AERONAUTICAL CHARTING FORUM
Instrument Procedures Group
April 28-29, 2003
HISTORY RECORD

FAA Control # 03-01-247

Subject: Holding Pattern Criteria Selection

Background/Discussion: FAA Order 7130.3A, "Holding Pattern Criteria," contains the containment criteria for all FAA holding patterns. The criteria assumptions contained in this order are predicated on a March 31, 1964 order, FAA Handbook AT P 7130.8, "Development of Holding Pattern Criteria and Procedures." 31 holding pattern templates were developed to fit over 100 different combinations of indicated airspeed (IAS), altitude, and distance from facility in the case of ground-based navaids. Averaged seasonal winds aloft were part of this extensive 1964 evaluation. An important fact is that the width and length each of the 31 templates are intrinsically linked. Thus, if you select a smaller pattern to conserve length, you also reduce the protected airspace for the dead reckoning entry and outbound flight.

In what appears to be a 1997 amendment to FAAO 7130.3A, a section was added to provide for the selection of GPS (RNAV) holding patterns. This GPS selection process reduces the pattern size by two to five pattern sizes, for a given altitude and IAS. An example is attached that shows holding at the missed approach fix for the KSUN RNAV (GPS) Rwy 31 SIAP. The selection process requires that the pattern for 230 knots, IAS, and 10,000 feet, be selected for this fix. If the non-GPS, holding-at-facility selection table were used, Pattern #9 would be used. But, because the GPS selection process was used, Pattern #7 would be used. A simulation with a 60 knot wind from the north was used and an IAS of 230 knots was used, which resulted in the ground track shown both in Figures 2 and 3. The track shown is not the entry turn, rather it is the first turn to enter a complete circuit of the holding pattern (the first turn subsequent to the entry turn). As you can see, containment is nearly breached in the DR outbound turn.

It appears that the selection process for GPS holding patterns was reduced because distance holding can be used all of the time instead of timed holding. Although reduction in the length of a GPS holding pattern is probably justified, a reduction in the width of the pattern is not. The wind, IAS, and turning performance assumptions made in the 1964 study are still valid (and required) for today's GPS flight operations until such time as the entire holding pattern is a positive course guidance (PCG) procedure, and predicated upon valid, updated studies of winds aloft, and turning performance in conditions of PCG. Most, if not all, TSO-C129A avionics devices require DR flight for both entry and outbound flight in the holding pattern. And, even the high-end LNAV platforms that employ a PCG scheme throughout the pattern probably are not reconciled to Order 7130.3A pattern containment areas.

Further examples of unjustified pattern size reduction for GPS are as follows: 10,000 feet, 265 knots—non-GPS selection results in Pattern #11; GPS selection results in Pattern #8. 14,000 feet, 310 knots—non GPS selection results in Pattern # 18; GPS selection results in Pattern #14. See Figures 4 and 5. (These are pattern sizes used for climb-in-hold "CIH" extraction patterns.)

The 1964 Order 7130.8 is available on my web site as an Acrobat file. Appendix 2, page 1 shows the intrinsic relationship between pattern width and length:

http://www.wallyroberts.com/hpcriteria

A related issue is the ambiguity about when either 265 or 310 knot holding is authorized for CIH purposes. Although there is some general AIM guidance about when 310 knots is authorized, the pilot has no way of knowing where it is safe to climb at speeds greater than level flight holding speeds.

Finally, the leg lengths that the GPS selection process specifies are often unflyable in adverse wind aloft conditions. Although 4-mile legs are shown at PRESN waypoint, 6-miles should have been charted. But, even 6 miles is an unflyable leg length under the wind conditions simulated for Figures 2 and 3.

Recommendations: That the GPS selection table in FAAO 7130.3A immediately be brought into conformance with the hold-at-facility selection table for non-GPS holding. Further, that charted leg lengths mileage values be of sufficient length to be flyable in jet aircraft, which operate at maximum level-flight holding speed, and with the assumed maximum adverse winds aloft existing during the hold. Further, the values to be charted must not be greater than the leg lengths that are provided for non-radar, timed holding.

In the future, PCG holding criteria should be developed, but only after all IFR-certified RNAV/GPS avionics are capable of PCG flight throughout the entry and entire circuit of the pattern, and in conformance with the containment criteria.

