United States Army Helicopter Instrument Departure Construction Criteria

1.0 GENERAL

This document is an addendum to helicopter instrument procedure guidance. Existing acronyms apply. These criteria are based on the assumption that the helicopter will climb at a minimum gradient of 400 feet per nautical mile until reaching the en route altitude, and that the heliport meets Army instrument heliport standards. When evaluating a heliport for instrument departure procedures, plan to construct the most simple, flexible procedure possible. The following three departure types are listed in order of complexity. Construct a diverse departure first. If obstructions or airspace prohibit the diverse options, construct a departure route. If conditions prohibit a departure route, construct a point-in-space (PinS) departure procedure.

2.0 DIVERSE DEPARTURE EVALUATION

A diverse departure provides the pilot the option of choosing the departure course within specified boundaries, or unrestricted. This is the preferred departure type. Minimum ceiling is 100 feet, and minimum visibility is 1/2 statute mile unless lower values are authorized by USAASA.

2.1 AREA

The area evaluated for obstructions begins at the outer edge of the FATO safety area and extends outward and upward until the obstruction clearance surface (OCS) reaches an altitude 1000 feet below the specified en route altitude.

2.1.1 DETERMINING EN ROUTE ALTITUDE

In non-mountainous areas, add 1000 feet ROC to the highest obstruction within a 15 NM radius of the heliport. In mountainous terrain, add 2000 feet ROC to the highest obstruction within a 25 NM radius of the heliport. Round the sum to the nearest 100-foot increment. The result is the en route altitude.

{Minimum climb gradient is 400 feet per NM. Assuming 24% of the 400 feet per NM is ROC: $0.24 \times 400' = 96'$ *is provided for each mile flown. Therefore, to determine the number of miles required to achieve 1000 feet of ROC:*

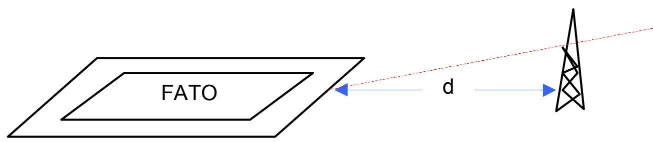
$\frac{1000'\text{ ROC}}{96} + 4\text{ NM buffer} = 14.42$ *which rounds up to 15 NM. Likewise, to determine the number of miles required to achieve 2000 feet of ROC:*

$\frac{2000'\text{ ROC}}{96} + 4\text{ NM buffer} = 24.83$ *which rounds up to 25 NM. The purpose of the 4 NM buffer is to assure the pilot can meet provisions of 14 CFR Part 91.177(a)(2).}*

2.1.2 OCS

The OCS rises at a ratio of 1-foot vertically for every 20 feet horizontally (20:1 slope or 5% gradient). Its beginning elevation is equal to the elevation of the highest surface point on the FATO. To determine the elevation of the OCS at an obstacle, measure the distance (d) in feet from the obstacle to the closest point on the FATO safety area boundary. Use the following formula to calculate the surface elevation at the obstacle:

Figure 1. Calculating OCS Height at an Obstruction



$$\text{OCS MSL height} = \frac{d}{20} + f$$

Where d = distance obstacle to OCS beginning
f = HRP elevation

2.1.2 **a. Climb Gradient (CG)** *{24% rule applies}*. Where an obstruction penetrates the OCS, a CG greater than 400 ft/NM is required until reaching an altitude equal to the height of the obstruction plus ROC. Determine the minimum required climb gradient and the minimum altitude the aircraft must attain before the CG may be discontinued using the following formula:

$$CG = \frac{h}{0.76 \times d}$$

$$\text{Altitude that CG may be discontinued} = CG \times d + \text{HRP elevation}$$

Where h = Obstruction MSL elevation minus (-) HRP elevation
d = Shortest distance (NM) from edge of safety area

