U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

National Policy

ORDER 8240.47D

Effective Date:
08/09/2015

SUBJ: Determination of Instrument Landing System (ILS) Glidepath Angle, Reference Datum Heights (RDH), and Achieved Reference Datum Heights (ARDH)

1. Purpose of This Order. This order prescribes the method by which the actual flight inspection glidepath angle, instrument landing system (ILS) reference datum height (RDH), and ILS-achieved reference datum height (ARDH) are determined.

2. Audience. The primary audience is Flight Inspection Services, who has the responsibility to complete the best fit straight line procedures to determine the correct glide slope aiming point. The secondary audience is facilities engineering and maintenance personnel including military and international entities.

3. Where Can I Find This Order? The order is available online at the FAA Orders and Notices webpage, on both the employee and public websites.

4. What This Order Cancels. Order 8240.47C, dated March 1, 2001 and Notice VN200 8200.3 dated October 1, 2004.

5. Explanation of Changes. Prior to this revision of the order, reference datum height (RDH) or achieved reference datum height (ARDH) replaced the calculated threshold crossing height (TCH) for procedural use. In this revision the procedural design (calculated) TCH will be published. The methods presented provide flexibility in siting glide slope facilities. This revision includes updates to the references, defines when this order should be applied, and clarifies required procedural actions.

a. General. Updated references and renumbered figures for new format.

b. General. Removed procedural use of RDH and ARDH references.

c. General. Removed references to ground point of intercept (GPI). GPI values after application of this order are not applied procedurally. Procedure data uses calculated GPI from survey data.

d. Paragraph 6b. Added to address special instructions regarding the change of the commissioned angle.

e. Paragraph 6g. Changed from "guidelines following a Mark 20 glide slope conversion" to "glide slope equipment upgrades." Broadened language to allow for newer and various types of ILS equipment.

f. Paragraph 6g. Removed the requirement that the facility be classified as a category (CAT) II/III prior to the equipment upgrade. The issue is if the facility had best fit straight line (BFSL) applied prior to the upgrade.

g. Paragraph 6g.(3). Added if site improvements change by less than or equal to 3 feet for the aiming point elevation or the threshold elevation and if the commissioned angle remains the same, then BFSL does not have to be completed during an equipment upgrade.

h. Paragraph 7. Added GPI as an item that must be agreed upon prior to commissioning because the data is based on facility location.

i. Paragraph 7a. Removed the requirement for an engineering review after flight inspection.

j. Paragraph 7b. Changed due to the requirement for procedure to be developed and published from the TCH.

k. Paragraph 7c. Removed requirement to round the glide slope origination elevation to the whole foot. Automated flight inspection system (AFIS) accepts and can be verified to a tenth of a foot. This results in more accurate measurements on future checks.

l. Paragraph 7d. Removed the last sentence about notifying the procedures office of changes in the RDH, ARDH, or glide slope origination elevation. Procedures office is developing procedures on TCH.

m. Paragraph 8a. Changed the glide slope offset of L00001 to either L00000 or R00000. AFIS will now accept all zeroes for the offset.

n. Paragraph 8a. Removed the alternate method of determining the initial reference elevation. The aiming point elevation is required survey data value.

o. Paragraph 8b. Removed the requirement for optimizing modulation equality. FAA Order 6750.49, Maintenance of Instrument Landing System (ILS) Facilities, requires the glide slope to operate at less than or equal to 5µA for modulation equality.

p. Paragraph 8b Note. Added note to emphasize the use of the zone 2 BFSL angle as the reference instead of the mean/announced angle.

q. Paragraph 8d. Modified the last sentence to state the facility can be commissioned for SA CAT II, CAT II, and CAT III use after the requirements have been met.

r. Paragraph 8f(1). Removed the requirement to inform the procedures specialist when the aiming point height is adjusted.

s. Paragraph 8f(1). Added the glide slope height determined during the BFSL process which will be the height used on subsequent inspections.

t. Paragraph 8h. Added to report the final results per 8240.36, Flight Inspection Report Processing System (FIRPS), and to submit FAA Form 8240-20, AVNIS Data Change Submission.

u. Paragraph 10. Changed RDH and ARDH tolerances.

v. Paragraph 10d. Changed the approval process for using ARDH.

w. Appendix A. Added TCH definition.

x. Appendix A. Added GPI definition.

y. Appendix A paragraph 3. Removed that RDH replaces the mathematical TCH and changed the definition of the calculation of the RDH.

z. Appendix A, Paragraph 4. Updated ARDH measurements to 6,000 feet - 1,000 feet.

aa. Appendix B, Paragraph 4.a. Updated ARDH measurements to 6,000 feet - 1,000 feet.

