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NAVIGATION DATABASE VALIDATION

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ABSTRACT

Automation is transforming aircraft navigation from the tuning and following of classic VOR and ILS course guidance to that of programming navigation computers for guidance in RNAV operations. Flight management systems (FMS) and stand-alone RNAV avionics are providing the most efficient means of navigating flight paths between airports. The heart of the capability is the navigation software or navigation database. The ARINC 424 path and terminator coding for the navigation database must be developed in conjunction with the flight procedure in order to provide the required vertical and lateral containment. Corruption of the designed navigation database path and terminator record is critical and can cause loss of obstruction clearance, invalid vertical guidance, airspace infringement, and other issues.

The navigation database coding is transparent to the pilot in most FMS and RNAV avionics systems. Therefore, it is essential for the navigation database to be coded correctly and portray the flight procedure chart in a software format.

The responsibility of flight inspection is changing to include the validation of ARINC 424 path and terminator data used in navigation databases. Compatibility with flight procedure charting is essential for safety and pilot situational awareness. This paper describes the methods and policies employed by the FAA to meet these requirements. Description of RNAV avionics systems and software tools involved in commissioning and periodic inspection of RNAV procedures are provided.

INTRODUCTION

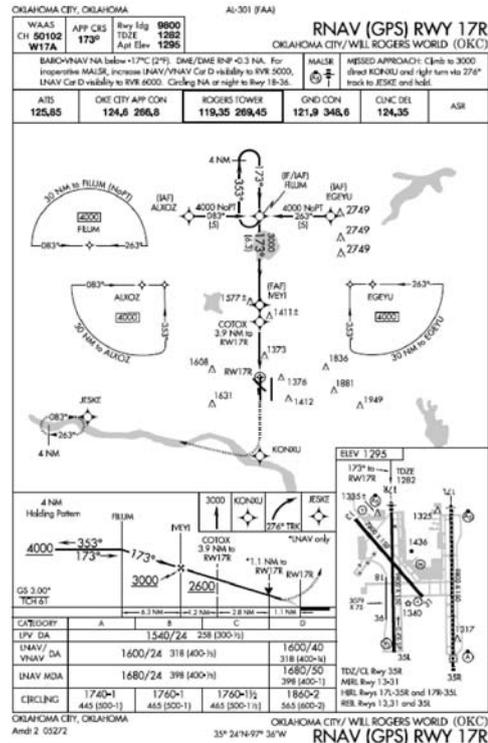
The Aviation Systems Standards (AVN) is a part of the FAA Air Traffic Organization. AVN provides flight inspection and other navigation system services including flight procedure development, charting, and navigation database. Offices for flight inspection and procedures development are located at the Mike Monroney Aeronautical Center in Oklahoma City, Oklahoma. Offices for charting and navigation database are located in Silver Spring, Maryland. The navigation database currently contains airways, SIDs, STARs and all RNAV procedures in the United States and Caribbean areas. Flight inspection and procedure development are world wide in scope.

The flight inspection mission is accomplished from five field offices located at Oklahoma City, OK, Atlanta, GA, Atlantic City, NJ, Anchorage, AK, Battle Creek, MI, and Sacramento, CA. International flight inspection is operated from Oklahoma City. The flight inspection aircraft fleet includes eighteen Beechcraft 300 King Airliners, 6 Learjet 60s, three British Aerospace 125-800, and four Bombardier Challenger aircraft.

Aircraft are equipped with an automated flight inspection system (AFIS). Each aircraft is equipped with a truth system for flight inspection purposes; some are equipped with differential GPS truth systems. The Bombardier and Learjet aircraft are equipped with flight management system computers, which are used in inspection of RNAV procedures as well as normal flight operations. The Learjet aircraft are equipped with multi-mode receivers that include both WAAS and LAAS sensors. All flight inspection aircraft are operated in accordance with Federal Aviation Regulations Part 135.

In addition to legacy procedures based on individual ground facilities; AVN is responsible for development, flight inspection, and a navigation database of public RNAV procedures in the national airspace system. Hundreds of these procedures now use the Wide Area Augmentation System (WAAS) to descend to the LPV minima.

