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INTEGRATION OF DEVELOPING TECHNOLOGIES INTO FLIGHT INSPECTION AIRCRAFT

ABSTRACT

The Office of Aviation System Standards (AVN) maintains and operates a fleet of aircraft which are used to flight inspect navigational aids and validate approach procedures. The aircraft are maintained in accordance with an FAA approved General Maintenance Manual (GMM) and operated in accordance with Federal Aviation Regulation (FAR) Part 135. As new navigation technologies are developed and implemented into the U.S. National Airways System (NAS), many unique and challenging aircraft integration issues arise. To meet these challenges, AVN maintains a Part 145 Repair Station certificate and a Designated Alteration Station (DAS) certificate in accordance with FAR Part 21. The DAS is composed of Engineering, Quality Assurance, and flight test pilots. Their prime responsibility is to provide AVN flight inspection pilots and technicians with an airborne platform for evaluating signals in space and approving procedures.

This paper will discuss recent and expected integration issues on AVN flight inspection aircraft. The developing technologies to be integrated are augmented Global Positioning System (GPS), both space and ground based, area navigation (RNAV), and Vertical Navigation (VNAV). Top-level block diagrams will show connectivity of Wide Area Augmentation System (WAAS) and Local Area Augmentation System (LAAS) sensors, the Automatic Flight Inspection System (AFIS), and cockpit avionics systems. Many times AVN is expected to flight inspect procedures that require installation of avionics equipment before off-the-shelf equipment is available and before a Technical Standard Order (TSO) is issued. This often requires an aircraft with the latest avionics that may be difficult to certify for operating in a Part 135 environment. FAA Advisory Circulars (AC) and other guidance material are often in draft form only.

INTRODUCTION

Flight inspection requires three essential components: aircraft with flight crews, procedures or navigation aid requiring validation, and a flight inspection system. With each component comes its own particular set of issues. Flight crews must be trained and current in the airframe. The airborne platform must be certificated, maintained, and operated. The flight inspection system consists of complex avionics equipment and software. Before a procedure can be flight inspected, flight inspection criteria must be developed and implemented. The procedure development will only be briefly discussed in this paper. The main focus will be on the airborne platform, the flight inspection system and incorporating developing technologies. For purposes of this paper "developing technologies" shall refer to aspects of GPS, differential GPS (DGPS), area navigation (RNAV), and vertical navigation.

BACKGROUND

AVN began flight checking GPS non-precision approach (NPA) procedures in the mid nineties on the Beech–300 aircraft (no vertical flight paths were defined for these approaches). The GPS equipment AVN installed complied with TSO C-129A Class A1.[1] "A" indicating the GPS sensor and navigator are contained in the same enclosure and "1" indicating approval for en route, terminal, and non-precision approach. TSO C-129A referenced the GPS Minimum Operational Performance Standards (MOPS)[2] but allowed significant exceptions. Visual Flight Rule (VFR) airworthiness approval was granted based on FAA AC 20-138[3] criteria (reference figure 1). Complete Instrument Flight Rule (IFR) approval was not granted due to Electronic Flight Instrument System (EFIS) annunciation issues. Considerable AVN resources were expended to modify the EFIS to gain full IFR approval.

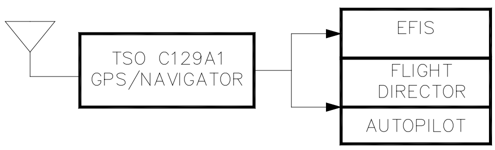

Figure 1. AC 20-138 GPS

Figure 2 shows the Beech instrument panel. Notice how densely packed the center panel is with the weather radar, Loran, GPS, and the pilots flight inspection control and display unit (CDU).