6. Application. This order must be applied to establish the glide slope origination elevation, RDH, and ARDH for all U.S. civil and military glide slope facilities proposed to provide Special Authorization (SA) CAT II, CAT II, and CAT III approach minimums regardless of "Official Category." Aeronautical Information Manual, Pilot/Controller Glossary defines the different ILS categories. Paragraphs 6a, 6b, 6c, and 6d define those conditions that require application of this order for all SA CAT II, CAT II, and CAT III facilities, as well as any CAT I facilities proposed to support SA CAT II minima. Paragraph 6e and 6f may be applied for all other CAT I facilities if jointly deemed advantageous by flight inspection and facilities engineering personnel. Paragraph 6g provides additional guidance for determining if the application of this order is required when the glide slope is upgraded to newer equipment. Application to non-U.S. facilities must be discussed with the facility managers and may be requested by the owning nation. When applying the provisions of this order, use the AFIS program for calculating glide path angle, RDH, and ARDH. Apply this order during:

a. Site, commissioning, and during an initial CAT II/III inspection if this order has not been previously applied.

b. Reconfiguration or special inspections as a result of a glide slope site relocation or commissioned angle change.

c. **A change to the glide slope antenna configuration** (null reference to capture effect, etc.)

d. Site improvements which change the documented aiming point or threshold elevation by more than 3 feet.

e. To establish a glide slope origination elevation for CAT I glide slopes when:

(1) All the requirements for a CAT I glide slope commissioning are satisfactory in accordance with FAA Order 8200.1, United States Standard Flight Inspection Manual, Chapter 15.

(2) The TCH, RDH, or ARDH meets the tolerances in paragraph 10 of this Order.

f. End Fire Glide Slope. Initial reference aiming point elevation corrections exceeding ± 3 feet must be reported to the installation engineer. Changes to site elevation for use as the AFIS aiming point elevation must only be accomplished by coordinating with the facilities engineering personnel. Engineering personnel may request a normal transverse structure evaluation in lieu of an approach to establish adjustment references. When applying this order, complete the application following antenna pedestal adjustments.

g. Glide Slope Equipment Upgrades. Application of this order is not required if all of the following requirements are met:

(1) Facility is currently classed as a SA CAT II, CAT II, or a CAT III.

(2) Prior to upgrade, the RDH was satisfactorily applied by this version or previous versions of this Order.

(3) Glide slope radiation characteristics remained the same, such as: glide slope remained the same type, aiming point elevation or threshold elevation changed by less than or equal to 3 feet, no significant (as determined by engineering) change to siting environment, the commissioned angle remains the same, etc.

(4) All requirements of FAA Order 8200.1 are completed satisfactory.

(5) The facility was not relocated.

7. Commissioning Sequence. Facilities engineering, flight standards operations, and procedures must agree on the proposed commissioned glide path angle, TCH, and GPI when a location has been selected for a glide slope installation. These values will be based on operational requirements, obstruction considerations, and siting constraints.

a. Engineering. Evaluate siting conditions and install the antenna at a position which should provide a glidepath conforming to the proposed values. Reference FAA Order 6750.36, Site Survey, Selection, and Engineering Documentation for Instrument Landing Systems and Ancillary Aids.

b. Procedures Development. Procedures personnel will conduct evaluations and perform calculations using the installation values. Procedures will use the calculated TCH for procedure design.

c. Flight Inspection. When engineering has installed the glide slope and it is ready for evaluation, flight inspection will check the glide slope and determine the actual angle, RDH, and ARDH, using BFSL procedures in this order.

(1) The final RDH and ARDH must be rounded to the nearest foot in accordance with FAA Order 8200.1, Appendix 2. RDH and ARDH rounding to achieve tolerance is acceptable, provided glide slope angle and structure parameters are satisfactory in accordance with the requirements of FAA Order 8200.1, Chapter 15. Rounding example: a RDH = 49.5 is rounded to 49 and a RDH of 49.6 is rounded to 50.

