tel. 261-517-252

POLITECHNIKA WARSZAWSKA WARSAW UNIVERSITY OF TECHNOLOGY

Uchwała nr 401/L/2023
Senatu Politechniki Warszawskiej
z dnia 20 września 2023 r.

w sprawie poparcia inicjatywy nadania tytułu doktora honoris causa Panu prof. Bradfordowi Parkinsonowi przez Uniwersytet Morski w Gdyni

Na podstawie § 42 ust. 2 pkt 3 Statutu PW w związku z wystąpieniem Senatu Uniwersytetu Morskiego w Gdyni uchwala się, co następuje:

§ 1

Po zapoznaniu się z dorobkiem naukowym Pana prof. Bradforda Parkinsona, Senat Politechniki Warszawskiej postanawia poprzeć inicjatywę nadania Panu prof. Bradfordowi Parkinsonowi tytułu doktora honoris causa przez Uniwersytet Morski w Gdyni.

§ 2

Uchwała wchodzi w życie z dniem podjęcia.

Sekretarz Senatu
mgr inż. Anna Stoczkiewicz

Rektor
prof. dr hab. inż. Krzysztof Zaremba

Warszawa
dnia 2023 -09- 25
ZA ZGODNOŚĆ Z ORYGINAŁEM

Kierownik Kancelarii Biura Rektora
mgr Helena Lechnio

Prof. dr hab. inż. Jarosław Bosy
Uniwersytet Przyrodniczy we Wrocławiu

OPINIA
w sprawie przyznania prof. Bradfordowi Parkinsonowi tytułu doktora honoris causa Uniwersytetu Morskiego w Gdyni

Prof. Bradford Parkinson jest emerytowanym profesorem Uniwersytetu Stanforda, wybitnym specjalistą w dziedzinie lotnictwa i astronautyki. Był głównym architektem Globalnego Systemu Pozycjonowania Satelitarnego GPS-NAVSTAR (ang. Global Positioning System – Navigation Signal Timing and Ranging), który tworzył jako dyrektor Biura Programowego systemu GPS Sił Powietrznych Stanów Zjednoczonych (USAF).

Prof. Bradford Parkinson urodził się 16 lutego 1935 roku w Madison w stanie Wisconsin, dorastał w Minneapolis w stanie Minnesota, gdzie w 1952 roku ukończył Breck School. Wstąpił do Sił Powietrznych Stanów Zjednoczonych (USAF) w roku 1957 roku, po uzyskaniu tytułu licencjata inżynierii ogólnej w Akademii Marynarki Wojennej Stanów Zjednoczonych. W 1961 roku uzyskał tytuł magistra aeronautyki i astronautyki w Massachusetts Institute of Technology (MIT), a pięć lat później stopień naukowy doktora na Uniwersytecie Stanforda. Po odbyciu misji bojowych w Azji Południowo-Wschodniej i służbie jako instruktor akademicki w Szkole Pilotów Testowych USAF awansował do stopnia pułkownika i szefował Wydziałowi Astronautyki i Informatyki w Akademii USAF.

W 1972 roku pułkownik Parkinson wszedł w skład Space and Missile Systems Organization (SAMSO). Przez krótki czas pełnił funkcję głównego inżyniera w programie Advanced Ballistic Re-Entry Systems (ABRES). Wkrótce po przeniesieniu do programu satelitów nawigacyjnych 621B, w listopadzie 1972 roku, został jego kierownikiem i nadzorował ten program, w ciągu następnego roku już jako program budowy Globalnego Systemu Pozycjonowania Satelitarnego (GPS).

Jako kierownik pierwszego biura programowego odegrał główną rolę w tworzeniu dla Sił Powietrznych, Marynarki Wojennej i Armii USA różnych systemów kosmicznych do precyzyjnego pozycjonowania, nawigacji i pomiaru czasu (ang. PNT – Positioning, Navigation and Timing). W tym okresie był głównym doradcą ds. systemu GPS w Departamencie Obrony USA. Kierował programem GPS aż do przejścia na emeryturę w 1978 roku, był dowódcą startu pierwszego prototypowego satelity GPS z Bloku 1.

