December 1, 2016

Ms. Peggy Gilligan
Associate Administrator for Aviation Safety
Federal Aviation Administration
800 Independence Avenue, S.W.
Washington, D.C. 20591

Dear Peggy:

The Performance-based Operations Aviation Rulemaking Committee (PARC) is pleased to submit the following recommendation regarding precipitous terrain criteria related to specific performance-based operations which is summarized below.

Accounting for the high fidelity performance tolerances of modern day RNP capable aircraft, the PARC Navigation Working Group (WG) proposed several revisions to existing criteria that will allow for more streamlined and efficient procedure development and will not affect the current level of safety associated with these operations. The criteria was duplicitous in many circumstances, or not necessary during the noted operations.

The WG gathered SME's from all disciplines associated with the tasking, and provided a data driven analysis. The WG highlighted specific immediate beneficial impacts at airports which would allow for restoration of existing RNP AR procedures (Sun Valley, Idaho) or allow for modifications to existing procedures that provides more efficient procedures. (Boise, Oakland, Portland & San Jose). More operational benefits will most likely emerge with follow-on analysis.

It is the request of the PARC Steering Group, as always, that we be provided a formal response.

The PARC appreciates your continued support of our activities and invites you to join us in a discussion of these recommendations at any time at your convenience. 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: Bruce DeCleene
Danny Hamilton
Mark Steinbicker
Mike Cramer

The following proposal was received from Industry with a request for Nav WG review:

The current criteria for RNP AR contains a blanket prohibition on providing VNAV on the final approach over precipitous terrain, see emphasis below:

> "RNP approaches are 3D procedures; the final segment provides the pilot with final segment vertical and lateral path deviation information based on BaroVNAV systems. Therefore, RNP procedures may not be developed for locations where the primary altimeter is a remote altimeter **or where the final segment overlies precipitous terrain**."

The proposal to the Nav WG from Industry forwarded through AFS is repeated below:

> "The PARC should recommend to the FAA that the foregoing highlighted criterion be deleted from FAAO 8260.58, Volume 5, and instead any precipitous terrain in any segment of an RNP AR approach procedure is subject to the same precipitous terrain risk assessment done for all other instrument approach procedures."

The working group, during its deliberations on this topic, was asked by SWA to expand the investigation into STARs that feed IAPs to explore harmonization between the two for additional ROC in precipitous terrain. At some locations IAPs are being extended much further from the airport than they should be to accommodate the 1700' ROC for the STAR. The WG agreed to take this up, and the SG asked us to combine the two activities.

This paper recommends solutions for both the AR problem and the STAR / IAP connection. The WG also added a recommendation regarding the current prohibition of LNAV/VNAV over precipitous terrain in the final segment, as it seems very similar to the RNP AR issue. The specific WG recommendations are presented in the next section; followed by a discussion of the reasoning and substantiation behind the recommendations in the last section.

Navigation Working Group Recommendations:

Regarding RNP AR:

1. Recommend that FAA remove the current restriction that prevents RNP AR IAPs from being developed where the final segment overlies precipitous terrain. (Reference: 8260.58A, 4-2-1b Restrictions.)
2. Recommend that no precipitous terrain additive ROC be applied to the RNP AR final segment, additives may still apply for the initial and intermediate segments. (Reference two analysis papers from AFS-420 showing a general equivalence between the DA achieved using RNP AR VEB with no correction and ILS with correction into the same location; paper is captured on the PARC website).

3. **Immediate Impact**: Sun Valley – all RNP AR approaches have been cancelled due to precipitous terrain under final segment. Since they are already designed and have been in operation for years, they could simply be restored to service. Monterrey – similar to SUN, approaches were cancelled and could be restored immediately.

Regarding STAR-IAP connection:

1. Recommend that, where necessary to merge a STAR with an IAP in mountainous terrain, current criteria be modified to allow reduction to 1000' of ROC on the portion of the STAR where the distance to be flown to the initial approach fix is 50NM or less.
2. **Immediate Impact**: BOI – KOURT STAR, OAK – EMZOH STAR, PDX – HHOOD STAR, SJC – SILCN STAR. Could be shortened, made less steep and less complex in design.