(2) Facilities not meeting TCH, RDH, or ARDH requirements for CAT II/III glide slope commissioning and are otherwise satisfactory in accordance with FAA Order 8200.1, Chapter 15, must be commissioned as CAT I until the problem is corrected.

d. Facility Data. Facility data must be updated to reflect the derived glide slope origination point. The final glide slope origination point must be the reference data for all subsequent glide slope flight inspections.

8. Flight Inspection Procedures.

a. Programming the AFIS. Enter the glide slope CL-ELEV-ABM elevation for AFIS GS HGT, enter L00000 or R00000 for GS OFF, and verify data sheet AIM-PT LAT/LON matches the AFIS GS LAT/LON within the tolerance of TI 8200.52, Flight Inspection Handbook, Appendix 10.

> Note: Engineering/installation personnel may request to modify the glide slope origination point as referenced in FAA Order 8200.1, Chapter 15 for glide slope facilities with unusual siting characteristics. This request only applies to CAT I glide slopes evaluated in accordance with paragraph 6e of this order. Flight Inspection Services Operations Division must approve the requested deviation in writing. The written approval must be stated on the facility data.

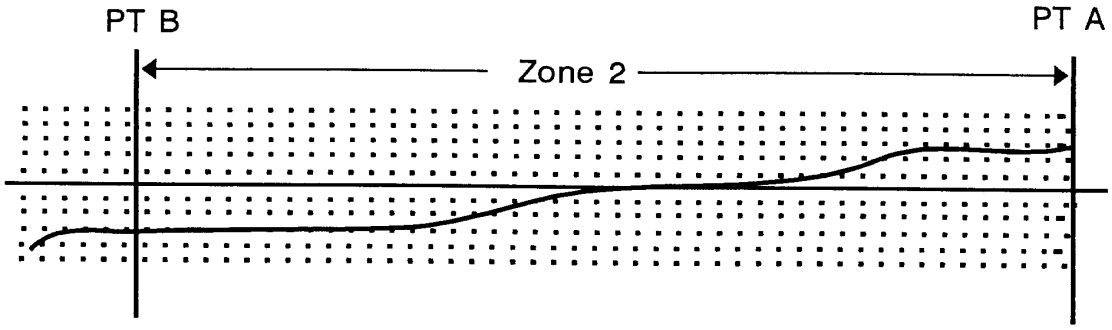
b. Optimizing. Complete phasing (if required), and optimize the glide slope path width and angle to within commissioning tolerances prior to collecting results for BFSL.

> Note: Use the zone 2 BFSL angle as a reference to determine if the angle needs adjustment. If the zone 2 BFSL angle is within tolerance and acceptable by maintenance, do not make an initial angle adjustment.

c. Data Collection. Conduct at least three glide slope approaches that produce similar trends in the AFIS Zone 2 corrected error traces. Similarity is required to ensure accurate and repeatable results. Approach results from commissioned glide slopes can be used to determine whether or not application of this order is feasible. Current approach results must be used provided the width and angle are within commissioning tolerances. Implementation will require the flight inspection be documented in accordance with FAA Order 8240.36.

d. Analysis. Refer to the AFIS Zone 2 corrected error trace (Figure 1). If a skew in the trace is present, it is indicative of a change in the glide path on-path locations throughout ILS Zone 2 as viewed from the aiming point. A skew may be caused by an incorrect AFIS aiming point reference elevation or be induced by environmental conditions. Each change in the reference elevation to correct the skew will require a reevaluation. Once the skew is minimized, the average of the three selected runs determine the actual Zone 2 BFSL glide slope angle and the glide slope aiming point elevation**.** BFSL results may only be applied when the zone 2 corrected error trace skew is minimized (Z2BF DHT $\leq$ 3 feet) and all requirements of FAA Order 8200.1, Chapter 15 for glide slope commissioning are satisfactory, paragraph 8f of this order, and the TCH, RDH, or ARDH tolerances in paragraph 10 are met. This requirement must be completed and satisfactory prior to the facility being used to support SA CAT II, CAT II, or CAT III.

Figure 1. Skewed trace presented on an AFIS Recording.
(This example indicates the programmed GS-HGT is higher than optimum)



e. Adjustments. Installation engineers must make adjustments to the glidepath angle predicated on the average of the BFSL angle evaluations. Before making further evaluations, the AFIS glide slope height must be reprogrammed to coincide with the new average glide slope aiming point elevation. Unusual glide slope siting conditions may produce bends or distortions in the glidepath. This condition can produce excessive glide slope aiming point elevation corrections and inconsistent glide slope angles. If the evaluation is to proceed under these conditions, use the BFSL angle as the reference and make both elevation and angle adjustments in half step increments.

f. Confirmation.

