GOVERNMENT/INDUSTRY AERONAUTICAL CHARTING FORUM
Instrument Procedures Group
October 23, 2007
HISTORY RECORD

FAA Control # 07-01-278

Subject: Advanced RNAV (FMS/GPS) Performance of Holding Patterns Defined By Leg Length

Background/Discussion:

AIM para. 5-3-7(j)(5) describes use of DME or GPS Along-Track Distance (ATD) in lieu of time values that are necessary to ensure holding pattern airspace protection. When distance is used in lieu of time on a holding pattern, the distance value specified on the procedure chart or provided by ATC is applicable to the outbound leg of the holding pattern. When GPS is used for holding with a distance specified, the holding fix will be a waypoint in the database and the end of the outbound leg will be determined by the ATD (see fig. 1).

NBAA has recently learned the above AIM directive description of GPS holding operation differs markedly from the actual operation of modern FMS/GPS systems providing positive course guidance around the holding pattern. The ARINC 424 navigation database coding specification calls for coding any specified holding pattern leg distance on the inbound leg. FMS/GPS holding pattern logic will attempt to adjust the length of the holding pattern's outbound leg as necessary to make good this specified distance value when the aircraft completes the turn and rolls wings level on the inbound leg. A holding distance value for the inbound leg may be coded in the navigation database for published holds or manually entered into the FMS/GPS system by the pilot in response to an ATC request.

FMS/GPS holding pattern logic common to most systems can result in the outbound leg's ATD exceeding the charted value by a significant amount when the turn inbound is initiated. This is illustrated by an actual example of a holding pattern event over the RDU VOR at FL410, see Fig 2. While this example is based on a specific FMS system, many FMS/GPS systems currently in service share the same nav-database coding specification and similar holding pattern logic. Therefore, it can be surmised that a similar result would occur using any FMS/GPS device that provides positive course guidance during holding operations.

NBAA is concerned that this demonstrated difference in holding pattern performance between the modern FMS/GPS navigation systems and that expected by FAA Order 7130.3A as amplified by the AIM directive on DME/GPS holding may result in an aircraft approaching or exceeding the limits of the holding pattern airspace area. This is especially worrisome with RNAV (GPS) procedures that have HIL and missed approach distance-limited holding patterns located in a non-radar environment, e.g. Alamosa, CO (KALS), see Fig 3.

Recommendations:

NBAA understands FAA reluctance to change existing holding pattern airspace containment criteria in FAA Order 7130.3A to accommodate current FMS/GPS holding pattern operation . Further, NBAA recognizes that the ARINC 424 coding specification document is beyond the FAA's control. However, FAA must recognize the inherent design logic of modern FMS/GPS systems and provide the necessary information to ensure that the performance of these systems is acceptable based on the FAA's existing holding pattern design criteria.

In support of that need, NBAA requests that the FAA develop and publish on Table 7 of FAA Order 7130.3A, "Holding Pattern Criteria", a corresponding maximum inbound leg distance value for each pattern type/ATD limit for use with electronic navigation database in coding the appropriate holding pattern. This inbound leg distance should be published on the holding data record form which should then used by navigation database providers to properly code the inbound leg of the respective holding pattern. The FAA should notify electronic navigation database suppliers and avionics manufacturers of the necessity to code the appropriate inbound leg distance value on any enroute, terminal, or instrument approach procedure holding pattern with a published outbound ATD leg distance value.

Since the described holding performance characteristics of FMS/GPS systems affects ad-hoc holding procedures as well (non-published holds issued by ATC in a radar environment), AIM guidance must be provided to pilots alerting them to the fact that holding pattern leg distances that are manually entered into the FMS/GPS system may result in the aircraft exceeding the specified outbound leg ATD. Pilot intervention or coordination with ATC may be necessary to remain within holding pattern airspace area.

FAA Order 7110.65R should be amended to alert controllers that the holding pattern performance characteristics of advanced RNAV equipped aircraft could result in flight path deviations from the holding pattern airspace area.

