AERONAUTICAL CHARTING FORUM
Instrument Procedures Group
October 27, 2009

HISTORY RECORD

FAA Control # 09-02-290

Subject: Call for Review and Revision of ARINC Leg Types Used in Construction of RNAV Departure Procedures.

Background/Discussion:

Experiences with the initial designs and introductions of RNAV Departure procedures throughout the NAS have revealed a pattern of unanticipated aircraft performance and deviations from intended routes. The introductions of new RNAV SIDs have frequently required publication of explanatory Letters to Airmen, modifications of ARINC leg types by avionics vendors, and/or withdrawals and revisions of the procedures themselves.

NBAA believes that the criteria in Orders 8260.44A and 8260.46D contain ARINC 424 leg types that are in the long term, unsuitable for construction of RNAV SIDs. These undesirable leg types have introduced wide variations in aircraft track performance as well as inconsistencies in charting and databases which tend to lead to confusion among pilots.

Aircraft track performance can be significantly improved by reducing the numbers of construction options embodied in Orders 8260.44A and 8260.46D.

While it is not possible to transition to RNP RNAV in a single leap, FAA and users should remain mindful that the foundation of NextGen rests on RNP RNAV. Therefore, when designing any new RNAV SID, it is highly desirable to emulate the RNP RNAV tighter, more repeatable aircraft tracks through careful selection of ARINC path-terminator construction options.

Table A-1 (Appendix A) specifies the following construction options – the highlighted leg types are among those listed as **prohibited** by RTCA DO-236B, 3.2.7:

Table A-1. Permissible Leg Types.

FROM	VIA (leg type)	TO
AER	VI[1]	See [1]
AER	VA[2]	ALT
AER	VM[8]	HDG
ALT	CF[3], DF[4]	FB/FO
AER	CF[3], DF[4]	FB/FO
FB	TF[5]	FB/FO
FO	DF[4], TF[5]	FB/FO
IF[4]	DF[4], TF[5]	FB/FO
FO	VM[8]	HDG
FB	RF[6]	FB

1 VI (Heading-to-intercept) may only be used as the first leg of a departure and must be followed by a CF leg.
2 VA (Heading-to-an-altitude) may only be used as the first leg of a departure and must be followed by either a CF or DF leg.
3 CF (Course-to-fix) may only be used as the first leg of a departure or as the leg following a departure VI or VA leg.
4 DF (Direct-to-fix) may be used as the first leg of a departure, the leg following a departure VA leg, and for any leg thereafter preceded by a FO WP only.
5 TF (Track-to-fix) is not used as the first leg of a departure. TF is the preferred leg after the first leg of a departure.
6 RF (Constant radius arc) may only be used when necessary because some users do not have RF capability. An RF leg may only be used after a TF, CF, or another RF leg.
7 IF (Initial fix) is used to designate the first fix of a departure transition, i.e., the IF is coincident with the DP termination fix. IF is also used to designate the point at which RNAV begins when used in conjunction with radar vectors.
8 VM (Vector-to-fix) legs are only to be used in conjunction with ATC radar vectoring.

Excerpt from RTCA DO-236B

3.2.7 Prohibited Leg Types

The intent of this section is to provide a list of flight plan elements which are prohibited from having an assigned RNP RNAV type by the airspace planners. It may also be used by navigation management system manufacturers as a set of assumptions to design their future systems to be certified for use in the RNP RNAV environment.

Excerpt from RTCA DO-236B, cont'd

> *Note: Many types of segments exist to support the design of departure or arrival procedures (refer to ARINC 424). Most of these types of segments, such as fixed heading segments or altitude terminating segments, were defined using old-style pilotage rules and* ***are not compatible with the objective of ensuring a consistent path****. It is believed that some of the following elements will still be used in some particular cases but will gradually be replaced by those listed in Section 3.2.1.*
> The following flight plan elements are prohibited from having an assigned RNP RNAV type:
> 1. Heading/vector segments
> 2. Track segments without a fixed termination waypoint
> 3. Procedure Turn segments
> 4. Radial or distance terminated legs
>
> This includes the following ARINC 424 leg types: CA, CD, CI, CR, **VA**, VD, **VI**, **VM**, VR, PI, FC, FD, FM, and AF.

