THE SELECTION OF Glide SLOPE ANTENNA PATTERNS FOR USE IN THE FREQUENCY ASSIGNMENT PROCESS

Mark Lopez

July 1979
Final Report

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Prepared for

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
Systems Research & Development Service
Washington, D.C. 20590
NOTICE

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The frequency assignment process is meant to preclude harmful interference within service volumes. This is done by choosing frequencies in a manner which provides certain minimum cochannel and adjacent channel desired to undesired signal ratios at critical points of the service volume. One of the factors which affects a station's signal strength in space is its horizontal antenna pattern. Consequently, the horizontal pattern can have a substantial effect on the separation required between glide slope frequency assignments. In some cases, it is desirable to consider the actual antenna patterns involved rather than using worst-case station separations. This report has been assembled so that the directivity of the horizontal pattern may be considered in the assignment process. For each antenna type, a particular antenna pattern is recommended.
The mission of the Spectrum Management Staff is to assist the Department of State, National Telecommunications and Information Administration, and the Federal Communications Commission in assuring the FAA's and the nation's aviation interests with sufficient protected electromagnetic telecommunications resources throughout the world and to provide for the safe conduct of aeronautical flight by fostering effective and efficient use of a natural resource - the electromagnetic radio frequency spectrum.

This objective is achieved through the following services:

- Planning and defending the acquisition and retention of sufficient radio frequency spectrum to support the aeronautical interests of the nation, at home and abroad, and spectrum standardization for the world's aviation community.

- Providing research, analysis, engineering, and evaluation in the development of spectrum related policy, planning, standards, criteria, measurement equipment, and measurement techniques.

- Conducting electromagnetic compatibility analyses to determine intra/intersystem viability and design parameters, to assure certification of adequate spectrum to support system operational use and projected growth patterns, to defend aeronautical services spectrum from encroachments by others, and to provide for the efficient use of the aeronautical spectrum.

- Developing automated frequency selection computer programs/routines to provide frequency planning, frequency assignment, and spectrum analysis capabilities in the spectrum supporting the National Airspace System.

- Providing spectrum management consultation, assistance, and guidance to all aviation interests, users, and providers of equipment and services, both national and international.
STATEMENT OF MISSION

The mission of the Spectrum Management Staff is to assist the Department of State, National Telecommunications and Information Administration, and the Federal Communications Commission in assuring the FAA's and the nation's aviation interests with sufficient protected electromagnetic telecommunications resources throughout the world and to provide for the safe conduct of aeronautical flight by fostering effective and efficient use of a natural resource - the electromagnetic radio frequency spectrum.

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E. End - Fire Slotted Cable Antenna
F. AIL Type 55 Antenna
G. FAA Antenna Specifications
H. Original NAFEC Data
I. Photographs of Different Antenna Types
INTRODUCTION

In the past, separation of frequency assignments for associated facilities has not considered the individual system components. Consideration of these components (VOR, DME, TACAN, LOCALIZER, GLIDESLOPE) had been included in the overall separation criteria. Separations required between VORTAC Stations did not require that VOR and TACAN separations be considered separately. Separations required between ILS stations did not require that LOCALIZER, GLIDESLOPE, and DME separations be considered separately. Years ago, there was enough standardization among facilities that this could be done. In recent years, however, the use of many stations types and the variation in the radiated powers of stations has lead us to reexamine old assumptions and conclusions. As a result of this examination, we have concluded that separation of frequency assignments for associated facilities should consider the individual system components.

The use of directional antennas can have a substantial effect on the separation required between ILS Localizer frequency assignments. Since cochannel separations are larger, the effect will be greater for them than for adjacent channel separations.

Consideration of horizontal glide slope antenna directivity is not expected to have a substantial effect on the separation required between cochannel ILS systems. Since the glide slope service volume is substantially smaller than the localizer service volume, localizer separation requirements are still expected to dominate in almost all circumstances. A similar statement could be
made for those first adjacent channel glide slope which are paired with first adjacent channel localizers (example: 18x and 18y).

The situation is somewhat different for second adjacent channel glide slope stations and for those first adjacent channel glide slopes not paired with first adjacent channel localizers (example: 18y and 38x). In these cases, the glide slope separation requirement must naturally be examined individually. The horizontal antenna patterns of the glide slope antennas may have a significant effect on separation required in these cases. Consideration of the antenna pattern may be preferable to using worst case separations.

We have assembled data from a number of sources. For antenna type where horizontal patterns were not available, we have made use of NAFEC's ability to measure them. Wherever possible, comparisons have been made between the following types of information:

- Theoretical Antenna Patterns
- Measured Antenna Patterns
- Applicable FAA Antenna Specifications

Data for each antenna type is included in the appendixes. On the basis of these data, antenna patterns have been chosen for use in the frequency assignment process. These patterns are shown in the report conclusions.
DISCUSSION

Rationale for Antenna Pattern Choices

From the information available, three types of antenna data have been compared: theoretical, measured, and FAA Specifications. Ideally, agreement would be expected among these types of data. Practically, this is not always the case. For some antennas, all three types of data are not available. In reviewing what was available, we used the following general glide lines in choosing horizontal antenna patterns for the frequency assignment process.