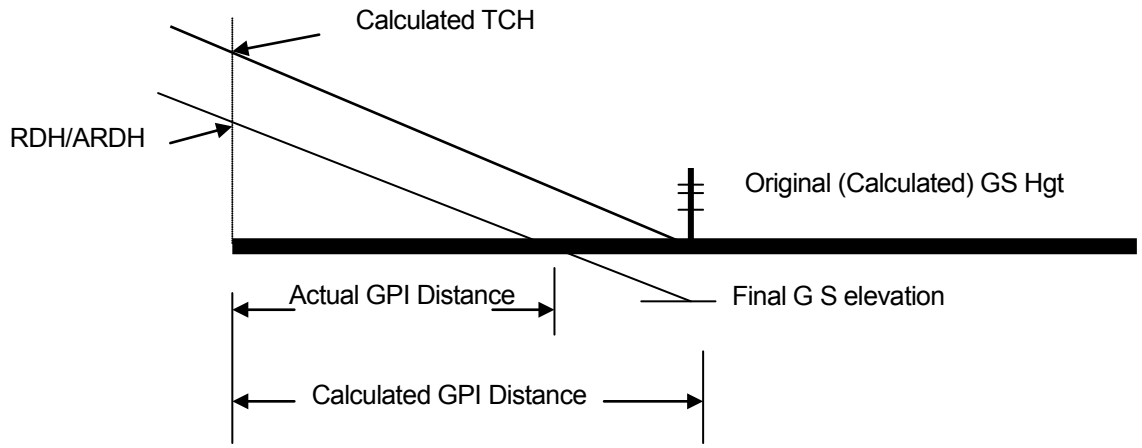
(1) Conduct additional AFIS glide slope evaluations until the Zone 2 Best Fit Delta Height (Z2BF DHT) corrections repeat within 3 feet of zero and within 3 feet of each other on three separate flight inspection approaches. The final glide slope height used to determine the correct aiming point elevation will be the new AFIS glide slope height. The elevation must be documented on the facility data sheet as the glide slope height and this height will be used for future inspections.

Note: When applying the order it is permissible to apply corrections within the 3 feet window due to meet RDH tolerances.

(2) The average of the three selected runs for Zone 2 BFSL path angles (Z2BF PA) and mean/announced path angles (MEAN PA) must be within ± .05° of the desired commissioned angle. When the average of the three selected runs for mean path angle and the Zone 2 BFSL path angle are within 0.03° of each other, the glide slope angle origination point has been optimized. A Zone 2 AFIS corrected error trace that has no skew relative to the zero microamp reference indicates the reference elevation has been optimized. (See Figure 1 for an example of a Zone 2 AFIS corrected error trace that is skewed.)

g. Application. The AFIS announced angle and Zone 2 structure analysis are predicated on the AFIS glide slope height. These evaluations are not valid until the glide slope height is correct. When the final GS HGT in AFIS is derived and three runs meet paragraph 8f tolerances, AFIS will compute the final RDH and ARDH.

Figure 2. Final 8240.47 Results.



h. Reporting.

(1) Report the results in accordance with FAA Order 8240.36.

(2) Submit FAA Form 8240-20 to enter the final glide slope origination elevation, TCH from AIRNAV prior to applying BFSL data, RDH, ARDH, and GPI values on the facility data sheet.

9. Periodic Inspections. There are no requirements to apply this order during periodic flight inspections. However, when the AFIS Zone 2 corrected error trace is not centered about the zero microampere reference line, it indicates one or more of the following conditions: (1) Incorrect AFIS glide slope height (aiming point elevation), (2) Inaccurate AFIS runway position updates, (3) The glide slope angle is not linear in Zone 2, or (4) change in environmental condition affecting the glidepath. If an AFIS error trace is not centered about the zero microamp line on an established glide slope facility, it is possible that the flight inspection evaluations could be improved if a new glide slope height/aiming point elevation, RDH, etc., is established.

