

AVIONIC SYSTEMS

OPERATION & MAINTENANCE



JAMES W. WASSON

JEPPESEN.
Sanderson Training Products

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About the Author

James W. Wasson was born December 9, 1951 in Pittsburgh, Pennsylvania. He is the son of Dolores H. Wuerl and George F. Wasson, a Mechanical Engineer by trade and retired executive from U.S. Steel Corporation, and has two brothers, Daniel, a Computer Programmer, and Gerard, an Attorney.

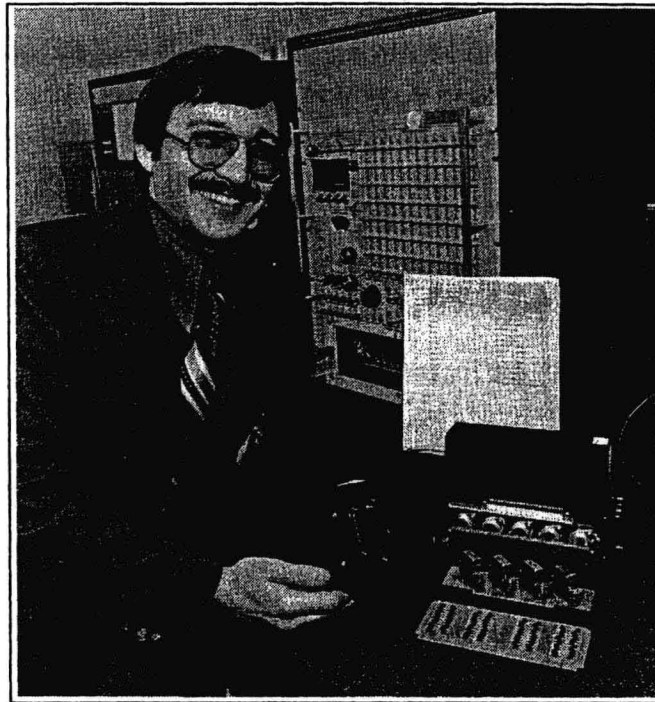
Mr. Wasson first became interested in electronics while in grade school. It was then that he learned on his own how to design and build power supplies and audio systems. It was during high school that he took electronic courses at the University of Pittsburgh, worked as a retail salesman and technician at Olson Electronics and Radio Shack, and earned his Federal Communications Commission (FCC) Commercial Radio-Telephone and Amateur Radio licenses. As a Ham Radio Operator, he organized the South Hills Catholic High School Amateur Radio Club and often designed and built his own telecommunications equipment.

Following high school, Jim Wasson attended Pittsburgh Institute of Aeronautics and earned an Associate in Specialized Technology (AST) degree and a Federal Aviation Administration (FAA) Airframe and Powerplant (A&P) Mechanics license. Following his graduation in November 1972, Mr. Wasson landed a job with Antilles Air Boats, a seaplane airline in the U.S. Virgin Islands, as an A&P mechanic. Shortly after hiring in, Jim realized that there was an acute shortage of qualified aircraft electronics (avionics) technicians. In fact, based on his previous experience as a Ham Radio Operator, he was the only employee at Antilles that knew how to troubleshoot and repair aircraft radio systems. It was at this point that he decided to pursue a career in avionics.

Naturally, Jim's first thought was to have a formal education in avionic systems operation and maintenance. Hence, he enrolled in the twelve-week avionics curriculum at Northrop Institute of Technology in Los Angeles, California. It was at this time, he also took private pilot ground school and flight school training at Long Beach Community College and at Hawthorne Airport, respectively.

Jim stayed at Northrop University and graduated Magna Cum Laude in June 1981 with a Bachelor of Science degree in Engineering Technology (BSET). While attending Northrop, now Rice Aviation School, he was employed full-time at Catalina Airlines, K.C. Aircraft, Great Western Aircraft Radio, and finally Garrett AiResearch Aviation as an avionics technician. In 1978, he was promoted to the position of Avionics Design Engineer at Garrett, where he was responsible for the design, development, integration, and flight test of avionic systems on the Lockheed Jetstar and Hawker-Siddeley HS-125 corporate jet aircraft retrofit programs. He also designed and developed production avionics equipment, such as the Garrett AiResearch Model 149 Annunciator Coupler Unit, which provided signal conversion and lamp driver dimming and test functions for the navigation/flight director annunciator panel.

During 1980, Jim was President of the Xi Beta Chapter of Tau Alpha Pi, the National Engineering Technology Honor Society, and was named "Student Engineer of the Year" at Northrop University. In 1981, he was honored at Pittsburgh Institute of Aeronautics (PIA) with the "Distinguished Alumnus Award" and was named advisor to the President of PIA. Also in 1981, he was asked to join the Northrop University Industry Advisory Committee to develop a one-year avionics technician curriculum, which is the genesis of this book.