If an FAA Antenna Specification was found to be applicable for an antenna type and if both the theoretical and the measured data compared reasonably well with it, we depended largely on the specification in choosing the pattern to be used in the frequency assignment process.

If an FAA Antenna Specification was found to be applicable and it did not compare well with the measured data, we chose a conservative frequency assignment pattern based on carefully chosen mixture of specification and measured data. An example of this method is seen in the frequency assignment pattern chosen for the type I and type II antennas.

If no FAA Antenna Specification was applicable and if theoretical data was only available for some portion of a pattern, we tried to get as much measured data as possible before choosing a conservative pattern.

If no FAA Antenna Specification was found to be applicable
and if no theoretical pattern was available, we chose a frequency assignment pattern on the basis of the measured data. The patterns chosen for the Stan-38, End-Yire Slotted-Cable, and the A.I.L. Type 55 Glide Slope Antennas are examples of this method.
CONCLUSIONS

1. The difference between the horizontal antenna patterns of various ILS glide slope antenna types are not as large as what has been found for ILS localizers. Nevertheless, some differences are apparent. In some cases, it may be desirable to take these differences into account in the frequency assignment process.

2. Recommended antenna patterns are shown in figures 1 thru 7. These patterns are intended as tools for avoiding interference between ILS glide slopes. In some cases, these are not the best patterns to use as tools for avoiding interferences between ILS glide slopes and other types of radio services. Should the need arise to make such an analysis, discussion with the Spectrum Management Staff (ARD-60) is recommended.

3. A frequency assignment antenna pattern is not included for the wave-glide antenna since no horizontal antenna patterns were found. Antenna data on this system is therefore still required. Additional data would also be helpful on the A.I.L. Type 55 glide slope and the end-fire slotted cable system.
TYPE VII AND ALL TYPE 55 GLIDE SLOPE ANTENNAS
FREQUENCY ASSIGNMENT ANTENNA PATTERN

RELATIVE ANTENNA GAIN IN DECIBELS

AZIMUTH IN DEGREES

FIGURE 4

SPECTRUM MANAGEMENT STAFF, AIN-60
Submitted: Approved: Hay:
MARK LOPEZ: J.L. FIERZGA 1979
TWO-LAMBDAA CASSEGRANIAN GLIDE SLOPE ANTENNA
FREQUENCY ASSIGNMENT ANTENNA PATTERN

RELATIVE ANTENNA GAIN IN DECIBELS

AZIMUTH IN DEGREES

FIGURE 5
TYPE VII AND ALL TYPE 55 GLIDE SLOPE ANTENNAS
FREQUENCY ASSIGNMENT ANTENNA PATTERN

RELATIVE ANTENNA GAIN IN DECIBELS

AZIMUTH IN DEGREES

SPECTRUM MANAGEMENT STAFF, ARD-60
Submitted Approved Mar.
MARK LOPEZ J.L. FIERZGA 1979

FIGURE 4
RELATED DOCUMENTS


7. FAA Instruction Book, Book I TI 6750.69, "Glideslope Station, One Frequency Type AN/GRN-27(V)," FAA Contract F33657-71-C-0103, Texas Instruments, June 1, 1974.

8. FAA Instruction Book, Book I TI 6750.70, "Glideslope Station, Two Frequency Type AN/GRN-27 (V)," FAA Contract F33657-71-C-0103, Texas Instruments, June 1, 1974.
   FAA Contract FA73WA-3176, February 9, 1973 and FA73WA-3358, Antenna
10. FAA Preliminary Instruction Book T16750.83, "Glide Slope Antenna Type
12. FAA Order 6750.6B, "Installation Instructions for Category I and
13. FAA Order 6750.16A, "Sitting Criteria for Instrument Landing Systems,
    25, 1971, Reprinted September 14, 1976 (Includes Changes 1 through 4).
15. FAA Order 6750.32, "Maintenance of Null Reference Glide Slope Equipment,
    August 9, 1976.
16. FAA Report No. RD-64-11, "Analysis of ILS Glide Slope Antennas in
    Operation and Under Development," FAA Contract FA-WA-4391, National
    Program," FAA Contract FA69WA-2066, Avionics Research Group, Department
    of Electrical Engineering, October 1971.
and Electronics Systems Division of Westinghouse Defense and Electronics Systems Center, August 1972.