Jego działania obejmowały rozwój satelitów, systemu naziemnego i sprzętu użytkownika, a także szeroko zakrojone systemy testowania w celu walidacji dokładności systemu i innych parametrów jakościowych systemu. Za tę pracę pułkownik Parkinson otrzymał nagrodę Departamentu Obrony „Superior Performance Award" jako najlepszy dyrektor programu w USAF w 1977 roku.

Powyższe dokonania uważam za przełomowe, wprowadziły nas bowiem w nową erę funkcjonowania Globalnego Systemu Obserwacji Ziemi, w którym wyznaczanie pozycji na ziemi, wodzie i w powietrzu oparte jest na jednolitym systemie satelitów nawigacyjnych.

Drugi, niezmiernie ważny rozdział życia prof. Parkinsona, rozpoczął się po przejściu na emeryturę wojskową i był związany z aktywnością naukową i biznesową.
Od 1978 roku Profesor pracował jako nauczyciel akademicki na Colorado State University, gdzie prowadził badania i wykładał na kursach dotyczących automatycznego sterowania obiektami. W latach 1979-1980 był wiceprezesem Rockwell International, w latach 1980-1984 – wiceprezesem i dyrektorem generalnym Intermetrics, firmy zajmującej się oprogramowaniem i inżynierią.
Do pracy naukowo-dydaktycznej wrócił w 1984 roku jako profesor na Uniwersytecie Stanforda, a w roku 1995 roku został profesorem aeronautyki i astronautyki.

Kierował projektami badawczymi, w których zrealizowano pionierskie i przełomowe badania dotyczące między innymi: lądowania samolotu tylko z wykorzystaniem systemu GPS, stworzenia prototypu (dla Federalnej Administracji Lotnictwa) powierzchniowego systemu wspomagania nawigacji i pozycjonowania GPS – Wide Area Augmentation System (WAAS) i prototypu systemu precyzyjnego sterowania ciągnikiem rolniczym za pomocą GPS.

Podczas pracy na Uniwersytecie Stanforda odegrał wiodącą rolę jako kierownik, zastępca kierownika i główny badacz w programie NASA Gravity Probe-B, który wykorzystywał orbitujące żyroskopy do testowania ogólnej teorii względności Einsteina.

Ten niezmiernie ważny etap życia zaowocował wieloma publikacjami naukowymi, a przede wszystkim budowaniem aplikacji wykorzystujących system GPS w różnych zastosowaniach, a także badaniami pola grawitacyjnego Ziemi. Działalność prof. Parkinsona w sektorze biznesowym pozwoliła na praktyczne zastosowanie wielu z tych aplikacji, co przyczyniło się do rozpowszechnienia systemu GPS jako wspomagającego wiele dziedzin gospodarki. Bradford Parkinson pełnił m.in. funkcję dyrektora generalnego i prezesa Trimble Navigation, światowego lidera w zakresie tworzenia aplikacji opartych o system GPS, a później GNSS.

W 2001 roku na Uniwersytecie Stanforda Bradford Parkinson uzyskał status emerytowanego profesora i nadal kierował zespołami badawczymi realizującymi projekty badawcze związane z rozwojem systemu GPS.

Lista instytucji, które w latach 90. ubiegłego stulecia i w pierwszej dekadzie XXI w. korzystały z wiedzy i kompetencji prof. Parkinsona jest imponująca: przewodniczył Radzie Doradczej NASA, był członkiem Prezydenckiej Komisji ds. Bezpieczeństwa Lotniczego, przewodniczył

Radzie Nadzorczej Aerospace Corporation i Radzie Doradczej JPL, zajmował różne stanowiska w National Academy of Engineering i był członkiem National Research Council's Precision Time and Interval S&T Study Committee. W 2009 roku nadal pracował w Niezależnym Zespole Walidacji Globalnego Systemu Pozycjonowania (GPS IRT), wypracowującym rekomendacje dotyczące GPS dla Dowództwa Sił Powietrznych.

