

July 23, 2018

Mr. Ali Bahrami  
Associate Administrator for Aviation Safety  
Federal Aviation Administration  
800 Independence Avenue, SW  
Washington, D.C. 20591

Dear Ali,

The Performance Based Operations Aviation Rulemaking Committee (PARC) is pleased to submit the following recommendation for your consideration. The PARC Navigation Working Group (NAV WG) completed an analysis in which the maximum bank angle allowed during RF (radius to fix) turns was looked at. The resulting recommendation allows for an increase in the limit to the bank angle from 20 to 25 degrees. The WG provided data to show that the margin remains within the limits of aircraft capabilities and system performance. Additionally, revising the bank angle limit in the design standards will allow for a greater number for beneficial procedures in locations that today would be unable to implement.

The PARC remains focused on reviewing and improving procedure designs and fine tuning criteria where appropriate, based on data driven comprehensive analysis. The performance based paradigm remains a foundational component in the evolution of NextGen.

PARC appreciates the continued energetic collaborative spirit and productive dialogue between the FAA and industry. Thanks to Navigation WG Chairman Mike Cramer and all of the participants for their dedication to this effort! The PARC also respectfully requests the FAA to provide us with a formal response to these recommendations.

We appreciate your continued support of our activities. Please call me if you have any questions or would like to set up a discussion.

Sincerely,



Mark Bradley  
Chairman, PARC  
404-915-2144

Cc: Mark Steinbicker  
Mike Cramer  
TJ Nichols  
Merrill Armstrong  
Lou Volchansky

**Problem Statement**

When designing PBN procedures (RNP AR, e.g., RNAV(RNP), or non-AR, e.g., RNAV(GPS)) using RF (radius to fix) turns, the procedure design criteria (8260.58A) limits the maximum bank angle that may be used in defining the minimum radius turn. The design criteria currently limits the bank to 20 degrees for RNP values below 1 NM, while allowing 25 degrees maximum for RNP 1 and higher. The design criteria also uses the 99% historical wind to compute the highest ground speed expected for the turn, thus setting the minimum radius for an RF turn. Per AC20-138D, Appendix 7-1c, all systems that can be approved for RF will need to utilize up to 25 degrees of bank for controlling to the path to pass some of the tests in the Appendix. Limiting the design bank angle to 20 degrees for RNP<1 preserves 5 degrees of bank margin AND accounts for the groundspeed induced by the 99.9% wind value, either one of which alone makes it very unlikely that the aircraft will depart the path under any conditions reasonably expected to occur.

MITRE did an FMS study several years ago which showed that when winds are accounted for, there is no need to preserve a bank margin as well. This was based on simulation data (many tracks and path configurations), and will be made part of this recommendation. The paper concluded with “The analysis and data support the position that design of the minimum radius using the full bank authority of the majority of aircraft (25 degrees) can be incorporated in the standards. The data show that one could eliminate the bank margin, but that to do so one must retain the adverse winds assumption.”

Additionally, since the time the analysis was done in 2009, RTCA SC-227 has updated the RNP RNAV MASPS (DO-236C) to require that all future systems must have control bank authority up to 30 degrees.

**Recommendation**

Amend the procedure design criteria in Order 8260.58A regarding maximum bank angles and remove the breakpoint for RF leg design at RNP 1. Set the new, maximum bank angle for RF legs to 25 degrees for all RNP values, including RNP values less than RNP 1.0 (RNP<1.0).

**Discussion / Reasoning**

Full analysis and reasoning behind the recommendation is contained in the MITRE paper “Analysis of Radius-to-Fix (RF) Bank Angle Margin Requirements”, Cramer/Herndon/Sprong, April 2009, MP090076.

