GOVERNMENT/INDUSTRY AERONAUTICAL CHARTING FORUM
Instrument Procedures Group
(Transcribed/Re-Formatted)
HISTORY RECORD

FAA Control # 96-01-156

SUBJECT: Along Track Distance (ATD) Error Assumption in GPS SIAP Criteria

BACKGROUND/DISCUSSION: ALPA presented the question of why along-track (ATRK) fix displacement error of GPS approaches, as specified in Order 8260.38A, is greater than that allowed for DME when close to the DME transmitter. A follow up letter also stated concern about Federal airway fixes being evaluated for considerably less than the 2 mile ATD fix error assumption for en route GPS operations. Documents: Status Document for Government/Industry Charting Forum, Oct 10, 96, AFS-450: Draft paper "Analysis of Fix Displacement Error (FDE) Tolerance Issue," Dr. Young Lee, MITRE, Mar 26, 1997.

The Fix Displacement Error (FDE) published in Order 8260.38A was based on GPS RAIM values. While accuracy was known to be much better than the FDE used, it was determined that the integrity issue should be represented in terms of FDE. This order was developed before practical use of the system had occurred and was considered a conservative approach to assigning an FDE value.

Research and discussions have been ongoing to arrive at a more representative number for GPS FDE including accuracy, availability, integrity and continuity. Some method of combining these values into an overall limit was sought, but no existing studies were found that combined these values. AFS-450 has had discussions with Dr. Young Lee, MITRE Corp., who is a recognized expert on RAIM and GPS integrity, regarding our issue. The GPS Program Office provided funding for Dr. Lee to perform more extended research into the issue. We have now received a preliminary report from Dr. Lee, which discusses how to combine the very low probability of a large integrity (RAIM) error with accuracy.

GPS accuracy is stated as the Horizontal Error value (expressed as Circular Error Probable (CEP)), which is 99.9 meters (95% to 98% of the time). Further, the stated accuracy is 300 meters or less, 99.99% of the time. Clearly normal GPS accuracy is much better than VOR/DME and only rarely approaches the RAIM limits, especially for terminal and en route operations. Further complicating the issue is the fact that a RAIM warning will occur well before the stated RAIM value is reached a very high percentage of the time.

The VOR/DME FDE values in TERPS are 95% accuracy values, with no consideration for other factors such as availability or integrity. A direct comparison of VOR/DME accuracy values to GPS, would be to compare them to the GPS 95% accuracy (99.9 meters) root-sum-squared with the airborne equipment error (0.124 nm en route and terminal and 0.056 for approach) for along track distance error and including CDI/FTE error (0.2 nm and 0.01 nm) for the cross track error. This would yield a value much smaller than even the minimum DME FDE of 0.5 nm. However, it does not take into account the probability of an undetected integrity error.

The 95% accuracy value for FOE for conventional navaids is tightly bounded with ground

monitors which provide the "integrity". Using 95% of the GPS accuracy value does not include GPS integrity which has a much larger limit. However, the GPS RAIM alarm limit covers extremely low probability occurrences (possibly as small as 10E-12 or 10E-15) which are truncated from the VOR/DME values. Therefore, some method of "truncating" the GPS values by a method which results in a protection factor at least equal to the VOR/DME could be used to arrive as a more reasonable value for GPS FDE.

After further discussions, a decision was made to attempt to establish the GPS FDE as a Circular Error Probable (CEP) value that a GPS-based position error would exceed with an extremely small probability (10E-7/hr). (The actual error distribution would be elliptical; however, the shape would be constantly changing, and is not usable for TERPS purposes.) Analysis so far, has shown this value to be approximately 700 meters or approximately 0.4 nm for en route and terminal operations. The RAIM value of 0.3 nm would still apply for approach operations.

This approach may be considered somewhat conservative in some areas. It does not include any adjustment for the probability of the error occurring at the same time the aircraft arrives at a fix. The majority of failures so far have been in Block I satellites which are being replaced, and small duration missed detection of errors, followed by an alarm, is treated as a complete missed detection, and the error is allowed to grow. The very low probability of occurrence of an error larger than the 10E-7 value would still be contained within the existing primary obstacle protection areas, even with full en route RAIM value. However, as previously noted, there is a high probability of receiving a RAIM alarm before reaching the actual limit.

Discussions on applying the CEP of 0.4nm/700 meters (10E-7) to FDE for en route and terminal are ongoing with Dr. Lee, who states that the entire value should be applied. He recommends that the value not be reduced to a 95% (2 sigma, approximately 233 meters) since it would not include all failure conditions

RECOMMENDATION: Discussions with Dr. Lee are progressing. We will continue to work with him to arrive at a final solution which can be used to revise FAA Order 8260.38A.

COMMENT: The solution derived from this discussion may apply to other RNAV type areas as well. The WAAS MOPS and TSO are nearing finalization and the results of this effort should be considered in the final decision of the integrity values to be used in WAAS. At present, the WAAS MOPS contains the similar differences between accuracy and integrity contained in TSO-CI29.

Submitted by: Steve Jackson AFS-420
April 7, 1997

INITIAL DISCUSSION (MEETING 96-01): Wally Roberts, ALPA presented the question as to why the along track (ATRK) fix displacement tolerance for GPS approaches, as specified in Order 8260.38A is greater than that allowed for DME. This poses concern that obstacle clearance requirements may not be satisfied when pilots are flying an overlay approach. Don

Pate, AFS-450 stated that the ATRK errors originally specified for GPS may be overly conservative. This issue is currently undergoing study by AFS-440/450. AFS-440/450 will provide study results the next meeting. **Action:** Item Open (AFS-440/450).

MEETING 96-02: Don Pate, AFS-450, presented a briefing paper on this issue. Research and discussions were undertaken to arrive at a more representative number for the GPS FIX displacement error (FDE) to include accuracy, integrity, availability and continuity. There has coordination with Dr. Young Lee, MITRE Corp., who is a recognized expert on RAIM and GPS integrity. The conclusion thus far is that the FDE is not a problem in the en route arena; however, further study is necessary to reach a final conclusion. It was suggested that, in the interim, ATC provide radar monitoring until aircraft are in approach phase. AFS-450 will continue discussion with Dr. Lee to ascertain accuracy and integrity values as they apply to use of GPS for en route navigation. **Action:** Item Open (AFS-450).

MEETING 97-01: Don Pate, AFS-450 presented a briefing paper on this issue. Research and coordination with Dr. Young Lee, MITRE who is a recognized expert on RAIM and GPS integrity issues, indicate that using GPS for en route navigation on existing airways will not compromise obstruction clearance. Errors associated with GPS fix positioning are considerably less than those associated with conventional NAVAIDs. AFS-450 will continue to consult with Dr. Lee to arrive at a final solution that can be used to revise Order 8260.38A. The consensus was that this issue can be closed. **Status:** Item Closed.