Example: $$\frac{1145}{0.76 \times 3.1} = 485.99 \approx 490 \text{ ft/NM CG}$$

$$490 \times 3.1 + 344 = 1863.00 \approx 1900 \text{ ft discontinue CG}$$

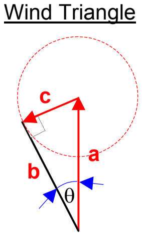
*{ **24% rule**. 24% of the total height gained by a helicopter climbing from the heliport to clear an obstruction that penetrates the missed approach surface is ROC. Therefore, 76% of the total amount of climb* (a) *is the obstruction height* (h) *above the starting altitude. Obstruction height defined in terms of* "h" *and* "a" *expressed in feet is:* $h = 0.76 \times a$ *Then, the total number of feet of required climb* "a" *is defined by solving for* "a"*:* $a = \frac{h}{0.76}$ *The required climb gradient* (CG) *is defined as the required amount of climb* "a" *divided by the distance in nautical miles* (d) *traveled from the closest edge of the safety area to the obstruction:* $CG = \frac{a}{d}$ *Finally, by substituting for* "a"*, climb gradient is defined as:* $CG = \frac{\frac{h}{0.76}}{d} \quad \therefore \quad CG = \frac{h}{0.76 \times d}$ *}*

EXCEPTION *(for use where directed by USAASA/ATAS-AI): In tactical environments where mission critical operations are required and aircraft performance cannot achieve the CG requirements of the 24% rule, the following formula may be used:* $CG = \frac{48 \times d + (o\text{-}e)}{d}$

2.1.2 **b. Sectored Diverse Departure**.. Where obstructions prohibit omnidirectional diverse departures, consider identifying a sector where diverse departure operations can be authorized. Identify sector boundaries from the center of the takeoff area. The sector boundary must lie at least x° (depending on ground speed and allowable crosswind component) from offending obstructions. The MINIMUM sector size is 30°.

{ Buffers provide obstruction protection in crosswind conditions (minimum 15°), plus an additional 5° to account for tracking errors.

Wind Triangle



$$c = a \times \sin\ (15° + 5°) \qquad 70 \times \sin\ (15° + 5°) = 23.94\ \text{kts}$$
$$90 \times \sin\ (15° + 5°) = 30.78\ \text{kts}$$

where c = maximum allowable crosswind component

23.94 Kts assumed crosswind @ 70 Kts ground speed
30.78 Kts assumed crosswind @ 90 Kts ground speed

In order to allow a greater crosswind component, the buffer must be increased from 20° to a larger value (θ) using the following formula:

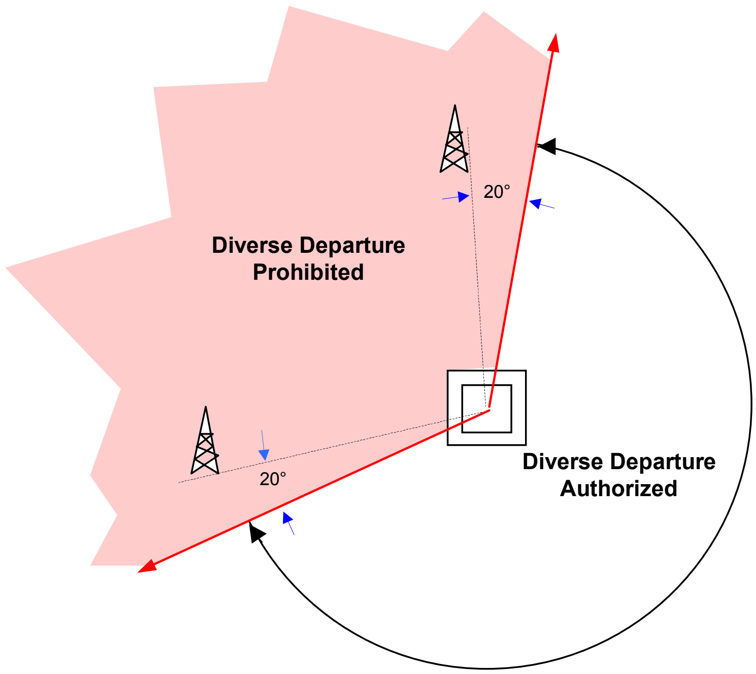
$$\theta = \sin^{-1}\left(\frac{c}{a}\right) \qquad \text{Example: } \sin^{-1}\left(\frac{40}{70}\right) = 34.85° \quad 40\text{ kt crosswind at } 70\text{ kts groundspeed}$$

where c = maximum allowable crosswind component $\qquad \sin^{-1}\left(\frac{40}{90}\right) = 26.39° \quad 40\text{ kt crosswind at } 90\text{ kts groundspeed}$

a = kts aircraft ground speed

A different ground speed component may be specified and the resulting changes in either crosswind component or buffer angle can be determined using the above formulas and substituting the desired ground speed for 70 Kts. }