Prof. Bradford Parkinson stał się mentorem wielu naukowców i inżynierów.
Jego doświadczenie i pozycja zdobyta w międzynarodowej społeczności pozwoliły na dynamiczny rozwój systemów nawigacji satelitarnej i ich praktycznego wykorzystania.
Jest autorem ponad 100 artykułów naukowych na temat GPS i Gravity Probe-B. Na szczególną uwagę zasługuje Jego udział jako współredaktora w opracowaniu fundamentalnej książki „Global Positioning System: Theory and Applications", wydanej jako dwutomowe dzieło przez Amerykański Instytut Aeronautyki i Astronautyki (AIAA) w 1996 roku. Jest to ponadczasowa publikacja, z której wiedzę czerpały, czerpią i będą czerpać tysiące badaczy i użytkowników systemu GPS.
Uhonorowany został kilkudziesięcioma nagrodami i wyróżnieniami – w tym: nagrodą AIAA Goddard Astronautics Award, Nagrodą Lloyda V. Berknera, Amerykańskiego Towarzystwa Astronautycznego, Złotym Medalem Królewskiego Instytutu Nawigacji, medalem NASA Distinguished Public Service Medal, Złotym Medalem Amerykańskiego Stowarzyszenia Inżynierów Mechaników (ASME), prestiżową Nagrodą Charlesa Starka Drapera, której drugim, obok prof. Parkinsona, laureatem w 2003 roku był również dr Ivan Getting. Jest członkiem NASA Hall of Fame i National Inventors Hall of Fame.

Wniosek końcowy

Prof. Bradford Parkinson to autor badań pionierskich i przełomowych, z ogromną skutecznością wprowadzający ich efekty do praktycznych zastosowań, pokazujący, jak wiedza naukowa może pozytywnie oddziaływać na rzeczywistość gospodarczą i społeczną.
Jego zasługi w budowie i rozwoju systemu GPS otworzyły nową perspektywę dla kolejnych pokoleń badaczy i inżynierów i wniosły postęp w życie milionów ludzi na całym świecie.

Biorąc pod uwagę wybitny dorobek naukowy i wdrożeniowy prof. Bradforda Parkinsona oraz Jego ogromne zaangażowanie w działalność instytucji naukowych, gospodarczych, publicznych, poważny wpływ na funkcjonowanie wielu gremiów naukowych i biznesowych całego świata, gorąco popieram wniosek Uniwersytetu Morskiego w Gdyni o nadanie Panu Profesorowi godności doktora honoris causa.

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Uniwersytet Przyrodniczy we Wrocławiu

Prof. dr hab. inż. kpt. ż.w. Zbigniew Burciu
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Wydział Nawigacyjny
Katedra Eksploatacji Statku

Gdynia, 29.10.2023 r.

Opinia w sprawie nadania tytułu doktora honoris causa Uniwersytetu Morskiego w Gdyni profesorowi Bradfordowi Parkinsonowi

Możliwość napisania recenzji dorobku prof. Bradforda Parkinsona w postępowaniu zmierzającym do nadania Mu tytułu doktora honoris causa przez Uniwersytet Morski w Gdyni odbieram jako duże wyróżnienie, a jednocześnie jako ogromne wyzwanie, bowiem prof. Bradford Parkinson wywarł ogromny wpływ na rozwój nauki w obszarze bezpieczeństwa transportu, a Jego prace związane z budową satelitarnych systemów pozycjonowania dają Mu szczególne miejsce wśród naukowców mających wpływ na rozwój światowego transportu morskiego.

W chwili wystrzelenia w 1957 roku pierwszego Sputnika – sztucznego satelity, środowisko światowego lotnictwa oraz wojska stwierdziło, że wykorzystanie satelitów do pozycjonowania obiektów jest możliwe. Pierwsze eksperymenty z wykorzystaniem tej technologii Marynarka Wojenna USA rozpoczęła w 1960 roku, wystrzeliwując satelity Transit.
Wypadki na morzu zawsze były przyczyną wprowadzania zmian w zakresie bezpieczeństwa transportu morskiego. Dotyczyły one m.in. bezpieczeństwa nawigacji oraz konstrukcji, wyposażenia i eksploatacji jednostek pływających.

