1.0 GENERAL.

- The OPTIMUM final segment descent angle for all category aircraft is 3.00°, which approximates a 318 ft/NM or 5.24% gradient.

- The MAXIMUM final segment descent angle for all category aircraft is 3.77°, which approximates a 400 ft/NM or 6.59% descent gradient, and

- the MAXIMUM final segment descent angle for original procedures submitted for publication for categories D and E is 3.50° (USN 3.77°) which approximates 372 ft/NM or 6.12%.

Where category C, D, and E minimums are to be published on original procedures, achieve as close to the OPTIMUM final segment descent angle as possible while remaining within the following preferred ranges:

FAA	2.50°-3.77° (CAT A & B)
	2.75°-3.77° (CAT C)
	2.75°-3.50° (CAT D & E)
USAF	2.50°-3.50°
USN	2.50°-3.77°

Calculate descent angles based on the distance from the plotted position of one fix to the plotted position of the next fix/FEP, and the difference in altitude between the:

FAF and [THRe+TCH] or FAF and lowest CMDA (CAT A or CAT D as appropriate)
FAF and S/D
S/D and [THRe+TCH] or S/D and lowest CMDA (CAT A or CAT D as appropriate)

2.0 STRAIGHT-IN APPROACHES.

Where the MAXIMUM descent angle is exceeded, do not publish straight -in minimums. See paragraph 3.0 for circling approach applicability.

2.1 CALCULATING STRAIGHT-IN DESCENT ANGLE

Calculate the descent angle using the following formula:

$$\text{angle} = \arctan\left(\frac{a - b}{d}\right)$$

Where: a = FAF or S/D altitude
b= S/D altitude or (THRe + TCH) as appropriate
d = Distance in ft from the FAF or S/D to S/D or FEP as appropriate
(to convert NM to feet: $ft = NM \times 6076.11548$)

If the equivalent gradient is desired, use the following formulas:

$$\text{gradient}(ft/NM) = \tan(\text{angle})\,6076.11548$$

$$\text{gradient}(\%) = \tan(\text{angle})\,100$$

2.2 DETERMINING STRAIGHT-IN FAF LOCATION BASED ON DESCENT ANGLE. (*Use where feasible; e.g., FAF is an RNAV, DME, or intersection fix*)

Select an appropriate fix location to provide, where feasible, a vertical path coincident in angle (± 0.20°) and TCH (± 3') with the lowest published VGSI angle. Where VGSI is not installed, select a fix location to achieve a near optimum descent angle. For stand-alone LNAV and non-RNAV approaches where the FAF is not a facility, determine the FAF location (distance from threshold to FAF) using the method described in figure 1.

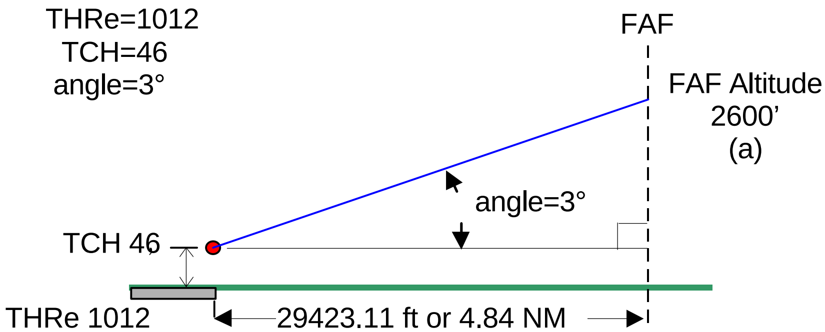
Figure 1. Determining Straight-In FAF Distance from Threshold Based on Required FAF Altitude

$$d = \frac{(a - b)}{\tan(\text{angle})}$$

$$\begin{aligned} \text{where: } d &= \text{Distance from FEP to FAF in feet} \\ a &= \text{FAF Altitude} \\ b &= \text{THRe} + \text{TCH} \\ \text{THRe} &= \text{Threshold Elevation} \\ \text{TCH} &= \text{TERPS Table 18A or the VGSI TCH as appropriate} \\ \text{angle} &= \text{Designed angle or VGSI angle as appropriate} \end{aligned}$$

EXAMPLE

a=2600'
THRe=1012
TCH=46
angle=3°



$$d = \frac{2600 - (1012 + 46)}{\tan(3°)} = 29423.11$$

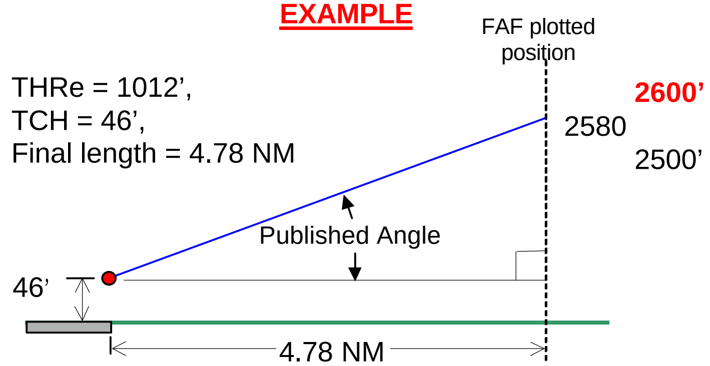
2.3 DETERMINING OPTIMUM STRAIGHT-IN FAF ALTITUDE BASED ON FIXED FAF LOCATION (*Use where FAF location is dictated by other factors; e.g., FAF is a facility, ATC requires FAF to be at a specific location, etc*)

2.3.1 Select an appropriate fix altitude to provide a descent angle to TCH coincident (± 0.20°, ± 3') with the lowest published VGSI angle, where feasible. Where VGSI is not installed, select a fix altitude to achieve a near optimum descent angle. When the FAF location is a facility or fixed by ATC, calculate the OPTIMUM FAF altitude using the method described in figure 2.