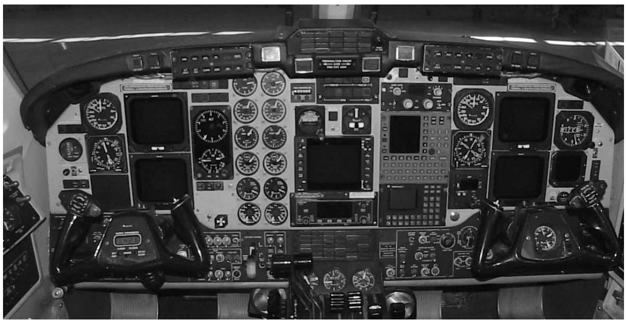

Figure 2. Beech-300 Instrument Panel

Throughout the late nineties AVN took delivery of six Lear 60s and three Challenger 601s. These aircraft were equipped with TSO C-129A Class B1/C1[1] GPS receivers. “B” indicating a GPS sensor only, “C” indicating the sensor transmits data to a navigation system providing guidance to an autopilot or flight director, and “1” indicating approval for en route, terminal and non-precision approach. The navigation system consists of a Flight Management System (FMS) with multiple sensor inputs (e.g. GPS, Distance Measuring Equipment (DME), Air Data Computer (ADC), inertial, etc.). Refer to the “References” for the FMS TSO[4] and MOPS.[5] VFR and IFR airworthiness approvals were granted based on criteria in FAA AC 20-130A[6] (reference figure 3). The aircraft were also delivered with IFR en route, terminal, and approach VNAV. The VNAV approval is based on FAA AC 20-129.[7]

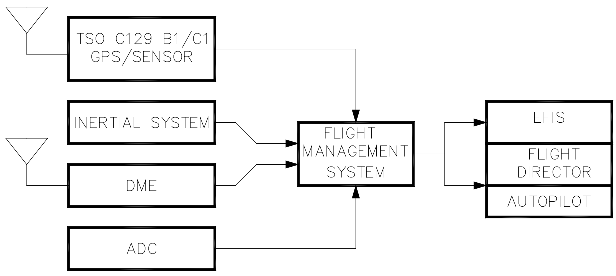

Figure 3. AC 20-130A FMS

Figure 4 shows the Lear instrument panel. And figure 5 shows the FMS CDUs in the pedestal. The CDUs are an integral part of the EFIS because they are used to select navigation modes The four EFIS displays are larger than the Beech’s, but they must display more data; e.g., airspeed, altitude, and vertical speed.

Figure 4. Lear 60 Instrument Panel

AVN’s fleet also includes six BAe, 125-800A aircraft. Past modifications to the BAe-800 aircraft include integration of an FMS with an internal GPS (TSO C-129A) receiver. This installation also gained airworthiness approval using AC 20-130A. Currently, the BAe-800 does not have VNAV capability.

Figure 5. Lear 60 Dual FMSs in Pedestal

The background presented identifies AVN’s current aircraft capability from an airworthiness standpoint. Operational and Flight Inspection (FI) issues will be addressed elsewhere in this paper to the extent appropriate. The Lear and Challenger aircraft were delivered with GPS, RNAV, and VNAV capability. The AVN Designated Alteration Station (DAS) issued Supplemental Type Certificates for the BAe-800 and Beech-300 to incorporate the GPS. The next section presents the issues of certification, airworthiness, support, and operations of a flight inspection fleet.

AIRBORNE PLATFORM

Alterations, maintenance, and operations of FAA flight inspection aircraft are conducted in accordance with applicable sections of the U.S. Code of Federal Regulations Title 14[8], also known as the Federal Aviation Regulations (FARs). This section identifies AVN’s manuals and procedures for supporting a flight inspection fleet and showing compliance with U.S. federal law.

Alterations and Certifications

FAR Part 21 identifies certification procedures for aircraft and parts. AVN maintains a DAS authorization per FAR Part 21, Subpart M. The DAS primary functions are to issue STCs and experimental and standard airworthiness certificates. Part 21 requires a DAS to have an approved procedures manual and qualified staff in order to issue the certificates. Technical Issuance (TI) 4100.21, Designated Alteration Station Procedure Manual,[9] is AVN's approved manual. Within the manual, the procedures for issuing STCs and other certificates are outlined. DAS staff qualifications and authorizations are also identified. The DAS staff consists of engineering, quality assurance, and flight test personnel. Our DAS issues an STC for each major aircraft modification. The alteration must comply with all applicable airworthiness standards for a particular aircraft type. AVN has Part 23, normal and commuter category (Beech-300), and Part 25, transport category (Lear, CL-601, and BAe-800), aircraft.