Pierwszych regulacji dokonano w XIX w. w prawie brytyjskim, czego przykładem jest *Regulation for Preventing Collisions at Sea* z 1863 roku czy wprowadzenie w 1890 roku do *Merchant Shipping Act* obowiązku oznaczenia wolnej burty statków. Pierwszą morską organizacją międzynarodową była, powstała w 1865 roku, „Międzynarodowa Unia Telegraficzna i Organizacja latarni morskiej na Przylądku Spartel"[1]. Zorganizowane działania zmierzające do zmniejszenia ryzyka utraty życia na morzu datują się od czasu katastrofy statku pasażerskiego „Titanic".
Ze względu na międzynarodowy charakter żeglugi morskiej, gdy załoga statku, operatorzy, czarterujący, towarzystwa klasyfikacyjne, ubezpieczyciele i inne strony występujące w handlu morskim przestały być związane z banderą, którą nosi statek, zaistniała potrzeba powołania międzynarodowej organizacji morskiej, która wprowadziłaby jednakowe regulacje prawne związane z bezpieczeństwem w transporcie morskim. Tak powstała Międzynarodowa Organizacja Morska (International Maritime Organization – IMO), której nadrzędnym celem jest tworzenie warunków do wdrażania na całym świecie najwyższych możliwych standardów dla zapewnienia bezpieczeństwa na morzu.

W przeciwieństwie do głównego celu IMO, jakim są działania legislacyjne mające pośredni wpływ na podniesienie poziomu bezpieczeństwa, prof. Bradford Parkinson zajmuje się pracami, które mają bezpośredni wpływ na bezpieczeństwo w transporcie morskim.

Realizował swoją drogę zawodową nie na drodze legislacyjnej, normowania prawa w obszarze transportu morskiego, ale w dziedzinie nauk technicznych, w szczególności w obszarach satelitarnych systemów nawigacyjnych, wyróżniając się nieprzeciętnymi osiągnięciami, a Jego wkład do szeroko rozumianego bezpieczeństwa na morzu jest nie do przecenienia – jest On bowiem głównym architektem systemu GPS.

Prof. Bradford Parkinson jako pułkownik Sił Powietrznych USA był liderem tworzenia Globalnego Systemu Pozycjonowania, narzędzia stosowanego w nawigacji, który nadal jest rozwijany. Można stwierdzić, że Jego osiągnięcia, wykorzystywane w systemach w ponad miliardzie odbiorników GPS, zrewolucjonizowały sposób funkcjonowania transportu morskiego i drogowego.

Pozycje wyznaczone za pomocą systemów satelitarnych umożliwiają bardzo dokładne zlokalizowanie miejsc katastrof na morzu, dokładność pozycji wyznaczonej przez GPS, liczona w centymetrach, umożliwia skrócenie czasu dotarcia na miejsce awarii, wpływa na wielkość obszaru poszukiwania, a tym samym na skrócenie czasu poszukiwania przez ratowników. Zwiększa w ten sposób prawdopodobieństwo uratowania rozbitków na tratwach i w wodzie. Jak sam o sobie mówi: „Od 50 lat jestem rewolucjonistą – bo GPS jest rewolucją i ta rewolucja nadal trwa".

Można zdecydowanie stwierdzić, że prof. Bradford Parkinson swoimi działaniami zrewolucjonizował świat w obszarze pozycjonowania/lokalizacji obiektów, w tym będących w zagrożeniu na morzu, zagrożeniu życia na morzu.

Prof. Bradford Parkinson urodził się 16 lutego 1935 roku, pochodzi ze stanu Wisconsin. Studia ukończył w Naval Academy, następnie pełnił służbę w Marynarce Wojennej i Siłach Powietrznych Stanów Zjednoczonych. Tytuł magistra uzyskał w specjalności Aeronautical and Astronautical Enngineering w Massachusetts Institute of Technology. Był zastępcą kierownika Katedry Astronautyki i Informatyki w US Air Force Academy. W latach 1973-1978 był liderem programu – budowy systemu GPS-NAVSTAR, kierownikiem programu Gravity Probe B. W 1978 roku Bradford Parkinson był szefem przygotowań do startu pierwszego prototypowego satelity GPS.

W ciągu swojej 26-letniej kariery wojskowej służył 21 lat w Siłach Powietrznych, od 1957 do 1978 roku, i pięć lat w Marynarce Wojennej. Odszedł na emeryturę w stopniu pułkownika.