Comments: This recommendation affects

FAA Order 7130.3A, Holding Pattern Criteria
Aeronautical Information Manual
FAA Order 7110.65R, Air Traffic Control

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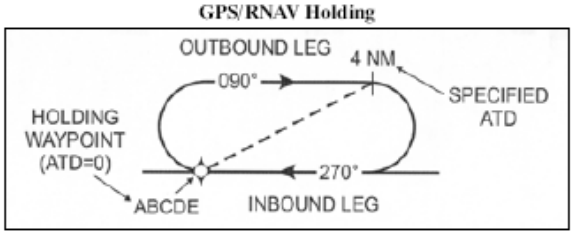
Fig 1: AIM pg. 5-3-13

FIG 5-3-7

GPS/RNAV Holding



NOTE-

The inbound course is always toward the waypoint and the ATD is zero at the waypoint. The end of the outbound leg of the holding pattern is reached when the ATD reads the specified distance.

Fig 2: FMS Positive Course Guidance hold; 20 nm leg selection.

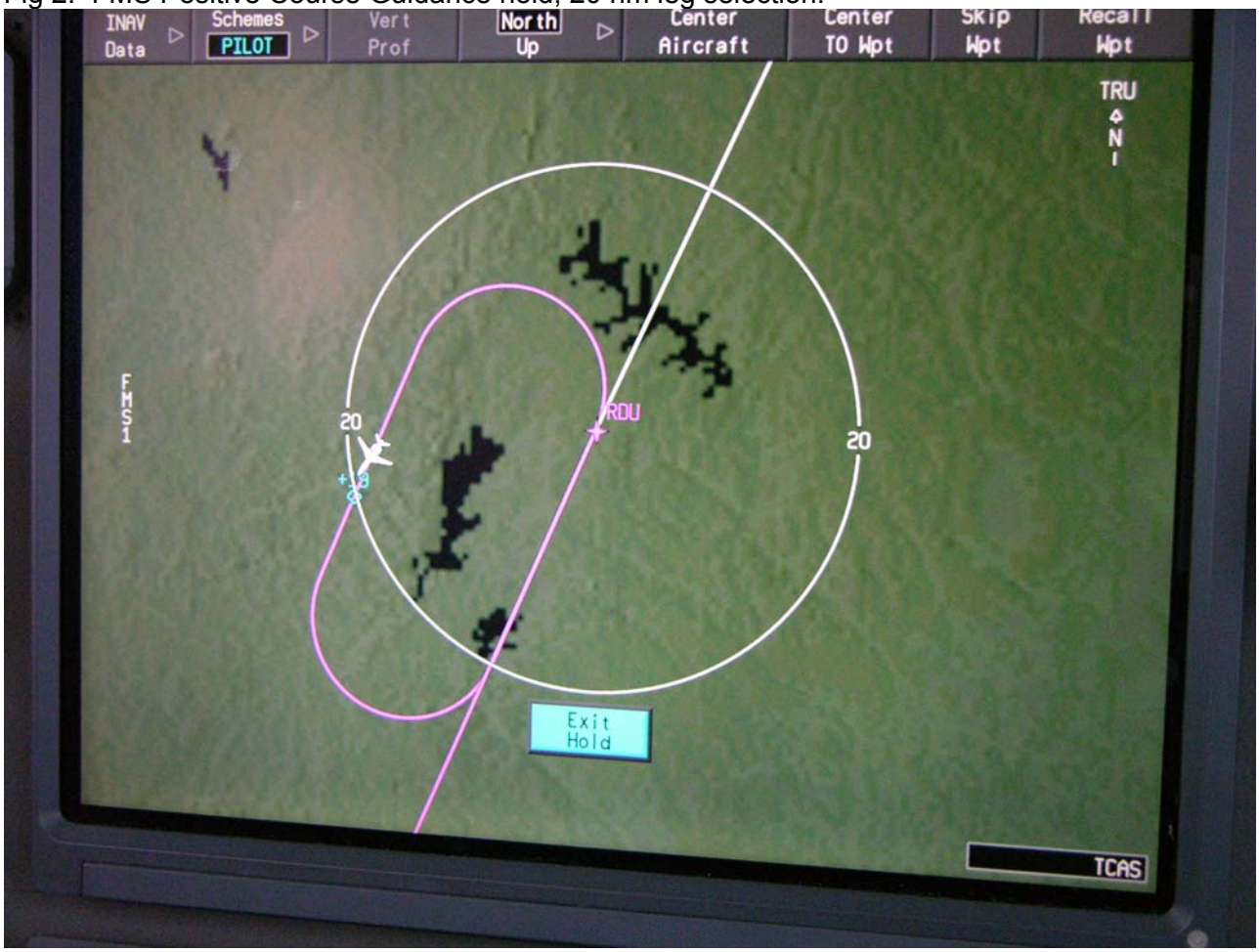
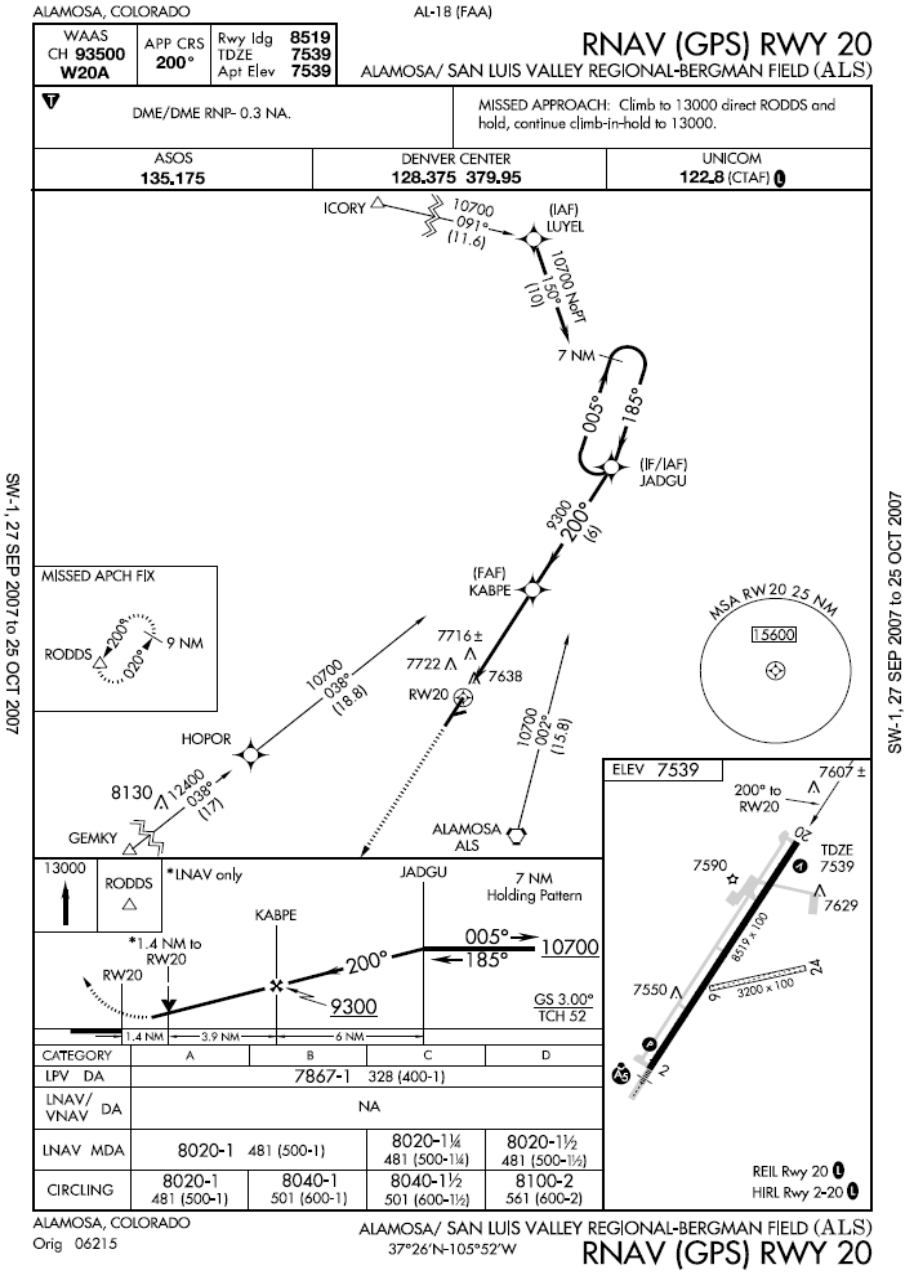


Fig 2A: DME Distance from RDU VOR = 29 NM at start of inbound turn from the outbound holding leg.