Although some efforts are already underway to clarify and chart CIH authorizations, that effort should be expedited.

Comments: This recommendation affects FAAOs 7130.3A, 8260.19C, the Aeronautical Information Manual (AIM), and IACC charting specifications.

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Date: April 4, 2003

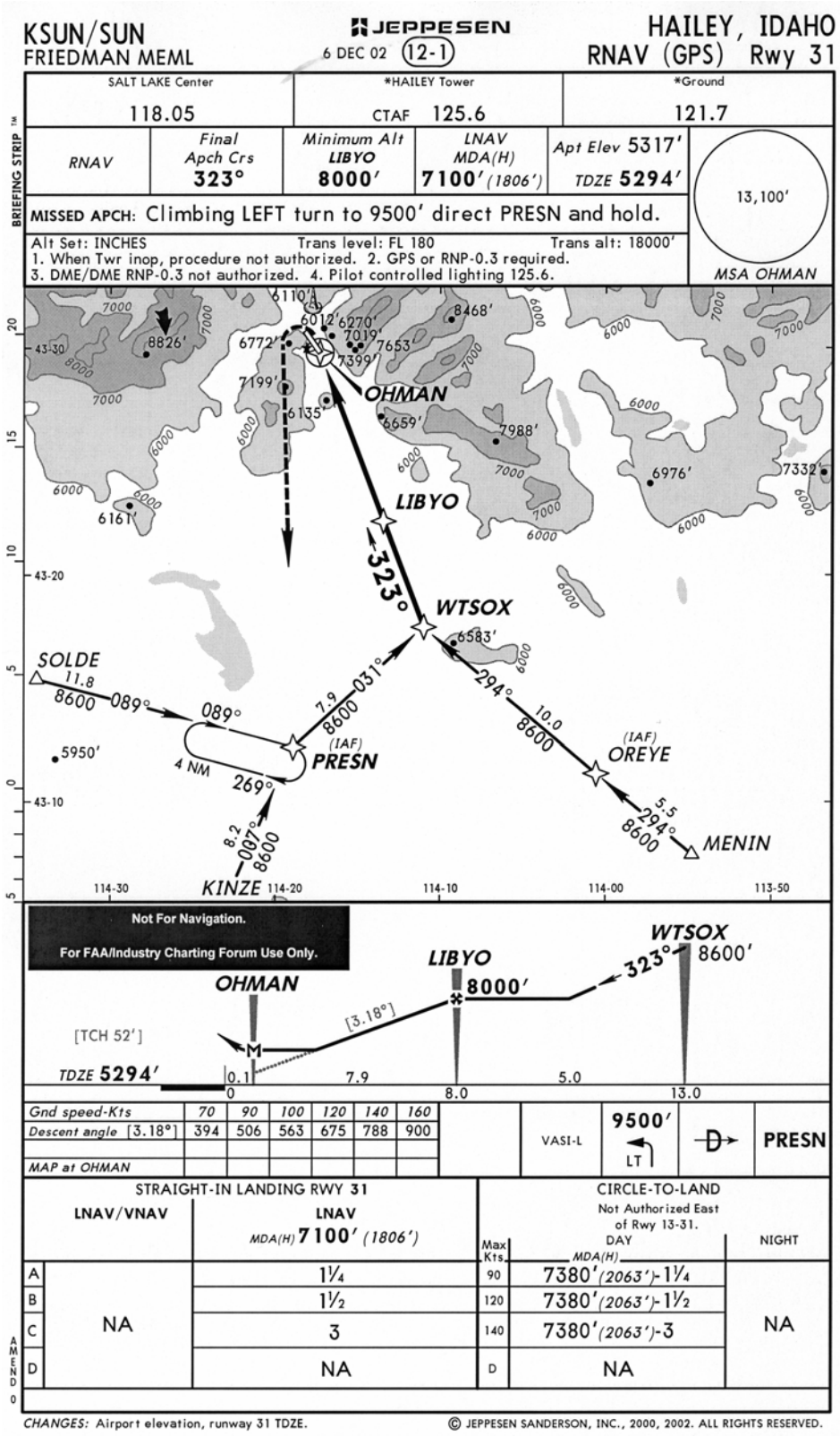

Figure 1 – Jeppesen Chart – KSUN RNAV 31

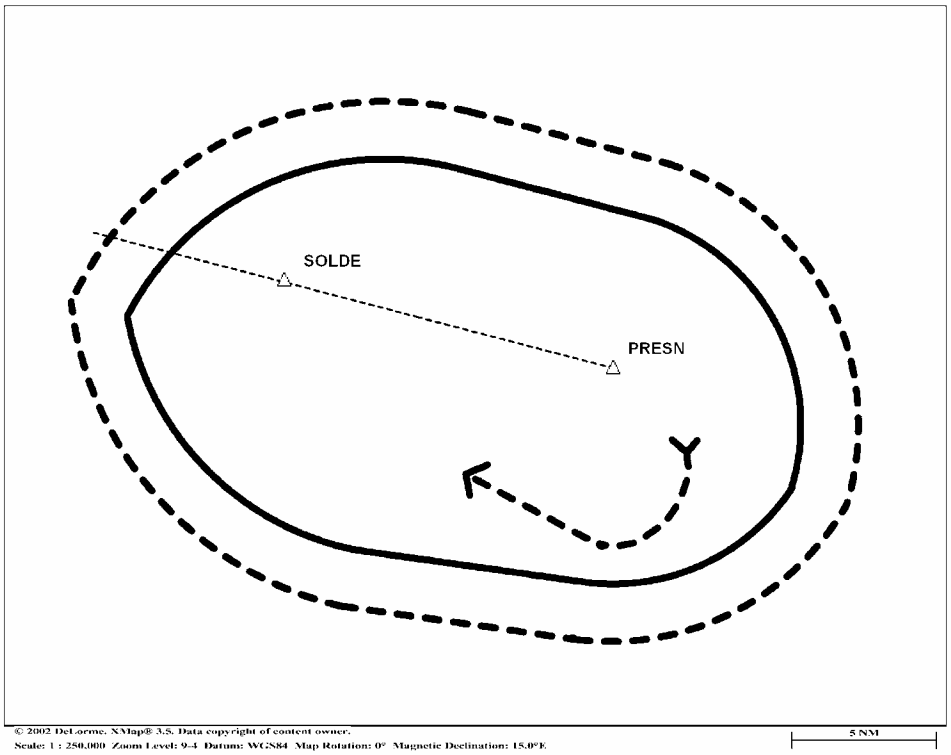