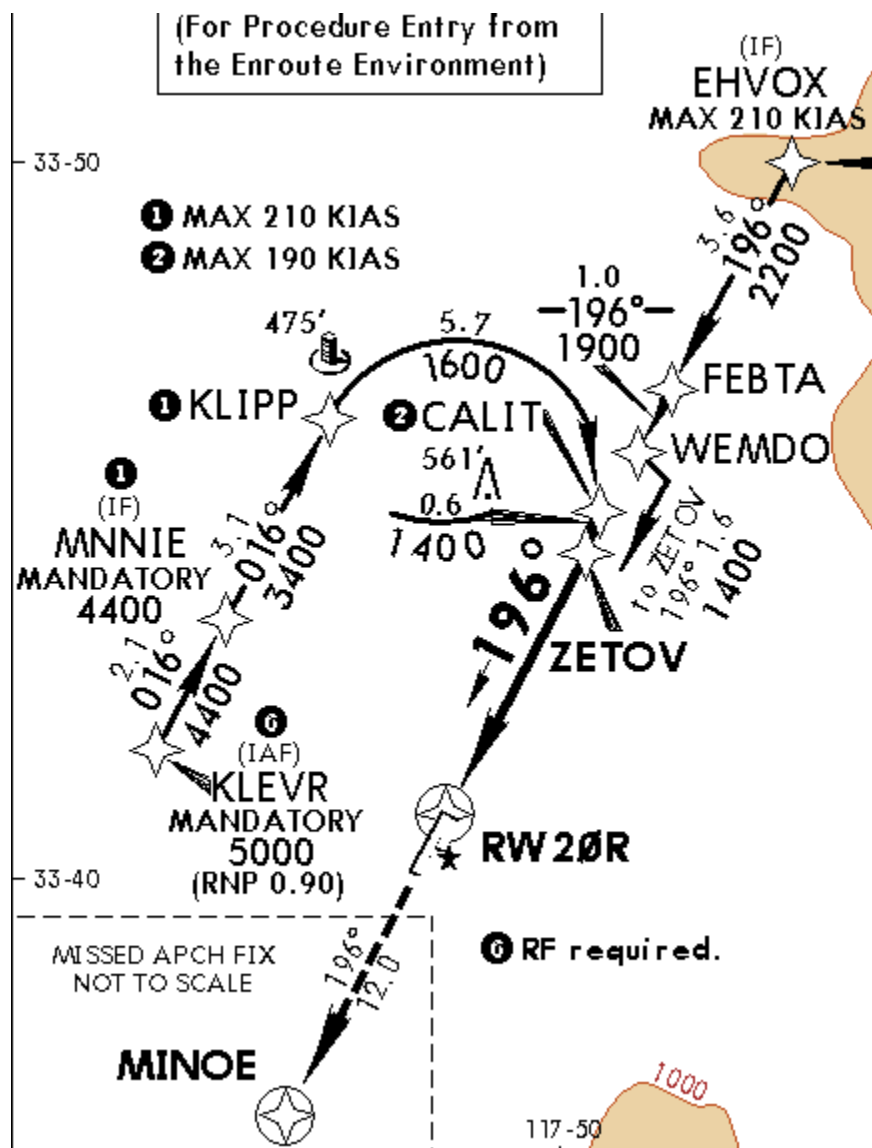
Reference DO-236C, Paragraph 2.6 Lateral Control Performance for the control authority requirement of 30 degrees for future systems.

Reference AC20-138D, Appendix 7-1c for the bank limit tested to in the RF demonstration for approval to use RF.

**Benefit Examples**

**Example 1 KSNA RWY 20R**

The procedure below at KSNA is an example of a procedure that when designed at RNP 1 picked up the obstacle near ZETOV, so the RNP value had to be reduced to 0.9 and which caused the addition of CALIT to change the arc radius. The designer was allowed to use 25 degrees from KLIPP to CALIT, however was not allowed to use 25 from CALIT to ZETOV. To preserve the ground track (the RF radius) from CALIT to ZETOV when using 20 degrees the optimal 210 KT needed to be reduced to 190 KT at CALIT. If the bank limit could remain at 25 degrees, the procedure could be 210 KT until established on the final approach course for configuring for landing.



**Example 2 - RNAV (RNP) Z Rwy 13R at KSAT**

The procedure below is another example of suboptimal design (speed limit) having to be applied to preserve the RF radius when the RNP needed to be less than 1 causing the maximum allowed bank to be reduced to 20 degrees. In order to satisfy the criteria, the maximum speed in the RF turns had to be reduced to 180 KT, which means extra drag due to flap extension to maintain that speed. If the maximum bank did not change at less than 1, the speed could again remain at 210 KT clean maneuvering speed for a more efficient procedure.