In the background presentation, several references were made to ACs and TSOs. What role do they play in the aircraft certification process? Like the STCs, the procedure for obtaining TSO approval is outlined in FAR Part 21. The TSO is a minimum performance standard for a piece of avionics equipment. Many times a TSO will reference an RTCA MOPS, in some cases include exceptions to MOPS. The TSO will also identify required markings, data, environmental,[10] and software[11] qualification requirements. Installing equipment with a TSO reduces testing requirements of the STC process.

The AC is a useful tool in the STC process. FAA published ACs address airworthiness approval demonstrating an acceptable means, but not the only means, of showing compliance to the FARs. Compliance with criteria established in the AC can significantly reduce the amount of testing and analysis in the STC process.

Maintenance and Repairs

The maintenance program for the AVN flight inspection fleet is identified in the AVN General Maintenance Manual (GMM) TI 4100.24.[12] AVN holds three FAA approvals under which FAA aircraft maintenance, repairs, and alterations are accomplished. AVN has been granted a FAR Part 145 Repair Station Certificate that identifies ratings for the type of work that may be accomplished. Such ratings include airframe, radio, instruments, and limited ratings in powerplant and propellers. AVN has a Special FAR (SFAR) 36 approval to do major aircraft repairs. Procedures for major repairs are identified in an Engineering Branch procedures manual.[13] AVN is also required to comply with maintenance requirements identified in FAR Part 135 Subpart J.

Operations and Approvals

AVN operates the flight inspection fleet under FAR Part 135 for on demand type operations. Part 135 identifies flight operational procedures, VFR/IFR limitations, weather requirements, and addresses aircraft and equipment requirements. Examples of equipment requirements are dual controls and cockpit voice recorders. Crew training, testing, and flight time requirements are also addressed. The Operations division conducts day-to-day flight operations in accordance with an FAA approved operations manual.[14] The operational manual identifies specific authorizations for performing FAA flight inspection. Authorizations for basic Instrument Approach Procedures (IAPS) and GPS and RNAV NPA without vertical guidance are approved. Operations personnel will use ACs for guidance for flights in U.S. airspace. AC 90-94A[15] specifies guidelines for GPS IFR operations.

PROCEDURES

Traditionally, instrument flight maneuvers have been based on ground based navigation systems; i.e., VOR, ILS, and DME. Today, with the proliferation of GPS and RNAV instrument procedures, procedure design is not constrained to follow emanations from a ground facility.

Design Criteria

FAA Flight Standards Services (AFS) develops criteria by which instrument procedures may be designed. The criteria are developed as a result of flight tests conducted by the FAA, U.S. military, contractors, and others. FAA Order 8260.3A,[16] U.S. Standard for Terminal Instrument Procedures (TERPS), identifies a standardized method for designing instrument flight procedures. Criteria are provided for precision and non-precision approach and departure procedures.

Over the past several years, AFS has issued additional orders with criteria to address the newer technologies. FAA Order 8260.38A[17] supplements the TERPS order for designing GPS non-precision approaches. Orders 8260.45A[18] and 8260.40B[19] detail design criteria for Terminal Arrival Areas (TAA) and FMS instrument procedures respectively. Criteria for WAAS and instrument procedures with vertical guidance (barometric or satellite elevation) are specified in FAA Order

8260.48.[20] As of this writing, LAAS approach design criteria has not been published. The TERPS document is being revised and is expected to include LAAS.

Approach Design

Based on approved criteria, AVN designs and compiles a data package consisting of a pictorial representation of the approach procedure and FAA forms that define the approach. Since GPS and RNAV approaches are defined by geographic waypoints (WP), a significant part of the package contains WP latitude, longitude, and altitude. This package is submitted to AVN Operations Division for validation.

DEVELOPING TECHNOLOGIES

When analyzing a navigation system, four fundamental elements are considered: integrity, accuracy, availability, and continuity. These elements by themselves could be discussed at length. They are mentioned here because they are the underlying requirements for safety of life applications. The reader is referred to the International Standards and Recommended Practices[21] (SARPS) for an international progress toward integrating GNSS into existing navigation infrastructures.