10. TCH, RDH, or ARDH Requirements.

a. Use TCH. If the TCH meets FAA Order 8260.3, United States Standard for Terminal Instrument procedures (TERPS), requirements or the TCH has a waiver, the RDH or ARDH do not have a tolerance.

b. Use RDH. If the TCH does not meet FAA Order 8260.3 requirements and the TCH does not have a waiver, the RDH must be within 50 feet or 60 feet.

c. Use ARDH. If either TCH or RDH does not meet requirements, the ARDH may be used if the ARDH is within 50 feet and 60 feet.

d. ARDH Exception. Use of RDH or ARDH must be reviewed by the Technical Services Team, AJW-331, and approved by Flight Inspection Services Director, AJW-3. Technical Services will forward an information copy to Flight Standards Flight Procedure Implementation and Oversight Branch, AFS-460.

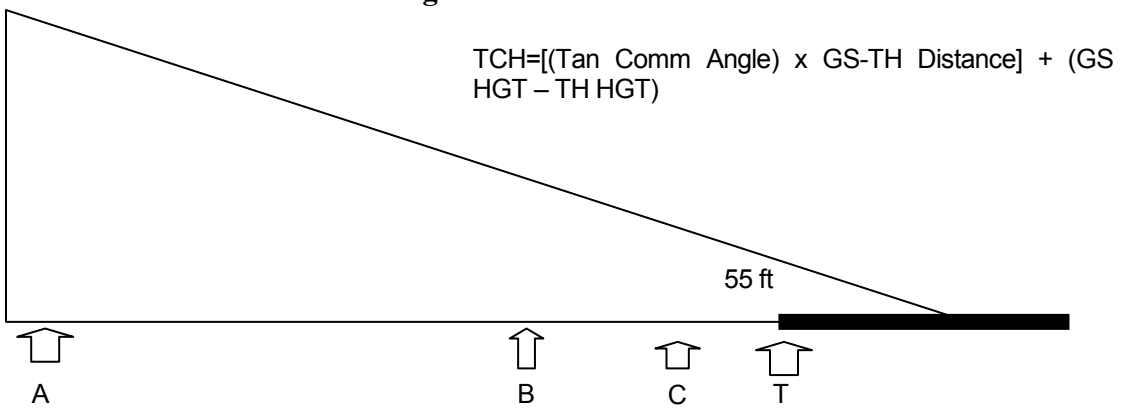
Edward W. Lucke Jr.
Director
Flight Inspection Services

Appendix A. Definitions.

1. Best Fit Straight Line (BFSL). A straight line segment of the glidepath derived by using a least squares mathematical technique. The slope of this straight line defines the height of the glidepath angle relative to the approach surface baseline and threshold. Upon application of this order, the BFSL in ILS Zone 2, projected through the threshold to the runway surface, becomes the RDH reference.

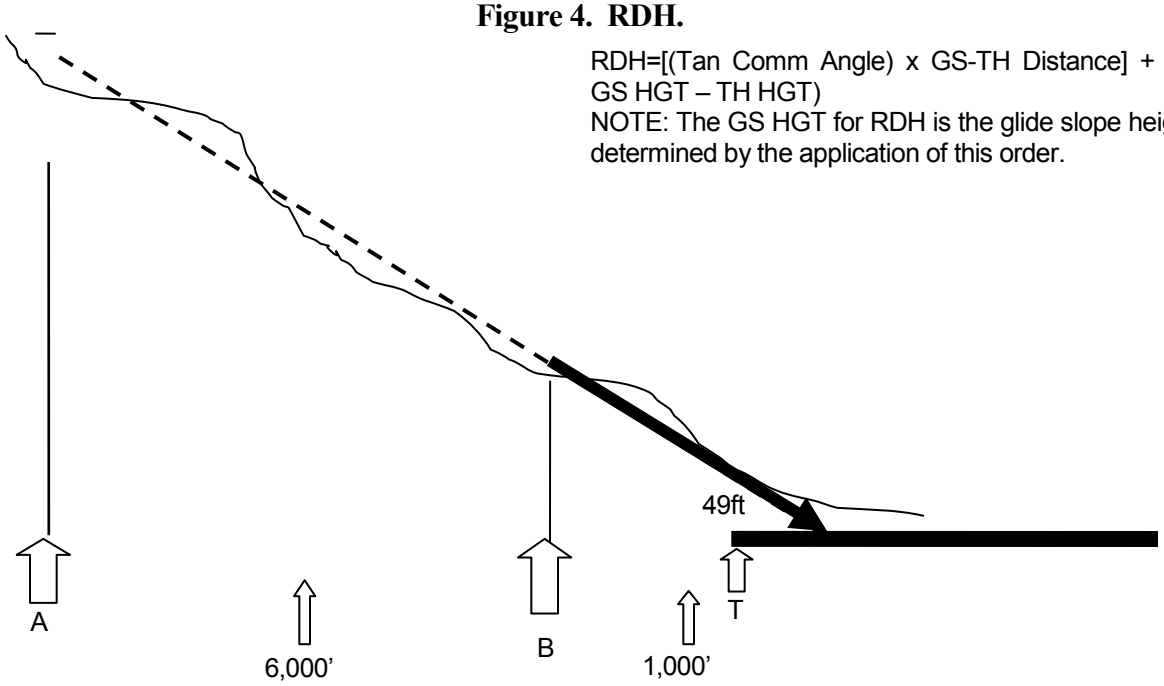
2. Threshold Crossing Height (TCH). The theoretical calculation as the glide slope crosses the threshold. The calculated value is based on survey data.