***Jim Wasson Displaying His Annunciator Coupler
Unit Design. (Courtesy Allied Signal Aerospace Company, 1980)***

In April of 1981, Mr. Wasson accepted a position with Northrop Aircraft Division as Senior Technical Specialist, in which he was responsible for leading a team of engineers and scientists in the design and development of military avionics systems for the U.S. Air Force's Advanced Tactical Fighter YF-23, the U.S. Navy's F/A-18 fighter/attack aircraft, and the export F-20 fighter. In January 1984, Jim accepted a position as Senior Program Manager for Advanced Avionics Systems at McDonnell Douglas Corporation, the world's largest military aerospace contractor, where he is currently employed managing multi-million dollar avionics research and development programs.

Jim attended the University of Phoenix in Arizona and earned a Master of Business Administration (MBA) degree in March of 1989. He was the first to receive a Business Research Award for his Master's Thesis entitled "Business Opportunities in Artificial Intelligence." (Artificial Intelligence is an advanced method of computer programming whereby a computer can "reason" based on a knowledge base built from subject matter expertise and a network of rules.)

Mr. Wasson is currently an Adjunct Professor of Business Management at the University of Phoenix and serves on the Board of Directors of two corporations. He was co-founder of Avionics Engineering Services, Inc. and Leading Edge Technologies, Inc., a producer of innovative consumer electronic systems. He served as National Chairman of the American Helicopter Society Avionics Committee, and was Senior Vice President of the Arizona Chapter of the Army Aviation Association of America. Jim is also a member of the Association for Avionics Education, the National Society of Professional Engineers, the American Defense Preparedness Association, and the Institute of Electrical and Electronic Engineers. He has authored numerous technical papers and appears in Who's Who in America and the International Who's Who. In May of 1991, he was inducted into the Career Colleges Association Hall of Fame.

Jim is married to Evelyn Fay Gonzales from Kauai, Hawaii. The Wassons reside in Mesa, Arizona with their sons, Robert and Brian, and spend their summer weekends at their ranch resort in the beautiful White Mountains of Northeastern Arizona.

Preface

In the past decade, new developments in electronics and computer technology have revolutionized the aircraft electronics (avionics) industry. Applications of high-speed microprocessors, large memories, and data distribution networks have caused a transformation from conventional analog communication, navigation, radar, and flight control systems to digital avionic systems that are less costly, smaller in size and weight, consume less power, and are more reliable and easier to maintain than their predecessors.

For example, the highly advanced, avionic system architectures currently being employed on our modern military fighter aircraft, such as the F/A-18 and F-16, use high-speed, digital computers that form a distributed data processing network. Within this network, the various avionic subsystems communicate with the central computer via messages sent on a multiplex digital data bus. In place of electromechanical instrumentation, cathode-ray tube (CRT) displays are used to present the pilot with a multitude of navigational, flight management, and weapon system information.

Civil aircraft are also integrating their avionic systems into a distributed processing network as seen in the new generation of commercial airliners, such as the McDonnell Douglas MD-11 and the Boeing 757/767. One of the significant achievements in digital avionic system integration is the flight management system, which stores flight plans, indicates flight progress, issues control steering commands to the flight director and autopilot, and monitors the aircraft performance for optimum safety and efficiency throughout the entire regime of the flight.

The flight deck of the McDonnell Douglas MD-11, shown on the front cover (courtesy Honeywell Commercial Flight Systems), has two Control Display Units (CDUs), located on the center console, which are actually computer terminals used to enter and receive data to and from the flight management computer. Video CRT screens on the CDUs display flight performance alphanumerically, while the Electronic Flight Instrumentation System (EFIS) projects a color graphic presentation of flight information as shown in Figure P-1. Even the conventional electromechanical engine instruments have been replaced with color CRT displays to bring a new level of cockpit sophistication to help ease the crew workload.



Figure P-1. Rockwell Collins Proline 4 Primary Flight Display.
(Courtesy Rockwell Collins Avionics)

With these advances in electronics technology, a resultant reduction in ownership cost has allowed modern private jet aircraft to also use integrated digital avionic systems. Most of these aircraft are installing EFIS, while some have elected to use the digital color weather radar indicator as a multifunction display (MFD) to present a variety of navigation operational/emergency checklist, and diagnostic formats, in addition to weather/turbulence avoidance and ground mapping functions.

The Beechcraft Starship is a typical example of a long-range corporate aircraft incorporating a modern avionics suite. As shown in Figure P-2, the crewstation of the Starship has one MFD located on the top center instrument panel for the display of the Engine Indication and Crew Alerting System (EICAS), which centralizes and prioritizes engine and caution status.

