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Von Zuben
Research & Consulting
Limited Company

Consulting Physicist and Navigation Systems Expert

Summary

Independent consultation and research in the following disciplines

- Precise positioning systems, satellite & inertial navigation systems, & precise timing systems
- Electrodynamics, classical dynamics, quantum physics, & the theory of relativity

Education

- Doctor of Philosophy, Physics, 1999
  Texas Christian University, Fort Worth, Texas
  Dissertation: *Quantum Time and Spatial Localization in Relativistic Quantum Mechanics*

- Master of Science, Physics, 1991
  Texas Christian University, Fort Worth, Texas
  Thesis: *Quadrature-Squeezed States of the Electromagnetic Field*

- Bachelor of Arts, 1981
  University of Texas, Austin, Texas
  Major: physics; minor: mathematics

Experience

- Consulting Physicist — Nov 2016 – Present
  Von Zuben Research & Consulting Limited Company

  Physics research; navigation, positioning, & timing systems design & evaluation; scientific & technical writing; software development. Consultant for PoLTE Corporation, developing a radio-navigation Kalman filter using cell-phone signals of opportunity. Consultant for Vortant Technologies, developing an inertial tracking algorithm and software using miniaturized inertial measurement units.

- Adjunct Instructor of Physics — Aug 2018 - Present
  Tarrant County College, Fort Worth, Texas

  Taught college courses in physics and astronomy.

- Senior Staff Electronics Engineer — Oct 2002 – Nov 2016
  Lockheed Martin Aeronautics Company, Fort Worth, Texas

  Principal scientist for design, development, and testing of the Joint Precision Approach and Landing System (JPALS) on the F-35 Joint Strike Fighter. Lead engineer for design and development of the core navigation and timing systems for the F-35. Performed fundamental research in differential satellite and inertial measurement algorithms to support precision approach and landing of aircraft on ships; anti-jamming & anti-spoofing technology; accuracy, integrity, continuity, and availability; algorithm development for a tightly-coupled

navigation system incorporating inertial, satellite, radio-frequency, electro-optical navigation aids, and precise timing. Coordinated with government representatives, Air Force, Navy, and defense contractors. Authored numerous technical papers, presentations, and training courses. Retired in November 2016.

- Product-Lead for Embedded Satellite / Inertial Navigation Systems Jan 1996 – Oct 2002
  Lockheed Martin Aeronautics Company, Fort Worth, Texas

  Lead engineer responsible for the competitive procurement, integration, and testing of Embedded Global Positioning System / Inertial Navigation Systems (EGI) for the F-16 fighter aircraft. Developed algorithms for time synchronization of flight-test range data. Resolved digital sampling problems in the motion compensation data for synthetic aperture radar. Authored trade-studies to assess future navigation requirements in light of emerging communication, navigation, and surveillance technologies and expected international policies. Taught classes on theory and operation of navigation systems.

- Navigation & Guidance Specialist Jul 1987 – Jan 1996
  General Dynamics Corporation (became Lockheed in 1993), Fort Worth, Texas

  Performed development, test, and evaluation of terrain-following radar and associated guidance systems for the F-16 aircraft. Included on-site and laboratory flight-testing, data analysis, and troubleshooting.

- Navigation Technician May 1982 - Aug 1986
  Western Geophysical Corporation, Houston, Texas

  Lead navigation technician performing operation and maintenance of navigation systems for marine seismic surveys. Systems included satellite navigation, radio-navigation, Doppler sonar, gyrocompasses, magnetometers, and gravity meters. Worked on-site in the Gulf of Mexico, Santa Barbara Channel, Bering Sea, North Sea, Irish Sea, and Persian Gulf.

Research Interests

- Information theory in physics and electrical engineering: Information theory has led to several technological advances, from data compression to optimal filtering techniques in Kalman filters. The equations of motion in a Kalman filter closely parallel those of quantum mechanics, and are largely inspired by them. This tends to support an "information only" interpretation of the quantum mechanics, but such a view is difficult to reconcile with experimental tests of the Einstein-Podolsky-Rosen paradox. This area of research attempts to clarify to what extent quantum wave functions represent knowledge of a physical system, and to what extent they may be regarded as real physical fields.

- Precise navigation and timing systems as tests of the theory of relativity: The Navstar Global Positioning System (GPS) was the first practical engineering project in which the theory of relativity (both special and general) needed to be taken account of from the outset. Without relativistic corrections, the system would not work. Follow-on experiments have confirmed the Lenz-Thirring effect, a key prediction of general relativity. This area of research attempts to use known relativistic relations to improve navigation and timing engineering, and to use navigation and timing technology to perform further tests of relativity theory.