The attached Honeywell analysis of database and procedure construction issues at DFW documented the dispersions of aircraft tracks caused by the VA-CF leg combination. Also see GENOT 09002.

While the concepts of flying a heading after takeoff (VI) and flying a heading until leaving an altitude (VA) are familiar to ATC as well as Procedures Specialists, these methods are generally incompatible with RNP RNAV and should be removed from the 8260.46 and 8260.44A toolboxes. Doing so would leave the CF as the principle construction option for the initial leg from the runway (AER in the Table A-1.) The TF leg would remain the option of choice following the initial CF leg.

A requirement to achieve a specified altitude prior to the waypoint at the terminus of the initial CF leg can be accomplished with a climb gradient restriction – e.g., "Minimum climb of 300'/nm to 2200' MSL" or by placing a constraint on the waypoint at the terminus of the CF leg – e.g. "Cross SHEMP at or above 2200"

While there may be exceptional cases requiring a CA-DF leg combination, the need for this combination should be documented in a waiver application to ensure that the proponents' requirements for the CA/DF combination cannot be satisfied by any other method

The analysis of the waiver by AFS should also consider the characteristics of airborne RNAV and autoflight systems – e.g., the CA leg should terminate with an "AT or ABOVE" designation and the subsequent DF leg must either have no altitude restriction or a restriction at least 500 feet higher than the terminus of the preceding CA leg. This requirement is necessary to ensure that waypoint and leg sequencing occurs as expected.

Recommendations:

FAA and industry experts should review the procedure construction options in the current versions of Orders 8260.44 and 8260.46 with the goal of removing ARINC leg types that are prohibited by DO-236B. This would be accomplished by attrition as new procedures are constructed and existing procedures are amended.

1. The CF/TF leg combination would become the primary construction option from the AER.
2. DF/TF would become the secondary option.
3. When a CA-DF leg combination from the AER is found (through the waiver application process) to be absolutely necessary, require that the CA climb-to altitude be designated as an "at or above" altitude constraint. Further, require that any altitude constraint at the subsequent DF terminus fix be higher than the CA altitude restriction by an increment of at least 500 feet.
4. Flyover waypoints should also require a waiver as path repeatability is reduced.

Comments: This recommendation affects FAAO 8260.44A and FAAO 8260.46D.

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Attachments:
1. Honeywell Analysis of DFW RNAV SIDs – May 31, 2006
2. GENOT 09002

Initial Discussion - MEETING 09-02: New issue presented by Rich Boll, NBAA. Rich stated that although closely related to Issue 09-02-289, this recommendation is a long term effort. NBAA believes it is time to take a comprehensive look at how RNAV SIDs are designed under DO-236B, *Minimum Aviation System Performance Standards: Required Navigation Performance for Area Navigation*. The FAA needs to more carefully evaluate current design criteria as we move more into the RNP world. RNP DP design must be based on leg types that provide repeated ground tracks - specific leg types and associated altitude restriction limitations are included in the Recommendation Document. Ted Thompson, Jeppesen, commented that the use of point-to-point leg types for RNAV departures represents a larger, long range policy that has to be addressed. The use of 'air mass' leg types is suited to 'overlaying' ground tracks of conventional departures, but include the inherent complications. Also, the ICAO IFPP is moving toward point-to-point RNAV departures. Along with that comes the need to address system alignment on the ground prior to take-off (i.e. Quick Alignment QA waypoints). Al Herndon, MITRE, stated that MITRE has been tasked with investigating RNP at 50 feet off the runway. He also pointed out that RNAV RNP will be based on GPS, not DME/DME, and Quick Alignment waypoints might not be necessary; however, the question remains as to what aircraft alignment is necessary to support the tighter, more precise ground tracks available by the use exclusive use of point-to-point leg types for RNAV departures. Tom Schneider, AFS-420, agreed to forward this issue to the US-IFPP for consideration.
ACTION: ACF-IPG Chair and US-IFPP.