Po odejściu ze służby w Siłach Powietrznych USA w 1978 roku został profesorem inżynierii mechanicznej na Colorado State University w Fort Collins, następnie był wiceprezesem w Space Systems Group firmy Rockwell International (później wchłoniętej przez Boeinga), gdzie zajmował się planowaniem strategicznym i rozwojem zaawansowanych – i tajnych – systemów kosmicznych. W latach 1980-1984 był wiceprezesem i dyrektorem generalnym bostońskiej firmy programistycznej Intermetrics, która była odpowiedzialna za stworzenie obecnie używanego języka programowania HAL/S dla programu promu kosmicznego NASA.

[1] Zob. Iwona Galewska, Znaczenie traktatów wielostronnych w dziejach Europy, Krakowskie Studia Małopolskie 2013, nr 18.

W latach 1984-1999 był profesorem i kierownikiem Katedry Aeronautyki i Astronautyki na Uniwersytecie Stanforda. W 1999 roku został dyrektorem generalnym Trimble Navigation, a od 2001 roku na Uniwersytecie Stanforda ma status Professor Emeritus. Od 2004 roku pełni funkcję pierwszego wiceprzewodniczącego The National Executive Commitee for Space-Based Positioning, Navigation and Timing.

W zakresie wynalazczości prof. Bradford Parkinson jest autorem siedmiu patentów.

Po 13 latach ustąpił ze stanowiska przewodniczącego Rady Doradczej Laboratorium Napędu Odrzutowego (Jet Propulsion Laboratory – JPL) – jednego z centrów badawczych NASA. Stanowisko piastował znacznie dłużej niż trwa zwykła dwuletnia kadencja. Nadal pełni funkcję współprzewodniczącego the National Executive Committee for Space-Based PNT Advisory Board.

Za wyniki w swej bogatej działalności badawczej, m.in. za stworzenie Global Positioning System, otrzymał wiele prestiżowych nagród i wyróżnień od organizacji prywatnych, wojska i organów rządowych, w tym Nagrodę Charlesa Starka Drapera, National lnventors Hall of Fame i IEEE Medal of Honor.

NASA przyznała mu zarówno Public Service Medal w 1994 roku, jak i Distinguished Public Service Medal w roku 2001. W 2016 roku otrzymał Nagrodę Marconiego. Brytyjski Instytut Nawigacji przyznał Mu w 1983 roku Złoty Medal. Został Wybitnym Absolwentem Akademii Marynarki Wojennej Stanów Zjednoczonych w 2011 roku i Bohaterem Inżynierii Uniwersytetu Stanforda w 2012 roku.

W 2019 roku otrzymał Nagrodę Królowej Elżbiety w dziedzinie inżynierii wraz z trzema innymi twórcami GPS: Jamesem Spilkerem, Hugo Freuhaufem i Richardem Schwartzem.

Prof. Bradford Parkinson jest honorowym członkiem Królewskiego Instytutu Nawigacji i AIAA. Jest także członkiem Amerykańskiego Towarzystwa Astronautycznego i Amerykańskiego Instytutu Nawigacji.

Dorobek zawodowy, naukowy, badawczo-rozwojowy Profesora Bradforda Parkinsona jest wybitny i budzi szacunek nie tylko w środowisku naukowym związanym z wykorzystywaniem technologii GPS. Jego dokonania są wykorzystywane na świecie w wielu gałęziach przemysłu, gospodarki, transportu, w tym morskiego. Są to dokonania, które bezpośrednio oddziałują na szeroko rozumiane bezpieczeństwo.

Należy podkreślić ponadprzeciętną aktywność zawodową i naukową Profesora. Prowadzi On wykłady dla studentów, wykazuje aktywność pozanaukową na forum międzynarodowych organizacji i w wielu komitetach. Jest wzorem dla studentów, społeczności akademickiej oraz sfer z obszaru biznesu.

Przedstawiony wyżej dorobek naukowy, osiągnięcia i zasługi godne są najwyższego uznania, dlatego gorąco popieram wniosek o nadanie zaszczytnej godności doktora honoris causa Profesorowi Bradfordowi Parkinsonowi, które będzie również zaszczytem dla społeczności akademickiej naszej uczelni.