- Theories of measurement and their relationship with localization of fields and wave functions: It can be argued that all measurements of physical systems are reducible in some way to measurements of position. The concept of an ideal measurement implies that the

measured system can be strictly localized; however, in relativistic quantum mechanics this assumption leads to the apparent conclusion that particles may travel faster than light (the Hegerfeldt paradox). Assumptions concerning the time at which the measurement occurs may play a role in this apparent paradox. This area of research attempts to clarify concepts of position measurement and theories of measurement in modern physics.

- The algebra of physical space in physics: Many physicists believe a wrong turn was taken in the early twentieth century when vector analysis emerged as the leading geometrical language of physics, relegating Clifford algebra to backwaters. If vectors in three-dimensional space are represented as Pauli spin matrices, for example, rather than the customary column matrices, the fourth dimension (time) emerges automatically in the algebra - and with the correct signature for relativity! Many famous equations in electrodynamics and quantum theory can then be re-expressed rendering geometric relationships, previously hidden in the formalism, explicit. This area of research attempts to shed light on some of the toughest problems in theoretical physics through use of Clifford algebra rather than traditional vector analysis in mathematical physics.

Publications

- Von Zuben, Francis S. G. and Marlow, Chad T., "Navigation Bias Shifts due to GPS Constellation Changes," *Proceedings of the Institute of Navigation 2006 National Technical Meeting* (Monterey, California, 2006).
- Von Zuben, Francis S. G., "Quantum Time and Spatial Localization; An Analysis of the Hegerfeldt Paradox," *Journal of Mathematical Physics,* Vol. 41, September 2000.
- Von Zuben, Francis S. G., David Jr., Alfred S., and Lay, June E., "Time Synchronization in Flight Test Data Analysis," *Proceedings of the International Telemetry Conference*, ITC/USA 2000 (San Diego, October 2000).
- Von Zuben, Francis S. G., "Quantum Time and Spatial Localization," *Proceedings of the IEEE 2000 Position, Location, and Navigation Symposium* (San Diego, March 2000).
- Von Zuben, Francis S. G., *Quantum Time and Spatial Localization in Relativistic Quantum Mechanics* (Ph. D. dissertation, UMI Company, Ann Arbor, Michigan, 1999).

Technical Reports

- Von Zuben, F.S.G. "Algorithm Description Document for the Vortant Technologies Inertial Tracker" (Von Zuben Research & Consulting, Fort Worth, Texas, 2019). This report includes software developed by the author based on the algorithm description document as well as test results using the algorithm.
- Von Zuben, F.S.G., "Algorithm Description Document for the PoLTE Tracker-Solver Kalman Filter" (PoLTE Corporation, Richardson, Texas, 2018).
- Von Zuben, F.S.G., "Guidance Quality and Availability for F-35 Joint Precision Approach and Landing System" (2YZA02640, Lockheed Martin, 2015).
- Von Zuben, F.S.G., "Test Report for the Navigation System Risk Reduction Test Program for the F-35 Joint Strike Fighter at Holloman Air Force Base" (2YZA02429, Lockheed Martin, 2015).
- Von Zuben, F.S.G., editor, "Architectural Description and Performance Analysis for the Joint Strike Fighter Joint Precision Approach and Landing System (Lockheed Martin, 2010)
- Von Zuben, F.S.G., editor: "Joint Strike Fighter Coordinate Systems" (2RZD00020, Lockheed Martin, 2009).
- Von Zuben, F.S.G., editor, "Joint Strike Fighter Coordinate Systems, Derivations" (2RZD00021, Lockheed Martin, 2009).

- Von Zuben, F.S.G., editor, "Joint Strike Fighter Coordinate Systems, Application Specific Representations" (2RZD00022, Lockheed Martin, 2009).
- Von Zuben, F.S.G., "Architectural Description of the F-35 Lightning II Navigation System (Lockheed Martin, 2007).
- Von Zuben, F.S.G., "Back-Up Heading Trade Study and Secondary Flight Reference Display Options for the F-35 Joint Strike Fighter" (J040016, Lockheed Martin, 2004).
- Von Zuben, F.S.G.; Bibb, Gene E.; Smith, Mike S.; Stuteville, Steve L., "F-16 Civil Navigation Interoperability Study" (16PR15906, Lockheed Martin, 2001).
- Von Zuben, F.S.G.; Bibb, Gene E.; Smith, Mike S.; Stuteville, Steve L., "Navigation Warfare Configuration Study for the F-16" (16PR15730, Lockheed Martin, 2001).
- Von Zuben, F.S.G.; Bibb, Gene E.; Stuteville, Steve L., "F-16 GPS Radio-Frequency Interface" (16PR15394, Lockheed Martin, 2000).
- Malaspina, R. E., Von Zuben, F S.G., "Installed Function and Performance of the Embedded GPS / INS on the F-16 Block 25/30/32 Aircraft" (16PR13939, Lockheed Martin, 2000).