29. Unpublished Measured Data Obtained from Neil Creedon, A.I.L. Cutler


<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tr>
<td>AGL</td>
<td>Above Ground Level</td>
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<tr>
<td>A.I.L.</td>
<td>Airborne Instrument Laboratory</td>
</tr>
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<td>A.P.C.</td>
<td>Antenna Products Company</td>
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<td>CE</td>
<td>Capture Effect Glide Slope System</td>
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<tr>
<td>dB</td>
<td>Decibel</td>
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<td>DWG</td>
<td>Drawing</td>
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<td>Federal Aviation Administration</td>
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<td>Glide Slope</td>
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<td>Instrument Landing System</td>
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<td>kHz</td>
<td>Kilohertz</td>
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<td>km</td>
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<td>National Aviation Facilities Experimental Center</td>
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<tr>
<td>nmi</td>
<td>Nautical Miles</td>
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<tr>
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<td>Null Reference Glide Slope System</td>
</tr>
<tr>
<td>RF</td>
<td>Radio Frequency</td>
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<tr>
<td>RWY</td>
<td>Runway</td>
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<tr>
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<td>Sideband Reference Glide Slope System</td>
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<tr>
<td>SRDS</td>
<td>Systems Research and Development Service</td>
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<tr>
<td>T.I.</td>
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<td>TTH</td>
<td>Telecommunication Technical Handbook</td>
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APPENDIX A

TYPE I AND TYPE II ANTENNAS

The Type I antenna consists of a half-wave dipole mounted on an elliptical ground plane and enclosed in a radome. The Type II antenna is the same as the Type I, except it is equipped with a heater. The addition of the heater does not affect the antenna pattern. These antennas have primarily been used with the older tube type transmitters. They are gradually being phased out in favor of antennas with a more directional azimuthal pattern. Only limited measured data was found on these antennas.

The measured data taken at NAFEC (Fig. A3) compares well with the theoretical patterns. In addition, it compares reasonably well with the requirements of specification FAA-E-2245 (Fig. G1). The measured data from Trenton (Fig. A4) does not compare quite as well. The main lobe of the pattern is somewhat narrower and the pattern slightly exceeds the -16dB limit between 242 and 264 degrees. No explanation was available for these discrepancies. The frequency assignment antenna pattern recommended for the Type I and Type II Glideslope Antennas (Fig. 1) is based on the specification (FAA-E-2245) and figures in Appendix A.
BENT DIPOLE GLIDE SLOPE ANTENNA
MEASURED HORIZONTAL RADIATION PATTERN

NAFEC Test Frequency: 313.8 MHz
April 2, 1975

RELATIVE POWER IN DECIBELS

AZIMUTH ANGLE IN DEGREES

FIGURE A 3

SPECTRUM MANAGEMENT SUBZ, ARD-60
Submitted Approved July
MARK LOPEZ J. L. PIÑEZA 1977
TYPE I - TYPE II Glide Slope Antenna
Measured Horizontal Antenna Pattern

Trenton, N.J., Mercer Co. Airport, RWY 6
I-TTN, 332.3 MHz., 4500 ft (1372m), AGL
Sideband Reference Configuration
NAFEC Aircraft, 25 Sept. 1978

Relative Antenna Gain in Decibels

Azimuth in Degrees

Figure A-4

Spectrum Management Effort, ARD-60
Submitted: Approved: Mar.
Mark Lopez J.L. Pineda 1979
APPENDIX B

TYPE III AND TYPE IV ANTENNAS

The Type III antenna is composed of three Type I antennas mounted on an iron frame with an array spacing of approximately 0.75 wavelengths at the mid-band frequency (332.0 MHz). The Type IV antenna is similar to the Type III antenna, except it contains three Type II antennas. (This amounts to the addition of 3 heaters and does not affect the horizontal antenna pattern). These two types are the most widely used glide slope antennas.

The available data includes nine theoretical and measured patterns taken from various publications (Figs. B1 thru B8 and B11). These data compare reasonably well with the applicable specifications; FAA-E-2245 and FAA-E-2429 (Figs. G2 and G5). An additional five measured patterns were obtained from NAFEC data (Figs. B9, B10, B12, B13, and B14). These patterns show some discrepancies. Allentown and Hagerstown compare well with both the theoretical pattern and the specifications, but don't appear to meet the modified requirement of the contract specification with regard to the lower limit of the antenna pattern between 0 and 50 degrees. Dulles does not compare well with either the theoretical pattern or the two specifications. No explanation for this disagreement is available at this time. Allegheny County compares reasonably well with the recommended Type III - Type II frequency assignment pattern, but contains an unexplained peak between 60 and 85 degrees where the data exceeds the -16dB maximum. Reading agrees well with the Type III - Type IV pattern in the front course, but contains some unusual variations in the data outside 20 degrees. NAFEC could provide no explanations for these irregularities.