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Opinia o dorobku naukowym, osiągnięciach i zasługach Profesora Bradforda Parkinsona, kandydata do tytułu i godności doktora honoris causa Uniwersytetu Morskiego w Gdyni

Mam wielki zaszczyt i honor przedstawić Profesora Bradforda Parkinsona jako twórcę Globalnego Systemu Pozycjonowania (GPS), wybitnego uczonego, twórcę rewolucji technologicznej w zakresie pozycjonowania i satelitarnej nawigacji, a w szczególności człowieka bardzo życzliwego ludziom. Stanowi On wzorzec wskazujący, jak wiele można osiągnąć pracowitością, inicjatywą, systematycznym odważnym działaniem, życzliwością dla kolegów i uczniów, koncentrując się nie tylko na własnych sukcesach, lecz na wspomaganiu rozwoju innych. Te cechy charakteru wraz z niezwykłą pracowitością i gotowością do poświęcenia czasu innym są źródłem pozycji naukowej Profesora.
Życie, twórczość i osiągnięcia tak wybitnej osoby jak Profesor są bardzo bogate i nie sposób poddawać je szczegółowej analizie. Skupię się zatem na tych faktach, które mogą mieć znaczenie w procedurze nadania zaszczytnej godności doktora honoris causa.

Profesor Bradford Parkinson urodził się 16 lutego 1935 roku w Madison, Wisconsin. W czasie studiów w Naval Academy specjalizował się w nawigacji, a po jej ukończeniu w 1957 roku pełnił służbę w Marynarce Wojennej i Siłach Powietrznych USA. Jako instruktor akademicki, a następnie Szef Wydziału Symulacji w Szkole Pilotów Testowych USAF posiada pięcioletnie doświadczenie w inercjalnych systemach naprowadzania i nawigacji. Jako Air Force Officer uzyskał tytuł magistra w specjalności Aeronautical and Astronautical Engineering w Massachusetts Institute of Technology (MIT) oraz współpracował z Draper Lab, pełniąc funkcję analityka inercjalnych naziemnych i kosmicznych systemów nawigacyjnych. W latach 1970-1971 pełnił funkcję zastępcy kierownika Katedry Astronautyki i Informatyki w US Air Force Academy. W latach 1973-1978 był kierownikiem programu 621B – budowy systemu GPS-NAVSTAR, następnie profesorem w Colorado State University oraz wiceprezesem Rockwell International (później Boeing Inc.). Od roku 1984 był profesorem i kierownikiem Katedry Aeronautyki i Astronautyki w Stanford University. W roku 1999 został dyrektorem generalnym Trimble Navigation, a w roku 2001 Stanford University nadał Mu tytuł Profesor Emeritus. Od roku 2004 jest pierwszym wiceprzewodniczącym The National Executive Committee for Space-Based Positioning, Navigation and Timing.

Profesor Bradford Parkinson, często nazywany „Father of GPS", w listopadzie 1972 roku, jako pułkownik Air Force, uzyskał stanowisko kierownika programu w dużym zespole tworzącym system NAVSTAR GPS, gdzie był głównym architektem, adwokatem i programistą tego systemu. Jego główną zasługą jest synteza wcześniejszych trzech programów i koncepcji: systemu wyznaczania orbit opracowanego dla pierwszego satelitarnego systemu nawigacyjnego Transit, technologii zegarów atomowych opracowanej w Naval Research Laboratory oraz struktury cyfrowego sygnału satelitarnego tworzonego w Air Force. Po wykonaniu kilku ulepszeń w tych trzech serwisach opracowano jednolitą koncepcję budowy i działania satelitarnego systemu nawigacyjnego drugiej generacji. Projekt, przewidujący użycie 24 satelitów z 12-godzinnymi wysokimi orbitami, uzyskał akceptację w 1973 roku i został skierowany do realizacji do 1978 roku. Zgodnie z tą koncepcją satelitarny system GPS wyznaczania pozycji, nawigacji i czasu (PNT - Positioning, Navigation and Timing) posiada obecnie konstelację 31 satelitów oraz następujące, genialne dla każdego użytkownika, charakterystyki:

- system GPS jest systemem globalnym działającym w każdej szerokości geograficznej;
- całodobowa jest dostępność systemu – w dzień i w nocy – 24/7/365;
- pozycjonowanie i nawigacja obiektu możliwe są w każdych warunkach atmosferycznych;
- do wyznaczenia pozycji i nawigacji zbędne są naziemne punkty referencyjne i pomoce nawigacyjne;
- jedyny warunek stanowi zapewnienie widoczności radiowej sfery niebieskiej z konstelacją czterech satelitów.