Global Positioning System

As GPS evolved and became available for civil aviation use, it was clear that GPS did not meet all of the integrity, accuracy, availability, and continuity requirements for precision approach applications; i.e., Selective Availability (SA) greatly affected GPS accuracy. These shortcomings are why the FAA approved GPS only for IFR supplemental en route and non-precision approach. Accuracy with SA off has improved. Availability and continuity with a full GPS constellation has improved, but with safety of life involved, the integrity issue becomes increasingly paramount. Future upgrades to the GPS constellation[22,23] may offer additional operational advantages and give rise to new flight inspection issues. A later section discusses FAA's differential GPS (DGPS), designed to enhance all the basic elements, especially integrity.

Area Navigation (RNAV)

Early RNAV equipment used primarily DME/VOR (rho-theta) distance and bearing to compute position. RNAV has evolved to a complex system of a navigation computer with database functions and multiple airborne sensors. With the advent of the modern FMS, aircraft can operate without the aid of ground based guidance signals. The FMS contains a database that defines airports, airways, and approach paths in space using latitude and longitude based on a geodetic survey. In the U.S., the WGS-84[24] and NAD-83[25] are the most common reference coordinate systems. The paths in space are composed of a series of waypoints; upon determining the aircraft position, horizontal linear deviations from the desired course are generated. Lateral steering commands, which can be coupled to an autopilot, are also provided.

With more complex RNAV systems, a Vertical Path Angle (VPA) between waypoints can be defined. The FMS computes a VPA for a set of waypoints. Using an air data computer's MSL altitude, the FMS generates vertical deviations and steering commands relative to the VPA.

Differential GPS

The FAA, various manufacturers, and other agencies are developing GPS Space and Ground Based Augmentation Systems (SBAS and GBAS). In the U.S., the SBAS is the Wide Area Augmentation System (WAAS) and the GBAS is the Local Area Augmentation System (LAAS). Both systems' architecture provides a set of corrections and other parameters over a datalink for the airborne receiver to apply to the GPS position solution. One of the most significant differences is the datalink. How WAAS and LAAS determine corrections and other parameters is beyond the scope of this paper.

WAAS

The WAAS signal is transmitted from a geostationary satellite on the GPS L1 frequency, 1575.42 MHz. The reader is referred to the WAAS MOPS[26] for details on the WAAS signal characteristics and data formats. More on the data types will be discussed in the flight inspection section of this paper. The WAAS MOPS identifies three functional classes of WAAS equipment, depicted in Figures 6, 7, and 8.

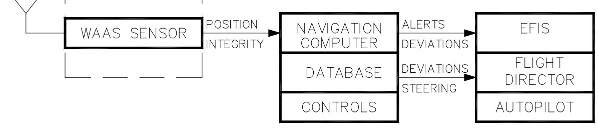

Figure 6. WAAS Class Beta Equipment

Typically, the Beta implementation will consist of a WAAS senor and an FMS that provides the navigator, database, and control functions. The Gamma class is a standalone system and performs RNAV functions like an FMS. The Beta and Gamma TSOs are TSO-C145[27] and TSO-C146[28] respectively.

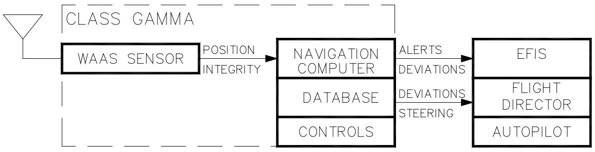

Figure 7. WAAS Class Gamma Equipment

The Delta is unique in that the navigator resides in a different enclosure than the database and controls. This implementation is expected to be an Instrument Landing System (ILS) replacement. As of this writing, a Delta Class TSO has not been approved.

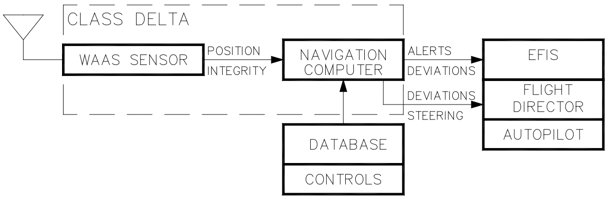

Figure 8. WAAS Class Delta Equipment

LAAS

The LAAS datalink is a VHF Data Broadcast (VDB) and Time Division Multiple Access (TDMA) on frequencies 108.025 to 117.950. The reader is referred to the LAAS MOPS[29] and Interface Control Document (ICD)[30] for details on the LAAS signal characteristics and data formats. The LAAS system is considered an ILS lookalike (reference figure 9). As of this writing a LAAS TSO has not been approved.