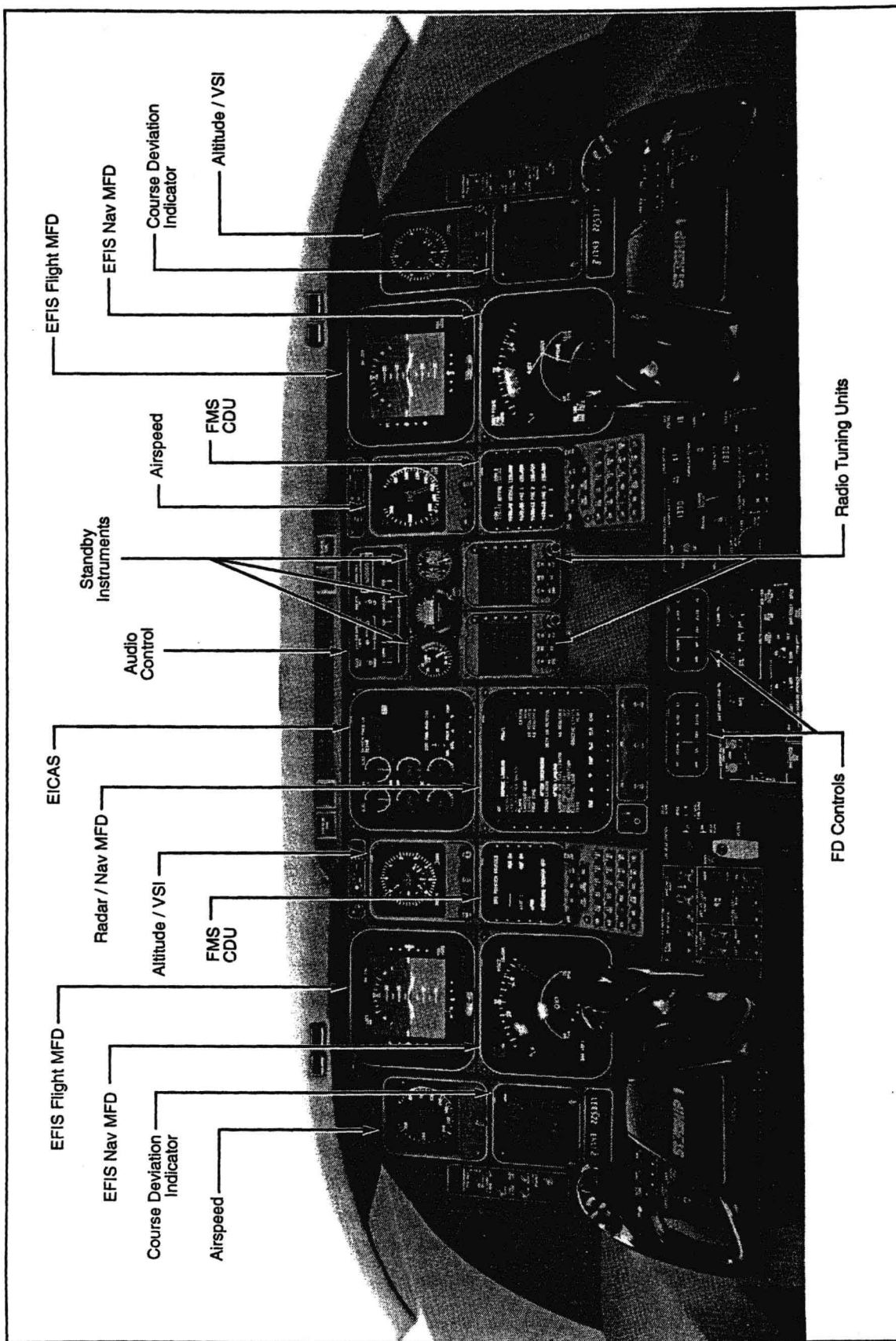


Figure P-2. Beechcraft Starship Crew Station.

Directly below the EICAS display is another color multifunction display used primarily for presenting flight management, navigation and radar information. To the left of this display is a CDU, for programming the flight management system and to control the communication and navigational functions of the avionic system. The Starship's avionic system also includes a flight director (FD) system to present the pilot and/or copilot with computer-generated steering commands on the EFIS MFDs. The pilot may elect to couple these steering commands to an autopilot system, whereby, a command signal from the flight control computer drives servo motors to cause the proper control surface deflection on the aircraft.

Advances in the application of solid-state digital electronics are providing solutions to the ever increasing problems of navigation and air traffic control as available airspace around terminal areas is limited due to the increase in air traffic. Newly developed avionic systems, such as the Terminal Collision Avoidance System (TCAS), Windshear Detection System, and Global Positioning System (GPS) are just being introduced. These sophisticated and highly advanced avionic systems provide much greater efficiency and safety in aircraft operation. However, the continued reliability and performance of avionic equipment and their associated systems depend entirely on the skills of the highly-trained professional, the avionics technician.

