FAA Draft Order 8260.GPSDEP, regarding GPS Departure Procedures

In addition to the narrative and formulaic descriptions of this Draft Order, here follows a listing of the accompanying graphic depictions:

Figure 1: GPS Departures, Minimum Distances from DER [Departure End of Runway] to WP

Figure 2: GPS Departure, up to 15-degree Turn

Figure 3: GPS Departure, 90-degree Turn Beyond 30 NM from ARP [Airport Reference Point]

Figure 4: GPS Departure, 120-degree Turn, Fly-Over Waypoint

Figure 5: GPS Departure, 90-degree Turn, Below 10,000' MSL, Fly-Over Waypoint

Figure 6: GPS Departure, 30-degree Turn, Fly-Over Waypoint

Figure 7: GPS Departure, 30-degree Turn, Fly-By Waypoint

Figure 8: GPS Departure, 120-degree Turn, Fly-Over Waypoint, 1 NM from DER

Figure 9: GPS Departure, 120-degree Turn, Fly-Over Waypoint, more than 30 NM from ARP

Figure 10: GPS Departure, Evaluation of Obstacles

Figure 11: GPS Departure, Climb and Hold Departure

[Figure XX, added by Mark Ingram]: General Turning Performance (Constant Altitude, Steady Turn) [with thanks to Al St. Germain, of MKC FAA]
Captain Randolph J. Babbitt President
Air Line Pilots' Association International
535 Herndon Parkway
P.O. Box 1169
Herndon, VA 22070

Dear Captain Babbitt:

Enclosed for your review is Draft FAA Order 8260.GPSDEP for GPS Departures.

Any comments or recommendations may be submitted to:

Federal Aviation Administration
Flight Procedures Branch, AFS-440
P.O. Box 25082
Oklahoma City, OK 73125

You may FAX your comments directly to this office at 405-954-4809.

Your comments need to be received by this office by October 17, 1996, in order to be given consideration in the development of this order. We value your input, and if you have any questions, please contact Chuck Everest at 405-954-5811.

Sincerely,

Lyle G. Wink
Manager, Flight Procedures Branch

Enclosure
CIVIL UTILIZATION OF GLOBAL POSITIONING SYSTEM (GPS)

SUBJ: DEPARTURE PROCEDURES

1. PURPOSE. This order, in conjunction with Order 8260.3B, United States Standard for Terminal Instrument Procedures (TERPS), and Order 8260.38A, Civil Utilization of Global Positioning System (GPS), provides criteria for establishing GPS departures for use by aircraft equipped and certified under TSO-C129, Airborne Supplemental Navigation Equipment Using the GPS.

2. DISTRIBUTION. This order is distributed to the branch level in the Offices of Air Traffic Systems Development; Communications, Navigation, and Surveillance Systems; Airport Safety and Standards; Aviation System Standards; and in the Air Traffic, and Flight Standards Services; to the National Flight Procedures Office; to the Regulatory Standards and Compliance Division at the Mike Monroney Aeronautical Center; to the regional Flight Standards, and Air Traffic divisions; to the Europe, Africa, and Middle East International Area Office; and to all Air Route Traffic Control Centers, Radar Approach Control Facilities, Radar Air Traffic Control Centers, and Terminal Radar Approach Control Facilities.

3. DEFINITIONS.

a. Baseline. A line, perpendicular to the course line at the latest position of the fix displacement tolerance area, used for construction of turn area expansion arcs.

b. Departure End of Runway (DER). The end of the TORA.

c. Fly-By Waypoint. A fly-by waypoint requires the turn be initiated prior to the waypoint (WP) to provide a smooth path transition to the succeeding course.

d. Fly-Over Waypoint. A fly-over waypoint precludes any turn until the WP is overflown and is followed by an intercept maneuver to the next segment.

e. Reference Line. A line parallel to the course line, following a turn waypoint (TWP), used to construct a second set of expansion arcs.

f. Reference Waypoint. A WP of known location used to geodetically compute the location of another WP.

g. Takeoff Run Available (TORA). The length of runway declared available for the ground run of an aircraft departure.
h. Turn Anticipation. The capability of GPS airborne equipment to determine, and enunciate to the pilot, the location of the point along a course, prior to a TWP, where a turn should be initiated to provide a smooth path to intercept the succeeding course.