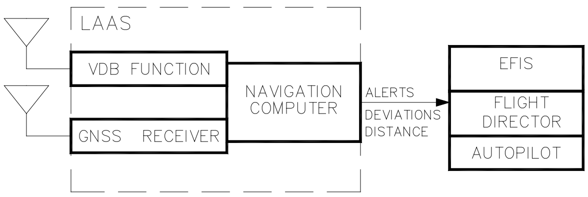

Figure 9. LAAS Equipment

FLIGHT INSPECTION

For the purpose of this paper, the flight inspection discussions will be limited to two general topics: the basic criteria and top level system description.

Flight Inspection (FI) Criteria

Flight inspection criteria for instrument approaches are contained in the U.S. Standard Flight Inspection Manual.[31]

General requirements are listed below:
- ♦ Database Integrity
- ♦ Bearing and Distance Accuracy
- ♦ Flyable and safe
- ♦ Obstacle Clearance
- ♦ Altitudes suitable for approach
- ♦ Ability to complete landing (upon reaching the Decision Altitude (DA) or Minimum Descent Altitude (MDA))
- ♦ Evaluate for Electromagnetic Interference (for GPS based approaches)

FMS and GPS

In addition to the general requirements, specific flight inspection criteria for FMS and GPS are also presented in the flight inspection manual.

FMS requirements:
The flight inspector shall compare the approach design with flight plan data on the FMS. The following tolerances shall apply for all segments.
- ♦ Azimuth to Next WP: ±1.0°
- ♦ Distance to Next WP: ±0.1 nm
- ♦ Vertical Path Angle: ±0.1°

GPS requirements:
- ♦ Record the following.
  - Horizontal Dilution of Precision (HDOP)
  - Horizontal Figure of Merit (HFOM)
  - Number of Satellites Tracked
  - Carrier to Noise Ration (C_o/N)

- ♦ AFIS Approach Path Tolerances
  - Initial/Intermediate Approach Segment
    - True Bearing to Next WP: ±2.0°
    - Distance to Next WP: ±0.5 nm
  - Final Approach Segment (FAS)
    - True Bearing to Next WP: ±2.0°
    - Distance to Next WP: ±0.3 nm
  - Missed Approach Segment
    - True Bearing to Next WP: ±2.0°
    - Distance to Next WP: ±0.5 nm

WAAS and LAAS

The WAAS flight inspection requirements are identified in FAA draft order 8200.WAAS.[32] The LAAS flight inspection requirements are identified in FAA draft order 8200.LAAS.[33]

Common requirements are listed below:

- ♦Record the following.
  - Vertical Dilution of Precision (VDOP)
  - Vertical Figure of Merit (VFOM)
  - Horizontal Dilution of Precision (HDOP)
  - Horizontal Figure of Merit (HFOM)
  - Vertical Protection Level (VPL)
  - Horizontal Protection Level (HPL)
  - For each satellite tracked:
    - Pseudo Random Noise (PRN) Code
    - C_o/N
    - Pseudo Ranges
    - Satellite Coordinates

WAAS requirements:

- ♦Record the following (partial list).
  - For each satellite tracked:
    - WAAS-Unhealthy, Unmonitored, and Healthy
    - GPS-Unhealthy, Unmonitored, and Healthy
  - For each WAAS Geo tracked:
    - Raw downlink data
    - WAAS Message timeout indicators
    - Corrections (fast, long, and iono) validity
    - Message parity error count
    - User Differential Range Estimator Indicator
    - Grid Ionospheric Vertical Error Indicators
- ♦ AFIS Approach Path Tolerances.
  - Initial/Intermediate Approach Segment
    - Magnetic Bearing to Next WP: ±1.0°
    - Distance to Next WP: ±0.1 nm
  - Final Approach Segment (FAS)
    - Magnetic Bearing to Next WP: ±0.1°
    - Distance to Next WP: ±0.1 nm
    - Glide Path Angle: ±0.2°
    - Horizontal Alignment: ±0.2°
  - Missed Approach Segment
    - Magnetic Bearing to Next WP: ±1.0°
    - Distance to Next WP: ±0.1 nm

LAAS requirements:

- ♦Record the following (partial list).
  - VDB Messages
  - VDB Signal Strength
  - Message Failure Rate (MFR)
- ♦Service Volume (SV) VDB coverage
- ♦ AFIS Approach Path Tolerances.
  - Final Approach Segment (FAS)
    - Magnetic Bearing to Next WP: ±0.1°
    - Distance to Next WP: ±0.1 nm
    - Glide Path Angle: ±0.2°
    - Horizontal Alignment: ±0.2°

<u>Flight Inspection (FI) System</u>

The Automatic Flight Inspection System (AFIS) is the standard for the FAA to collect data and analyze approach procedures. Figure 10 shows a top-level block diagram of AFIS and the basic interconnects.