Figure 2 – Pattern Template 9

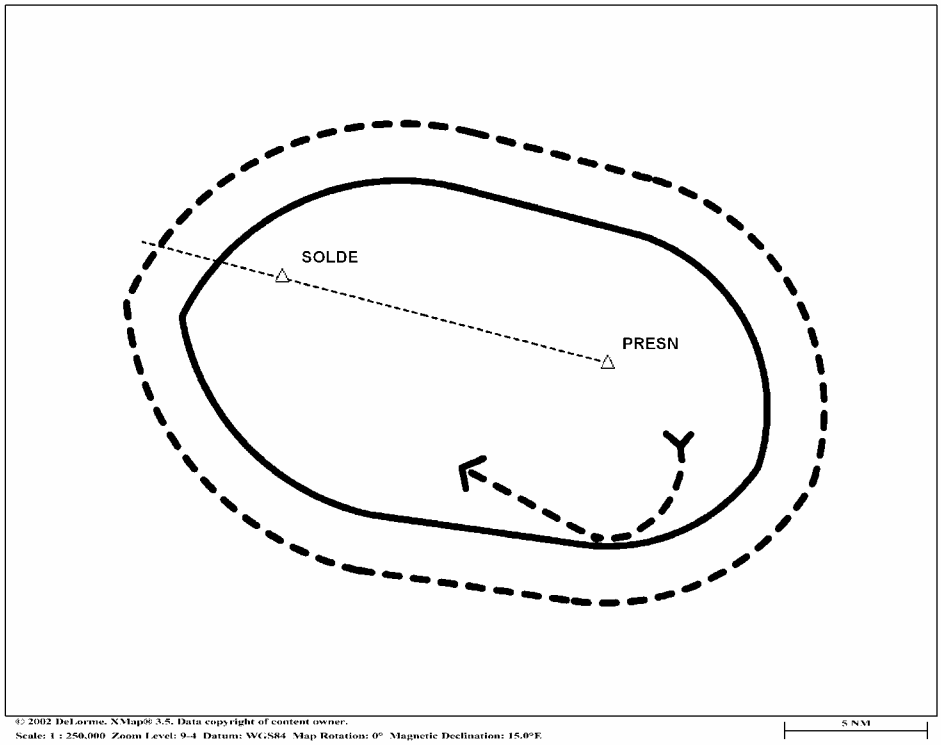

Figure 3 – Pattern Template 7

Parameters: Holding east of the facility/waypoint on the 270-degree (true) bearing, right-turns, 1-minute legs. 310 knots, IAS, 14,000 feet, ISA +15 degrees, Celsius. Wind from 180 degrees, true at 60 knots. Track shown is first turn subsequent to teardrop entry while wind correction is still being assessed.

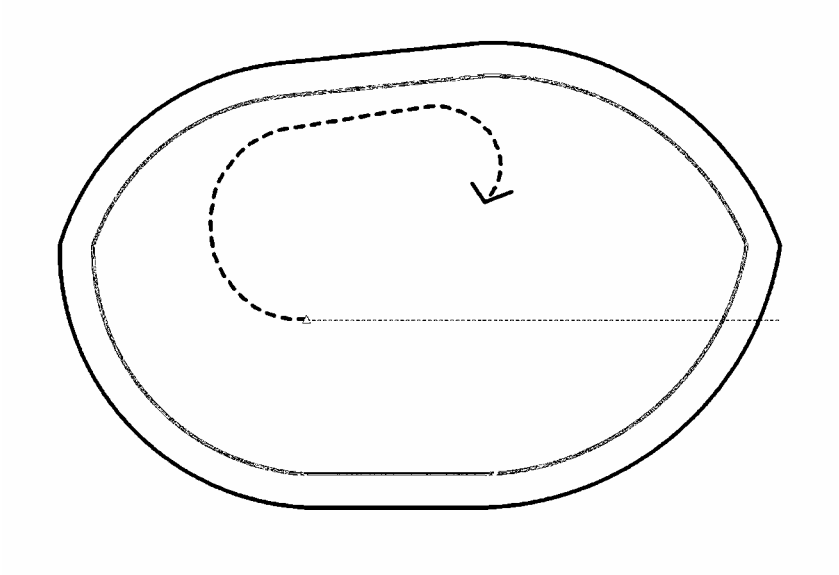