Figure 3. Calculated TCH.



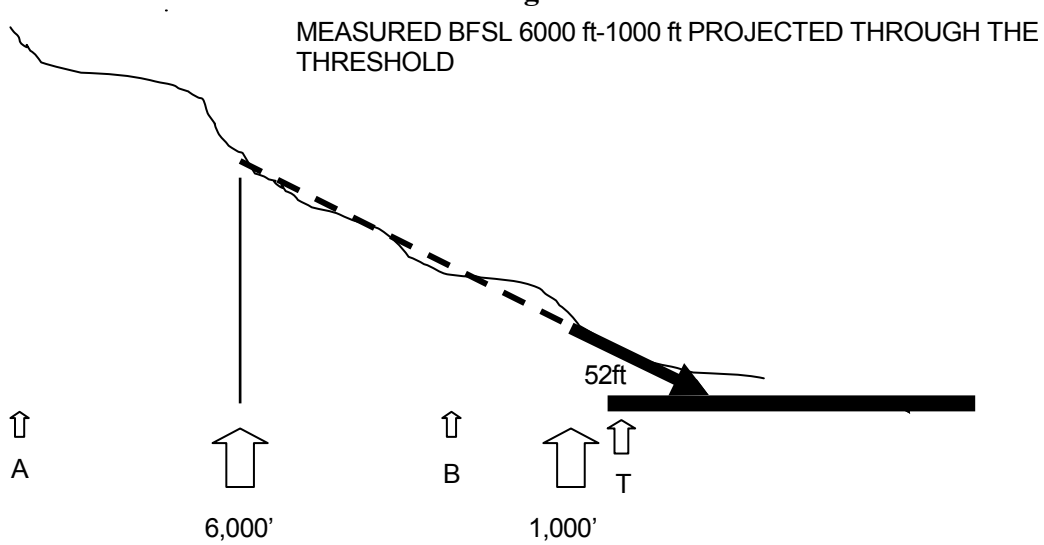
3. ILS Reference Datum Height (RDH). The height of the commissioned glidepath located vertically above the runway threshold. The RDH is computed the same as the TCH except the glide slope height is the derived glide slope height computed after the application of this order. RDH is synonymous with the ILS reference datum as defined in the International Civil Aviation Organization (ICAO) Annex 10.

Figure 4. RDH.



4. ILS Achieved Reference Datum Height (ARDH). The height that the "close in" glide path segment crosses the runway threshold. The ARDH is derived by computing the BFSL glide path between 6,000 feet and 1,000 feet and projecting the downward extension through the threshold.

Figure 5. ARDH.



5. Glide Slope Origination Point. Prior to the application of this order, it is a calculated point, generally at the center or base of the glide slope antenna array, which has been defined by engineering to be the point of theoretical signal emanation. After the application of this order, this point is redefined to be the same as the aiming point latitude, longitude, and elevation as determined by this order (AFIS glide slope height).

6. Aiming Point. The location that is programmed into the automated flight inspection system (AFIS) from which glide path measurement results are referenced. The aiming point may not be coincident with the glide slope origination point. For application of this order, the AFIS glide slope latitude and longitude will be programmed to use, as the measurement reference, the coordinates which coincide with the point on the commissioned localizer course which is abeam the theoretical glide slope origination point. Listed as the AIM-PT LAT/LON on the FAA facility data sheet.