SECTION 1. GENERAL CRITERIA

4. GENERAL.

a. Positive Course Guidance. All GPS segments are assumed to have positive course guidance. NOTE: Criteria for instructions “Climb to an altitude and turn” is not provided due to the inability to specify a positive course.

b. Waypoint Substitution. Existing fixes/navigational aids (NAVAIDS) may be substituted for a WP where conveniently located. For purposes of simplicity in this criteria, the term WP will be used arc to denote a fix.

c. Waypoint Displacement Area. Terminal GPS fix displacement tolerance applies where the plotted position of the WP is at, or within, 30 nautical miles (NM) of the departure airport’s reference point (ARP). En route fix displacement applies beyond 30 NM from the ARP. See Order 8260.38A, appendix 1, table 1.

d. Waypoints. Provide “fly-by waypoints” whenever possible. Specify “fly-over waypoints” only to achieve an operational advantage or benefit. Establish WP’s at route course changes and at other points of operational benefit.

e. Departure Route Segment Terminators. Departure route segments begin and end at a WP.

f. Waypoint Definition. For departure WP’s located on runway centerline extended, establish coordinates using the reciprocal of the opposite direction runway true bearing and the appropriate distance applied from the DER. Where two or more segments are aligned along a continuous geodesic line, align and construct all succeeding WP’s based on a true bearing and distance from the first (reference) WP in the sequence. Where turns are established, use the TWP as the reference WP to construct succeeding WP’s and segments aligned on a continuous geodesic line following the turn.

g. Course Change at Waypoints. The departure course at a WP is the bearing from that WP to the following WP. The arrival course at the WP is the reciprocal of the course from that WP to the preceding WP. The difference between the departure course and the arrival course at a WP equals the amount of turn at that WP. Maximum course change allowable is 120 °.

5. IDENTIFICATION OF GPS INSTRUMENT DEPARTURE PROCEDURES. Departure procedures, based on GPS, are identified by using the term “GPS Departure,” followed by the takeoff runway (RWY) number; e.g., GPS DEPARTURE RWY 27. Multiple departure procedures from the same runway must identify a geographical route or use a transitional route name; e.g., BRAXTON FOUR GPS DEPARTURE, or GPS DEPARTURE, RWY 27, LEMHI TRANSITION.
6. ROUTE DESCRIPTION. Specify the magnetic courses and include the names of all WP’s in the order flown with any altitude restriction crossing requirements specified at the WP’s or alongtrack distance (ATD) fixes. Preface the route description with, “Select 1 NM receiver sensitivity.” For clarity, chart procedures with three or more WP’s beyond DER and add a statement to FAA Form 8260-15, Departure Procedures/Takeoff Minimums; e.g., “Chart runway 27, Lemhi transition, departure procedure.”

7. APPLICATION. Apply diverse departure criteria contained in Order 8260.3B, chapter 12, to determine if GPS departure routes are required.

a. Departures begin at DER.


(1) For all turns below 10,000 feet mean sea level (MSL), use 250 knots indicated airspeed (KIAS) unless a speed restriction of 180 KIAS is noted on the procedure for that turn.

(2) For turns at 10,000 feet MSL and above, use 310 KIAS unless a speed restriction of 180 or 250 KIAS is noted on the procedure for that turn.

(3) Exception: Use 1.75 NM turn radius where the first turnpoint is within 6 NM of DER.

(4) Where 180 or 250 KIAS is required, publish a speed restriction. Example: “Do not exceed (180/250) KIAS,” or “Do not exceed (180/250) KIAS until Chuck WP.”

8. AREA.

a. Initial Climb Area. See appendix 1, figure 1.