Figure 4 – Pattern Template 18

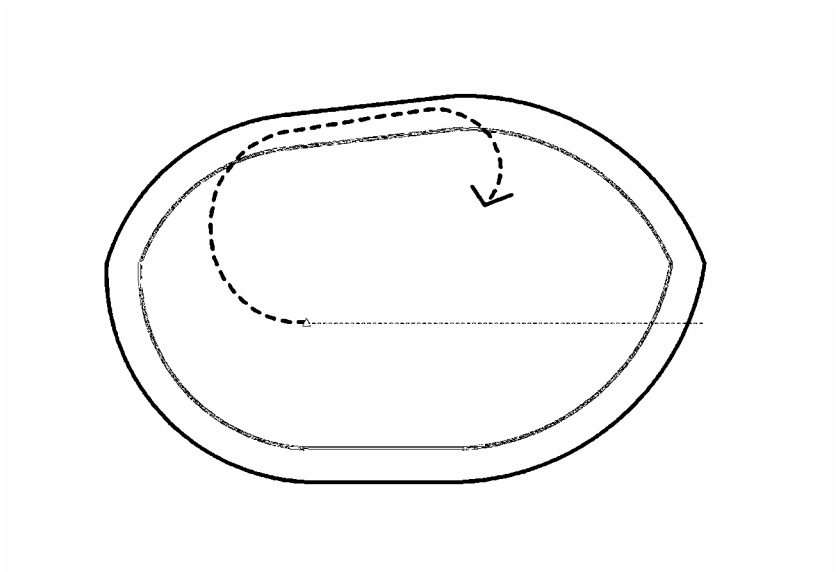

Figure 5 – Pattern Template 14

Conclusion: This evaluation validates the 1964 study and resultant holding pattern criteria for dead reckoning entry and outbound flight. It shows the 1997 “GPS” selection-process-reduction is invalid, as the flight parameters used are not extreme and thus should not result in departing the primary area and nearly departing the secondary area.

