

Stephen B. Heppe, D.Sc.

Professional Summary

Dr. Heppe has 40 years of technical, regulatory, and managerial experience in aerospace, navigation and communications supporting private industry, FAA, DoD, NASA, and other US Government agencies and international clients. He currently operates Telenergy, Inc., an engineering consulting firm specializing in RF terrestrial and satellite communications, absolute and relative positioning, navigation, spectrum management and product integration.

Regulatory experience includes WRC-95 and WRC-97, ITU WP5B, ICAO AMCP and SP COM/OPS/95, and RTCA SC-159, SC-186, SC-203, and SC-223. Specific topics included GPS/GNSS spectrum, MSS feeder link spectrum, Earth Station site coordination, aeronautical communications, and UAV control and communications. Dr. Heppe was a primary author, or participated in, international standards for GPS WAAS/SBAS, LAAS/GBAS, and VHF Data Link Mode 4 (VDL-4). Further details and project experience are provided below.

From 2002 until 2009, Dr. Heppe was Vice President and Chief Scientist for Insitu, Inc., a manufacturer of small robotic aircraft (SeaScan, ScanEagle/Insight, Integrator). His primary areas of responsibility included the aircraft avionics (radios, GPS navigation including absolute and relative positioning for aircraft recovery, satellite communications, and video processing), engineering and flight safety reviews, support for technology roadmap development, management of the Company's portfolio of intellectual property, and spectrum planning.

Prior experience in RF, satellite, and terrestrial communications includes:

- Support for the international development and standardization of a VHF radio communications protocol for aircraft networking and GPS positioning (VDL-4);
- Spectrum engineering and sharing studies for a Big LEO satellite communications system (Globalstar); Gateway siting and coordination; GPS/GNSS interference assessments; MLS/MSS spectrum reallocation studies, and technical support regarding aviation issues;
- Design and engineering support for various space-based Government systems, envisioned and operational, including Defense Satellite Communications System (DSCS), the Strategic Defense System (SDS), Space-Based Radar (SBR), Milstar, NASA's Tracking and Data Relay Satellite System (TDRSS) and its follow-ons;
- Various Naval satellite communications systems and the network for the US Air Force Consolidated Space Operations Center (CSOC).
- Litigation support relating to standards-based cellular communications including GSM, CDMA, UMTS, GPRS, EDGE, USPA, and mobile positioning systems including A-GPS.

Communication Systems. Government/military work includes system design and analysis for multiple MILSATCOM systems including DSCS, Milstar, FLTSATCOM, AFSATCOM, Space-Based Radar, the Strategic Defense System (SDS), UAV C², and non-military systems for NASA (TDRSS/TDAS) and the FAA. Commercial work includes design of a SATCOM system for Saudi Arabia, design of a VSAT network for domestic US customers, support for Globalstar, and analysis of standards-based cellular communication systems for various clients. Dr. Heppe also led the data link engineering effort for the design, development and successful flight testing of a precision approach and landing system relying on DGPS, systems for UAV C², video D/L and recovery, and VDL-4. Dr. Heppe participated in the development of standards for DGPS data link (WAAS and LAAS). Areas of technical expertise include protocol development, multi-access techniques, rain adaptation, fault detection/response, routing and network management.

Specific areas of technical expertise in the area of communications engineering include:

- Spacecraft and space system design including project experience in:
 - Payload design (FAA satcom system design)
 - Spacecraft bus elements (TDAS, Brilliant Pebbles, ISS video-conferencing)
 - Constellation (Navy proliferated satcom, FAA, MILSATCOM architecture)
- Communications analysis over linear and nonlinear channels
 - Militarily significant channels (highly ionized/disturbed/obstructed)
 - Commercial channels (multipath/fading for communications and GPS)
- Anti-jam and low probability of intercept system design (DSCS, Milstar, BP)
- Detailed communications engineering disciplines including:
 - protocol design for RF communications (addressing, control, multiple access)
 - modulation/coding/information theory
 - network analysis and traffic loading studies
 - propagation studies

Experience in the area of communications control includes protocol development for VDL-4 and data links for unmanned aircraft, as well as network design and control segment design for DSCS, Milstar, SBR, the SDS, and commercial SATCOM networks.