Tak śmiała uniwersalna koncepcja sytemu GPS stanowi prawdziwą światową rewolucję w geodezji, nawigacji lotniczej, morskiej i lądowej, w sterowaniu automatycznych obiektów, a obecnie także w systemach Artificial Intelligence (AI). Beneficjentem systemu jest zatem kilka miliardów użytkowników.

W Polsce pierwsze statyczne pomiary satelitarne GPS, we współpracy z ośrodkami naukowymi z zachodniej Europy i USA, zostały wykonane w latach 1989-1992 na punktach referencyjnych tzw. zerowej sieci satelitarnej EUREF-POL w celu dowiązania podstawowej krajowej sieci geodezyjnej do układu współrzędnych Europy Zachodniej. Dzięki pomiarom satelitarnym Polska dołączyła do zjednoczonej Europy na długo przed przystąpieniem do Unii Europejskiej (2004). W latach 1990-1991 kilka ośrodków naukowych w Polsce zakupiło wysokiej klasy dwuczęstotliwościowe odbiorniki geodezyjne firm Trimble oraz Aschtech, dzięki uzyskaniu zgody Departamentu Stanu USA, gdyż na zakup tego sprzętu obowiązywało w owym czasie embargo.

Rozpoczęto geodezyjne i nawigacyjne badania technik obserwacyjnych – pomiarów statycznych, pseudo-kinematycznych oraz technik różnicowych DGPS, wykonano pomiary testowe, dokonano włączenia technologii GPS do programów studiów, rozpoczęto szkolenia użytkowników i wdrażania systemu do praktyki. Techniki DGPS zostały wdrożone przez urzędy morskie do stworzenia systemu stacji referencyjnych osłony nawigacyjnej Południowego Bałtyku, natomiast uczelnie morskie z sukcesem zastosowały te systemy do nawigacji morskiej, hydrografii i obsługi nawigacyjnej portów. Uczelnie lotnicze prowadziły badania nad satelitarną nawigacją lotniczą w czasie rzeczywistym, projektowaniem planów lotów oraz procedurami startu i lądowania statków powietrznych podczas kontroli ruchu lotniczego.

Pomyślnie rozwijały się metody nawigacji lądowej, w tym tworzenia map w technice cyfrowej mobilnej kartografii i dystrybucji produktów komercyjnych dla tysięcy użytkowników nawigacji samochodowej. Na obszarze kraju utworzono sieci precyzyjnych stacji referencyjnych systemów GNSS (ASG-EUPOS oraz kilka sieci komercyjnych), które umożliwiają wyznaczenie położenia punktów z dokładnością centymetrową oraz precyzyjną nawigację bezzałogowych statków powietrznych (UAV). Precyzyjne multisystemowe odbiorniki GNSS oraz wyrafinowane metody matematycznego opracowania obserwacji satelitów umożliwiają osiągnięcie dokładności milimetrowych wyznaczenia współrzędnych punktów. Techniki satelitarne znalazły zastosowanie w badaniu deformacji poziomych i pionowych skorupy ziemskiej. Przykładem może być wyznaczenie miejsc osiadania terenu na obszarze Starego Miasta w Gdańsku, a także badania deformacji terenu na obszarach górniczych KGHM Polska Miedź oraz na obszarach górniczych Śląska.