7. Ground Point of Intercept (GPI). A point in the vertical plane on the runway centerline at which it is assumed that the straight line extension of the glide slope intercepts the run way approach surface baseline.

8. Approach Surface Baseline (ASBL). A horizontal plane, tangent to the surface of the earth at the runway threshold point.

Appendix B. Computation of the Best Fit Straight Line.

1. This appendix provides the methods for computing the BFSL. AFIS performs the following calculations automatically. The following mathematical procedure may be used when the complete AFIS solutions are not available. A computer is recommended when performing these calculations.

2. Symbols and Formulas.

θ_m = Measured angle as derived from the AFIS Zone 2 corrected error trace.

X = Distance from a point on the localizer course; the AFIS aiming point; or a point directly abeam, if offset; to the sample point as derived from the corrected error trace.

0 = Perpendicular distance the glide slope aiming point is offset from the localizer course if the offset is not zero.

$X_o = \sqrt{X^2 + 0^2}$ = Distance from the glide slope offset to the sample point. This value is used to determine Y and is required only if the glide slope aiming point is offset from the localizer course when analyzing old AFIS recordings where the glide slope coordinates were used for the aiming point.

$Y = [(\text{Tan } \theta_m)(X)]$ = Height of the sample point above the glide slope aiming point.

NOTE: Use X_0 if offset.

$\overline{X}$ = Average of all X distances.

$\overline{Y}$ = Average of all Y heights.

$x = X - \overline{X}$ (i.e., each individual distance value minus the average of all sample distances).

$\sum xY$ = The sum of all the products of x and Y.

$\sum x^2$ = The sum of all the squares of x.

$\frac{\sum xY}{\sum x^2}$ = The tangent of the angle of the BFSL.

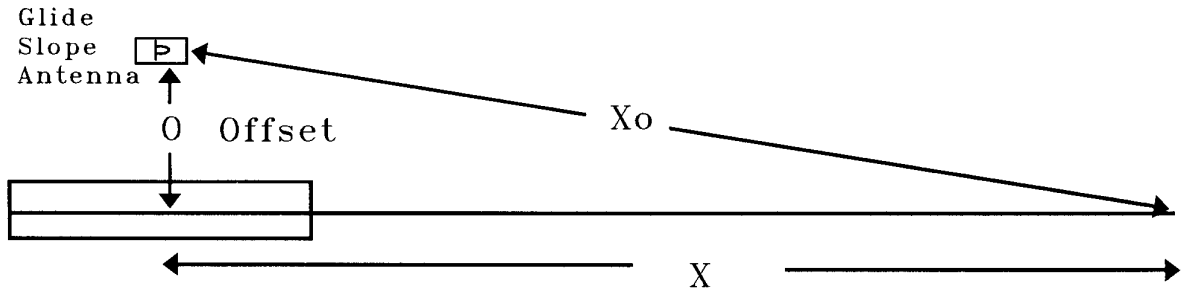
θ_b = Angle of the BFSL.

$\overline{Y} - [(\tan \theta_b)(X)] = \overline{Y}$ Vertical height of the aiming point elevation must be adjusted to be in line with the extended BFSL. A minus value would indicate that the aiming point elevation must be lowered.

3. Symbol Illustration.

a. Plan View. Determine "X" and "X_O."

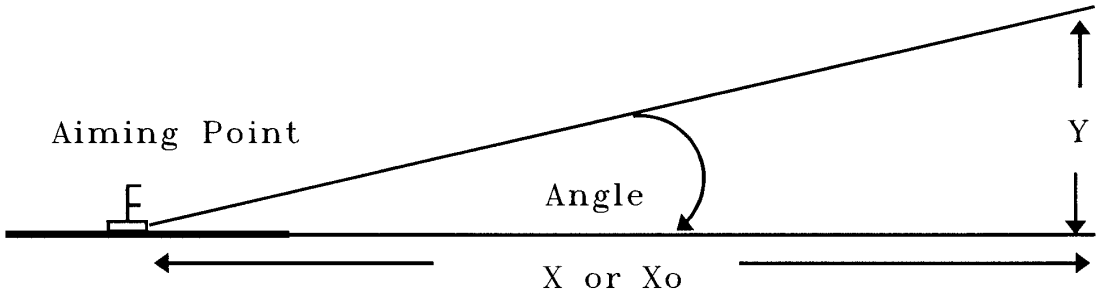
Figure 6.