Navigation Systems. Dr. Heppe's areas of technical expertise include GPS position and velocity determination for aircraft, spacecraft and ground vehicles, relative positioning and attitude determination for aircraft recovery and antenna pointing, Differential GPS (DGPS) and Automatic Dependent Surveillance (ADS) systems, navigation accuracy determination, temporal and geographic studies of system effectiveness, architectural development, specification development, flight testing of hardware/software systems, and cost/benefit studies for government and commercial customers. Dr. Heppe participated in RTCA Task Force 1, which developed the aviation industry position on appropriate transition planning to a GNSS-based navigation and surveillance architecture. He was the Chairman of RTCA/SC-159 WG6 (Interference issues for GNSS) and teaches courses on GPS and DGPS technology and systems.

Project experience in the area of navigation includes:

- Design, development and successful flight test of a DGPS precision approach and landing system for the US Marine Corps;
- Concept development for GPS-based navigation systems for the International Space Station, the Strategic Defense System (SDS), Space-based Radar (SBR) and commercial ground vehicles;
- Standards development for the DGNSS Instrument Approach System: Special Category I (DIAS:SCAT-I; RTCA/DO-217), and participation in RTCA SC-159 regarding the Wide Area Augmentation System and local augmentations for Category II/III operations;
- Support to the US Navy for the ground-based augmentation system (GBAS) intended to support GPS-based precision approach and landing;
- Support for the international development and standardization of a VHF radio communications protocol for aircraft networking and GPS positioning (VDL-4).

Surveillance Systems. Experience in the area of surveillance includes concept development and engineering analysis of Automatic Dependent Surveillance (ADS) systems for en route and surface applications, and design, development, and implementation of Insitu's UAV-based surveillance systems. Additional experience in the area of surveillance, specifically radar signal processing and direction finding, derives from Dr. Heppe's doctoral research and dissertation entitled "Iteratively Convergent Methods of Signal Characterization Based on Eigenspace Analysis." This work combines the popular MUSIC technique for signal characterization with adaptive beamforming and optimization strategies to simultaneously enhance DF performance for low-level signals, while reducing computational load.

Employment History

From:	1994	Telenergy, Inc
To:	Present	Hood River, OR
	Position:	<i>President</i>
		<p>Dr. Heppe provides consulting services through Telenergy in the area of telecommunications, satcom, national and international regulatory activity and GPS navigation. Project experience includes:</p> <ul style="list-style-type: none"> ▪ Support for development of new standards for command and control of unmanned aircraft in the US National Airspace; ▪ Systems engineering and standards development for a GNSS-based time-synchronized self-organizing TDMA concept for VHF data link communications in support of civil aviation; ▪ Evaluation of GPS-based and GNSS-based navigation performance in an environment containing RF interference;

		<ul style="list-style-type: none"> ▪ Support for the development of new international frequency standards associated with low-Earth orbiting (LEO) Mobile Satellite Service (MSS) systems; ▪ Interference studies between LEO MSS systems and the MLS; ▪ Expert witness support (patent litigation; breach of contract). <p>In the area of international standards development and spectrum coordination, Dr. Heppe was a member of the U.S. delegation to WRC-95, has experience in ITU SG4, WP4A and WP8D, and has participated in ICAO/AMCP, ICAO/GNSSP and the ICAO Special COM/OPS Divisional meeting (1995).</p> <p><i>[Note: Activity in Telenergy was curtailed between 1997 and 2009, while Dr. Heppe served at Insitu, Inc. and ADSI (see below)]</i></p>
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From:	2002	Insitu, Inc.
To:	2009	Bingen, WA
	Position:	<i>Vice President and Chief Scientist</i>
		As VP and Chief Scientist, Dr. Heppe developed concepts for new engineering initiatives, performed design reviews, safety reviews, and incident analyses, handled the corporate technology roadmap, and maintained the company's IP portfolio. Dr. Heppe was responsible for the RF communications and GPS subsystem of the company's small robotic aircraft product line, designing the long-range RF communications system and the relative positioning and navigation system used for precision recovery of the aircraft.

From:	1997	ADSI
To:	2002	Bethesda, MD
	Position:	<i>President</i>
		Dr Heppe was President of ADSI, a start-up company dedicated to air/ground data networking for civil aviation using VDL4. Over a five year period, ADSI was successful in developing flight-qualified hardware and software which resulted in successful flight testing of the radio technology, GPS, and associated networking software. Dr. Heppe's responsibilities included system architecture development, system simulation, international standardization, test planning, technical marketing and investor relations.