(1) All departures must proceed along the runway alignment during the initial climb to a specified WP past DER. Locate the first WP after DER on extended runway centerline at a sufficient distance from DER to allow the aircraft to climb to at least 400 feet above airport elevation. The minimum distance allowable is 2 NM, based on a climb of 200 ft/NM, where DER elevation is the airport elevation. See appendix 1, figure 1. Where a shorter distance is required, or the 400-foot rule above airport elevation cannot be achieved within 2 miles of the DER, publish a climb gradient. Climb gradients exceeding 400 ft/NM require FAA, Flight Standards Service, approval.

(a) Locate a fly-by waypoint so as to provide a minimum distance of 2 NM plus distance of turn anticipation (DTA) from DER. See appendix 1, figure 1. The distance is measured from DER to the plotted position of the WP.

(b) Locate a fly-over waypoint at a minimum distance of 2 NM from DER. See appendix 1, figure 1. The distance is measured from DER to the plotted position of the WP.
(2) **Initial Segment Width.** See appendix 1, figure 2. From a point 500 feet each side of runway centerline:

(a) **Splay the area at 7.5°,** angular with the course line, until it reaches the width of the primary area.

(b) **From the same point, splay a line at 15°,** angular with the course line, until it reaches a distance of 1 mile from the primary area boundary. This defines the secondary area width.

b. **Departure Route Segments.**

(1) **Length.** Segment length is measured between plotted positions of the WP’s. The length of a segment shall be sufficient to encompass all turn anticipation and outside turn expansion requirements. **The minimum segment length:**

(a) **In the case of two successive fly-by turning waypoints,** is the DTA of the first WP plus the DTA of the second WP.

(b) **In the case of two successive fly-over waypoints,** is the amount of outside turn expansion required to complete the construction of the turn and intercept the course to the second WP.

(c) **From a fly-by to a fly-over waypoint,** is the DTA of the first WP.

(d) **From a fly-over to a fly-by waypoint,** is the amount of outside turn expansion required to complete the construction of the turn at the first WP, and intercept the course to the second WP, plus the DTA of the second WP.

(2) **Width.**

(a) **Where the segment begins at, or within, 30 NM from the ARP.** See appendix 1, figure 3.

1 **Primary Area:** 2 miles on each side of the segment centerline.

2 **Secondary Area:** 1 mile on each side of the primary area.

(b) **Where the segment begins or extends beyond 30 NM from the ARP.** See appendix 1, figures 3 and 9.

1 **Primary Area:** 3 miles on each side of the segment centerline.

2 **Secondary Area:** 3 miles on each side of the primary area.

(c) **Once the departure segment expands to the respective primary and secondary area widths,** the area widths remain constant, except for turn expansion areas, until reaching 30 NM
from ARP, or the en route structure, whichever occurs first. See paragraph 12. At the 30 NM point from the ARP, the areas splay to the dimensions stated in paragraph 8b(2), using the primary area 30 ° splay method. Secondary area splay lines begin and end abeam their corresponding primary area splay lines. See appendix 1, figure 3.

9. TURN AREA EXPANSION. Expand obstacle clearance areas for turns of more than 15 °.
Establish outside expansion areas for fly-over waypoints. See appendix 1, figures 4 and 5. Inside expansion is not required for fly-over waypoints. Provide inside expansion area for fly-by waypoints. See appendix 1, figure 6.

a. Outside Expansion Area.

(1) Construct a line perpendicular to the course centerline at the latest point of the displacement tolerance of the TWP. This line, C'-A-B, is the baseline for constructing a set of arcs to establish boundaries of the outside expansion areas. See appendix 1, figure 5.

(2) Using point C on the baseline as a center point, draw an arc with radius R1 from C' on the outside edge of the primary area of the turn. (R1 is a turning radius selected from table 1.) Draw a second arc with radius R2, using point C as a center point, from the outer edge of the secondary area on the outside of the turn. (R2 is R1 plus [1 NM or 3 NM] of secondary width, whichever applies.) See appendix 1, figure 5.