X_O = Distance used to calculate Y when the offset is used for the aiming point.
X = Distance used to calculate Y when the CL is used as the aiming point.

b. Profile Views.

Figure 7.



Determine Y by use of X or X_O as appropriate

4. Preparing for Calculation.

a. The calculations for BFSL angle, RDH, ARDH, and GPI are made using an AFIS Zone 2 corrected error trace. Identify and mark points "A" and "B" on this trace and divide this segment into 20 equal parts. A 10-point divider may be utilized for this task. The calculations for ARDH are automatically made by AFIS, using corrected error data taken from 6,000 feet to 1,000 feet from the threshold.

b. Record the MEAN angle about each sample point (i.e., plus or minus one-half the distance to the adjacent samples). Each mean angle measurement is recorded as a "light line" value. For analysis, each "light line" will equate to 1.0 (estimate to a tenth of a line for repeatability). "Light lines" are considered "plus" values when above the announced AFIS angle reference, and "minus" values when below the reference.

c. Determine the horizontal distance "X" for each angle. Calculate the distance "X_O" if the AFIS aiming point was offset from the localizer course.

d. Compile all the preceding data and perform the following BFSL calculations.

5. BFSL Calculation. The following is an example of a Zone 2 BFSL calculation.

- Distance from the point abeam the glide slope on the localizer centerline to the runway threshold = 1,075 feet.

- Height of the AFIS aiming point relative to the runway threshold = +1 foot higher than threshold elevation.

- Offset distance = 401 feet.

Sample#	θ_m	X	X_o	Y	x
Pt. "A"	3.00	25379	25382	1330	10402
2	3.00	24339	24342	1276	9362
3	3.00	23299	23302	1221	8322
4	3.00	22258	22262	1167	7281
5	2.99	21218	21222	1108	6241
6	2.98	20178	20182	1051	5201
7	2.98	19138	19142	997	4161
8	2.97	18098	18102	939	3121
9	2.97	17057	17062	885	2080
10	2.96	16017	16022	828	1040
11	2.95	14977	14982	772	0
12	2.95	13937	13943	719	-1040
13	2.94	12897	12903	663	-2080
14	2.93	11856	11863	607	-3121
15	2.92	10816	10823	552	-4161
16	2.91	9776	9784	497	-5201
17	2.90	8736	8745	443	-6241
18	2.89	7696	7706	389	-7281
19	2.84	6655	6667	331	-8322
20	2.80	5615	5629	275	-9362
Pt. "B"	2.74	4575	4593	220	-10402

a. Results of BFSL Calculations.

$\overline{X} = 14977$ $\overline{Y} = 774.77$ $\sum x Y = 44483336$ $\sum x^2 = 833160000$

b. Tangent of BFSL Angle.

$$\frac{\sum xY}{\sum x^2} = \frac{44483336}{833160000} = 0.0533911 = \text{Tan of } 3.056 \text{ degrees.}$$

c. Determining the difference in height between the aiming point elevation and the BFSL extension.

$\overline{Y} - [(\text{Tan } \theta_b)(\overline{X})] = \text{Adjustment to height.}$
$774.77 - [(0.0533911)(14977)] = -24.87 \text{ feet.}$

d. Determining the Commissioned RDH.

(1) Step 1. Multiply the tangent of the COMMISSIONED angle by the "distance" from the threshold to the AFIS aiming point. If the localizer is offset from the runway centerline, the "distance" shall be from a point abeam the AFIS aiming point to a point abeam the threshold on the commissioned final approach course.

(2) Step 2. Subtract the threshold elevation from the final AFIS aiming point elevation. Then, algebraically add the difference to the value determined in step 1. This value is the RDH.

e. Determining the GPI. Divide the RDH by the tangent of the commissioned angle.

6. ARDH Calculation. ARDH is calculated the same as RDH except for measuring glide slope between 6,000 feet and 1,000 feet prior to threshold.

Appendix C. Administrative Information.

1. Distribution. This order is distributed to the branch level in the National Procedures Office and Flight Inspection Operations Division in Flight Inspection Services, to the branch level in the National Airway Systems Engineering Division, Washington headquarters; to the branch level in the regional Airway Facilities and Flight Standards divisions; all Flight Inspection Offices; and special military addressees.

2. Directives Feedback Information. This order can be updated by using FAA Form 1320-19.