Conference Participation

- IEEE Position, Location, & Navigation Conference, Indian Wells, California, 2010.
- Joint Navigation Conference, Orlando, Florida, 2009: presented developmental status of the F-35 Joint Precision Approach and Landing System.
- Navy Air Program Review, Patuxent River Naval Air Base, Maryland, 2008: presented developmental status of the F-35 Joint Precision Approach and Landing System.
- Joint Navigation Conference, Las Vegas, Nevada, 2008: presented developmental status of F-35 navigation system.
- Guidance, Navigation, and Control Conference, San Jose, California, 2007: presented developmental status of F-35 navigation system.
- Institute of Navigation Global Navigation Satellite Systems International Technical Meeting; Fort Worth, Texas, 2006.
- Institute of Navigation, National Technical Meeting; Monterey, California, 2006: presented paper entitled "Navigation Bias Shifts due to GPS Constellation Changes".
- Institute of Navigation Global Navigation Satellite Systems International Technical Meeting; Long Beach, California, 2004.
- Institute of Navigation, National Technical Meeting; Los Angeles, 2003.
- American Physical Society Meeting, Texas Chapter; Fort Worth, Texas, 2001.
- IEEE Position, Location, and Navigation Symposium, San Diego, 2000: presented paper entitled "Quantum Time and Spatial Localization".
- Joint Services Data Exchange for Guidance, Navigation and Control; Norfolk, Va., 1999.
- Texas Christian University Physics Conference, 1999: presented dissertation entitled *Quantum Time and Spatial Localization in Relativistic Quantum Mechanics.*
- Texas Christian University Physics Conference, 1998: presented interim research results on Hegerfeldt paradox.
- Joint Services Data Exchange for Guidance, Navigation and Control; Los Angeles, 1996
- Institute of Navigation, National Technical Meeting; Los Angeles, 1995.
- Texas Christian University Physics Conference, 1992: presented review of current research on Einstein-Podolsky-Rosen paradox .
- American Physical Society Meeting, Texas Chapter, 1991: presented two papers entitled "A Quantum Mechanical Derivation of Caves' Vacuum Hypothesis," and "Particle Versus Wave Interpretation of Homodyne Detection".
- Texas Christian University Physics Conference, 1991: presented master's thesis entitled *Quadrature-Squeezed States of the Electromagnetic Field.*

Awards and Certificates

- SPOT Award, Lockheed Martin, 2015: for resolution of ship-to-aircraft signal interface problems with the F-35 Joint Precision Approach and Landing System
- Peer to Peer Award, Lockheed Martin, 2013: for resolution of boresight and sensor pointing errors on F-35 Joint Strike Fighter
- Special Recognition Award, Lockheed Martin, 2007: for contributions to the F-35 Joint Precision Approach and Landing System
- Certificate of Appreciation, Lockheed Martin, 2004: for contributions to the F-35 Joint Precision Approach and Landing System
- Recognition Award, Lockheed Martin, 2002: for resolving digital sampling problems in the navigation aiding of the Radar for synthetic aperture radar (SAR) mode on the F-16 aircraft
- Recognition Award, Lockheed Martin, 2000: for flight-test activity supporting Navstar Global Positioning System modernization studies for the F-16
- Recognition Award, Lockheed Martin, 1999: for completion of doctoral studies
- Certificate of Appreciation, Lockheed, 1999: for activity supporting procurement of the Embedded Global Positioning System / Inertial Navigation System
- Certificate of Appreciation, 1993: for activity supporting successful demonstration of precision guided munitions
- Completion of Training, Shipley Associates, 1988: technical writing course
- Completion of Training, Western Geophysical, 1982: marine navigation course

Miscellaneous

- Security clearance (secret) until retirement from Lockheed Martin in 2016
- United States citizen
- Member, American Physical Society
- Member, Institute of Navigation
- References available on request