U.S. Department of Transportation
Federal Aviation Administration

Memorandum

Subject: **ACTION**: Automated Precipitous Terrain Adjustments

Date: JUN 18 2004

From: Manager, Flight Technologies and Procedures Division, AFS-400

Reply to Attn. of:

To: Program Director, Aviation Systems Standards, AVN-1

We are working toward resolution of an Aeronautical Charting Forum, Instrument Procedures Group (ACF-IPG) agenda item and National Transportation Safety Board (NTSB) Safety Recommendations A-96-131 and A-96-132, regarding precipitous terrain adjustments for instrument approach procedures. The precipitous terrain automated evaluation program is part of Change 20 to Order 8260.3B, *U.S. Standard for Terminal Instrument Procedures (TERPS)*, in response to the National Transportation Safety Board's recommendations regarding this issue. Since work began on this project, a revised version of the Instrument Approach Procedures Automation (IAPA) system software that implements the precipitous terrain evaluation routines developed and provided by AFS-400 was accomplished and is awaiting implementation. Our original intent was to implement this program concurrent with TERPS, Change 20; however, recent changes to Title 14 of the Code of Federal Regulations (14 CFR), Part 97.20 is delaying processing the change.

During the April 26-27, 2004 meeting of the ACF-IPG, industry representatives questioned why the FAA does not begin using the revised IAPA programming immediately. The ACF-IPG believes the automated program will ensure a uniform application of precipitous terrain adjustments for civil instrument approach procedures and it should be implemented without delay.

We agree that the safety benefit provided by implementation should not be delayed. Please take action to implement the precipitous terrain IAPA programming under the attached guidelines as soon as possible.

If you have any questions, please contact AFS-420 at 405-954-4164.

For
John W. McGraw

Attachment

Automated Precipitous Terrain Adjustment Software Implementation

1. Apply the IAPA Precipitous Terrain Adjustment software on all new instrument approach procedures and during periodic review of all existing procedures.

2. Give priority consideration to airports located in mountainous terrain and those procedures that currently include a manual precipitous terrain adjustment.

3. The following note must be entered into the 8260-9 Remarks section when precipitous adjustments are not required.

   "PRECIPITOUS TERRAIN EVALUATION COMPLETED (DATE), NO ADJUSTMENTS REQUIRED."

4. Apply the following IAPA adjustments where terrain is identified as precipitous:

   a. Initial, Intermediate, and Non Precision Final: Increase the required obstacle clearance (ROC) by the minimum amount provided by the software.

   b. Category I Precision and APV Final: Increase the HAT by 10% of the ROC value provided by the software; e.g., 119' ROC = 11.9' adjustment. Round HAT values as specified under current guidelines. Baro-VNAV operations are not authorized in a precipitous terrain environment.

   c. Feeder Routes: ROC reductions as outlined in Volume 1, chapter 17, paragraph 1720 b (1) are not authorized. No additives are required.

5. Use FAA Order 8260.19C, paragraph 860a(1)(g) to document precipitous terrain adjustments.

Precipitous Terrain Equations, Parameters, Interests, Weights, and Adjustment Values

A digital terrain data base (100 m or 3 arcsecond separation density or better) must be used for the determination of precipitous terrain. The precipitous terrain area will include the prescribed segment area (both primary and secondary, if applicable) and a 2 NM buffer surrounding that segment area. This digital terrain data within that defined area will be analyzed electronically to determine the values of five specific parameters (**g(1)** through **g(5)**), which in turn will be transformed into interest values (**I(1)** through **I(5)**), weighted (**W(1)** through **W(5)**) and combined to finally determine a precipitous adjustment if appropriate.

For each parameter there will be a threshold value and a maximum value. The interest values are based upon the parameter values and are found by a piecewise function defined as follows:

I(i) = 0 if g(i) < threshold(i)
I(i) = (g(i)-threshold(i))/(max(i)-threshold(i)) if threshold(i) ≤ g(i) ≤ max(i)
I(i) = 1 if g(i) > max(i)

The threshold and maximum values for each parameter follow:

g(1): Average elevation
threshold = 600 m
max = 3000 m

g(2): 98th percentile – 2nd percentile height differential
threshold = 250 m
max = 2500 m

g(3): Slope gradient
threshold = .015
max = .060

g(4): Standard deviation from plane of best fit
threshold = 40 m
max = 200 m

g(5): 98th percentile maximum - minimum height differential on tiles
threshold = 100 m
max = 1000 m

The combined interest is as follows:

$$\boldsymbol{CI} = \sum_{i=1}^{5} \left(\mathbf{W}(i)\mathbf{I}(i)\right)$$

where the weight values are:

W(1) = .05
W(2) = .30
W(3) = .10
W(4) = .35
W(5) = .20

That is:

CI = .05(I(1)) + .30(I(2)) + .10(I(3)) + .35(I(4)) + .20(I(5))

Finally, the adjustment for precipitous terrain is also a piecewise function with threshold value **0.2** and maximum value **0.6**.

For final

A = 0 if CI < threshold
A = 50 + 200(CI - threshold)/(max - threshold) if threshold <= CI <= max
A = 250 if CI > max

For intermediate

$1.25 \times A$

For initial

$1.5 \times A$

All values rounded up to nearest 10 feet.

The equation for each parameter follows:

$$g(1) = \frac{\sum h(x,y)}{n}$$

$$g(2) = h_{98\%tile} - h_{2\%tile}$$

$$g(3)=\sqrt{a^2+b^2}\text{, where a and b are from } \hat{h}(x,y)=ax+by+c,$$

$$a=\frac{D_a}{D}, b=\frac{D_b}{D}, c=\frac{D_c}{D},$$

$$D=\begin{vmatrix}\sum x^2 & \sum xy & \sum x\\ \sum xy & \sum y^2 & \sum y\\ \sum x & \sum y & n\end{vmatrix}, D_a=\begin{vmatrix}\sum xh(x,y) & \sum xy & \sum x\\ \sum yh(x,y) & \sum y^2 & \sum y\\ \sum h(x,y) & \sum y & n\end{vmatrix},$$

$$D_b=\begin{vmatrix}\sum x^2 & \sum xh(x,y) & \sum x\\ \sum xy & \sum yh(x,y) & \sum y\\ \sum x & \sum h(x,y) & n\end{vmatrix}, D_c=\begin{vmatrix}\sum x^2 & \sum xy & \sum xh(x,y)\\ \sum xy & \sum y^2 & \sum yh(x,y)\\ \sum x & \sum y & \sum h(x,y)\end{vmatrix}$$

$$g(4)=\sqrt{\frac{\sum\left(h(x,y)-\hat{h}(x,y)\right)^2}{n}}$$

$g(5)=(h_{max}-h_{min})_{98\%tile}$ within all 1 NM square tiles centered upon each h(x,y)

Notes:

i. $$\begin{vmatrix}a & b & c\\ d & e & f\\ g & h & i\end{vmatrix}=aei+bfg+cdh-afh-bdi-ceg$$

ii. Precipitous terrain criteria based upon these equations was implemented via a Letter of Memorandum dated June 18, 2004.

Alan Jones
AFS-420
Original: November, 2003
Edited: January, 2007 (no substantive change)