ATD Mileage (38.3 NM) represents total miles from current position back to the holding fix

Fig 3: Alamosa, CO (ALS) RNAV (GPS) 20 Approach
Note: HIL ATD = 7 NM's
MAP Holding ATD = 9 NM's



Initial Discussion - Meeting 07-02: New issue introduced by Rich Boll, NBAA. An NBAA member, flying an advanced RNAV aircraft was assigned RNAV holding with 20 mile legs. Because the FMS was programmed to provide a wings-level rollout on a 20 NM inbound leg, the aircraft far exceeded the outbound holding airspace protected area (actually flew a 29 NM outbound leg). This programming logic is contrary to the guidance provided in AIM figure 5-3-7. Rich added that following conversations with various FMS manufacturers, the problem appears to be resulting from the application of the underlying ARINC holding pattern record (fix, inbound course, & leg length) within the FMS's holding pattern logic. Tom Schneider, AFS-420, stated the problem has been known to FAA Flight Standards for at least one year. It was identified during their work in re-evaluation holding pattern criteria. Ted Thompson, Jeppesen, noted that the problem extends beyond the United States. John Moore, AJW-351, added the subject is also being discussed in the ICAO IFPP. Tom concluded that this issue will be added to the AFS-450 holding pattern study. There was some disagreement; however, no one could recommend what other group would/should work the issue. It was noted during discussion that changing the AIRNC coding methodology would require changing all avionics boxes. Ted stressed that the issue needs to be fixed at the root cause, AIRNC Specifications, not various work-arounds. John Moore, AJW-351, briefed that the ICAO IFPP is considering publishing the diagonal distance where the turn inbound should be made. Brad Rush suggested that an easy solution would be to specify all RNAV holding be time-referenced. Tom will ensure the issue is included in the AFS-450 holding pattern study. Mark Steinbicker, AFS-470, stated they will also review the issue and provide comments/recommendations to AFS-450 for inclusion in the study. ACTION: AFS-420, AFS-470 and AFS-450.

MEETING 08-01: Sherri Avery, AFS-450, briefed that this issue has been included in the holding pattern study. Advanced FMS holding allows pilots to see exactly where they are flying but not whether they have containment in the holding protected area. Sherri further briefed that an initial review indicates that the containment areas are better than thought. She showed several examples where if the FMS flew the specified leg length as **inbound** vice **ATD outbound**, the aircraft would still be contained. Rich Boll, NBAA, questioned how this is possible when the avionics will fly whatever outbound is necessary to achieve the specified inbound leg length, Tom Schneider, AFS-420, questioned whether all FMS' are performing the same way. Rich responded that ARINC 424 only specifies coding of the inbound leg track and a length (distance). Adrienne Funk, AJW-352 reminded the group that this distance is not specific to either the outbound or inbound leg. Bill Hammett, AFS-420 (ISI), stated that this could be a serious safety issue, especially when holding in areas tightly constrained by terrain. Steve Barnes, AFS-450, re-iterated that if the correct template is used, it is not a safety factor. Either slant range or inbound leg length will provide containment. There is no indication that it is a significant safety issue; however, it will be assessed in the study. Tom added that as an interim measure, AFS policy terminated using smaller RNAV holding pattern templates and requires conventional criteria application for all holding. Ted Thompson, Jeppesen, briefed that this issue has been discussed at the Jeppesen Standards Group. At present there is no forum addressing this coding issue. Ted has recommended that it be considered by the ATA sub group designated to address FMS programming standardization. Mark Ingram, ALPA, stated that something needs to be done to study how FMS' are flying holding patterns especially on SIDs and STARs. Rich recommended something similar to the study MITRE accomplished on SID and STAR lateral flight tracks. Kevin Comstock, ALPA, recommended the issue be brought before ARINC. Tom stated that the AFS-420 representative on the ARINC 424 committee is aware of the

issue and will pursue assurance that ARINC coding specifications are in consonance with holding pattern containment requirements. In the interim, AFS-450 will to continue to work the issue in conjunction with the holding study with input from AFS-470.
ACTION: AFS-420, AFS-470 and AFS-450.