From:	1978	Stanford Telecommunications, Inc.
To:	1994	
		<i>1991-1994: Director, FAA Navigation and Landing Systems</i>
		<p>Responsible for business development and engineering management related to the FAA's evolution toward satellite-based navigation systems such as the NAVSTAR/GPS. Supported the FAA and the Volpe National Transportation Systems Center in this broad area through several contract vehicles. Specific tasking included architectural and performance studies of unaugmented GPS as well as local and wide-area Differential GPS (DGPS) alternatives, requirements definition for specific systems, and specification development. Participated in the RTCA's Task Force 1, and was one of the principal authors of the Minimum Aviation System Performance Standard for DGNSS Instrument Approach Systems: Special Category I (MASPS for DIAS: SCAT-I), RTCA/DO-217. Dr. Heppe led a design team focused on the extension of AMSS to Air Traffic Control (ATC) and other flight-critical/high priority services. This 12-month effort, funded by the FAA, developed a full system architecture tailored to future ATC, AAC and AOC communications as well as continued support to Airline Passenger Communications (APC) such as telephony. The study investigated alternative satellite constellations from LEO to GEO, alternative modulation techniques for air/ground connectivity, control strategies, satellite payload design tradeoffs, avionics design and ground earth station design, management requirements and redundancy/sparing strategies. User avionics included both low-cost omni-directional equipment sets for General Aviation as well as high-performance steerable units for air carrier/air taxi. Cost estimates for the overall system, as well as required user charges, were based on assessment of the spacecraft payload and bus design, launch alternatives, ground segment architecture, non-recurring expenses, program management and replenishment costs, and reasonable investment recovery strategies. The study supports FAA policy and decision-making as the NAS transitions from a predominantly ground-based architecture to one that relies more heavily on satellite technology for CNS.</p>
		<i>1985-1991: Director, DoD SATCOM Systems Engineering</i>

		Provided management and technical direction of systems engineering activity related to military satellite communications systems (DSCS, Milstar and other MILSATCOM systems), space-based defense systems such as SDS and Space Based Radar (SBR), and space-based navigation systems (e.g., GPS, and augmentations of GPS required for civil aviation). Customers included the U.S. Air Force, SDIO, Martin Marietta and Lockheed. Architectural studies of intersatellite and space/ground communications alternatives for highly proliferated satellite constellations; communications systems design effort for the "Brilliant Pebbles" and their earth stations.
		<i>1978-1985: Principal Engineer/Manager and Prior Positions</i>
		Supported a multitude of satellite communications and navigation projects including: <ul style="list-style-type: none"> ▪ BCAS (a forerunner of the TCAS collision avoidance system) ▪ DSCS, Milstar, TDRSS, ATDRSS and GPS ▪ Prototype/flight test of a precision landing system

From:	1977	General Electric Space Division
To:	1978	Valley Forge, PA
		Projects included the Defense Satellite Communications Program, LANDSAT D and NIMBUS G (a weather satellite).

Education

<u>Year</u>	<u>College/University</u>	<u>Degree</u>
1989	George Washington University	D.Sc., EE/Communications
1982	George Washington University	MS, EE/Communications
1977	Princeton University	BSEE, CS

Professional Associations

- Member, IEEE
- Member, ION
- Member, RTCA
- Member, Technical Board of Navtech Seminars, for DGPS and Communication Links