The frequency assignment antenna pattern recommended for the Type III and
Type IV glide slope antennas is based on specification FAA-E-2245 (Fig. G2) and the material in Appendix B.
TYPE III GLIDE SLOPE ANTENNA
ANTENNA TYPE 4401
THEORETICAL HORIZONTAL RADIATION PATTERN

Scanwell Laboratories Instruction Manual
GLIDE SLOPE ANTENNA SYSTEM, TYPE 4400
July, 1970 Fig. 2 Fig. 24

AZIMUTH ANGLE IN DEGREES

FIGURE B 1
TYPE III GLIDE SLOPE ANTENNA
ANTENNA TYPE 4401
MEASURED HORIZONTAL RADIATION PATTERN

Pueblo Memorial Airport, Runway 25R
I-FTR Test Frequency: 334.1 MHz
Scanwell Laboratories Instruction Manual
GLIDE SLOPE ANTENNA SYSTEM, TYPE 4400
July, 1970 Fig. 5 Pg. 27

FIGURE B 2
TYPE III GLIDE SLOPE ANTENNA IN A 90° CORNER REFLECTOR
MEASURED HORIZONTAL RADIATION PATTERN

Test Frequency: 332.0 MHz
SRDS Report No. RD-71-30
INSTRUMENT LANDING SYSTEM IMPROVEMENT PROGRAM
Avionics Research Group, E.E. Dept.,
Ohio University
October, 1971 Fig. 2-9 Pg. 16
TYPE III GLIDE SLOPE ANTENNA
ANTENNA TYPE PA 8664
THEORETICAL HORIZONTAL RADIATION PATTERN

ALL Preliminary Instruction Book
TT 6750.44
GLIDE SLOPE ANTENNA SYSTEM
June 30, 1969 Fig. 3-1 Pg. 3-5
TYPE IV GLIDE SLOPE ANTENNA
ANTENNA TYPE FA-8730
THEORETICAL HORIZONTAL RADIATION PATTERN
Scanwell Preliminary Instruction Book
TI 6750.32
Glide Slope Antenna
June 30, 1970 Fig. 3-5 Pg. 3-10

FIGURE B 6

RELATIVE POWER IN DECIBELS

AZIMUTH ANGLE IN DEGREES

SPECTRUM MANAGEMENT, NAVY, AROD-60
Submitted APPROVED July
MARK LOPEZ J.L. FIERROA 1978
TYPE IV GLIDE SLOPE ANTENNA
ANTENNA TYPE FA-8976
MEASURED HORIZONTAL RADIATION PATTERN

Test Frequency: 332.0 MHz
APC Instruction Book TI 6750.76
GLIDE SLOPE ANTENNA SYSTEM
October 16, 1973 Fig. 1-12 Pg. 1-18
TYPE IV GLIDE SLOPE ANTENNA
ANTENNA TYPE PA-2373
THEORETICAL HORIZONTAL RADIATION PATTERN

Preliminary Instruction Book TI 6750.83
APC Antenna, Wilcox Drawing No.177-705-2
October 13, 1973  Fig. 2-2  Pg. 2-3

AZIMUTH ANGLE IN DEGREES

FIGURE B 8

SPECTRUM MANAGEMENT STAFF, ARD-60
Submitted  Approved  July
MARK LOPEZ  J.L. PIERZGA  1978
TYPE III - TYPE IV GLIDE SLOPE ANTENNA
MEASURED HORIZONTAL ANTENNA PATTERN

Allentown, Pa., Allentown-Beth.-Easton Airport, RWY 13
1-BXY, 331.1 MHz., 4500 ft (1372m) AGL
Null Reference Configuration
NAFEC Aircraft, 25 Sept. 1978

RELATIVE ANTENNA GAIN IN DBS

AZIMUTH IN DEGREES

FIGURE B 9

SPECSION MANAGEMENT STAFF, AFGO
Submitted
APPROVED
May 1979
MARK LOPEZ J.L. FRENDA 1979
Type IV Glide Slope Antenna
Antenna Nomenclature, FA-8870
Theoretical Horizontal Antenna Pattern

Preliminary Instruction Book, TI 6750.63
Scarowell Antenna, Wilcox Dwg. No. 1588-1009-2
December 30, 1970, Fig. 3-5, Pg. 3-10

Relative Antenna Gain in Decibels

Azimuth in Degrees

Figure 3-11

Spectrum Management Staff, ARD-60
Submitted Approved Aug.
Mark Lopez J.L. Perez 1978
TYPE III - TYPE IV GLIDE SLOPE ANTENNA
MEASURED HORIZONTAL ANTENNA PATTERN

Chantilly, Va., Dulles Airport, RWY 19L
1-SGC, 334.4 MHz, 4500 ft (1372m) AGL
Capture Effect Configuration
NAFEC Aircraft, 30 Sept. 1978

AZIMUTH IN DEGREES

RELATIVE ANTENNA GAIN IN DECIBELS

FIGURE B 12
Type III - Type IV Glide Slope Antenna
Measured Horizontal Antenna Pattern

Pittsburgh, Pa., Allegheny Co. Airport, RWY 27
I-AGC, 331.4 MHz, 4500 ft (1372m) AGL
Null Reference Configuration
NAFA Aircraft, 3 Oct. 1978
TYPE III - TYPE IV GLIDE SLOPE ANTENNA
MEASURED HORIZONTAL ANTENNA PATTERN