TABLE 1

FLY-BY or FLY-OVER WAYPOINT TURN RADIUS (R1)
FOR INSIDE and OUTSIDE TURNS

<table>
<thead>
<tr>
<th>AIRCRAFT SPEEDS (KIAS)</th>
<th>180</th>
<th>250</th>
<th>310</th>
</tr>
</thead>
<tbody>
<tr>
<td>TURNING RADIUS (NM) :</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Below 10,000' MSL</td>
<td>2.5</td>
<td>4.2</td>
<td>NA</td>
</tr>
<tr>
<td>10,000' MSL and Above</td>
<td>3.4</td>
<td>5.5</td>
<td>7.7</td>
</tr>
</tbody>
</table>

(3) To determine the elevation for application of table 1, use the flight track distance to the WP applying the 200-feet per mile and/or published climb gradient where applicable.

(4) Locate point D:

(a) On the baseline at a distance R1 from point C for turns 90 ° or greater. See
appendix 1, figure 5.

(b) **On the reference line at a distance from point C for turns less than 90°.**

Construct this reference line from point C parallel to the course following the TWP. See appendix 1, figure 6.

(c) **At the intersection of R1 radius arc and the baseline, or reference line,** whichever is applicable.

(5) **Using point D as a center point,** draw two arcs with radius R1 and R2, respectively. Using tangent lines at 30° relative to the succeeding course, connect these arcs to the succeeding primary and secondary area boundaries, respectively. See appendix 1, figure 5. (On shallow angled turns, the 30° tangent will not always be possible. This occurs where the tangent point falls inside the secondary area's boundary.) See appendix 1, figure 6. Radius R1 and R2 arcs define the primary and secondary expansion areas, respectively.

(6) **Connect corresponding arcs** with straight tangent lines.

(7) **The radii in table 1 apply also for the primary area boundary radii.** Use the turning radius for 250 KIAS.

(8) **Expansion within the splay areas.** When a turn occurs prior to the splayed areas reaching the primary and secondary widths, the same construction applies as above; except, the primary area is drawn from the edge of the primary area abeam the latest point of the displacement tolerance of the TWP. Draw the secondary arc of radius R2. Extend the secondary area splay (prior to turn), until it intersects the arc at point E. See appendix 1, figure 8. Crosstrack fix displacement tolerances need not be considered in the construction of the 7.5°, 15°, and 30° splay areas, with regard to possible overlap of the splay boundary.

b. **Inside Expansion Area.**

(1) **Locate a point on the primary area boundary on the inside of the turn,** at the DTA measured parallel to the course back from the earliest point of the TWP’s displacement area. See appendix 1, figure 7. The DTA is determined by the following formula:

\[
\text{DTA} = \text{TR} \times \tan \left(\frac{\text{turn angle}}{2}\right)
\]

Where: \(\text{TR} = \text{Turning Radius from table 1}\)

(2) **From the DTA point,** splay the primary area by an angle equal to one-half of the course change.

(3) **Draw the secondary area parallel to the primary splay,** a distance equal to the secondary area width at the DTA point.

(4) **When the first WP is less than 2 NM beyond the DER,** the inside turn boundary begins 500 feet abeam the DER. See appendix 1, figure 8.
10. OBSTACLE CLEARANCE. The area considered for obstacle clearance begins at the DER. The maximum required obstacle clearance (ROC) for level flight is 1,000 feet in non-mountainous areas, and 2,000 feet in designated mountainous areas, except when Order 8260.3B, paragraph 1720, is applied. Do not compute a climb gradient above an altitude which satisfies these ROC’s.

   a. Primary Area. No obstacle shall penetrate a 40:1 obstacle identification surface (OIS) which begins at the DER and rises from DER elevation in the direction of flight. The 40:1 OIS rises along the shortest distance in the primary area from its beginning to the obstacle. See appendix 1, figures 2 and 10.

   b. Secondary Area. No obstacle shall penetrate a 12:1 OIS which rises from the edge of the primary area perpendicular to the segment course. In a turn expansion area, the 12:1 OIS rises perpendicular to the edge of the primary area. See appendix 1, figures 2 and 10. Determine the height of an equivalent obstacle on the edge of the primary area, then evaluate the equivalent obstacle relative to the 40:1 OIS, at that point.