Figure 2. Sectored Departure



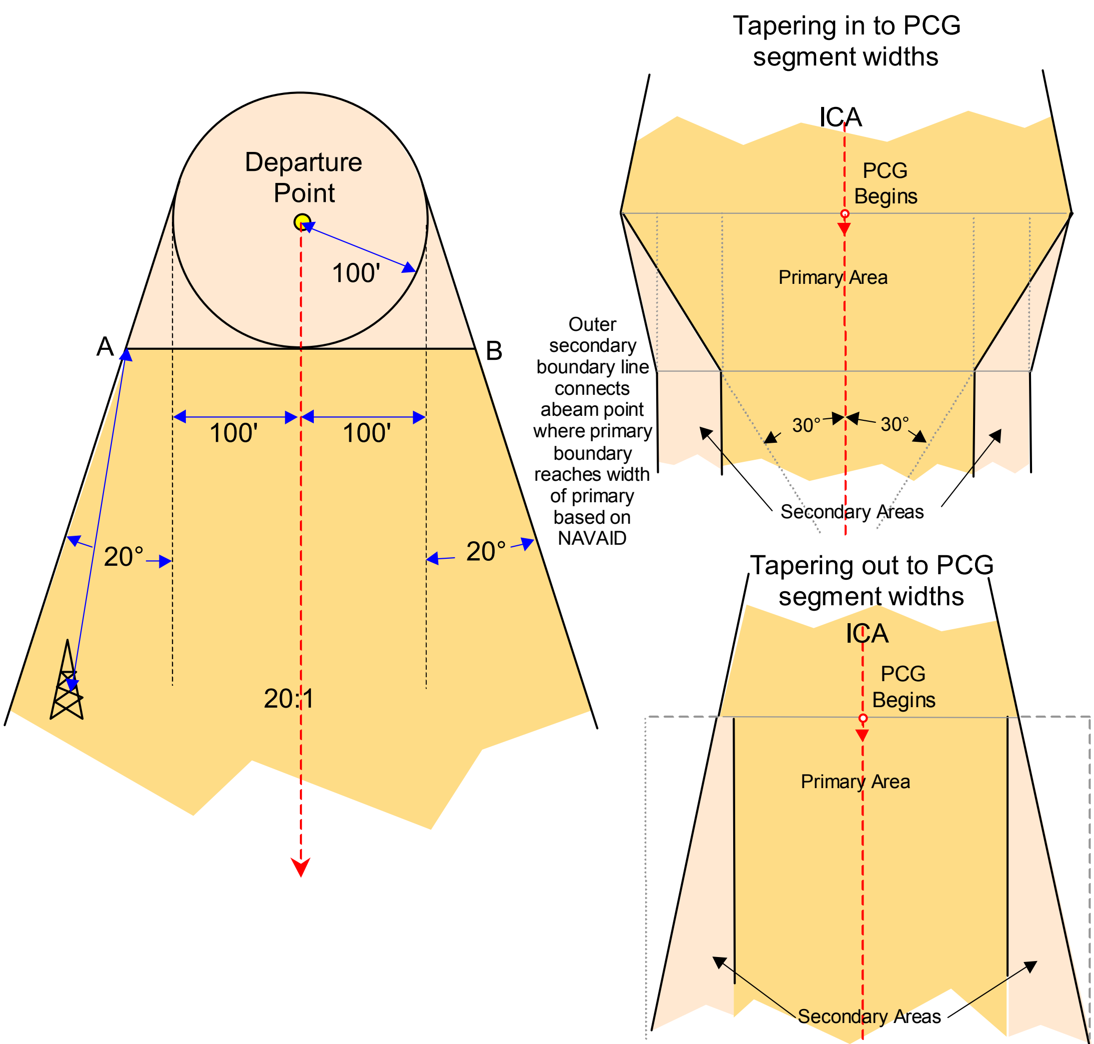
3.0 DEPARTURE ROUTE

If the obstruction environment or airspace prohibits a diverse departure, construct a departure route. The initial climb is based on dead reckoning until positive course guidance (PCG) can be attained. Positive course guidance must be provided within a flight track distance of 10 NM of HRP. See TERPS chapters 11 and 12 for departure segment widths based on specific navigational aids.