Initial Discussion - Meeting 03-01: New issue submitted by Wally Roberts, Aviation Consultant. The issue raises concern over the holding pattern size reduction for GPS holding verses the pattern size required for conventional NAVAID/fix holding. Wally is concerned that this reduction may have been subjective and rather than based on a full technical analysis. Bill Hammett, AFS-420 (ISI) briefed that the manager of AFS-420 has directed a full Airspace Simulation and Analysis for TERPS (ASAT) evaluation of GPS as well as helicopter/STOL holding pattern sizes. The results will be briefed to the ACF when complete. Bill recommended that the issue be re-titled "Holding Pattern Criteria Selection" as the climb-in-hold portion of the paper is being addressed under issue 02-01-241. The attachment relating to climb-in-hold will also be transferred to issue 02-01-241. Past experience has proven that issue papers that cover more than one topic often become confusing and become difficult to manage and resolve. The group agreed.
ACTION: AFS-420.

MEETING 03-02: Bill Hammett, AFS-420 (ISI), briefed that this issue went awry within AFS-420 and a study was initiated on helicopter/STOL holding. The issue has been re-focused to conduct an Airspace Simulation and Analysis for TERPS (ASAT) evaluation for holding pattern selection as requested in the original issue paper. ACTION: AFS-440.

Editors Note: *On November 3rd, AFS-420 was re-organized into two branches. AFS-420 will retain TERPS criteria and policy. AFS-440 will assume all ASAT and simulator functions.*

MEETING 04-01: Tom Schneider, AFS-420, briefed that the GPS holding pattern study has been tasked to AFS-440 for Airspace Simulation and Analysis for TERPS (ASAT) study. A test plan has been developed that will not only assess the original GPS holding issue, but include helicopter and STOL holding patterns as well. The analysis will take approximately two years. Mark Ingram, ALPA, asked if the smaller GPS holding patterns could be held in abeyance pending results of the study. Steve Bergner, NBAA, noted that pilot use of GPS to navigate to a holding fix does not necessarily mean that positive course guidance is provided while holding. Both ALPA and NBAA believe that the GPS criteria is suspect and recommend using the larger conventional holding patterns to preclude having to amend procedures later. Jeff Formosa, MITRE, asked why RNP holding was so far down on the ASAT priority list. Tom agreed to discuss this and the ACF-IPG concerns with the Managers of AFS-420 and AFS-440. ACTION: ACF-IPG Chair and AFS-440.

MEETING 04-02: Tom Schneider, AFS-420, briefed that a study is ongoing by AFS-440 on this issue. Thus far, the desktop analysis has been completed for helicopter holding. The analysis confirmed that the patterns in FAA order 7130.3, *Holding Pattern Criteria*, Chapter 5, does not provide sufficient protection for aircraft conducting an entry to holding on the non-maneuvering side of the holding pattern. The HELICOPTER/STOL holding patterns criteria did not include a GPS horizontal fix error (+/- .5 NM) allowance, nor did it protect for an aircraft being blown off course by a crosswind on the initial turn when the aircraft is under dead reckoning guidance on the initial turn outbound. As a result of the study thus far, AFS-420 issued a policy memorandum to AVN-1 on June 17th directing that Order 7130.3A, Chapter 2, Conventional Holding Criteria be used to develop all RNAV holding patterns. The minimum pattern size to be used in the interim for helicopter RNAV procedures is pattern template size four.

Testing to be completed includes helicopter holding at the FAA Tech Center, which will be used to validate AFS-440 helicopter computer models that will then be used for data collection for criteria development. Also, FAA order 7130.3, Chapter 6 is to be re-evaluated. The time frame for the completion of these tests by AFS-440 has been revised due to the loss of a key person that was responsible for these tests. Tom handed out a revised project completion timeline. The tentative date for completion of these tests by AFS-440 and submitting the data to AFS-420 is 1 July 2005. Based on these time lines AFS-420 expects to have criteria ready for review before 3 March 2006.
ACTION: AFS-440.