Reading, Pa., Reading Municipal Airport; RWY 36
1-RDG, 332.6 MHz, 4500 ft (1372m) AGL
Null Reference Configuration
NAFEC Aircraft, 30 Sept. 1978

RELATIVE ANTENNA GAIN IN DECIBELS

AZIMUTH IN DEGREES

FIGURE B 14

SPECTRUM MANAGEMENT STAFF, ARD-60
Submitted Approved Mar.
MARK LOPEZ J.L. PIENZGA 1979
The two-lambda cassegranian glide slope antenna is produced by Texas Instruments for use with its AN/GRN-27 (V) and Mark III glide slope systems. Each antenna consists of a single dipole with a director, reflector, secondary two-lambda by one-lambda reflecting surface, and two proximity (monitor) probes, all enclosed in a radome.

Only limited data on this system was available. The three measured patterns supplied by T.I. (Figs. C2 thru C4) agree well with the theoretical pattern (Fig. C1). In addition, they fall within the limits of FAA specification FAA-E-2429 (Fig. G5). The two patterns produced from NAFEC data (Figs. C5 and C6) don't agree very well with the theoretical pattern. In addition, they appear to have a narrower front course pattern than what is required by the specification.

The frequency assignment antenna pattern recommended for the two-lambda cassegranian glide slope antenna is based on specification FAA-E-2429 (Fig. 5) and the figures in Appendix C.
TWO-LAMBDAA CASSEGRANIAN GLIDE SLOPE ANTENNA
THEORETICAL HORIZONTAL ANTENNA PATTERN

T.I. Proposal No. FB 71-096, 4 May 1971
Proposal to Design, Develop, Fabricate, Test
and Install, VHF/UHF Category III ILS
Volume 1, Technical, Fig. 3-52, Pg. 3-112

RELATIVE ANTENNA GAIN IN DEGREES
AZIMUTH IN DEGREES

FIGURE C 1

SPECTRUM MANAGEMENT STAFF, AND-60
Submitted
July
MARK LOPEZ, J.L. FIERRO 1978
TWO-LAMBDA CASSEGRANIAN GLIDE SLOPE ANTENNA
ANTENNA NOMENCLATURE, AN/GRN-27(V)
MEASURED HORIZONTAL ANTENNA PATTERN

Unnumbered T.I. Drawing, 328.0 MHz

RELATIVE POWER IN DECIBELS

AZIMUTH ANGLE IN DEGREES

FIGURE C 2

SPECTRUM MANAGEMENT STAFF, ARD-60
Submitted Approved Aug.
MARK LOPEZ J.L. FINZGA 1978
TWO-LAMBDA CASSEGRANIAN GLIDE SLOPE ANTENNA
ANTENNA NOMENCLATURE, AN/GRN-27(V)
MEASURED HORIZONTAL ANTENNA PATTERN

Unnumbered I.I. Drawing, 332.0 MHz

RELATIVE ANTENNA GAIN IN DECIBELS

AZIMUTH IN DEGREES

FIGURE C 3

SPECTRUM MANAGEMENT STAFF, ARD-60
Submitted
MARK LOPEZ  J.L. PIERRO  1978
TWO-LAMBOA CASSEGRANIAN Glide SLOPE ANTENNA
ANTENNA NOMENCLATURE, AN/GRN-27(V)
MEASURED HORIZONTAL ANTENNA PATTERN

Unnumbered T.I. Drawing, 336.0 MHz
TWO-LAMBDA CASSEGRAINIAN GLIDE SLOPE ANTENNA
MEASURED HORIZONTAL ANTENNA PATTERN

Pittsburgh, Pa., Greater Pitt. Airport, RWY 10L
I-LX8, 333.5 MHz., 4500 ft (1372m) AGL
Capture Effect Configuration
NAFEC Aircraft, 30 Oct. 1978

FIGURE C 6
APPENDIX D

THE STAN-38 ANTENNA

The Stan-38 glide slope is a part of the British ILS system located at Dulles Airport. This is the only system of its kind presently commissioned in the U.S. Additional installations in this country are unlikely.

This system uses an image-type antenna designed for use in the conventional null reference, sideband reference, and capture effect systems. The antenna is unique in that each aerial contains six dipoles (U.S. manufactured arrays house a maximum of three).

Only limited information was available on the Stan-38. The one antenna pattern obtained (Fig. D1) was taken from the British instruction manual. The frequency assignment pattern is based on this pattern, the theoretical 3dB points, the side lobe ratio, and the front-to-back ratio.
STAN 38 GLIDE SLOPE ANTENNA
MEASURED HORIZONTAL RADIATION PATTERN

Test Frequency: 332.0 MHz
British Report No. TTH 309,
HB 1268/2-A Issue 1
INSTRUMENT LANDING SYSTEM EQUIPMENT
GLIDE PATH TYPE STAN 38
June, 1968 Fig. 7/2
APPENDIX E

THE END-FIRE SLOTTED CABLE ANTENNA

This antenna system is a non-image, end-fire type glide slope currently under development. A ground image is not required to form the glide path. Rather, the difference in path lengths from the two antennas to the aircraft produces the on-or-off course signals. This system is designed to provide glide slope service for runways where site conditions make it difficult to install the existing systems.

