Federal Aviation Administration

Memorandum

Date: FEB - 9 2011

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Subject: United States Standard for Locating the Precise Final Approach Fix (PFAF, FAF) On Instrument Approach Procedures and Locating Fixes for Air Traffic Control (ATC) Vertical Separation Purposes

PURPOSE. This memorandum specifies the Terminal Instrument Procedures (TERPS) standard for locating the PFAF on instrument approach procedures. Additionally, the Flight Technologies and Procedures Division's, July 24, 2009 memorandum Standard for Locating a Final Approach Fix and Fixes Used for Glidepath Intercept Support regarding Simultaneous Operations is cancelled.

DISCUSSION. The Federal Aviation Administration fully supports the effort to optimize descent trajectories for all instrument approach procedures (vertically guided and non-vertically guided). To achieve a common vertical path in the final segment, a single precisely located PFAF should serve all approaches to a given runway. Additionally, fixes in the intermediate and initial segment designed to support Air Traffic vertical separation requirements when intercepting the glide slope should support optimized descent and assure glide slope intercept will occur at or following the fix in historical high temperature conditions.

POLICY

1. PFAF Location Standard

To the greatest extent possible, locate a single PFAF to serve approach procedures aligned "straight-in" to a runway based on the along-track distance in feet ($D_{PFAF(ft)}$) from landing threshold point (LTP) or fictitious threshold point (FTP) to PFAF using the following algorithm.

Plain Text Algorithm

Function round(x,f) rounds the number X to the nearest f number of decimal places (0-9). *{round(265.485,2)=265.49}*

[start]
(1) input LTP_{elev} *(LTP MSL elevation)*
$PFAF_{alt}$ *(minimum intermediate segment altitude)*
θ *(glidepath angle)*
TCH *(threshold crossing height)*
r *(mean earth radius 20890537 feet)*

(2) $D_{PFAF(ft)}$=round(**r*ln((r+$PFAF_{alt}$)/(r+LTP_{elev}+TCH))/tan(θ*pi/180)**,0)
[end]

Math Notation

$$D_{PFAF(ft)} = round\left(r \times \frac{\ln\left(\frac{r + PFAF_{alt}}{r + LTP_{elev} + TCH}\right)}{\tan\left(\theta \times \frac{pi}{180}\right)}, 0\right)$$

Note: This is consistent with Order 8260.54A, United States Standard for Area Navigation (RNAV), formula 2-16b.

Example:

[start]
(1) LTP_{elev} is 104, TCH is 56, $PFAF_{alt}$ is 1900, θ is 3 degrees
(2) $D_{PFAF(ft)}$=round(**20890537*ln((20890537+1900)/(20890537+104+56))/ tan(3*pi/180)**,0)=**33200 ft**
$D_{PFAF(NM)}$=round(33200***0.3048/1852**,2)=**5.46 NM**
[end]

2. Non-standard PFAF Location

a. Where the final approach course does NOT meet "straight-in" alignment requirements, locate the PFAF at an along-track position where the descent angle from PFAF to the lowest circling minimum descent altitude (CMDA) at the missed approach point (MAP) does not exceed maximum TERPS standards. The parenthetical statement at the end of Order 8260.54A, United States Standard for Area Navigation (RNAV) paragraph 3.0 does not apply. Do not publish a descent angle.

b. Except for instrument landing system (ILS), localizer performance with vertical guidance (LPV), and precision approach radar (PAR), where the final approach course is aligned "straight-in" to a runway and the PFAF location is an outer marker or other existing fix, or if the procedure is circling-only because of higher than maximum descent angle, publish the effective descent angle (**$\theta_{effective}$**) from the PFAF to TCH. Calculate (**$\theta_{effective}$**) using the following algorithm:

Plain Text Algorithm

Function round(x,f) rounds the number X to the nearest f number of decimal places (0-9). *{round(265.485,2)=265.49}*

```
[start]
(1)    input LTPelev (LTP MSL elevation)
             PFAFalt (minimum intermediate segment altitude)
             TCH     (threshold crossing height)
             r       (mean earth radius 20890537 feet)
             DPFAF   (along-track distance in feet LTP to PFAF)
(2)    θeffective=round(180/pi*atan(ln((r+PFAFalt)/(r+LTPelev+TCH))*(r/DPFAF)),2)
[end]
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Math Notation

$$\theta_{effective} = round\left(\frac{180}{pi} \times atan\left(\ln\left(\frac{r+PFAF_{alt}}{r+LTP_{elev}+TCH}\right) \times \frac{r}{D_{PFAF}}\right), 2\right)$$

Note: This is consistent with Order 8260.54A, United States Standard for Area Navigation (RNAV), formula 2-16c.

Example:

```
[start]
(1)    LTPelev is 104, PFAFalt is 1900, TCH is 56, DPFAF is 29852
(2)    θeffective=round(180/pi*atan(ln((20890537+1900)/(20890537+104+56))*
                                                   (20890537/29852)),2)=3.34
[end]
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3. Standard for locating fixes on straight-in aligned procedures for ATC vertical separation purposes at locations where high temperature induce premature descent.

The following algorithm calculates the MINIMUM distance from LTP to locate the fix to assure glidepath intercept at a specified altitude ($alt_{intercept}$) does not occur prior to the fix when temperatures are as high as the 3-5 year highest average airport temperature ($temp_{high}$).

Plain Text Algorithm

Function round(x,f) rounds the number X to the nearest f number of decimal places (0-9). {*round(265.485,2)=265.49*}

```
[start]
  (1) input altintercept      altitude required for separation
            temphigh          the highest expected Celsius temperature for the
                                   location
            LTPelev           the threshold MSL elevation
            θ                 glidepath angle
            TCH               threshold crossing height
(2)   isa=15-altintercept*0.00198
(3)   verticaladjustment=round((altintercept-(LTPelev+(altintercept-LTPelev)*
                            ((273+isa)/(273+temphigh)))),0)
(4)   z=100*ceiling((altintercept+verticaladjustment)/100)
(5)   DFIX(ft)=round(r*ln((r+z)/(r+LTPelev+TCH))/tan(θ*pi/180),0)
[end]
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Math Notation

$$isa = 15 - alt_{intercept} \times 0.00198$$

$$vertical_{adjustment} = round\left(alt_{intercept} - \left(LTP_{elev} + \left(alt_{intercept} - LTP_{elev}\right) \times \frac{273 + isa}{273 + temp_{high}}\right), 0\right)$$

$$z = 100 \times ceiling\left(\frac{alt_{intercept} + vertical_{adjustment}}{100}\right)$$

$$D_{FIX(ft)} = round\left(r \times \frac{\ln\left(\frac{r + z}{r + LTP_{elev} + TCH}\right)}{\tan\left(\theta \times \frac{pi}{180}\right)}, 0\right)$$

Example:

(1) $alt_{intercept}$ is 5000, LTP_{elev} is 104, TCH is 56, θ is 3 degrees, $temp_{high}$ is 40°C

(2) isa=15-5000*0.00198=5.1

(3) $vertical_{adjustment}$=round((5000-(104+(5000-104)*((273+5.1)/(273+40)))),0)=546

(4) z=5000+546=5546

(5) $D_{FIX(ft)}$=round(20890537*ln((20890537+5546)/(20890537+104+56))/tan(3*pi/180),0)=102757 feet

If you have any questions regarding this recommendation, please contact Mr. Jack Corman, TERPS standards specialist, Flight Procedure Standards Branch, AFS-420 at (405) 954-4164.