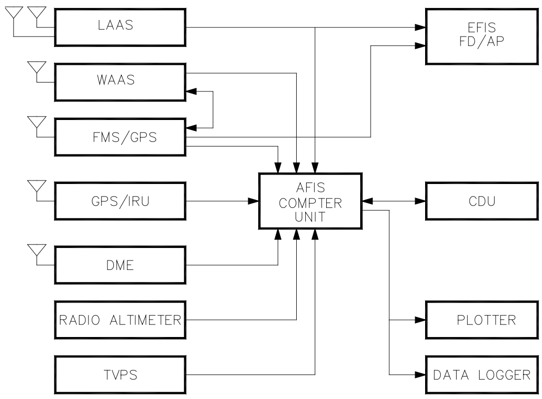

Figure 10. AFIS Simplified

A control and display unit (CDU) provides the operator interface with the AFIS computer. It allows the operator to select modes, change setup parameters, and monitor real time data. Figure 11 shows the flight inspection operator's station on a Lear 60.

Figure 11. Lear 60 Flight Inspection Station

The AFIS receives positioning data from a variety of sensors: DME, GPS/Initial Reference Unit (IRU), and radio altimeter. The Television Positioning System (TVPS) accurately provides position updates to the AFIS for evaluation of approach segment accuracies. AFIS accuracies with TVPS updates have been shown to be ±1.0 foot crosstrack error and ±4.0 foot along track error.[34] The radio altimeter accuracy at threshold is ±1.5 feet.

For Class Beta WAAS, GPS, and RNAV, a flight plan with waypoints and altitudes must be transmitted to AFIS from the FMS. LAAS receives the FAS data from the VDB and transmits data to the AFIS directly. The flight plan defines geometric lines in space; AFIS must verify they are in the proper location.

In order for AFIS to correlate the "true position" data with the navigation sensor position data, a timing synchronization pulse is needed. GPS receivers generally output a one pulse per second (PPS) signal. The flight inspection system is designed to accept a one PPS as defined by ARINC 743,[35] the Global Navigation Satellite System (GNSS) specification. The standard defines the pulse and its timing relationship to data validity.

AIRCRAFT IMPLEMENTATIONS

During the WAAS development in the mid nineties, AVN became involved with other government organizations and industry to develop avionics to commission and initially flight inspect WAAS. A Beta Class implementation was chosen. AVN supported the Beta because the architecture appeared to be most suited to the newest aircraft in the flight inspection fleet. The FMSs in Lears and Challengers required modification in order to process WAAS sensor inputs and provide lateral and vertical guidance for flying WAAS approaches and maneuvers. The GPS Program Office provided funding to support the development of a WAAS Verification Receiver (WVR) and integration into FAA aircraft. A vendor was chosen for the WVR and an existing off the shelf military GPS receiver would be modified to process WAAS messages.

Initial WAAS Integration

Considering the experimental nature of the project, AVN did not immediately move forward with an aircraft modification program. AVN closely monitored the FAA Tech Center and Oklahoma University WAAS flight programs. As the WVR and FMS software matured, AVN installed provisions for the WVR in six Lears. The provisions were installed in a manner that did not affect the Standard Airworthiness Certificate of the aircraft. Coordinating with the appropriate FAA oversight offices, AVN obtained an Experimental Certificate for Research and Development (R&D) for flight test.

Several series of WAAS flight tests were conducted to accomplish two objectives: Evaluate the FMS and WAAS performance with respect to the EFIS, flight director, and autopilot and develop a new WAAS flight inspection mode. Many issues and details required resolution; highlights are provided below.