Flight inspection of an RNAV procedure and its associated navigation database are critical for obstruction clearance, air traffic separation, and environmental issues.



Example of RNAV Approach Chart

Today's and future airspace restraints require precise navigation and repeatable ground tracks. Operators are requiring all weather access to airports in more challenging terrain environments. Airport and airspace capacity is being increased by new operational procedures, including RNAV. Environmental issues are becoming complex and requiring aircraft to maintain precise repeatable navigation over designed ground tracks. This all requires strict adherence to navigation database leg types that provide software guidance for the flight procedure.

ARINC 424 SPECIFICATION CODING

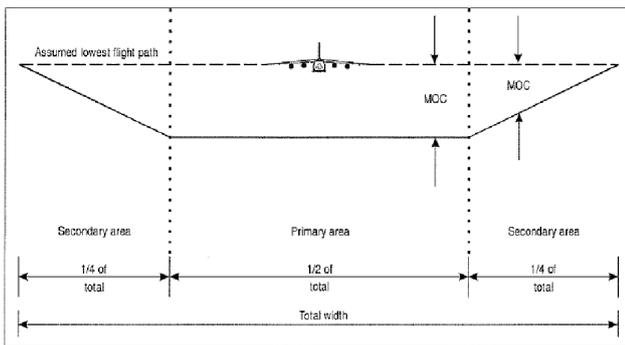
ARINC 424 is the air transport industry's recommended standard for the preparation and transmission of data for the assembly of airborne system navigation databases. The data is intended for merging with the aircraft navigation system software to provide a source of navigation reference. Each subsequent version of ARINC 424 Specification provides additional capability for navigation systems to utilize. Merging of ARINC 424 data with each manufacturer's system software is unique and is not an issue for flight inspection. At issue are the ARINC 424 leg types providing vertical guidance and ground track for a specific flight procedure. These leg types must provide repeatable flight tracks for the procedure design.

The navigation database leg type is the "path / terminator" concept. ARINC 424 Specification describes 23 leg types by their path and terminator. The path describes how the aircraft gets to the terminator - by flying direct, a heading, a track, a course, etc. The terminator is the event or condition that causes the navigation computer system to switch to the next leg - a fix, an altitude, an intercept, etc. When a flight procedure instructs the pilot to fly runway heading to 2000' then direct to a fix, this is the "path / terminator" concept. The path is the heading and the terminator is 2000'. Then the next leg is then automatically sequenced. A series of leg types are coded into a navigation database to make a flight procedure. The navigation database will allow an FMS or GPS navigator to create a continuous display of navigational data, thus enabling an aircraft to be flown along a specific route. Vertical navigation can also be coded.

As the flight procedure is developed, ARINC 424 Specification path/terminator coding should be assigned to each segment. The specified leg path must meet the flight path requirement of the procedure

design. An example is: a “Direct-to-Fix” leg path may not meet the containment requirements where positive course guidance is required. “Track-to-Fix” and “Course-to-Fix” leg types provide positive course guidance. Flight procedures developed using Pans/Ops and TERPS criteria allow for secondary areas with sloping surfaces for obstruction evaluation, if positive course guidance is provided. The secondary area gives relief to obstructions in these areas.

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Changing of the procedure designed leg type in the navigation database to get a particular FMS or GPS navigator box to “work” may compromise the safety and integrity of a flight procedure. Consideration should be given to stripping flight procedures from the navigation database of an FMS or GPS navigator that is not capable of processing the designed leg types.

DATA CORRUPTION

The standard flight inspection practice for RNAV commissioning has been to manually enter procedure data. This can lead to human error, misinterpretation, inadequate waypoint resolution, limitations by flight inspection RNAV equipment, and other issues. Normally the inspector uses the flight procedure documentation paper forms from which to create RNAV flight paths to commission new flight procedures. This can lead to transposing of numbers and lengthy preflight preparation. Some RNAV systems are not capable of accepting adequate resolution of manually entered waypoints for flight inspection purposes. This is especially critical with vertically guided procedures. These issues make electronic transfer of new RNAV flight procedure ARINC 424 data to the flight inspection system very desirable.