The only pattern available (Fig. E1) was taken from the test evaluation at Rock Springs, Wy. The frequency assignment pattern was chosen using this data and a conservative estimate of the systems off-course azimuthal pattern.
Watts Mark-3 Endfire Glide Slope Antenna
MEASURED HORIZONTAL RADIATION PATTERN

Average Signal Strength Measured by a 360° Orbit with a 4 mi. Radius.
Technical Memorandum Number S-56
Second Evaluation of Watts Mark-3
Endfire Glide Slope Performance at
Rock Springs, Wyoming, Runway 27
Avionic Engineering Center, Ohio U.
May, 1978
TYPE III - TYPE IV GLIDE SLOPE ANTENNA
MEASURED HORIZONTAL ANTENNA PATTERN

Chantilly, Va., Dulles Airport, RWY 19L
1-SGC, 334.4 MHz, 4500 ft (1372m) AGL
Capture Effect Configuration
NAFEC Aircraft, 30 Sept. 1978

RELATIVE ANTENNA GAIN IN DECIBELS

AZIMUTH IN DEGREES

FIGURE B 12

SPECTRUM MANAGEMENT STAFF, AND-50
Submitted Approved Mar.
MARK LOPEZ J.L. FIERROA 1979
TWO AIL TYPE 55 GLIDE SLOPE ANTENNAS SIDE BY SIDE
MEASURED HORIZONTAL RADIATION PATTERN

Two Antennas Placed Side by Side to Avoid
Reflections From Obstacles in the Near Field.
Pattern Provided to ARD-60 by AIL
December 19, 1977

RELATIVE POWER IN DECIBELS

AZIMUTH ANGLE IN DEGREES

FIGURE P 2

SPECTRUM MANAGEMENT STAFF, ARD-60
Submitted  Approved  Aug.
MARK LOPEZ  J.L. FIERRO  1978.
APPENDIX G

FAA SPECIFICATIONS

In our search for glide slope antenna specifications, the following documents were found to be applicable:

FAA-E-2245. This document was originally published March 11, 1966. Three amendments, the most recent dating March 24, 1969, have been authorized. Seven types of antennas are described in this specification.

Type I - This antenna contains a single dipole mounted on an elliptical ground plane and completely enclosed in a radome. Its horizontal free space radiation pattern is shown in Figure G1.

Type II - Type II antennas are the same as Type I, except they are equipped with a heater system. Its antenna pattern is the same as the Type I.

Type III - This is an array of three Type I antennas grouped to provide azimuthal directivity. The curve in Figure G2 provides the horizontal free space pattern for the Type III and the Type IV antennas.

Type IV - This antenna is the same as a Type III antenna, except for the addition of heaters (Type II antenna elements). Its pattern is the same as the Type III.

Type V - This is an array of two dipoles mounted one quarter-wavelength from a vertical ground plane. The horizontal free space radiation patterns given in Figure G3.
Type VI - This is a single dipole identical to those comprising the Type V antenna, but utilizes a smaller ground plane. The nominal antenna pattern is to be defined by the contractor at the time that the initial equipment is submitted.

Type VII - This antenna consists of an array of two colinear dipoles mounted one quarter-wavelength from a parabolic ground plane. Figure G4 provides the horizontal free space pattern requirements.

This specification (FAA-E-2245) covers most glide slope antennas in use today. Type III and Type IV antennas are the most abundant.

FAA-E-2429. This specification, dated January 2, 1970, is used in purchasing new image-type glide slope antenna systems. Both class 1 (null reference) and class 2 (capture effect) systems are covered. The sideband reference system is a modified version of the null reference system (Section 1.1, FAA-E-2557, April 2, 1973) and must meet the same horizontal pattern requirements.

This document does not differentiate between antenna types or element numbers, but rather sets general antenna array requirements. The antenna array is defined as "single or multiple horizontally polarized elements..." Thus, whether the antennas are in the null reference, sideband reference, or capture effect configuration, the same horizontal radiation pattern will be required by the specification.