The significant front-end avionics concerns are:
♦ An external annunciation of WAAS mode
♦ Display of HPL and VPL on the FMS
♦ Lateral and vertical aircraft tracking anomalies
♦ Flight director mode selection and autopilot coupling

Several flight inspection issues were identified:
♦ Additional ARINC 429 output labels: fine longitude and latitude words and an altitude word.
♦ Resolution of waypoint entry and display
♦ Resolution of the vertical path angle entry and display
♦ Configurable Horizontal Alert Limit and Vertical Alert Limit
♦ WAAS receiver one PPS timing issues

After several AFIS software iterations, a working engineering version of the software was tested. Modifications to the WVR's one PPS output were required to resolve AFIS horizontal alignment anomalies. This latest version provides the baseline for AVN to proceed with any software upgrades for interfacing to a new WAAS sensor (next section).

During the flight tests, AVN Engineering and the flight test pilots established cockpit procedures for flying WAAS approaches in our Lear 60 aircraft. The procedures will be formalized in a supplement to the Aircraft Flight Manual (AFM) when the WAAS equipment is installed permanently and an STC is accomplished.

While working with the FMS vendor to refine the WAAS functionality, it became apparent that a transition to the newest model FMS would be required. The new model would require an aircraft modification to accommodate some of the new features such as an internal GPS and an Ethernet interface for database loading. The most prominent feature was a WAAS mode for FAA use only (WAAS operations are not IFR certified). Recently AVN Engineering and Operations verified that the new FMS would support WAAS flight inspection using the WVR. We should note that the tracking anomalies were not as prominent as with the earlier model FMS. Additional flight testing and analysis may be required to resolve any significant tracking issues that may develop.

The Multi-Mode Receiver (MMR)

As LAAS Ground Facilities (LGF) development moved forward, the GPS program office realized the requirement for an airborne receiver to validate the LGF and flight inspect LAAS. A result of the LAAS Government Industry Partnership (GIP) program, an avionics manufacturer[36] has incorporated the LAAS into an air transport quality ARINC 755[37] multi-mode receiver. Basic system architecture is shown in Figure 12. The MMR appeared to be a reasonable candidate for AVN LAAS flight inspection.

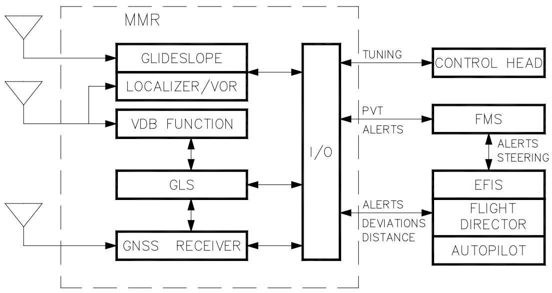

Figure 12. MMR with GPS Landing System (GLS)

Previously LAAS (GLS) was referred to as an ILS lookalike (reference figure 9). The ARINC 429 data bus provides deviations and alerts. This data will correspond to either ILS or GLS depending on tuning. In the GLS mode, a distance to go (DTG) to the threshold will be output for the distance displays. In the VOR or ILS mode, DME distance is usually displayed. With the ILS lookalike implementation, minimal impact to the EFIS, flight director, and autopilot are expected. Mode annunciation, GLS or ILS, must be addressed.

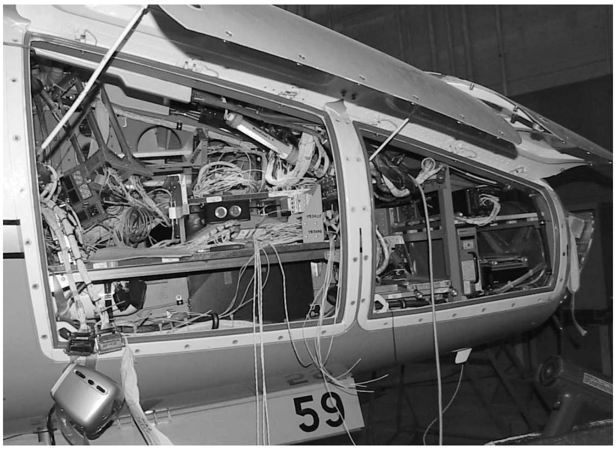

Figure 13. Lear 60 Nose Compartment

In order to develop GLS guidance, the MMR requires a GNSS subsystem. The GNSS sub-system outputs position, velocity, and time (PVT) data that are ARINC 743A compliant. With the PVT provided to an FMS, GPS and RNAV capability are obtained. In an attempt to obtain a long term solution for WAAS, the FAA contracted with the MMR vendor to incorporate WAAS. We never expected the WVR discussed in the previous section to become a TSO certified receiver. The contract also provided for support to integrate the MMR into the FAA Tech Center and AVN aircraft. ARINC 743A and 755 provide guidance and standards for implementing WAAS.