Additional Recommendation for LNAV/VNAV

1. Recommend the FAA evaluate removing the prohibition of LNAV/VNAV final over precipitous terrain. This is needed to prevent a scenario where LNAV/VNAV isn't published and yet an LNAV line is published. The reason is that it is likely that the LNAV procedure will be flown with baro-VNAV advisory vertical guidance which introduces an inconsistency in application. Further, all of the evidence cited in the section below applies equally to LNAV/VNAV as to RNP AR since the vertical guidance is the same.

Discussion and Further Justification for the Recommendations:

The Nav WG has been unable to find any direct evidence that precipitous terrain can, or has, caused destabilization of an aircraft's vertical path. However, there is a long history (20+ years) of aircraft operating in VNAV over precipitous terrain without incident. The next sections will provide a brief summary of the original report and intervening actions, followed by what the WG agreed was a good measure of operational impact. This is followed by a list of places and numbers of operations (both RNP AR and LNAV/VNAV) over precipitous terrain where no adverse effects have been seen.

Origins & History

An incident in 1995 at Bradley International (BDL) in which an aircraft impacted some trees on a ridgeline during a non-precision approach resulted in an NTSB report (A-96-128 to 140) the requested better definition of the effects of precipitous terrain on aircraft flight paths. However, the report puts the cause of the incident as the failure to properly set the altimeter prior to the approach. The paragraph related to precipitous terrain states:

"These conditions are likely to result in wind velocities in excess of 20 knots over the ridge line, which occurred the night of the accident. Such winds can adversely affect airplane altimetry. Although it does not appear to have been a factor in this accident, the Safety Board concludes

that the FAA should have, but did not, consider the issue of precipitous terrain when developing and modifying the approach to runway 15. Therefore, the Safety Board believes that the FAA should incorporate precipitous terrain adjustments in the runway 15 approach."

So, although the terrain was not thought to be a factor, it was recommended that FAA take action. There is much more in the NTSB report, which has been captured on the PARC website for reference. Through the intervening years, to the present, there have been no incidents where precipitous terrain has been thought to be a factor in destabilization of the vertical path of an aircraft. The history of FAA responses and actions to the original report are also captured on the PARC site for this recommendation.

Proposed Measure of Effects

The Nav WG has come to consensus that a reasonable measure of the possible effects of precipitous terrain would be any recorded incidents of vertical path destabilization that resulted in a missed approach during operation over such terrain.

It would also be instructive to gather some level of actual aircraft data from FOQA or other sources during such operations to analyze the actual altimetry effects due to turbulence and winds. This would allow quantitatively assessing the actual effects of the aircraft path.

At this time, the WG considers the lack of evidence FOR precipitous terrain effect, and the abundance of evidence showing NO precipitous terrain effect adequate for this recommendation; however, we will be analyzing FOQA data as it becomes available to further supply information to FAA.

Operational Exposure & Experience

Airlines and business operators have been operating into very challenging terrain using VNAV since the early 1990's, beginning with Eagle, CO and American Airlines. In this section we have begun to list the operators, airports and procedures that have been in operation over the years with approximately how many operations have been conducted. This is intended to support our conclusion that precipitous terrain should not be considered a factor because there have been no reported incidents of missed approaches due to VNAV destabilization in any of the many operations that have been conducted over the years. While operations history numbers are still being gathered, the WG has obtained statements from operators (as noted below) regarding the absence of any destabilized VNAV operations in their history of precipitous terrain ops. The WG consensus is that this lack of problems over the last 20+ years is sufficient evidence to support our recommendations.

In support of this recommendation, several operators have researched their past history of operations (RNP AR specials, LNAV/VNAV specials, etc.) looking for precipitous terrain operations (airports / procedures). These operators are:

1. Alaska Airlines
2. American Airlines
3. Delta Airlines
4. Federal Express
5. Southwest Airlines
6. Qantas
7. WestJet

Their research is in two parts. First, each operator has tried to determine if any of their operations ever met the WG criteria for being impacted by the precipitous terrain (see above definition). Second, where possible, they will provide a list of specific procedures / airports that involve operation over or near precipitous terrain, including the date of inception for the use of the procedures and the numbers of operations completed for each.