MEETING 10-01: Tom Schneider, AFS-420, briefed that Jack Corman, AFS-420, and Executive Director of the US-IFPP, has advised that, "within the US-IFPP, this issue will be worked jointly with 09-02-289. Both issues have been referred to the US-IFPP Coding subgroup for resolution recommendation." the Executive Director of the US-IFPP will keep the ACF apprised of the issue status. ACTION: AFS-420 (US-IFPP).

MEETING 10-02: Tom Schneider, AFS-420, provided the following update from Jack Corman, the AFS-420 TERPS RNAV criteria specialist: "This issue is being worked jointly with issue 09-02-289 and is being addressed by the US-IFPP Database and Coding Working Groups. It currently appears that a long-term solution is to move away from using headings." ACTION: AFS-420 (US-IFPP).

MEETING 11-01: Tom Schneider, AFS-420, provided the following update that applies equally to this issue and 09-02-289 from Ron Brumback, AFS-420 (ISI), departure criteria specialist: "Based upon feedback from AFS-470 and AIR-130, RNAV departure criteria that outlines leg-type coding methods will be withdrawn. Coders can use whatever ARINC implementation their box requires to adhere to the path of the described construction." Brad Rush, AJV-3B, asked whether procedure designers would continue to document the leg type used in the procedure design. Ted Thompson, Jeppesen, asked whether this was discussed through the ATA CNS Task Force for input. Tom responded that he didn't think so, but AIR was a participant in the US-IFPP discussion. John Moore, AJV-3B, stated that when missed approach icons first appeared on the scene, there was much confusion regarding interpreting the text on the procedure source to be depicted as a symbol. Likewise here, the intent of the procedure designer must be crystal clear for coding purposes. John added that it would be beneficial for the US-IFPP to bring industry into this conversation. Brad added that designers are putting the leg type used in the design and to be coded on the forms now. Don't change something that is working; additionally, a change will affect several ACs. Ted interjected that some avionics, especially older systems, may not be able to support the specified leg types Rich Boll, NBAA, responded that pilots must always be ready to intervene if an aircraft is not going where it is supposed to. He also cautioned that the FAA must be careful in allowing coders to change the leg type specified to be coded and didn't believe that this allowance is good idea. Brad closed by saying that if coders are allowed to unilaterally change leg types from the specified source, then that practice must be sanctioned by AIR. The ACF-IPG comments will be addressed by the US-IFPP. ACTION: AFS-420 (US-IFPP).

MEETING 11-02: Tom Schneider, AFS-420, provided the following update that applies equally to this issue and 09-02-289 from Jack Corman, AFS-420, and Ron Brumback, AFS-420 (ISI): "Order 8260.19 will continue to require procedure specialists to list the type leg used in the design of the procedure on the associated 8260-series form. However, AFS cannot at this time mandate how manufacturers apply the designated code. The US-IFPP Database and Coding WG has been working on establishing an FAA coding standard. However, many US-IFPP initiatives have been halted because of the impact any regulatory guidance (standards) would have on the proprietary nature of existing navigation databases and systems. For example, the US-IFPP Coding WG did address the issues and drafted a letter to AVS for a formal tasking to develop regulatory guidance for coding. However, after the last coding WG meeting, the letter was cancelled and there has not been any progress since then due to Nav Lean priorities. Until such a coding standard is established, PBN

criteria will only contain example ARINC combinations that may or may not guarantee track compliance since all FMSs may not implement the codes in the same manner." Rich Boll, NBAA, emphasized that this issue was submitted with the goal of getting long-term standardized coding for RNAV departures. Tom Schneider, AFS-420, added that this issue is being addressed by the US-IFPP Departure Working Group as a revision to Order 8260.44. ACTION: AFS-420 (US-IFPP).

MEETING 12-01: Tom Schneider, AFS-420, briefed that per the most recent US-IFPP meeting on April 13, it is AFS-420's understanding that the use of “leg-types” is now going to be addressed at RTCA within subcommittee 227 (SC-227). The US-IFPP will monitor further developments as they occur and provide support where needed. Tom recommended the issue be closed. Rich Boll, NBAA, stated that NBAA was satisfied with the action and agreed that the issue can be closed. Item CLOSED.