3.1 INITIAL CLIMB AREA (ICA)

Locate the center of the departure area (helipad, runway, etc.). Construct a circle of 100-foot radius from the center. Draw the departure course extending from the circle center. Draw a line each side of the course line, tangent to the 100-foot radius circle, splaying at an angle of 20° relative to course. These lines define the lateral boundary lines of the initial climb area. The lateral boundary lines continue to splay until reaching the width appropriate for the navigation system providing positive course guidance. If the ICA boundary is wider than required by the PCG navigational system when PCG is achieved, taper the boundary inward toward the course line at a 30° angle. Construct a line (**AB**) perpendicular to the departure course tangent to the point on the 100-foot radius circle that the departure course crosses the circle. The area on the circle side of the **AB** line is a flat surface at the elevation of the highest point of the take-off surface. The surface in the direction of departure from the **AB** line is a 20:1 surface rising in the direction of flight.

Figure 3. Initial Climb Area



Evaluate the 20:1 surface by measuring the shortest distance from an obstruction to the AB line.

3.1.1 OCS.

Only frangible objects fixed by function can penetrate the surfaces of the initial climb area. Takeoff normally commences from the helipad surface. The FAA does not endorse and has not tested instrument departures from high hover heights. However, if directed by USAASA/ATAS-AI, takeoff may be specified to commence from specified heights above the pad. It is the responsibility of the U.S. Army to provide pilots operational procedures that provide an acceptable level of safety for this maneuver. If the hover height exceeds 10 feet, the level surface will originate 10 feet below the hover height. The 20:1 suface begins at the elevation of the edge of the level surface. Paragraph 2.1.2a applies.

4.0 PinS DEPARTURES

Where the obstruction and/or airspace environment prohibits a diverse departure or a departure route, establish a PinS depature. All PinS departures depart VFR or special VFR. IFR obstruction clearance begins at the point specified as the initial departure fix (IDF). PCG must be provided from the IDF to the point the departure joins the enroute structure. Establish the IDF within 5 NM of the heliport.

4.1 AREA

Construct the departure as a route departure, except the starting point is the IDF. There is not an initial climb area segment; therefore, there is not a segment requiring a DR splay. Apply the area dimensions, starting at the IDF, applicable to the NAVAID that provides PCG for the segment.

4.2 OCS

Apply a 20:1 (5%) surface starting at an altitude equal to $96 \times d$ (where d=the distance in NM from FATO center) below the selected altitude at the the IDF. Paragraph 2.1.2a applies.

EXCEPTION *(for use where directed by USAASA/ATAS-AI): The starting altitude may be calculated using 48d vice 96d in tactical environments where mission critical operations are required and aircraft performance cannot achieve the CG requirements to achieve a value of 96d.*

MATHEMATICS CONVENTION

$a + b$ indicates addition
$a - b$ indicates subtraction
$a \times b$ indicates multiplication
$\frac{a}{b}$ indicates division
$(a \times b)$ indicates the result of the process within the parethesis
$|a - b|$ indicates absolute value $\{$the result of the process between the vertical lines is assigned a positive sign$\}$
$\approx$ indicates approximate equality
$\sqrt{a}$ indicates the square root of quantity "a"
a^2 indicates $a \times a$
$\tan(a)$ indicates the tangent of "a" degrees
$\tan^{-1}(a)$ indicates the arc tangent of "a"
$\sin(a)$ indicates the sine of "a" degrees
$\sin^{-1}(a)$ indicates the arc sine of "a"
$\cos(a)$ indicates the cosine of "a" degrees
$\cos^{-1}(a)$ indicates the arc cosine of "a"

Operational Precedence (Order of Operations)

Grouping Symbols: parentheses, brackets, braces, fraction bars, etc.
Functions: tangent, sine, cosine, arcsine and other defined functions
Exponentiation: powers and roots
Multiplication and Division: products and quotients
Addition and Subtraction: sums and differences

e.g.,

$5 - 3 \times 2 = -1$ because multiplication takes precedence over subtraction
$(5 - 3) \times 2 = 4$ because parentheses take precedence over multiplication
$\frac{6^2}{3} = 12$ because exponentiation takes precedence over division
$\sqrt{9 + 16} = 5$ because the square root sign is a grouping symbol
$\sqrt{9} + \sqrt{16} = 7$ because roots take precedence over addition
$\frac{\sin(30^\circ)}{0.5} = 1$ because functions take precedence over division
$\sin\left(\frac{30^\circ}{0.5}\right) = 0.8660254$ because parentheses take precedence over functions

Notes on calculator usage:

1. Most calculators are programmed with these rules of precedence.
2. When possible, let the calculator maintain all of the available digits of a number in memory rather than re-entering a rounded number. For highest accuracy from a calculator, any rounding that is necessary should be done at the latest opportunity.