Regarding the first determination, *none* of the operators has found any instance of a destabilized vertical path that resulted in a missed approach anywhere in their history of operations on these procedures. The WG has email confirmation of this from each of the operators which are part of the record on the PARC website. This is the first significant finding of the WG research into this issue which supports the recommendations above.

Further supporting evidence is contained in the actual numbers of operations conducted and over what length of time. The WG has obtained data from Alaska Airlines, American Airlines, Qantas and WestJet covering their RNP operations; that data is presented in tables below. Where practical, if specific data are not available for early years of operation, we have added an extrapolation to the years since the procedures were put into operation.

American Airlines

American has been flying VNAV (and later RNP) procedures into areas of precipitous terrain for over 20 years. The airline supplied the WG with a list of airports, each of which has averaged two operations per day for the past 20 years. There are 17 locations where these operations are taking place (UIO, TGU, GUA, SJO, BOG, CLO, SAP, MEX, GDL, LPB, MDE, GIG, EGE, JAC, GUC, RNO, SAN). This gives a total of 248,200 operations without any VNAV upsets (as described above): (20 years) x (365 days per year) x (2 ops per day) x (17 locations).

Alaska Airlines

The following compilation of operations over precipitous terrain was provided by Alaska Airlines for the last three years of history. Extrapolation back into history might not be extremely accurate, but the recent counts generally support total numbers of operations exceeding 100,000 since the beginning of their RNP operations.

	A	B	C	D	E	F	G	H	I
1	Airport	Runways	Precip Terrain?	Precip in Final?	2014	2015	2016	Total	YEAR
2	KPSP	13/31	Y	N	84	105	97	286	Nov-04
3	KPUW	06/24	Y	N	0	1	0	1	Jul-15
4	KSAN	09/27	Y	N	0	163	215	378	May-15
5	PACV	09/27	Y	Y	320	310	231	861	Aug-02
6	PADG	03/21	?	?	96	96	72	264	Sep-07
7	PADK	05/23	Y	Y	44	49	43	136	Dec-09
8	PADQ	01/26	Y	Y	65	89	160	314	Nov-98
9	PAJN	08/26	Y	Y	2597	2642	1919	7158	May-95
10	PAKT	11/29	Y	Y	702	812	160	1674	Jan-95
11	PAPG	05/23	Y	Y	355	395	259	1009	Nov-98
12	PASC	05/23	N	N	0	0	139	139	Dec-15
13	PASI	11/29	Y	Y	950	909	647	2506	Mar-98
14	PAWG	10/28	Y	Y	361	371	246	978	Nov-98
15	PAYA	11/29	N	N	285	298	173	756	May-11
16									
17								16460	

Qantas

The table below shows operations into Queenstown, NZ., again with no VNAV instabilities.

Operator	Airport	Procedure	Inception Date	Total Ops	Precip Terrain	Precip in Final
QAN	NZQN	RNV05	Sep-04	758	Y	N
QAN	NZQN	RNV23	Sep-04	190	Y	Y

There are three other operators flying these same procedures, though for less time than Qantas. They are:

Air New Zealand – Jun-05
Jetstar – Jun-09
Virgin Australia – Jun-13

The rest of Qantas numerous RNP-AR operations do not trigger the precipitous terrain threshold, primarily because the flight path has been designed to avoid it, even inside the FAF.

WestJet

Below is a summary table of RNAV RNP AR APCH utilization completed by WestJet since 2004. The 5 airports listed are those within WestJet's domestic and US network that are considered to be within mountainous terrain. The data demonstrates a 100% completion rate with no vertical path destabilization issues or other VNAV path anomalies observed.

Airport	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Sum:
HOG	14	46	11	24	32	29	37	53	39	42	42	37	30	**436**
PSP		91	220	261	438	517	554	544	669	767	893	1071	795	**6820**
YKA			2		17	421	491	350	312	303	6			**1902**
YLW	28	1431	3693	4127	4221	4570	4732	4758	4190	4709	4065	4185	3497	**48206**
YXX	9	60	279	424	222	260	1637	1929	1719	1920	1885	1981	1691	**14016**
Sum:	**51**	**1628**	**4205**	**4836**	**4930**	**5797**	**7451**	**7634**	**6929**	**7741**	**6891**	**7274**	**6013**	**71380**