Na uwagę zasługują projekty satelitarne zrealizowane na obszarach Trójmiasta: w roku 2000 powstała pilotażowa sieć stacji referencyjnych DGPS w Urzędach Miejskich w Gdyni, w Sopocie i w Gdańsku dla celów pozycjonowania i nawigacji transportu miejskiego, służb obsługi miasta oraz lokalizacji zdarzeń w Centrum Zarządzania Kryzysowego. Uczelnia morska w Gdyni kształci specjalistów z zakresu metod satelitarnego pozycjonowania i nawigacji oraz realizuje wiele projektów naukowych i wdrożeniowych dotyczących nowoczesnych technik GNSS w nawigacji morskiej, hydrografii oraz nawigacji kolejowej i komunikacji miejskiej.

Podsumowując, system GPS i inne satelitarne systemy GNSS mają w Polsce obecnie wielomilionową rzeszę użytkowników, a wszystko to jest możliwe dzięki wynikom pracy Profesora Bradforda Parkinsona, realizacji Jego koncepcji z wielkim sukcesem oraz bezpłatnego udostępnienia w skali światowej systemu GPS.

Profesor Bradford Parkinson ma także olbrzymie zasługi w zakresie organizacji i koordynacji wielu dużych inicjatyw naukowo-badawczych, które stymulowały integrację środowisk naukowych oraz licznych nawigacyjnych działań praktycznych. Ogromne osiągnięcia naukowe, technologiczne, organizacyjne i dydaktyczne Profesora spotkały się z licznymi wyrazami najwyższego uznania w formie światowych prestiżowych nagród, godności, wyróżnień i odznaczeń. Spośród wielu ważnych nagród i wyróżnień, którymi może się szczycić Profesor Bardford Parkinson, wymienić należy: Queen Elizabeth Price (2019), Medal of Honor, IEEE (2018), Marconi Award (2016), Honorary Fellow, Royal Institute of Navigation (2014), Pioneer's Award, US Space Command (2009), Goddard Astronautics Award, AIAA (2006), Charles

Stark Draper Prize, NAE (2003), Distinguished Public Service Medal, NASA (2001), Fellow, The Institute of Navigation (1999), Hall of Fame, NASA (1998), GPS Hall of Fame Award, NAVSTAR Joint Program Office (1995), Johannes Kepler Award (1991), Gold Medal Award, Royal Institute of Navigation (1983), Legion of Merit, US Air Force (1978).

Profesor Bradford Parkinson jest autorem i współautorem wielu publikacji naukowych i książek, z których 84 to publikacje w renomowanych światowych czasopismach naukowych. Jako profesor zatrudniony w kilku uniwersytetach posiada także bogate doświadczenie dydaktyczne.

Wyniki pracy Profesora we wszystkich dziedzinach budzą szacunek i podziw. Jest człowiekiem wiedzy, pasji i talentu. Jest także człowiekiem odważnym, ma bowiem odwagę wybiegać marzeniami w przyszłość i konsekwentnym działaniem wcielać te marzenia w życie.

Profesor Bradford Parkinson w pełni zasługuje na zaszczytny tytuł doktora honoris causa renomowanej uczelni, za jaką uważam Uniwersytet Morski w Gdyni. Uczelni, której misja jest przecież bliska profilowi działalności prowadzonej z wielkim sukcesem przez Profesora.

Wysoka kultura Profesora, Jego humanitaryzm, szerokie spojrzenie na świat i na problemy naukowe, wybitny intelekt i ujmujący sposób bycia to cechy Jego osobowości, które mogą być wzorem dla pracowników naukowych, dla społeczności akademickiej, uczniów i studentów. W każdym kontakcie z Profesorem zauważa się Jego tolerancję i rzetelność w stosunku do sądów i opinii osób trzecich. Podkreślić należy Jego niezwykłą aktywność zawodowo-naukową, która łączy się z Jego znaną na całym świecie aktywnością organizacyjną i dydaktyczną propagującą innowacyjne podejście do satelitarnych technik nawigacyjnych i pomiarowych oraz szerzenie tej wiedzy i kształcenie kadr na całym świecie.

Popieram gorąco wniosek o nadanie tytułu doktora honoris causa Profesorowi Bradfordowi Parkinsonowi i wnoszę o podjęcie przez Senat Uniwersytetu Morskiego w Gdyni uchwały w tej sprawie.

Olsztyn, 28 sierpnia 2023 r.

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