Example: A 9,840-foot MSL obstacle is located in the secondary area, 2,700' from the edge of the primary area.

   Step 1. Determine the elevation of an equivalent obstacle (E_E) on the edge of the primary area:

   Rise of 12:1 slope to edge of primary area: \[
   \frac{2700'}{12} = 225'
   \]

   Elevation of obstacle (E_O) 9,840'

   Less 12:1 rise - 225'

   E_E 9,615'

   Step 2. Determine the 40:1 OIS elevation at equivalent obstacle:

   \[
   D = \text{distance (NM) from DER measured along the shortest distance within the primary area} = 21,344' = 3.513 \text{ NM}
   \]

   Plus 40:1 rise: \[
   \frac{21,344'}{40} = 533.6'
   \]

   DER elevation 7,640.0'

   40:1 rise + 533.6'

   40:1 OIS elevation at equivalent obstacle 8,173.6'

   (Equivalent obstacle elevation exceeds 40:1 OIS elevation;
an OIS penetration exists. Proceed to step 3.)

**Step 3.** Determine minimum climb gradient (G):

\[
E_E = 9,615' \\
\text{DER elevation} = -7,640' \\
\text{Height (H_E) of equivalent obstruction above DER} = 1,975'
\]

\[
G = \frac{48D + H_E}{D} \quad \text{(round to next higher 5-foot increment)}
\]

\[
\frac{48(3.513) + 1975}{3.513} = 610.2' = 615/\text{NM}
\]

**Step 4.** Minimum climb gradient termination altitude (A_T):

\[
A_T = 48D + E_E \quad \text{(round to the next higher 100-foot increment)}
\]

\[
[3.513 \times 48] + 9615' = 168.6' + 9615' = 9783.6' = 9800' \text{ MSL}
\]

### 11. Climb Gradients.

**a. For the initial climb area**, calculate a climb gradient to the first WP, as necessary, using the following formula:

\[
G = \frac{H_C}{D_t}
\]

Where:  
G = climb gradient (ft/NM)  
D_t = distance (NM) from DER measured along the route centerline  
H_C = height (ft) to climb above DER (allow for elevation differential between airport elevation and DER elevation)

**Example:** The first WP is located 1.6 NM beyond the DER:

\[
G = \frac{400}{1.6} = 250 \text{ ft / NM}
\]
For any segment, including the initial climb area, avoid obstacles (including equivalent obstacles from paragraph 10b) which penetrate the OIS, by specifying a climb gradient that provides 48 ft/NM ROC applied over distance (D). Apply the minimum climb gradient required for obstacle clearance. The minimum climb gradient for an obstacle is determined from the formula:

\[ G = \frac{(48D) + H_o}{D} \]

Where:
- \( G \) = Climb Gradient (ft/NM)
- \( H_o \) = Height (ft) of obstacle above DER (ft)
- \( D \) = Distance (NM) from DER measured along the shortest distance within the primary area

Specify the climb gradient to an altitude where a gradient greater than 200 ft/NM is no longer required. The climb gradient termination altitude \( (A_T) \) may be determined by the formula:

\[ A_T = 48D + E_o \]

(round to the next higher 100-foot increment)

Where:
- \( E_o \) = Obstacle Elevation (MSL)
- \( D \) = (as defined in paragraph 11b)

\[ A_T = (3.15 \times 48) + 9,615' = 9,783.6' = 9,800' \]

d. Multiple Climb Gradients.

(1) Where multiple climb gradients exist within a segment (e.g., due to obstacle clearance, as well as Air Traffic Control requirements), publish the highest computed climb gradient for that segment.

(2) Where climb gradients change within a segment, specify a WP to mark that change. Publish other than standard climb gradients according to their respective segments or required distance.

12. CLIMB IN A HOLDING PATTERN. Apply the criteria in Order 8260.3B, paragraph 293b, and Order 8260.38A, paragraph 8. See appendix 1, figure 11.