Patents

Patent Number	Year	Title
4,654,854	1987	Method And Apparatus For Decoding Threshold-Decodable Forward-Error Correcting Codes
6,477,359	2002	Diversity Reception For Aeronautical Packet Data Communications Systems
6,873,288	2005	Enhanced GNSS Receiver
Bahamas 1318	2003	End-to-End Aeronautical Data Network Architecture and Method and Apparatus for Transitioning Thereto
Bahamas 1319	2003	Antenna Technology For Enhanced And Cost-Efficient Operation Of Multiple Avionics Systems
6,961,018	2005	Method And Apparatus For Satellite-Based Relative Positioning Of Moving Platforms
7,185,261	2007	Multidimensional Turbo Product Code Decoding Of Encoded Data Transmitted Over Diversity Channel
7,798,045	2010	Systems And Methods For Recovering And Controlling Post-Recovery Motion Of Unmanned Aircraft
8,140,200	2012	Turret Assemblies For Small Aerial Platforms, Including Unmanned Aircraft, And Associated Methods
8,668,161	2014	Systems and Methods for Long Endurance Stratospheric Operations
8,678,309	2014	Lifting Gas Replenishment in a Tethered Airship System
8,864,063	2014	Tethered Airships
9,139,279	2015	Systems and Methods for Long Endurance Airship Operations
9,216,806	2015	Durable Airship Hull and In Situ Airship Hull Repair
9,266,596	2016	Additional Systems and Methods for Long Endurance Airship Operations Using a Free-Flying Tethered Airship System
9,522,733	2016	Airship Launch from a Cargo Airship
9,611,025	2017	Additional Systems and Methods for Long Endurance Airship Operations Using a Free-Flying Tethered Airship System
9,623,949	2017	Systems and Methods for Long Endurance Airship Operations
9,639,841	2017	Promoting Learned Discourse in Online Media
9,669,917	2017	Airship Launch from a Cargo Airship
EP2897860 B1	2017	Systems and Methods for Long Endurance Airship Operations
10,450,047	2019	Durable Airship Hull and In Situ Airship Hull Repair
10,457,394	2019	Airship Launch From a Cargo Airship
10,494,075	2019	Systems and Methods for Long Endurance Airship Operations

Publications

"Improved Method and Apparatus for Decoding Threshold-Decodable Forward-Error-Correcting Codes" (patent). Describes an improved decoder for a certain class of error correcting codes used on digital channels.

"Viewpoints on Control of Military Satellite Communications," IEEE Communications magazine, July 1983 (describes current and future adaptive control systems for MILSATCOM).

"Iteratively Convergent Methods of Signal Characterization Based on Eigenspace Analysis," (Ph.D. Dissertation).

"RF Waveform Synthesis for the SDS," Dr. Stephen Heppe and Mr. John Farserotu, Milcom '90.

"Waveform Design for SDS Ground-based Interceptors," Dr. Stephen Heppe and Mr. Laurence Mailaender, Milcom '90.

"Cost Minimization in Large Nonhomogeneous Space Communications Networks," Milcom '91.

"Issues for GNSS-Based Precision Approach," 48th Annual Meeting of the ION, June 29, 1992.

"Flying the Tunnel -- System Engineering Tradeoffs Among Accuracy, Availability, Continuity and Integrity for Category I Precision Approach," Mr. Bruce DeCleene and Dr. Stephen Heppe, 1994 National Technical Meeting of the ION, January 23-26, 1994.

"A Systems Engineering Approach to Resolving GNSS Interference," co-authored with Gregory Joyner, Robert Frazier, Nelson Keeler, Woody Phlong, Ed Sayadian and Michael Geyer, presented at the International Symposium on Precision Approach and Automatic Landing (German Institute of Navigation), February 21, 1995.

"Radio Frequency Interference to GNSS: Status, Concerns and Issues," co-authored with Keith McDonald, presented at GNSS '97, Munich, Germany, 21-25 April, 1997.

ASTA Architectural Alternatives Comparative Assessment, prepared under contract to Federal Systems Integration and Management Center, 1993. (Dr. Heppe was team lead and lead author).

MSS Study Final Report, prepared under contract to Federal Systems Integration and Management Center, April 1994. (Dr. Heppe was team leader and lead author).

Evaluation of Swedish GP&C System for ASTA Data Link, prepared under contract to Federal Systems Integration and Management Center, 1994. (Dr. Heppe was team lead and lead author).

Assessment of Radio Frequency Interference Relevant To The GNSS, RTCA/DO-235, 1997. (Dr. Heppe was subcommittee chairman and a significant contributor).

"The Problem of UAV Communications", book chapter appearing in Handbook of Unmanned Aerial Vehicles, ed. by K. Valavanis & G. Vachtsevanas, Springer Books, 2014.

Short Courses Related To Radio Communications and GPS (Prepared by Dr. Hepe and Offered Through Navtech Seminars and GPS Supply)

- GPS/GNSS Operation for Engineers and Technical Professionals
- Differential GPS Data Links, Technology, Applications and Use
- Mobile Wireless Communication Systems Integrated With GPS
- Radio Frequency Interference and Jamming Concerns
- Communications Theory Basis of GPS and DGPS
- GPS Operation for Engineers
- GPS Basics for Sales Staff