

October 5, 2015

Ms. Margaret Gilligan
Associate Administrator for Aviation Safety
Federal Aviation Administration
800 Independence Avenue
Washington, DC 20591

Dear Peggy:

The Performance-based Operations Aviation Rulemaking Committee (PARC) is pleased to submit the following recommendations which address design and operational issues regarding two types of procedures; procedures using 'radius to fix' legs, and others that use 'track to fix' legs.

The PARC Navigation Working Group was assigned these tasks, which they completed in September 2015. The WG recommendations were approved by the PARC SG during the September 25, 2015 telecon discussion. The attached recommendation includes more detail for your review.

PARC has retained a history of meetings and backup substantiation of conclusions on the PARC website. The PARC appreciates your continued support of its activities and invites you to discuss any aspects of these recommendations at your earliest convenience. The PARC respectfully requests the FAA to provide the PARC with a formal response.

Sincerely,



Mark Bradley
Chairman, PARC

Cc: B. DeCleene
M. Steinbicker
M. Cramer

OPS & DESIGN GUIDANCE RECOMMENDATIONS FOR RNP (TF/RF) to ILS**Background**

The PARC Navigation WG was tasked with defining design criteria for RNP to xLS instrument approach procedures in early 2014. The WG narrowed the scope to ILS to begin with, and provided recommendations for the design of RNP (RF) to ILS temperature compensated procedures in August of 2014. Those recommendations were approved by the SG and forwarded to FAA to become part of 8260.58A. The SG then asked the WG to continue to develop an RNP (TF) to ILS design as well as to provide operational and design guidance for the use of these types of procedures. This document provides that guidance, and the WG will move forward with RNP to GLS and LPV operations in the coming year.

The working group based the TF procedure design directly on the RF designs, using the final and intermediate segments of the RF design unchanged. Additional fixes (3) were added to provide for three 60 degree TF-TF (fly-by) turns to transition from downwind to final in lieu of the single RF leg. An additional distance prior to the IF was added to allow for turn anticipation prior to the IF which accommodates the last flyby turn to final rolling out just prior to the FAF.

When the TF design concept was completed, plans were made to test the procedures in airline and manufacturer simulators to gain experience in a representative cross-section of the current fleet. The first test procedures were all RF designs, a total of 18 of them to the ILS for RW28R at KSFO. The 18 procedures covered all the major design variations (all combinations of 1) final lengths of 3, 4, and 5 NM; 2) shallow segments of 0, 1, and 2 degrees, and 3) RF turns to final of 2 and 3 NM). The TF procedures were designed as overlays of six of the 2 degree shallow segment RF designs, also at KSFO. Later, some of the procedures were relocated to a high elevation airport (KDEN) to show that the shallow segment design still accounted for the design ISA deviation even at a higher elevation airport.

The first tests were conducted at Boeing in November, 2014 to test three variations. First, the aircraft that has the most restrictive (tightest capture criteria) (B737) was tested, then an aircraft with an older generation autopilot (B747-400) was tested and finally, an aircraft (B787) with the latest generation autoflight system was tested. These were all done in Boeing engineering test stations over a range of temperatures using the KSFO procedures. Each trial flight captured as expected when flown on both the hottest and a normal day. At this point, the WG started plans to test in CRJ, ERJ and Airbus systems. The CRJ200 was tested by ExpressJet (Delta) in Atlanta after Rockwell provided us with a navigation database (NDB) containing the test procedures. The ERJ145 was tested in Houston by ExpressJet (United) using a Honeywell provided NDB. We also tested in the A330 (Delta) in Atlanta with a Honeywell NDB. Thanks to our Honeywell and Rockwell colleagues for providing the test databases.

The conclusion was that for all the tests, conducted both at standard day temperature and the plus 35 degree delta ISA, the localizer and glideslope captures occurred at the expected locations and aircraft operations will not be required to deviate from standard current practice with the exception of the precautions applied noted below for the CRJ200 fleet. It should be noted that

although all the tests were for normal or above ISA deviation, the procedures will be utilized in below ISA conditions as well. Testing for cold weather operation was not included because operationally these procedures will have the same characteristics as present day ILS operations. Criteria provides protection for ILS procedures initial and intermediate segments, and the yearly cold temperature analysis of all procedures will provide a lower limit for airports and their procedures if necessary. Operationally the GS captures will occur later on the procedure for the cold day, perhaps even after the FAF, but this is no different than current operations and designs.