13. END OF DEPARTURE. The departure area shall terminate at a WP or an existing en route fix/NAVAID from which the aircraft can continue en route operations. When the departure joins an en route airway, the departure dimensions end at the point where the departure course and the en route course intersect. At that point, if the aircraft has not reached the minimum en route altitude, as determined by flight track distance and applicable climb gradient, the departure obstacle evaluation
continues to the point where the minimum altitude for en route is reached. This evaluation is conducted using the same method for all 40:1 OIS evaluations. A climb gradient may be required to clear any penetration or to reach the minimum en route altitude at the point where the departure evaluation terminates. Measure the shortest distance within the merged primary areas to the obstacle to be evaluated. See appendix 1, figure 10. This evaluation includes all possible transition routings.

SECTION 2. DIRECTIVE FEEDBACK INFORMATION

14. INFORMATION UPDATE. Forward for consideration any deficiencies found, clarification needed, or suggested improvements regarding the content of this order to:

DOT/FAA
ATTN: Flight Procedures Branch, AFS-440
P.O. Box 25082
Oklahoma City, OK 73125

a. Your Assistance is Welcome. FAA Form 1320-19, Directive Feedback Information, is included at the end of this order, for your convenience. If an interpretation is needed immediately, you may call the originating office for guidance. However, you should also use the FAA Form 1320-19 as a follow-up to the verbal conversation.

b. Use the "Other Comments" block of this form to provide a complete explanation of why the suggested change is necessary.

Thomas C. Accardi
Director, Flight Standards Service

William J. White
Deputy Director, Flight Standards Service
FIGURE 1. GPS DEPARTURES MINIMUM DISTANCES FROM DER TO WP.

- FLY-OVER WP
- Initial climb area
- DER

- FLY-BY WP
- Minimum distance from DER to WP is 2NM plus DTA
- Initial climb area
- DER

- UP TO 15° Turn
- Initial climb area
- DER

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FIGURE 2. GPS DEPARTURE, UP TO 15° TURN

1 nm  2 nm  2 nm  1 nm

Primary

Secondary

14.6 NM

7.34 NM

DER

1,000 FT

500 FT

15°
FIGURE 3. GPS DEPARTURE, 90° TURN BEYOND 30 NM FROM ARP.

Primary and secondary areas 3nm widths.

Displacement = 2nm ATRK, 2.8nm XTRK

R1 = turn radius, table 1
R2 = R1 + 3nm

FLY-OVER WAYPOINT

30nm of ARP
FIGURE 4. GPS DEPARTURE, 120° TURN, FLY-OVER WAYPOINT.

EXPANSION CONSTRUCTED AT LATEST POINT OF ATRK DISPLACEMENT

Inside expansion not required for fly-over WP.
FIGURE 5. GPS DEPARTURE, 90° TURN, BELOW 10,000' MSL, FLY-OVER WAYPOINT.

No inside turn expansion required for fly-over WP.

Fly-over WP

$R_1 = \text{From table 1}$

$R_2 = R_1 + 1\text{nm}$

Base line $C' - A - B$
FIGURE 6. GPS DEPARTURE 30° TURN, FLY-OVER WAYPOINT.
FIGURE 7. GPS DEPARTURE 30° TURN, FLY-BY WAYPOINT.
FIGURE 8. GPS DEPARTURE, 120°
TURM FLY-OVER WP, 1NM FROM DER.

R1 = from table 1
R2 = R1 + 1nm

EXPANSION CONSTRUCTION BEGINS 1NM BEYOND
PLOTTED POSITION
OF TURN WP.

Displacement
area not
applicable
FIGURE 9. GPS DEPARTURE 120° TURN FLY-OVER WAYPOINT MORE THAN 30 NM FROM ARP.

OUTSIDE EXPANSION CONSTRUCTED FROM LATEST POINT OF ATRK DISPLACEMENT.

FLY-OVER WP.
R1 = FROM TABLE 1
R2 = R1 + 3 NM
FIGURE 11. CLIMB AND HOLD DEPARTURE.
Figure 16-4. General Turning Performance (Constant Altitude, Steady Turn) (para 16-8b).