The lower limit of this specification was modified in the contract specification FA744A-3364. Measured data indicates that this requirement is difficult to meet, even for the antennas built under this contract (Figs.
The end-fire slotted cable and the waveguide glide slope antennas are still under development. Consequently, there are no current FAA specifications which apply to these non-image type antenna systems.
TYPE I AND TYPE II GLIDE SLOPE ANTENNA
HORIZONTAL RADIATION PATTERN REQUIREMENTS
FEDERAL AVIATION ADMINISTRATION SPECIFICATION

--- Limits ---- Ideal Pattern
Specification No. FAA-E-2245
March 24, 1969 Par. 3.10 Pg. 3

RELATIVE POWER IN DECIBELS

AZIMUTH ANGLE IN DEGREES

FIGURE C.1

SPECTRUM MANAGEMENT STAFF, AMD-60
Submitted Approved Sept.
MARK LOPES J.L. FIERZGA 1978
TYPE V GLIDE SLOPE ANTENNA
HORIZONTAL RADIATION PATTERN REQUIREMENTS
FEDERAL AVIATION ADMINISTRATION SPECIFICATION

Limits ---- Ideal Pattern
Specification No. FAA-Z-2245
March 24, 1969 Par. 3.14 Pg. 12

RELATIVE POWER IN DECIBELS

AZIMUTH ANGLE IN DEGREES

SPECTRUM MANAGEMENT STAFF, ARD-50
Submitted Approved Aug.
MARK LOPEZ J.L. FIERZGA 1978

FIGURE G 3
TYPE VII GLIDE SLOPE ANTENNA
HORIZONTAL RADIATION PATTERN REQUIREMENTS
FEDERAL AVIATION ADMINISTRATION SPECIFICATION

Limits ---- Ideal Pattern
Specification No. FAA-E-2245
March 24, 1969 Par. 3.18 Fig. 3, Amend. 3

RECEIVED: 1978
MARK LOPEZ S. J. SANCHEZ

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FROM COPY FURNISHED TO DOC
GLIDE SLOPE ANTENNA
HORIZONTAL RADIATION PATTERN REQUIREMENTS
FEDERAL AVIATION ADMINISTRATION SPECIFICATION

Antenna Types: Class 1 Null Reference
Class 2 Capture Effect
Specification No. FAA-E-2429
January 2, 1970 Fig. 1 Fig. 13

SPECTRUM MANAGEMENT STAFF, ARD-60
Submitted Approved Aug.
MARK LOPEZ J.L. FIERRO 1978
GLIDE SLOPE ANTENNA
HORIZONTAL RADIATION PATTERN REQUIREMENTS
CONTRACT SPECIFICATION-CONTRACT FA74WA-3364

Antenna Type FA-9373
Preliminary Instruction Book TI6750.83
A.P.C. Antenna, Wilcox Drawing No. 177-705-2
October 18, 1973 Fig. 2-2 Pg. 2-3
APPENDIX H

DATA OBTAINED FROM NAFEC

This section contains copies of the raw data collected by NAFEC. The following list shows the type of antenna elements are used in each antenna.

<table>
<thead>
<tr>
<th>LOCATION</th>
<th>FIGURE NO.</th>
<th>SYSTEM TYPE</th>
<th>ELEMENT TYPE</th>
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<td>B9</td>
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<td>III or IV</td>
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<td>Allegheny Co., Pa.</td>
<td>B14</td>
<td>NR</td>
<td>III or IV</td>
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<td>B15</td>
<td>NR</td>
<td>III or IV</td>
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<td>Hagerstown, Md.</td>
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<td>SBR</td>
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<td>CE</td>
<td>III or IV</td>
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<td>Trenton, N.J.</td>
<td>A4</td>
<td>SBR</td>
<td>I or II</td>
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<td>Atlantic City, N.J.</td>
<td>C5</td>
<td>CE</td>
<td>Two-Lambda</td>
</tr>
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<td>Gr. Pittsburgh, Pa.</td>
<td>C6</td>
<td>CE</td>
<td>Two-Lambda</td>
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Data from the Allentown glide slope is the only antenna pattern replotted in detail. In order to save time, the remaining antenna patterns were replotted using lines to outline the maximum and minimum limits of the data. Should detailed information be desired on a particular antenna pattern, it is available in this appendix.

The data taken at Johnstown, Pa. has not been replotted. This glide slope system was shut down just prior to when the test orbit was flown. The data is no more than the ambient noise level.
GLIDE SLOPE AT ALLENTOWN, PA.

FREQUENCY 3.311E+08 MHz
SPECTRUM ANALYZER HZ/DIV= 50000 HZ    GAIN=10DB/DIV
FLIGHT NO. 10    ALTITUDE=4500 FEET
MAX PTS. IN PLOT= 590    START OF 340, END OF 276 DEGREES

FIGURE H 1
GLIDE SLOPE AT ATLANTIC CITY, NEW JERSEY

FREQUENCY 3.3146E+08 MHZ
SPECTRUM ANALYZER HZ/DIV= 500000 HZ  GAIN=10DB/DIV
FLIGHT NO. 1 ALTITUDE=4500 FEET
MAX PTS. IN PLOT= 736  START OF 21, END OF 225 DEGREES

FIGURE H.2
GLIDE SLOPE LOCALIZER AT DULLES, GLIDE SLOPE, 'X'.