Lessons Learned During Testing

The following were the takeaways from the various tests:

- 1) CRJ and ERJ operation –
 - a) Manual intervention is needed to transition to ILS guidance from RNAV,
 - b) The transition must be delayed until nearly on final approach course, therefore
 - c) Operator pilots preferred the longer intermediate and final (2 degrees and 5 miles)
- 2) Airbus operation –
 - a) The autoflight operation does an automatic transition to ILS when capture criteria are satisfied,
 - b) No issues were experienced with the shortest, 3 NM final or the 2 NM RF radius
 - c) The crew can arm for approach on downwind or on the RF approaching the IF. However Airbus logic allows a descent to the IF altitude to occur before the RF is complete resulting in level flight until the IF. ATC says that is not a problem as those systems behave that way on all procedures.
 - d) Arming on the downwind is not recommended as we experienced a GS capture on the downwind resulting in a climb because of the temperature error on the hot day. The Airbus flight crew manual recommends not arming until on an intercept course to final.
- 3) Boeing operations –
 - a) The autoflight systems all do an automatic transition to ILS when criteria are satisfied,
 - b) No issues were experienced with the shortest, 3 NM final or the 2 NM RF radius
 - c) The approach can be armed anywhere along the procedure, but it is best (as with Airbus, Boeing flight crew procedures recommend this as well) to wait until later on the turn to final,
 - d) ILS capture occurs without a transient maneuver,
 - e) GS capture was as predicted for both sea level and high elevation airports.

Recommended Guidance for Design and Operations

Based on the candidate procedures designs and the operational testing on many variations of the procedures in representative aircraft / avionics combinations, the Navigation Working Group recommends that the following elements of procedure design guidance and of operational guidance be approved by the SG and forwarded to FAA and operators as necessary:

Procedure Design Guidance

- 1) Intermediate segment design:
 - a) Design the intermediate segment based on +40C Δ ISA; this generally allows the desired glideslope capture from below at the majority of locations and recorded temperatures. Allow the use of historical temperatures at the procedure location by designing the intermediate segment using an ISA deviation that is higher than 95% of the recorded temperatures in the past five years.

- b) Design the intermediate segment as close to a 2 degree descent gradient as possible; this provides more time for the RJ crews to set up for the capture of the ILS and should not require added power,
 - c) Note that it would be possible to allow the intermediate segment to lie along the RF turn to final should operations require it.
- 2) Final segment design
- a) Design the final segment at or near 5 NM in length, but do not preclude the use of shorter final segments when operationally necessary. The recommended minimum length is 3 NM, however we also recommend that shorter segments be allowed with AFS approval.
 - b) When designing to an existing ILS, use the final segment without modification; this also provides more distance for the RJs if they should have difficulty with the capture,
- 3) Recommend that the turn radius to final (offset of downwind to final = 2 times radius) be chosen based on operational need and current criteria bank / speed, without limitation based on RNP value. The 2 NM radius worked well for all the tested aircraft, LOC capture occurred normally.
- 4) Place an AT or BELOW speed at the start of the RF or first TF turn point that is appropriate for the design winds and the altitude of the turn to assure lateral conformance with the turn radius.
- 5) Given the final and intermediate segments noted above, the WG recommends that each location (airport) be given the option to use either the RF to final or the TF-TF-TF to final subject to the following to limit path length stretching:
- a) Design an RF to final first, where the end of the 180 deg RF is the same as the intermediate fix (start of the shallow segment); this gives the shortest path length,
 - b) Design the TF-TF-TF version by adding a turn fix on the extended intermediate segment course a minimum distance equal to the turn anticipation distance (DTA) prior to the IF (DTA is based on the speed restriction that begins the turns to the final course); this provides the least amount of extension of the path,
 - c) Design the remaining two fixes for the TF transitions to meet standard TF criteria, with turn angles of 60 degrees at each fix,
- 6) The WG recommends that guidance include a strong preference for the RF design while still allowing the TF design as an option if necessary to accommodate those aircraft not RF capable, depending on traffic mix.

Operational Guidance

- 1) Boeing and Airbus – cockpit operation is no different for these procedures than for current procedures with a downwind and 180 degree turn to final. While technically approach mode can be armed on the downwind, during the A330 tests we demonstrated a GS capture on the downwind on the hot day that resulted in a climb. Therefore, the working group concurs with the Boeing and Airbus crew manual recommended practice of arming when nearing the final approach course.
- 2) CRJ200; ERJ145 - Operators without the ability to transition from RNAV to ILS automatically will operate the aircraft like they do now, but they should provide flight crew training that includes explanation of the shallow intermediate segment. In addition, manual tracking of the VDEV indication is new to crews as they must control to cross the IF “AT” altitude, and consideration should be given to this operation as part of annual training. On very hot days the aircraft will fly through the glideslope from below very early in the intermediate segment. The required actions (changing from RNAV to ILS guidance) need to be complete at or shortly past the Intermediate Fix that begins the shallow segment.