Figure 2. Determining Straight-In FAF Altitude Based on Fixed FAF Location

$$\text{FAF Altitude} = \text{THRe} + \text{TCH} + [\tan(\text{VGSI angle}) \times d]$$
$$\text{where: THRe} = \text{THR Elevation}$$
$$d = \text{Distance from FEP to FAF in feet}$$

EXAMPLE



$$\text{FAF Alt} = 1012 + 46 + [\tan(3°) \times (4.78 \times 6076.11548)] = 2580.12 \approx 2600$$

$$\text{Published angle} = \arctan\left(\frac{a - b}{d}\right)$$

$$\text{Published angle} = \arctan\left(\frac{2600 - (1012 + 46)}{4.78 \times 6076.11548}\right) = 3.04°$$

Round the answer to the nearest 100-foot increment. Publish the angle from the rounded FAF altitude to the TCH value.

3.0 CIRCLING APPROACHES.

3.1 DETERMINING CIRCLING DESCENT ANGLE

The circling approach descent angle shall not exceed MAXIMUM. Calculate the descent angle on circling approaches based on Category A and/or D CMDAs as appropriate instead of THRe + TCH. See figure 3.

Figure 3. Calculating Descent /Angle for Circling Approaches

$$\text{Descent angle} = \arctan\left(\frac{a - b}{d}\right)$$

Where $a = \text{FAF alt}$

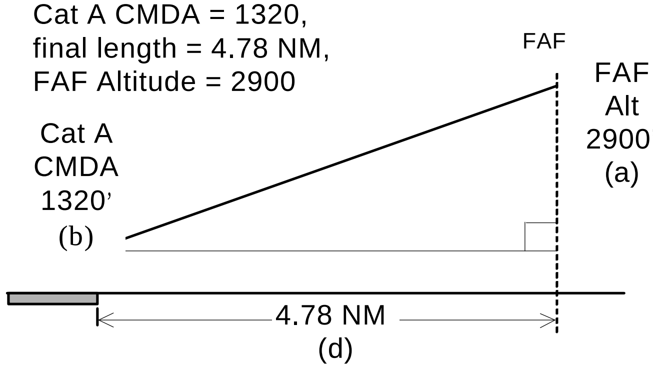
$b = \text{CMDA for CAT A and/or CAT D}$

$d = \text{Final length in feet}$

$(\text{to convert NM to feet}: \ ft = NM \times 6076.11548)$

EXAMPLE

Cat A CMDA = 1320,
final length = 4.78 NM,
FAF Altitude = 2900



$$\text{Descent Angle} = \arctan\left(\frac{2900 - 1320}{4.78 \times 6076.11548}\right) = 3.12°$$

<u>Do not publish a descent angle on circling approaches</u> except where straight-in alignment requirements are met. In this case, calculate the <u>published</u> descent angle as described in paragraph 2.1, assuming descent from FAF altitude to THRe + TCH.

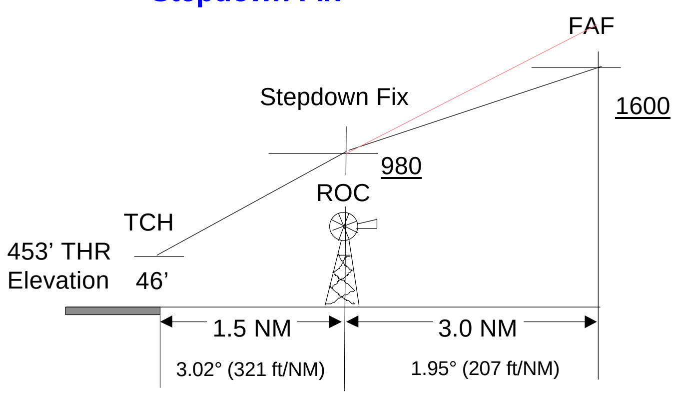
3.2 ESTABLISHING CIRCLING-ONLY PROCEDURE FAF LOCATION

A circling approach is not normally flown using a stabilized descent from the FAF to landing. Therefore, the location of the FAF is not predicated on the descent angle from FAF altitude to CMDA. Establish the FAF under the alignment and segment length criteria applicable to the final approach NAVAID or system.

4.0 STEPDOWN FIXES

For approaches with a published descent angle, select the S/D location that allows a minimum S/D altitude at or below the descent angle from the FAF to TCH. When the altitude at the S/D is above the descent angle from the FAF to TCH, increase the FAF altitude or adjust the S/D location accordingly. See figure 5. Where this is not feasible, publish the angle from the S/D to TCH rather than the angle from FAF to TCH.

Figure 5. Comparing Descent Before and After a Stepdown Fix



$$\text{Descent Angle} = \arctan\left(\frac{1600 - 980}{3 \times 6076.11548}\right) = 1.95^\circ$$

$$\text{Descent Angle} = \arctan\left(\frac{980 - (453 + 46)}{1.5 \times 6076.11548}\right) = 3.02^\circ$$

If possible, raise the FAF altitude as described in paragraph 2.3 to achieve at least a 3.02° angle