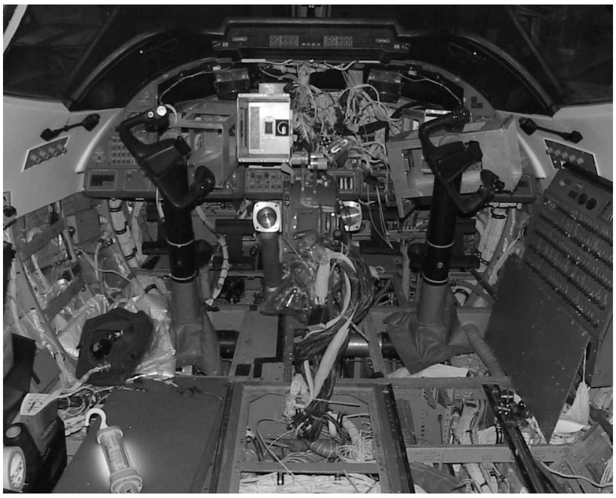

Figure 14. Lear 60 Cockpit and Instrument Panel

Currently, AVN has a Lear 60 undergoing modification for the MMR installation. Figure 13 shows the right hand nose compartment. The MMR and switching will be installed in the aft section. Two switch/annunciators will be installed in the instrument panel and center pedestal will be reconfigured. Figure 14 shows the extent to which the aircraft must be dismantled to install wiring, switches, circuit breakers and control panels. The cabin and main equipment rack are shown in figure 15.

Figure 15. Cabin and Main Equipment Rack

During development of the installation data, several concerns have arisen:

♦ Cockpit annunciations for the WAAS and LAAS modes

♦ Integration of air transport quality (ARINC) avionics with non-ARINC equipment

♦ EFIS display of LAAS distance to go

♦ Evaluation of elliptically polarized ground stations using a vertically polarized antenna

♦ Integration of the MMR WAAS functionality with the FMS

♦ Integration of the MMR WAAS functionality with AFIS

♦ Development, test, and implementation of a LAAS flight inspection mode

CONCLUSION

In summary, a significant portion of this paper was devoted to discussion of the myriad of U.S. laws, standards, and guidance material for aircraft certification and operation. An in-depth knowledge of each of the documents is required to provide engineering support for a modern flight inspection fleet in the U.S. Maintaining, operating, meeting mission requirements, and complying with applicable standards and FARs are very complex tasks.

The avionics in the previously referenced BAe-800 and Beech-300 are becoming antiquated and difficult to maintain. AVN personnel continue to assess options for modernizing the FAA flight inspection fleet. Refer to figure 16.

Figure 16. Beech, Challenger, BAe, and Lear Flight Inspection Aircraft

The MMR solution for Lear and Challenger looks very promising. AVN engineering and flight test personnel will be very busy throughout the rest of 2002. We expect to STC the WAAS flight inspection capability in early 2003 and the LAAS within the next eighteen months.

REFERENCES

[1] “Airborne Supplemental Navigation Equipment Using the Global Positioning System (GPS),” FAA Technical Standard Order, TSO-C129A.

[2] “Minimum Operational Performance Standards for Airborne Supplemental Navigation Equipment Using Global Positioning System (GPS),” RTCA/DO-208.

[3] “Airworthiness Approval of Global Positioning System (GPS) Navigation Equipment for Use As a VFR and IFR Supplemental Navigation System,” FAA AC 20-138.

[4] “Airborne Area Navigation Equipment Multi-Sensor Inputs,” FAA Technical Standard Order, TSO-C115b.

[5] “Minimum Operational Performance Standards for Airborne Area Navigation Equipment Multi-Sensor Inputs,” RTCA/DO-187.

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