FREQUENCY 3.344095E+08 MHZ
SPECTRUM ANALYZER HZ/DIV= 50000 Hz GAIN=10DB/DIV
FLIGHT NO. 11 ALTITUDE=4500 FEET
MAX PTS. IN PLOT= 637 START OF 329, END OF 291 DEGREES

FIGURE H 3
GLIDE SLOPE AT HAGERSTOWN, MD.

FREQUENCY 3.31100E+08 MHZ
SPECTRUM ANALYZER HZ/DIV= 50000 HZ, GAIN=10 DB/DIV
FLIGHT NO. 10, ALTITUDE=4500 FEET
MAX PTS. IN PLOT= 527, START OF 314, END OF 356 DEGREES

FIGURE H 4
GLIDE SLOPE AT JOHNSTOWN, PA.

4466E+08 HZ
SPECTRUM ANALYZER HZ/DIV = 50000 HZ
GAIN = 1003/DIV
FLIGHT NO. 35
MAX PTS. IN PLOT = 493
ALTITUDE = 4529 FEET
START OF 231, END OF 228 DEGREES

FIGURE H 5
GLIDE SLOPE AT GREATER PITTSBURG, PA.  FREQUENCY 3.3

3500E+08 Hz
SPECTRUM ANALYZER HZ/DIV = 50000 Hz
FLIGHT NO. 34
MAX PTS. IN PLOT = 459
ALTITUDE = 4500 FEET
GAIN = 160 DB/DIV
START OF 265, END OF 247 DEGREES

FIGURE H 6
GLIDE SLOPE AT PITTSBURG (ALLEGHENY COUNTY), PA.

FREQUENCY 3.314E+08 HZ
SPECTRUM ANALYZER HZ/DIV= 50000 HZ    GAIN=10DB/DIV
FLIGHT NO. 33    ALTITUDE=4500 FEET
MAX PTS. IN PLOT= 527    START OF 103, END OF 124 DEGREES

FIGURE H 7
Glide slope at Reading, PA.

Frequency: 3.32602E+03 MHz
Spectrum analyzer Hz/Div: 50000 Hz  Gain=1000/Div
Flight No.: 7  Altitude=4500 feet
Max pts. in plot: 692
Start of 134, end of 26 degrees

Figure 10.8
GLIDE SLOPE AT TRENTON, N.J.

FREQUENCY 3.3

2300E+08 HZ
SPECTRUM ANALYZER HZ/DIV= 50000 HZ
FLIGHT NO. 2 ALTITUDE= 4500 FEET
MAX PTS. IN PLOT= 516
START OF 11, END OF 19 DEGREES

FIGURE H 9
APPENDIX I

PICTURES OF ILS GLIDE SLOPE ANTENNAS

Different types of glide slope antennas have different antenna patterns. Consideration of these differences may be desirable in the frequency assignment process. Consideration requires knowledge of the desired and undesired stations' antenna types. FAA sector offices provide this information to the Electromagnetic Compatibility Analysis Center (ECAC). FAA has an interagency agreement with ECAC. The FAA provides to ECAC data on telecommunication systems. ECAC does the record keeping and provides to FAA computer printouts upon request. For the frequency assignment process, the Frequency Management Officer (FMO) may choose to use the ECAC records or he may contact the FAA sector offices directly. In either case, the identification of the antenna type comes from the FAA sector maintenance office. Since this is the case, sector personnel should be capable of identifying the different antenna types. With the many different glide slope antenna types, this can be a difficult assignment. FAA type numbers are helpful but they have not been assigned to all antenna types. In many cases, visual identification is essential. Since, to our knowledge no single FAA publication shows all glide slope antenna types, this appendix has been an attempt to do that.
Conventional Glide Slope Antenna System Configurations

FIGURE I-1

73
FIGURE I 2
Type I Antenna With Pick-Up Device
Antenna Type FA-8090

FIGURE I 3
Type I Antenna With Reflector Removed
Antenna Type FA-8090
Antenna Type FA-8730 In The Null Reference And Capture Effect Configurations

FIGURE 14
Dipole For Antenna Type FA-8730

FIGURE I 5

Type IV Antenna Without Radomes
Antenna Type FA-8730

FIGURE I 6
Type III Antenna With Radomes
Antenna Type FA-8021

FIGURE 17

SIDEBAND ANTENNA

CARRIER ANTENNA

Type III Antenna In The Null Reference Configuration

FIGURE 18
FIGURE I 10
Inside View Of The Casing For The
AIL Type 55 Glide Slope Antenna Element

FIGURE I 11
AIL Type 55 Glide Slope Antenna Element
Fig. 112  
Stan. 38 Glide Slope Elements in The  
Capture Effect Configuration
Fig. 1-14

Stain of Slide Slope Element
Two-Lambda Antenna

Capture Effect M-Array Glide Slope, General View

FIGURE I 14
FIGURE 3.1

The Idaho Cassapramar White Slope Antenna Capture Effectiveness.
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<th>fl. pt</th>
<th>fl. qt</th>
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### TEMPERATURE

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°F = ⁹/₅°C + 32