In the following chapters, we will explore the entire spectrum of avionic equipment and systems from the simple magnetic compass to the most advanced integrated flight management systems found on modern jet aircraft. Each chapter attempts to illustrate the functional operation of systems developed in the past 10 to 15 years that the avionics technician will most likely encounter, along with discussions concerning the operation of more recently developed microprocessor-based hybrid systems which the student will encounter in increasing numbers in the future as they replace transistorized systems of the past. The basic concepts of communication, navigation, radar and flight instrumentation will be presented, followed by a detailed technical discussion of prevalent systems that are currently being employed in private, corporate and commercial aircraft. Finally, we will study the techniques of avionic systems operation and maintenance including the methodology of avionic systems operational analysis and performance validation. The basic avionic systems found in all aircraft are discussed in the context of circuit theory, while the more complex integrated systems (found in larger jet transport aircraft) are discussed more in terms of systems operation, since the latter is typically a matter of knowing which black box to return to the manufacturer for repair and recertification. The contents of this text assume the student has a thorough understanding of basic electronic theory.

We begin our discussion with a review of aircraft electrical systems in Chapter One. Chapter Two will cover radio communication theory as a primer for more detailed technical discussions of receivers, transmitters, and audio systems used in aircraft. The VHF Communications Transceiver is heavily relied upon, and is required by Federal Air Regulations (FARs) for any aircraft that passes through an airport's controlled airspace. HF Communication Systems, required for transoceanic flights, will also be discussed.

The next four chapters deal with various types of navigation equipment, which is used for determining the aircraft's location and for plotting a course to a desired destination. Automatic Direction Finders (ADF) are installed in aircraft to aid in flying in and out of small airports not equipped with VHF Omnidirectional Range (VOR) stations. VOR Navigation Receivers allow aircraft to fly any desired course radial to or from a VOR ground station. ADF and VOR systems are discussed in Chapters Three and Four, respectively.

Instrument Landing Systems (ILS), presented in Chapter Five, are used for take-offs and landings from larger airports, even in near zero visibility. The ILS consists of a Localizer (LOC), which provides an indication of whether the aircraft is left or right of the runway; a Glideslope (GS), which provides an indication of the desired angle of descent; and a Marker Beacon (MB), which marks the distance from the runway along the glidepath at two or three distinct intervals.

Chapter Six contains a discussion of Distance Measuring Equipment (DME), which provides the pilot with an indication of the distance to or from a ground station. DMEs are required in aircraft with gross weight of 10,000 pounds or more. Also in compliance with the FARs, aircraft flying through Terminal Control Areas (TCA) must be equipped with a Radio Beacon Transponder. The Transponder, discussed in Chapter Seven, assists the Air Traffic Controller in identifying aircraft within the TCA on his/her radar screen.

Weather is a threat to any aircraft flying any appreciable distance. Smaller planes rely on tuning in the Air Terminal Information Service (ATIS) on the VHF Communications Receiver to hear local weather advisories. Larger aircraft have onboard Weather Radar Systems to allow the pilot to reroute his or her flight path around storm activity. Weather Radar Systems are discussed in Chapter Eight.

Chapter Nine presents a different kind of onboard radar, the radio altimeter, which is used to measure the actual distance the aircraft is from the terrain when flying at low altitudes. The radio altimeter is much more accurate than the barometric altimeter, which measures height above sea level at a given barometric pressure.

This leads into a discussion on Flight Instrumentation. Chapter Ten describes pitot-static systems, which drive basic pneumatic instruments, such as the airspeed indicator and the altimeter. It also covers air data computers, which convert air pressure from the pitot-static system to electrical signals to drive a variety of instruments in larger aircraft. Altimeters, airspeed indicators, machmeters, vertical speed indicators, and other instruments will be examined in detail in this chapter.

This book concludes with an introduction to some of the more sophisticated avionic systems found primarily in larger transport and business jet aircraft. Chapter Twelve, titled Flight Management and Display/Control Systems, also discusses EFIS. However, to fully understand Flight Management Systems (FMS), one must be familiar with the principles of operation of Inertial Navigation Systems (INS) and other long-range navigation systems. These systems will be discussed in the context of FMS operation in Chapter Eleven.

The author wishes to thank Allied-Signal Aerospace Company, Baker Electronics, Boeing Commercial Aircraft Company, the Federal Aviation Administration, Honeywell Commercial Flight Systems Group, ITT Avionics, Kollsman Division of Sequa Corporation, Litton Aero Products, Magnavox, McDonnell Douglas Aerospace Corporation, Rockwell Collins Avionics, and S-TEC Corporation for their contributions toward making possible the publication of this book. We sincerely hope that those who study the following pages will become proficient in the techniques of avionics systems operation and maintenance and will join us in promoting safer and more efficient air travel.

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