MEETING 05-01: Tom Schneider, AFS-420, briefed the following status report provided by Richard Greenlaw, AFS-440. AFS-440 has begun a project to deliver GPS, helicopter, STOL, CAT AB, Conventional, and RNP holding criteria analyses. Requirements & priorities for the project have been established and the following schedule is provided for the ACF-IPG's information: GPS holding analysis results by 8/31/05; conventional holding results by 10/31/05; helicopter/STOL/CAT AB results by 11/30/05; and RNP results by 3/1/06. The GPS holding model has been built (on schedule) and the GPS simulation tool is under development (on schedule). ACTION: AFS-440

MEETING 05-02: Tom Schneider, AFS-420, briefed the following status report on the issue, which was provided by Dr. Richard Greenlaw, AFS--440. Requirements & priorities have been established for the project. However, the contractor failed to deliver the holding simulation tool on schedule. The new delivery date for the tool from the contractor is December 30. As a result, AFS-440 has changed the delivery schedule as follows (old dates in parenthesis, followed by revised dates):

- GPS Holding Analyses Results by (8/31/05) 4/27/06
- Conventional Results by (10/31/05) 4/27/06
- Helicopter/STOL/Cat AB Results by (11/30/05) 4/27/06
- RNP Results by (3/1/06) 6/21/06

ACTION: AFS-440

MEETING 06-01: Tom Schneider, AFS-420, briefed that he coordinated with Dr. Richard Greenlaw, AFS-440, and the project is awaiting software delivery. The software is due in April, at which time analysis will begin. Scheduled completion dates are as indicated below:

- GPS Holding Analyses Results by 4/27/06
- Conventional Results by 4/27/06
- Helicopter/STOL/Cat AB Results by 4/27/06
- RNP Results by 6/21/06

ACTION: AFS-440

MEETING 06-02: Tom Schneider, AFS-420, briefed the following progress report as received from Dr. Richard Greenlaw, AFS-440: "We have recently received the holding analysis software from the contractor. This software will allow us to run simulations for multiple types of holding at various altitudes and aircraft speeds with variation in variables such as wind speed and direction. We will analyze conventional (including low speed) holding first, then GPS holding, then RNP holding. Our plan calls for conventional holding to be complete by March 2007." AFS-420 will update Order 7130.3 after the study is complete. ACTION: AFS-440

MEETING 07-01: Tom Schneider, AFS-420, briefed the following progress report as received from Dr. Richard Greenhaw, AFS-440: The holding pattern analysis is on schedule. The following target dates are applicable:

GPS Holding Report: 7/2/2007
Conventional (including Helicopter/STOL/Cat AB) Holding Report: 7/2/2007
RNP Holding Report: 9/4/2007.

AFS-420 will update Order 7130.3 as necessary after the study is complete.

> ***Editor's Note**: After the ACF-IPG meeting, the following update was received from Dr. Greenhaw: After reviewing the holding test results with Carl Moore and Greg Cox here in AFS-440, we have decided to ask the contractor (ATSI) to modify the pilot model to more accurately reflect typical pilot behavior during a holding operation. This will likely delay our report date for about 45 days. However, we believe the change to the software is necessary and that neither AFS-420 nor AFS-440 would be satisfied with the results without this change.*

ACTION: AFS-440

MEETING 07-02: Tom Schneider, AFS-420, briefed the following progress report as received from AFS-450, the office now responsible for the study. On October 16th, AFS-450 reported that they have changed lead analysts on the project; however, Dr. Richard Greenhaw will still be involved in the project. The new Lead, Dr. Sherri Avery, reports that the Branch is still waiting on a new version of ATSI's Holding Simulation Software containing a more accurate pilot response model. ATSI has been reminded of the need for the updated software to complete the analysis. AFS-420 will update Order 7130.3 as necessary after the study is complete. ACTION: AFS-450

MEETING 08-01: Dr. Sherri Avery, AFS-450, briefed she has recently taken over the holding study. There has been some recent progress; however, the holding pattern software tool was delayed due to erroneous pilot assumptions. New logic has been developed and the software tool is expected very soon. Conventional holding evaluations will be accomplished first to be followed by an RNAV holding assessment.
ACTION: AFS-450