MAGNETIC VARIATION

Different FMS / GPS navigation systems apply different magnetic variation. Different software updates within a specific manufacturer’s navigation system may apply magnetic variation differently. Differences may be observed between FMS / GPS displayed tracks and courses and those published on aeronautical charts. These differences are due to the fact that the charts are published using an Epoch Year value assigned to the facility/airport on which the flight procedure is based. The FMS/GPS may display the computed course using current local magnetic variation. Magnetic variation models may vary slightly among FMS/GPS manufacturers software and navigation databases. Flight Plan Legs with XXX° displays may vary from the published data by the amount of difference between the assigned facility/airport Epoch Year declination and the actual magnetic variation at the originating waypoint. Magnetic variation constantly shifts with time, where as the facility/airport Epoch Year declination is constant until it is realigned for Pans/Ops or TERPS design use. The facility/airport Epoch Year declination may vary by several degrees from the current local magnetic variation. This depends upon how long ago the facility/airport was realigned for the nearest future Epoch Year declination value. This should be taken into consideration when conducting flight inspection of RNAV procedures.

The FAA does not apply a tolerance to the published magnetic value on flight procedures during the flight inspection. However, a tolerance is applied to the “True North” course of all “Track-to-Fix” leg paths. Flight inspection FMS /GPS navigation systems have the capability of displaying these values in “True”.

“Course-to-” leg paths are coded into the navigation database with the proper magnetic variation applied for the procedure. Some FMS / GPS systems may apply additional magnetic variation to the path leg. Any course value of an ARINC 424 “Course-to-” leg path must be checked without the FMS / GPS internal software applying magnetic variation. FAA flight inspection flight management systems have this capability.

PROCEDURE DEVELOPMENT AND DOCUMENTATION

AVN designed flight procedures are developed utilizing a computer software program. This program is based on TERPS procedure development criteria. The software program also contains known terrain and obstruction data. During the procedure development, ARINC 424 coding is specified for navigation database reference. This assures containment and obstruction clearance requirements of each segment of the procedure are met.

When flight procedure development is completed, the data is entered into a software program called Instrument Flight Procedures Program (IFP). IFP documents and validates the information. Validation includes ARINC 424 specification, TERPS criteria, and obstacle data. The data is considered “pending” data packages until flight inspection is completed. After a satisfactory flight inspection and a publication date is established, IFP will make new flight procedures available to commercial database suppliers. IFP is a new process for AVN. Migration of all AVN flight procedures into IFP will be done over a period of time.

NAVIGATION DATA PACKING FOR FLIGHT INSPECTION

One of the functions of the IFP is to maintain the pending data for ARINC 424 coding into the flight inspection navigation database.

The coding is raw ARINC 424 Specification and must be packed to a format for the flight inspection aircraft FMS to use. Each flight procedure containing multiple ARINC 424 path and terminators, route qualifiers and other data is termed a “packet”.

Downloading rules specify which packets and when the data packer is to download pending packets for each 28-day navigation database cycle update. The pending packets are packed along with the flight inspection aircraft’s normal navigation database.

NAVIGATION DATABASE REVIEW

Computer software programs are now available to “preview” a navigation database. This can be done from a typical office computer. Each new flight procedure can be reviewed to determine if it contains all feeder, initial, intermediate, final, and missed approach segments. ARINC 424 path and terminator coding can be displayed.

FLIGHT INSPECTION

RNAV flight inspection has evolved from use of early model stand-alone GPS navigators to FMS. Navigation data on un-commissioned flight procedures has been nonexistent. Early model GPS navigators were only capable of “direct-to-fix” and “track-to-fix” ARINC 424 leg paths for manually entered data. Today’s RNAV procedures take advantage of many more capabilities in the ARINC 424 Specifications. Capabilities in updated ARINC 424 Specification include coding for RNP, GBAS, and SBAS flight procedures. The use of Radius-to-Fix legs in RNP flight procedures has greatly increased the capabilities of procedure design in challenging airspace environments.

